

ADDIS ABABA UNIVERSITY INSTITUTE OF TECHNOLOGY (AAiT)
DEPARTMENT OF CIVIL ENGINEERING (POSTGRADUATE STUDIES)
STREAM: CONSTRUCTION TECHNOLOGYandMANAGEMENT

TITLE PROJECT: PROJECT CONSTRUCTION OPERATION PLANNING and CONTROLLING of BUILDING PROJECTS
A Case Study on Crafts Construction PLC

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Table of **Contents**

Acknowledgements ii
List of table v
List of figure v
Abbreviations vi
Abstract vii
1. INTRODUCTION 1
1.1 GENERAL 1
1.2 TYPES OF PLANNING 2
1.3 WHAT IS CONSTRUCTION MASTER PLAN? 4
1.4 BACK GROUND OF THE PROBLEM 5
1.5 OBJECTIVES 6
1.6 SCOPE and LIMITATION OF THE STUDY 8
1.7 APPLICATION OF RESULTS 9
2. STATEMENT OF THE PROBLEM 10
3. LITERATURE REVIEW 11
3.1 Planning Project Works Scope 13
3.1.1 Project Work Scope Definition Processes 14
3.1.2 Components of Project Work Scope Definition 14
3.2 Planning Construction Resources 26
3.2.1 Activity Duration Estimation 26
3.2.2 Activity Resource Estimation 34
3.2.3 Construction Manpower Planning 35
3.2.4 Construction Material Planning 37
3.2.5 Construction Equipment and machinery Planning 39
3.3 Construction Direct Production Cost and Project Budget Planning 41
3.4 Resource scheduling 45
3.5 Project Control System 45
3.5.1 Project Work Scope Controlling 47

3.5.2 Resource Productivity and Direct Cost Controlling 48
3.5.3 Time Schedule Controlling 55
4. RESEARCH DESIGNE AND METHODOLOGY 58
4.1 Overview of the Research Process 58
4.2 The Study Approach and Research Instrument 58
5. ANALYSIS AND DISCUSSION 60
5.1 Scope of work Definition 62
5.2 Method of Execution of the Activity 62
5.3 Construction Resource estimation 63
5.4 Activity Duration Estimation 63
5.5 Direct Cost Estimation 64
5.6 Direct cost Controlling 64
5.7 Organization Performance with respect to Profit 64
5.8 Organization Performance with respect to Time 64
5.9 Planning and Controlling Tools 64
6. CONCLUSIONS AND RECOMMENDATIONS 66
6.1 Conclusions 66
6.2 Recommendations 68
REFERENCES 71
APPENDIX 73
SIGNED DECLEARATION SHEET 75

List of table

Table 5.1 Performance Evaluation of All active Projects of CCPLC

List of figure

Figure 3.1 Direct cost Variance Breakdown

Figure 3.2 Estimation activity Duration inputs, Tools &techniques & Output

Figure 6.1 Typical Work Breakdown Structure Configurations

Abbreviations

PCOPC =Project Construction Operation Planning and Controlling

HRM =Human Resource Management

EaM =Equipment and Machinery

WBS =Work Breakdown Structure

BCWS =Budgeted Cost of Work Schedule

PV = Planned Value respectively.

BCWP =Budgeted Cost of Work Performed

EV = Earned Value respectively

ACWP = Actual Cost of Work Performed or

AC =Actual Cost respectively

BCAC = Budgeted cost at completion

AQWP =Actual Quantity of Work Performed.

BQAC =Budgeted Quantity at Completion

CV =Cost Variance

SV =Schedule Variance

CPI =Cost Performance Index

SPI =Schedule Performance Index

EAC =Estimated Cost at Completion

VAC = Variance at Completion (VAC)

F = Favorable Variance

U =Unfavorable Variance

BDU = Bahirdar University

HTTC =Holly Trinity Theological Collage

JICS =Japan international Corporation System

CCPLC = Crafts Construction PLC

Abstract

Almost every study finds that failures are caused primarily by poor project management, especially the failure to plan properly, (P. Lewis, 2007)

My research focuses, how we can prepare detailed good, realistic & applicable good plan. Once the detailed plan is developed the next step is how we can control resource productivity, cost & time by identifying the cause for resource productivity variance, direct cost variance and time variance. Finally applying corrective measures to minimize the wastage of input resource and improve the performance by applying planning and controlling which are the management processes with case study on crafts construction plc.

The research findings indicated that financial progress report of the organization shows to date work executed of the projects is below 50%of the contract amount until the completion time is elapsed. The result more over indicates that most of the projects are unable to finish the project on its completion time.

According to the result of the research, most of the surveyed projects of the organization are an able to obtain the profit they anticipate from their project plans. The anticipated planned profit from the surveyed project is 60% without considering the overheads of the project & head office, where as the actual profit is 30%. The major contributing factors, in order of their influence are in adequate planning, lack of cost controlling systems, in accuracy of quantity estimation, in accuracy of duration estimation , in accuracy of resource estimation during planning stage and unable to revise the plan .

Lack of recorded daily productivity output of past experience of the organization and the absence of summarized, revised, of standard of these daily productivity output are the major errors in estimating physical resources (labour, material equipment & time) and their direct costs.

The result revealed the organization cost controlling process is not integrated with the budget prepared for the project budgetary control is not popular. The process

focuses mainly on revealing the amount of profit and fails to indicate identify activities or operations. In addition to this the organization uses MS-project software only for scheduling of activities without resource assignment in each activity. The organization does not use software's for planning and controlling.

During direct cost controlling, the organization identifies the direct cost variance of (labour, material & equipment), however it does not go deep through the cause of the direct cost variances like for Labour (productivity variance & rate variance), for material (usage variance and price variance) and for equipment (rent/ purchase price variance and productivity variance).

If you have no plan, by definition, you have no control, because it is your plan that tells you where you are supposed to be in the first place. Furthermore, if you don't know where you are you can't have control. This knowledge comes from your information system, (P. Lewis, 2011).

Key Words: Planning, direct cost controlling, work scope definition, Activity definition , labour direct cost, equipment direct cost, material direct costs, duration estimation method, work breakdown structure, resource estimation, profit, software Primavera p6 planner.

1. INTRODUCTION

1.1 GENERAL

Construction is the major component of the new investments. Construction industry is the essential ingredient for the growth of the economy of the country, (Chitkara, 2011). The construction industry needs various resources (Material, Labour, and Equipment); to become the construction operation efficient and effective it needs detailed planning and controlling. No planning or poor planning leads to profit declining of the construction business companies.

One of the major causes of project failures is poor planning. Actually, I am being kind. Most of the time the problem is due to no planning! The team simply tries to "wing it," to do the work without doing any planning at all. As we will see when we turn to controlling the project, failing to develop a plan means that there can be no actual control of the project. We are just kidding ourselves, (P. Lewis). The results moreover indicated that most of the surveyed contractors are unable to obtain the profit they anticipate from their projects. 86% of the contractors have obtained below 75% of the amount they expected from most of the projects they have undertaken so far. Among these, 48% obtained less than 50% of the anticipated amount. The major contributing factors, in the order of their influence are price escalation, delays caused by owners and/or consultants, inadequate financial planning practices, lack of cost controlling system and inaccuracy of the estimates prepared during the tendering stage, (Abeselom, 2008).

Construction planning is a fundamental and challenging activity in the management and execution of construction projects. It involves the choice of technology, the definition of work tasks, the estimation of the required resources and durations for individual tasks, and the identification of any interactions among the different work tasks. A good construction plan is the basis for developing the budget and the schedule for work. Developing the construction plan is a critical task in the management of construction, even if the plan is not written or otherwise formally recorded, (Hendrickson, 2003).

Project planning is the function in which project and construction managers and their key staff members prepares the master plan. Then this master plan is put into time schedule by scheduling people which is called project scheduling. A project plan is mostly responsible for the success or failure of the project, (Http//the contractor.org.).

Definition of Planning:

Planning is a bridge between the experiences of the past projects and the proposed actions that produces favorable results in the future. It can also be said that it is a precaution by which we can reduce undesirable effects or unexpected happenings and thereby eliminating confusion, waste, and loss of efficiency. Planning involves prior determination, specification of factors, forces, effects and relationships necessary to reach the desired goals, (Http//the contractor.org.).

Planning Philosophy:

Planning should be done logically, thoroughly and honestly to have a chance to succeed. The previous experience of projects provides basic planning logic. Then difference between previous projects and current projects shall be known to make any exceptional features in the basic planning logic. These differences can be unusual client requirement, out of the way location, potential external or internal delaying factors etc. these potential problems shall have to be tackled in order to reduce their negative effect preparing master plan of the project and later scheduling of the project. Provide each aspect of the plan an individual scrutiny with input from past experiences and from experts, (Http//the contractor.org.).

1.2 TYPES OF PLANNING

There are several types of project planning. The three major types of construction project planning are:

1. **Strategic planning:** this involves the high-level selection of the project objectives
2. **Operational planning:** this involves the detailed planning required to meet the strategic objectives. According to Abebe, Ninatubu & Alfred operational planning for con-

struction project on the other hand, employs various tools and techniques to help the planner achieve better optimization for decisions involved as discussed below.

3. **Scheduling:** this puts the detailed operational plan on a time scale set by the strategic objectives.

Strategic planning is done by the owner's corporate planners. In this they decide what project to build and what the completion date has to be to meet the owner's project goals. The construction team formulates the master construction execution plan within the guidelines set in the strategic and contracting plans, (Http//the contractor.org.).

Operational Planning:

Operational planning that includes a tender plan, feasibility plan & construction plan, among others, allows a more detailed treatment of the project resource requirement that is not obvious at the strategic level, (Abebe, Ninatubu &Alfred).

Operational planning is done by construction teams. They ask certain questions before making operational plan for the project. They are:

Will the operational plan meet the strategic planning target date?

- Are sufficient construction resources and services available within the company to meet the project objectives?
- What is the impact of the new project on the existing work load?
- Where will we get the resources to handle any overload?
- What company policies may prevent the plan from meeting the target date?
- Are usually long delivery equipment or materials involved?
- Are the project concepts and design firmly established and red to start the construction?
- Is the original contracting plan still valid?
- Will it be more economical to use a fast-track scheduling approach?

All these questions are answered in preparation of the construction master plan before detailed scheduling of the project, (Http//the contractor.org.).

Controlling

Control is exercised by comparing where project work is to where it is supposed to be, then taking action to correct for any deviations from target. Now the plan tells where the work should be. Without a plan, you don't know where you should be, so control is impossible, by definition, (P. Lewis, 2007).

Measuring Performance

Project performance is measured by comparing the work performance data from the project execution against the performance measurement baseline, which is an approved integrated plan for scope, schedule, and cost for the project, (sanghera, 2009).

Completing a project successfully includes delivering the planned scope according to the planned schedule and within the planned budget. The fundamental parameters for budget and schedule are cost and time, respectively: Budget is the cost with a timeline, and schedule is determined from the time estimates for completing the schedule activities. So, scope, time, and cost make the heart of any project, (sanghera, 2009).

1.3 WHAT IS CONSTRUCTION MASTER PLAN?

A construction master plan addresses how will the project be planned, organized, and major work activities be controlled to meet the goals of finishing the work on time, within budget and as specified, (Http//the contractor.org.).

Contracting plan is the major consideration in formulating the master construction plan, which answers a lot of questions. Questions related to government and social restraint, resources for construction, owner's policies or legal requirements, contractual requirement affecting master plan are not answered by contracting plan. Answers to these questions must be found during the development of the project execution plan, (Http//the contractor.org.).

Project execution plan shall be reviewed and evaluation shall be done as the work progresses. Minor variations are common but major changes shall be considered with extreme caution, (Http//the contractor.org.).

The construction project master plan shall be completed and approved and after that time plan (scheduling), budget plan, resource plan shall be carried out, (Http//the contractor.org.).

1.4 BACK GROUND OF THE PROBLEM

Contractors are ambitious to get new projects for the growth of their companies & to survive their employees. To get new projects they participate in the tendering by summiting their bid during bid submit ion date. Finally after the award of the project the contractor starts the execution of the project with little or poor, or no planning and during the execution of the project faces many obstacles like cash flow problem, delay, cost overrun, profit loss all these are because of no proper planning &controlling. However, getting of new projects only will not help the company profitable it needs planning how to execute the project based on the estimated budget and specified completion time.

Almost every study finds that failures are caused primarily by poor project management, especially the failure to plan properly, (P. Lewis, 2007).

If you have no plan, by definition, you have no control, because it is your plan that tells you where you are supposed to be in the first place. Furthermore, if you don't know where you are you can't have control. This knowledge comes from your information system, (P. Lewis, 2011).

Therefore contractors to get their profit margin and to finish the project on its specified completion time they have to plan properly before the start & control during execution of the project.

Project management is accomplished through the use of the process such as initiating, planning, executing, controlling &closing Project. It is important to note that many of the process with in project management are iterative in nature, (PMBOk guidelines, 2000).Project is the heart of the contractor. The source of cash flow /income/ is project as the blood flows from the heart. If the project faces cash flow problem it is similar to heart without blood flow, there for we have to protect the contractor heart (project) to survive &to have healthy cash flow on its construction company. The best way of pro-

tecting the project is implementing of planning and controlling, which are the process of project management.

The motivation for this research is originated from my own experience in organization. Through my experience & observation I have clearly identified that the organization have a gap in planning and controlling the construction projects. So I am really happy to investigate and propose solutions for this real-life management issues and problems.

1.5 OBJECTIVES

General Objectives

The main objective of this study is:-

1. To complete projects on their specified time and cost by improving planning, scheduling and controlling methods of the construction operation.
2. To add up/increase or to keep up the contractor's profit, which is submitted during the bid preparation/tendering by achieving the required/specified quality of work using PCOPC.
3. To deploy the required Construction Operation inputs in a timely manner to make the construction operation effective and avoid costs incurred due to input shortages.
4. To create a smooth construction operation and improve the quality of life of CRAFTS employees working at all levels.
5. To provide a systematic method for how we can control the resources in building construction projects using software.

Specific Objectives

1. For Logistics department
    a) To deliver industrial and quarry material on the specified time and at the intended price.
    b) To assign the required Equipment and Machinery in line with the schedule.

c) To facilitate the productions like HCB, Door, window, Manhole cover, Concrete pipe and so on.

2. For Finance and Administration Department
    a) To develop a cash flow statement for each specific project, which will be used to monitor and control the cash utilization by the respective project.
    b) To set the average, maximum and minimum wages of the unskilled, semiskilled, and skilled workers to be deployed in the project.
    c) To control the cost of the manpower, material and equipment, and machinery associates in line with the plan developed.
    d) To monitor and control the average number of unskilled, semiskilled, and skilled manpower deployed in each specific period of the project life.
    e) To categorize the project according to the project price or/and monthly turn over and establish project HRM structure, office facility and camp facility accordingly.
3. For Construction Operation Department
    a) To set the desired output of the projects of specific period.
    b) To facilitate and coordinate the complete delivery of planned input in a timely manner.
    c) To monitor the construction operation by providing a method of statement.
4. For office Engineering Department
    a) To do the quantity surveying for the actual work volume that can be input for the (Material, Labour and Equipment, and Machinery definition.
    b) To certify interim payment certificates at monthly basis for all projects.

5. For Commercial Department
    a) To define the planned inputs required to achieve the stated desired output for the coming period.
    b) To evaluate the actual output compared with the previously stated output.
    c) To evaluate the resource utilization of each project by comparing the planned input with the actual input of the specific period.
    d) To minimize input resource wastage.
    e) To identify the cause for resource productivity variance and to apply corrective measures.
    f) To identify the cause for direct cost variance and applying corrective measures to improve the performance.
    g) To indicate monthly price adjustment is needed or not.

6. To decrease the overhead cost of the company.

1.6 SCOPE and LIMITATION OF THE STUDY

- The scope of this research project is limited to projects constructed by Crafts Construction PLC.
    i. Because almost all my experience time is spent on Crafts Construction Plc.
    ii. This company is the one I know, and I can access complete data easily to complete my research.
    iii. Because the initiator for the research is the company's gap in planning and controlling.
    iv. The company is willing and happy to conduct my research on Crafts Construction PLC. Planning and

scheduling of projects, and promises to cover the costs during my research work.

v. The selection of another company may not have enough time to assess.

vi. Finally, the selection of other company may not have enough data to complete my research.

- The research concentrates only on Building Construction and water works. Because most of the experience of the company are on these.
- The detailed planning and controlling will be done only for four projects, because if there are more than these it needs additional time and resources than the work plan and estimated budget for the research.

1.7 APPLICATION OF RESULTS

The results will be applied to the Ethiopian construction industry to develop an effective construction management technique especially in construction operation Planning.

Beneficiaries of the Results

- Contractors
- Consultants
- Clients
- Planers, Schedulers, Office engineers
- Educational Institution
- Farther studies in construction management and related topics

2. STATEMENT OF THE PROBLEM

Construction Contractors so as to get the profit they anticipate from their projects and to complete the project on the intended completion date; they should have to properly, logically done the plan before starting and control during the execution of the project and, Finally taking an action to correct for any deviations from the plan or target.

However, as described in the introduction most of the surveyed contractors are unable to obtain the profit they anticipate from the projects. [8] In addition to this from my experience Crafts Construction PLC C has a gap in planning and controlling of construction projects. The major gaps or problems in planning and controlling that I have identified are the following.

1. The actual input resources (labour, material, equipment and machinery are highly deviated from the planed input resources (labour, Material, Equipment and Machinery)
2. The actual input cost (Labour cost, material cost and equipment and machinery cost) are highly deviated from the planned/budgeted cost (labour cost, material cost, equipment, and machinery cost.
3. The project cannot complete with in intended completion date.
4. Cash flow problem.
5. Delay in payment preparation and certification.
6. Unable to request the exact escalated price amount during price adjustment.
7. Planned input resources (labour, material, equipment, and machinery) are not delivered to the project on time.

Hence, this research is an applied research aimed at finding a solution for the above real -life problem faced by the crafts construction plc. The research focuses on planning and controlling construction operation projects in detail to fulfill the gap that I have identified in the above and to meet the objectives of the company.

3. LITERATURE REVIEW

Introduction

When a contractor decides to participate in bid or tendering, he will purchase the complete bid document from the client or responsible body and then he will understand and study all the bid documents (i.e. Drawings, Technical specifications, General special condition of contracts).after making site visit and knowing the scope of work, he will decided the technology/method of execution which is best specially for that project ,and based on the selected technology or method of execution he will estimate the bid.

Immediately, when the contractor wins the bid that means when it receives letter of acceptance, the contractor should start preliminary planning and depending on the time of bid submission & letter of acceptance or project mobilization start the contractor forced to update the estimate because it might have been change in method of execution, price of materials & rate of labour and equipment. According to Hendrickson (2003), for contractor the bid estimate is usually required as budgeted estimate, which will be used for control purpose as well as for planning construction financing. The budgeted cost should be also updated periodically to reflect the estimated cost to completion as well as to insure adequate cash flow for the completion of the project. The contractor must adopt some baseline for cost control during the construction.

The contractor before starts planning, the first step must do is that, identifying and defining the work scope of the project by asking the questions what is going to be done? (How much is the work done value or quantity in terms of standard units?), what quality and type of work is required to accomplish each activity or work package?

As we know building construction projects consists of numerous activities than other construction project. For this reason it is advisable to organize the activity in some way to allow communication of plan information to other and to maintain an understanding of the various aspects of the project. While there are many ways that a plan can be organized, one common practice is the work breakdown structure (WBS) (De Macro,

2011). This WBS are used to break down the complex work item in to simple, identifiable, quantifiable, measurable, and constable, discrete lower level element of work is called activity. In short WBS is the basic tool employed to identify activities (Chitkara, 2011).

Once what is going to be done is identified through WBS, it is necessary that all human resources required to perform the project are identified. Depending on the portion of work scope, the project may need engineering skills, procurement capabilities, construction labour, management staff, etc. the organizational work breakdown structure is a practical method to decompose the pool of human resource needed to execute all of the tasks into different competence areas and then into project roles, independently of the number of individuals that will be assigned the specified role (De Macro, 2011).

The second step the contractor should follow after identifying the activities are activity definition, by asking the questions what it needs to be done or to execute each activity? Each activity consumes or needs physical resources (like labour, material, equipment and plant, time, and money for accomplishment (Heerkens, 2002). Defining activity or knowing the resources needed by each activity to complete the work indirectly means preparing Activity Data Base. According to chitkara (2011) activity data base parameters includes;

- Activity description.
- The quantity of work involved, expressed in standard units of measures.
- Method of execution of the activity.
- The quantity of physical resource needed including direct labour, direct material, and direct equipment.
- Activity estimated duration.
- The estimated production direct cost including direct labour costs, direct material cost, direct equipment costs and sub-contractor costs.
- The budgeted cost or earned (contract) value.

The third step after defining the activity through activity data base is that to allocate or assign the physical resource and their costs, and duration to each activity from the activity data base we have.

The fourth step after allocating or assigning the physical resources & their costs, and durations, we develop work programme called scheduling. A project planning is not complete until all the activities are schedule and forecast of major resources is developed. The project management software can aid in speedy development of network and project schedule, (chitkara, 2011). In this research we use primavera P6 Enterprise Project Portfolio Management: release 6.0 Software.

The fifth step after completing project planning making a baseline the plan which consists of scope of work, work done value, physical resources & their costs and durations. This step is last a preparation for comparison of the actual from the planned one.

The last most important step is controlling the deviated parameters from the planned one and applying appropriate corrective measures.

3.1 Planning Project Works Scope

Project scope is the work that needs to be done to deliver the planned outcome-product, service, or result-of the project and Project scope planning conceders various options for execution of project work before making implementation decision, (Sanghera, 2009) & (chitkara, 2011).

Work Scope Planning

Work scope planning focuses on the project scope of work and its components (deliverables), generally identified with its attributes expressed in terms of work break down structure (WBS), design and drawings, the facility production quality specifications, it's costing in Bill-of-quantities (BOQ), and the production method statement, (chitkara, 2011).

3.1.1 Project Work Scope Definition Processes

General

The major goal of scope management is to ensure that the required work-and only the required work-is included and performed in the project, (Sanghera, 2009) .The project scope of work is an iterative process that is generally done by the project team with the use of a work break down structure (WBS), allowing the team to capture and then de-compose all of the work of the project, (PMBOk guidelines, 2000).

The planning of a project involves the concept of an objective or facility, and a Scope of work defining the work product or deliverable, (Halpin, 2006).

3.1.2 Components of Project Work Scope Definition

According to Chitkara (2011) Project work scope definition focuses only on the works to be executed. It aims at ensuring that the project includes all the works conforming to stipulated design, drawings, specifications and BOQ, and is concerned only with the work required to complete the project successfully. The work scope components included but not limited the following:

- Work Beak down Structure (WBS)
- Development of detailed design, drawings and Specifications
- Estimation and structuring of quantities of work
- Production method statement

3.1.2.1 Work Breakdown Structure (WBS)

A major problem in project planning is determining how long tasks will take and what it will cost to do them. In accurate estimates are leading cause of project failures and missed cost target are common cause of stress and recrimination in project management. The most useful tool for accomplishing all of these tasks is the work breakdown structure (WBS). The idea behind the WBS is simple: you can subdivide a complicated

task into smaller task until you reach a level that cannot be further subdivided. At that point, it is usually easier to estimate how long the small task will take and how much it will cost to perform than it would have been to estimate these factors for the higher levels, (P. Lewis, 2007).

Work Breakdown Structure (WBS) is a, "deliverable-focused hierarchical grouping of projects. It defines the total work scope of project", (chitkara, 2011). Works not in the WBS is outside the scope of the project. As with the scope statement the WBS is often used to develop or confirm a common understanding of project scope (PMBOk guidelines, 2000). And the process of dividing project deliverables (and hence the project work to produce them) in to smaller, more manageable pieces is called creating the Work Breakdown structure, (Sanghera, 2009). In addition to this (Halpin, 2006) defines, The WBS is'' progressive hierarchal break –down of the project in to smaller pieces to the lowest practical level to which cost is applied.''

Purpose of Work Breakdown Structure

As project increases in size, duration and complexity and become more globalized, the need to prepare WBS has increased. The following internal and external factor can be identified as the reasons for the WBS, (Ohara, 2005).

a) Necessity arising from the management of the project (internal factor).
b) Requirements of the customer (external factor).
c) Necessity arising from the performance of the project by a consortium or joint venture.

The purpose of WBS and its effect in project management are as follows (Ohara, 2005).

- Grasping and identifying all the tasks required for the project.
- Clarifying the range of tasks, responsibilities and power corresponding to the organization. It is especially important when the project is carried out by matrix organization.

- Setting of a frame work for cost control and schedule control.
- Supplying a foundation for grasping the rate of progress and productivity of the project.
- Supplying calculations units for project resources.
- Quick response to specifications changes and additional orders.
- Flexible handling of requirements on various reporting.
- Supplying common communication tools for project members.
- Providing feedback of the results data of the project.

The work Breakdown Structure is the single most important element because it provides a common framework from which, (Kerzner).

- The total program can be described as a summation of sub divided elements.
- Planning can be performed.
- Cost and budget can be established.
- Time, cost and performance can be tracked.
- Objectives can be linked to company resources in logical manner.
- Schedule and status-reporting procedure can be initiated.
- The responsibility assignments for each element can be established.

It helps in organization planning, responsibility assignment and project management software applications, (chitkara, 2011).

The Work Breakdown is a good way to portray the scope of a project. And assigning responsibility for tasks is another important use of the WBS, (P. Lewis, 2007).

WBS is always useful. Here's why, (P. Lewis, 2011):

- It identifies all works to be done in the project graphically, so that it can be reviewed by all stakeholders to ensure that nothing has been forgotten.

- It provides graphical representation of the scope (or magnitude) of the job. This is important because people are sometimes surprised at the cost estimate you give them, and this helps them see why the job is going to cost as much as you have said it would.
- The WBS provides the basis on which resource assignment are made.
- It allows you to estimate working times for each task.
- Knowing the working times then allows you to calculate labor cost for all works, so that you develop a labor budget for the project. The time also provide for developing a schedule.
- You can also identify material, capital equipment, and other costs associated with each activity (such as insurance costs).

  WBS is extremely useful in developing both cost and time (schedule) plans (Halpin, 2006).

Project Work Breakdown levels Development Methodology

WBS DESIGN PRINCIPLES

The 100% Rule

One of the most important WBS design principles is called the 100% Rule. The Practice Standard for Work Breakdown Structures (Second Edition), published by the Project Management Institute (PMI) defines the 100% Rule as follows:

The 100% Rule...states that the WBS includes 100% of the work defined by the project scope and captures ALL deliverables – internal, external, interim – in terms of the work to be completed, including project management. The 100% rule is one of the most important principles guiding the development, decomposition and evaluation of the WBS. The rule applies at all levels within the hierarchy: the sum of the work at the "child" level must equal 100% of the work represented by the "parent" and the WBS should not include any work that falls outside the actual scope of the project, that is, it cannot include more than 100% of the work… It is important to remember that the 100% rule also

applies to the activity level. The work represented by the activities in each work package must add up to 100% of the work necessary to complete the work

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The 100% Rule [4, 6]

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The 40-Hour Rule of Decomposition

- Another rule-of-thumb for determining how far down a WBS should be decomposed is called the "40 Hour Rule."
- Generally, when a project has been decomposed down to an element that has about 40 hours of allocated direct labor, there is no need to decompose further.

- The 40 Hour Rule is based on a 40-hour work week. Because of this, most WBS diagrams are not symmetrical. Some legs may go down to Level-4 while others may go down to Level-5

The 4% Rule of Decomposition

- Gary Heerkens suggests a 4% Rule for decomposing a WBS. With this rule a WBS is adequately decomposed when the lowest element is about 4% of the total project.

- For a 26-week schedule, the lowest element should be about one week. For a $2.6M project, the lowest level should be about $104K.

Level of detail

One must decide when to stop dividing work into smaller elements. This will assist in determining the duration of activities necessary to produce a deliverable defined by the WBS. There are several heuristics or "rules of thumb" used when determining the appropriate duration of an activity or group of activities necessary to produce a specific deliverable defined by the WBS.

- The first is the "80 hour rule" which means that no single activity or group of activities at the lowest level of detail of the WBS to produce a single deliverable should be more than 80 hours of effort.
- The second rule of thumb is that no activity or group of activities at the lowest level of detail of the WBS should be longer than a single reporting period. Thus if the project team is reporting progress monthly, then no single activity or series of activities should be longer than one month long.
- The last heuristic is the "if it makes sense" rule. Applying this rule of thumb, one can apply "common sense" when creating the duration of a single activity or group of activities necessary to produce a deliverable defined by the WBS.

Guidelines to flow in developing the Work Breakdown Structure

The following are some guidelines that you should follow in developing a WBS (P. Lewis, 2011):

- Up to 20 levels can be used. More than 20 are considered overkill.
- All paths on WBS do not have to go down to the same level. One path my go down five levels and another only three levels. When you have reached a point that allows you to manage the work you stop. Don't force the structure to be symmetrical.
- The WBS does not show the sequencing of work except in the sense that all level 5 work packages hanging below that subtask might be performed in series or in parallel. Sequencing is determined when schedules are developed.
- A WBS should be developed before scheduling and resource allocation. Identify the task first, then come back and decide who will do them, and estimate how long they will take.
- The WBS should be followed by individuals who are knowledgeable about the work. Different parts of the WBS will be developed by various. Then the separate parts will be combined. Remember, the first rule of project planning is that the people who will ultimately do the work should develop the plan.
- Break down a project only to a level that is sufficient to produce an estimate of required accuracy, this should be explained. One big advantage that a WBS offers is greater accuracy of cost and time estimate then you would get simply comparing one project to another.
- A WBS is a list of activities not a grocery list.

In establishing the WBS, the following guidelines need to be considered (Halpin, 2006):

1. Work packages must be clearly distinguishable from other packages.
2. Each work package must have unique starting and ending dates.
3. Each work package must have unique budget.

4. Work package should be small enough that precise measurement of work progress is possible.

Guide lines for developing the WBS, (P. Lewis, 2007).

- ''when do you stop breaking down the work?" you stop when you reach a point where either you can estimate time and cost to the desired degree of accuracy or the work will take an amount of time equal to the smallest units you want to schedule.
- The WBS should be developed before the schedule is worked out but without trying to identify the sequence of activities.
- A WBS does not have to be symmetrical all path do not have to go down to the level.

There are also preparation guidelines for the WBS [Kerzner].

- Develop the WBS structure by subdividing the total effort into discrete and logical sub elements, usually a program subdivides in to projects, major systems, major subsystems, and various lower levels until manageable-size element level is reached. Wide variations may occur, depending up on the type of effort (e.g., major system development, support services, etc.). Included more than one cost center and more than one contractor if this reflects the actual situation.
- Check the proposed WBS and contemplated efforts for completeness, compatibility, and continuity.
- Determine that the WBS satisfies functional (engineering/manufacturing/test) and program/ project (hardware, service, etc.) requirements, including recurring and non-recurring costs.
- Check to determine if the WBS provides for logical subdivision of all project work.
- Establish assignment of responsibilities for all identified effort to specific organizations.

- Check the proposal WBS against the reporting requirements of the organization involved.

You decompose the project deliverables by executing the following steps, (sanghear, 2009)

1. Identify the deliverables and hence the work involved by analyzing the project scope statement.
2. Structure and organize the first level (just below the root of the hierarchical tree) of the WBS hierarchy: Based on the project at hand, you can use one of the following approaches
   - Use the deliverables as components in the first level.
   - Use the phase of project as components in the first level.
   - Use the subproject as components in the first level. A subproject is a part of the project that is independent enough of the rest of the project that it can be performed by another project team. This approach is useful when you want to outsource parts of the project.
   - Depending on what you are dealing with, you can use different approaches within each branch of the WBS-for example, a subproject and deliverables in the first level.
3. Decompose the upper level into more detailed components for the lower level.
4. Keep decomposing to lower levels until necessary and sufficient decomposition has been achieved.
5. For a complex project, you usually assign identification codes to the WBS components to better organize them.

The extent to which the project is subdivided into activities depends upon the number of practical considerations; however, the following factors must be taken into account, (Fisk, 2000).

1. Different areas of responsibilities, such as subcontracted work, that are distinctly separate from that being done directly by prime contractor.
2. Different categories of work as distinguished by crafts or crew requirements.
3. Different categories of work as distinguished by equipment requirements.
4. Different categories of work as distinguished by materials such as concrete, timber, or steel.
5. Distinct and identifiable subdivisions of structural work such as walls, slabs, beams, and columns.
6. Location of the work within the project that necessitates different time or different crews to perform.
7. Owner's breakdown for bidding or payment purposes.
8. Contractor's breakdown for estimating or cost accounting purpose.
9. Outage schedule or limiting times that existing utility services.

3.1.2.2 Development of detailed design, drawings and Specifications

Before starting to plane we have to understand and interlink the drawing and specification.

3.1.2.3 Estimation and structuring of quantities of work

Estimation and structuring of the quantity of the work is the basic and first in put for planning and controlling. Inaccuracies of quantity estimation have direct effect on cost and time.

3.1.2.4 Production method statement

Before start planning we have to see the site plan of the project what it looks like? Do we have enough space and place to damp the materials, to freely move the laborer or workers and equipment to execute the work according to the method of production selected? Only knowing the work scope or work done value is not enough to decide which method of production is best fit to execute the activity work identified. It needs to consider the space of your site and the resource you have. In other words site plan

layout is the most critical plan for your continual of your construction planning and controlling. For example if your activity is placing concrete and if the resources (materials like sand, aggregate, cement, and water) damping or stocking area is more farther than the distance you considered in your method of production. If you use laborer, then it will increase number of crews of laborers or it will increase number of working hours to transport the materials from the stock area to mixing area more than you considered in your method of execution. Or if you use equipment it will increase also the equipment working hours than you considered in the selected method of production. At the same time transporting long distance more than you considered in the selected method of production also increases material wastage all these leads to increase the cost of an activity more than you estimate in the selected method of execution. Therefore a great care should be taken during method of production selection, planning and scheduling that you have considered the site layout plan.

As I have stated in the above the first prerequisite for method of production selection is that site layout plan and there are other factors to be considered during selection of the method. These are as following:

1. The resources already have on the contractors hand and the remaining resource that will be purchase or lease or hire or manufactured?
2. Cost analysis for the different options of method production and select the least one.
3. According to your site layout plan which method of production is best to execute the work?
4. Considering the time or duration given to accomplish your project. If you have short time, according to your crews output you will select the method of production that can complete in short time and if it is long you will select proportional method with your given time.
5. Considered the quality of work that is described in your contract document and it affect the selection of your production or technology.

6. Consider your degree of work complexity of your work.

Construction site layout planning

- Among the important task of site management is the Site layout planning.
- A detailed planning of the site layout & location of temporary facilities can enable the management to make considerable improvement by minimizing travel time, waiting time, & increasing worker moral by showing better & safer work environment.
- Construction site lay out involves the following points within the boundaries of construction site.
    - Identifying Temporary facilities (TFs)
    - Sizing Temporary facilities (TFs)
    - Placing Temporary facilities (TFs)
- Required temporary facilities & their areas are depended on the following factors.
    - Project type
    - Scale
    - Design
    - Location &
    - Holy trinity project organization of Crafts construction plc
- The site planning will be the condition that site personnel will live with for the total duration of the construction period one year & six months.
- Labor cost on a large projects constitute approximately 50 to 60 % of the total project cost, significant saving can occurred if the labor force moved freely & quickly within the site.
- Temporary facilities are important elements that can either enhance or adversely affect construction productivity.
- When we develop the construction site layout plan, we have to sure that all includes the following points.

1st site must be designed to:

- Maximize efficiency of operations in order to promote worker productivity.
- To shorten project time
- To reduce cost

2nd Final plan must:

- Create project with a good work environment in order to attract and retain the best personnel & those contribute better work quality & productivity.

3.2 Planning Construction Resources

3.2.1 Activity Duration Estimation

Chitkara (2011) Defined as Duration of an activity is the expected economical transaction time required to per-form an activity according to the specified execution method. The estimation of this time is based upon the specified practice carried out in an organized manner under the normal prevailing conditions, and its assessment is done preferably, by the person responsible for its performance. Also PMBOk guidelines (2013) defined as Estimate activity durations is the process of estimating the number of work period to complete individual activities with estimated resources. The key benefit of this process is that it provides the amount of time each activity will take to complete, which is a major input into the develop schedule process. As Chitkara (2011) noted, the first step in duration estimation is the methodology to be used for transforming these input resources into the desired activity. The choice of the method of execution of an activity depends upon the past experience, the market availability of appropriate resources, the resources available with the contractor, and the cost-benefit analysis of the

various method of reduction. In short, it is the method of production that dictates the resource required for accomplishment of activity.

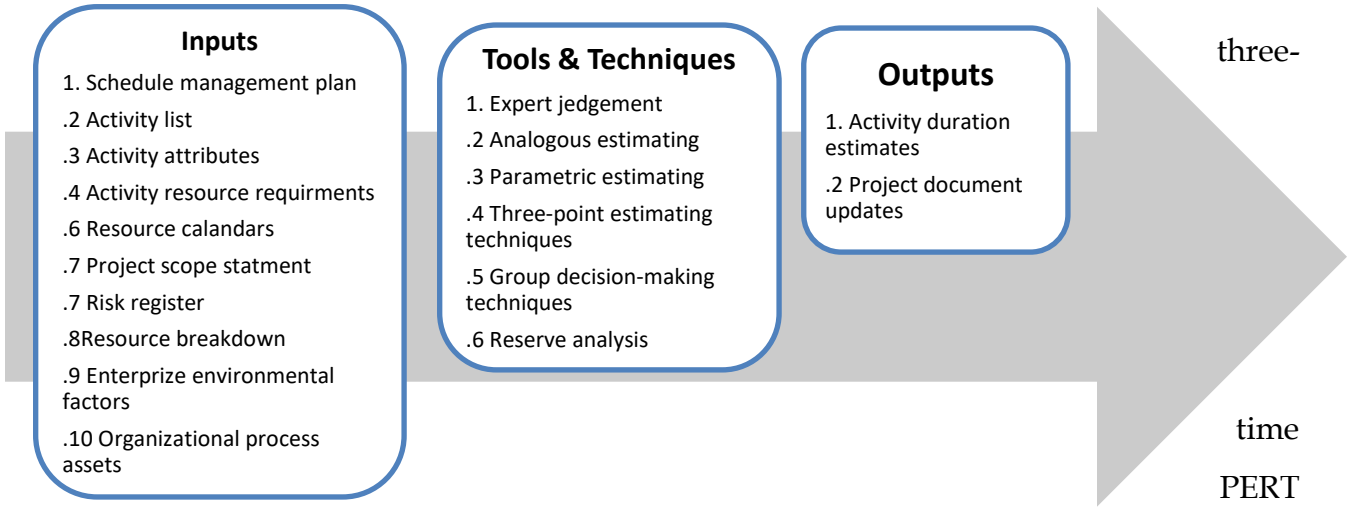
Final after we decide the method of production, we need the information or inputs for each activity to estimate duration , and PMBOk guidelines (2013) explains that estimating activity durations uses information on activity scope of work, required resource type, estimated resource quantities and resource calendar. Also Sanghera (2009) stated that to estimate the activity duration you will be obviously need the activity list and the information about each activity the attributes. Other items that you will need are discussed in the following lists

- Activity resource requirements
- Resource calendar
- Project scope statement
- Enterprise environment factors
- Organizational assets

Chitkara (2011) suggested that the initial stage of time planning, it is necessary to make a preliminary assessment of the resource of men, machinery and materials required for the execution of each activity. This assessment is used to determine the duration of an activity, to develop a time schedule based on the optimum level of resource or on resource constraints and to evaluate the connected costs. According to Sanghera (2009) once the activity have been identified and the resource required to perform each activity have been estimated, you have enough information to begin estimating the time needed to compute each activity which is called activity duration.

Duration Estimation Methods

After gathering the necessary information or input data to estimate duration of each activity is to select the suitable methods or tools and techniques which fits to your project type. According to Chitkara (2011), generally any of the three methods are employed for assessing, the duration of construction activities. These are termed as one-time estimate,



estimate and non-linear distribution (e.g. trapezoidal) estimate. Also Sanghera (2009) stated that standard estimation techniques include alternative analysis, analogous estimating, bottom-up estimating, parametric estimating, three-point estimating, reserve analysis and expert judgment. In addition to these, PMBOk guidelines (2013) depicted that the inputs, tools, and techniques and out puts of this process in the figure below.

Figure 3.1 Estimation activity durations and: inputs, Tools & techniques, and Out puts , PMBOk guidelines (2013

From the above discussions we have observed that, there are several tools and techniques that can be used to estimate activity durations. The main role of the planner in activity duration estimation is to deiced which tools and technique or method should use based on the information he has about the project or activity, and must know that the various tools and techniques when must use.

The various tools and techniques with brief description and when they are typically used are listed below:

1. **One-time estimate/parametric estimate/**

Chitkara (2011) described that **One-time estimate.** The estimation is based on one or more of the following.

1. Planning data.
2. Past experience on execution of a similar project.

3. Average time assessed by a grouping of executives.

The one-time estimation methodology, given above, assumes average daily uniform manpower (effort) of work throughout the execution of activity.

The advantage of parametric model estimating it is quick and accurate. Because it uses a statistical or quantitative relationship between planned project activities and historical or known data to develop estimates.

2. **Three-time PERT estimate:** When the exact duration of an activity, like research and development, is not certain, the three-time estimate is used to compute its expected duration. The following relation is used to calculate the expected duration of such an activity.

$$T_e = \frac{T_o + 4T_m + T_p}{6} \dots [3.1]$$

Where, T_e= expected completion time

T_o= optimistic time, assuming that everything goes extremely well with no delays

T_p= pessimistic time, assuming that ever thing goes wrong

T_m= most likely time, assuming normal conditions

This method may be the most accurate but also relies on the availability of data to perform the calculations. It also provides a range of estimates which helps in any reserve planning that may be required.

In this technique three estimates are generated for the project activity using three different sets of assumptions. The first estimate is a best case or optimistic estimate. The second estimate is a worst case or pessimistic estimate. The third estimate is between the other two and is the most likely estimate. The way those estimates are developed is by

using one of the other techniques such as Analogous or Parametric Model. However, because of the high degree of uncertainty due to the risk assumptions, the three estimates are used to create a boundary on expectations for the activity. A variation on this technique, the PERT analysis, uses a weighted average of these estimates to create a PERT estimate. When using this approach, the most likely estimate is normally what is put in the project plan but the optimistic and pessimistic estimates are used during the reserve analysis. Also, an activity that has a great deal of difference between the optimistic and pessimistic estimates is an uncertain activity and should be tracked in the Risk Register. The advantage of this technique is that it provides boundaries on expectations. The disadvantages are that it takes more work - since three estimates must be created not one - and the most likely is still very much a guess - the actual could be significantly better or worse, (http://www.projectmanagementguru.com/).

3. **Non-Linear distribution estimate**:

Chitkara (2011) described that, the one-time estimation methodology, given above, assumes average daily uniform manpower (effort) of work throughout the execution of activity. But execution of some activities may need effort in non-linear pattern. Such as nonlinear distributions may follow triangular, trapezoidal, binomial, beta, gama, normal other pattern. In such cases, the activity duration estimation for nonlinear will be converted to one time estimate through probability distributions.

4. **Expert judgment**

According PMBOk guidelines (2013), expert Judgment estimating is guided by historical information, can provided duration estimate information or recommended max activity duration from prior similar projects. Expert judgment also used to determine whether to combine methods of estimates and how to reconcile differences between them.

Expert Judgment estimating is easy to do - provided you have an expert on the project. This technique looks to the expert to create an estimate based upon their understanding of the project requirements. Many, if not most, project estimates are created in this fashion. The advantage of this is that it is quick and if the expert is knowledgeable, it is of-

ten the most accurate estimate for uncertain activities. The disadvantages are that you may not have an expert available and even if you do, the expert often can provide no solid rationale for their estimate beyond, "That's what I think it will take to do this." uses historical information or information from past projects to develop estimates. Depending on size and complexity of the project this method may not be extremely accurate. Sometimes used early in the project lifecycle when there is limited information available, (http://www.projectmanagementguru.com/).

5. **Analogous estimating**

Analogous Estimating is one of the most common forms of estimating project activities. This technique uses the experience from previous projects and extrapolates that onto the current project. This technique is appropriate for those cases where the type of work is similar and the resources doing the work are the same between projects. Its advantage is that it is quick and, when the conditions are appropriate, it is usually fairly accurate. The disadvantage is that the organization must have similar projects for comparison, (http://www.projectmanagementguru.com/).

6. **Group decision-making techniques:**

Team-based approach, such as brainstorming, the Delphi or nominal group techniques, are useful for engaging team members to improve estimate accuracy and commitment to the emerging estimates. By involving a structured group of people who are closed to the technical execution of work in the estimation process, additional information is gained and more accurate estimates obtained. Additionally, when people are involved in the estimation process, their commitment towards meeting the resulting estimate increases, (PMBOk guidelines,2013).

7. **Reserve analysis:**

Duration estimates may include contingency reserves, sometimes referred to as time reserve or buffers, into the project schedule to account for schedule uncertainty. Contingency reserves are estimated duration within the schedule baseline, which is calculated

for identified risks that are accepted and for which contingent or mitigation responses are developed, (PMBOk guidelines, 2013).

The Reserve Analysis is a fundamental technique for estimating. This technique considers the level of uncertainty and risk in the project and establishes a reserve pool of time, resources, or possibly performance that can be drawn upon to offset the un estimated issues that arise. With respect to schedule reserve, I will allocate the path float that I have on non-critical path tasks to provide a buffer around those tasks with the most uncertain estimates. For critical path tasks, I will either use a conservative estimate or include a "reserve" task that is used to resolve any problems that arise. With respect to resource reserves, I will set the level of reserve based upon the uncertainty in the project and the risks. It is common to have resource reserves of 10% to 20% over the estimated cost of a project for those projects with high uncertainty. Although projects with low uncertainty might have 0% to 5% reserve. Again I allocate that reserve to the areas of highest uncertainty. I also will allocate a portion of the resource reserve to each phase in a phased project. This is to better match the actual the planned timing for the use of the reserve with when it is likely to be used. This avoids unnecessary variance reports. The use of performance reserves is when task deliverables are expanded to address unknown issues. For instance, we would typically design with a 50% design margin on our mechanical device designs so that if there was a slight error in calculations or material properties, the design would still be robust enough to perform as needed. At the end of the day, the reserve analysis is a guess on the part of the project manager and stakeholders. If your organization has policies regarding reserves, use them. If not, use your best judgment, (http://www.projectmanagementguru.com/). One method of calculating the contingency reserve is to take a percentage of the original activity duration estimate as contingency reserve, (Paul Sanghera, 2009). And PMBOk guidelines (2000) noted that the reserve time can later be reduced or eliminated, as more precise information about the project becomes available. Such reserve time should be documented along with other data and assumptions.

8. Alternative analysis

When considering the resource requirements for each activity (estimate activity resources), it may be helpful to consider alternative ways of carrying out the work as well as the resources needed to do so. This may result in a more effective and efficient way to carry out the activity such as buying procurement rather than designing in-house, (http://pm-primer.com).

9. Bottom-up estimating

A Bottom Up analysis is a technique to improve the accuracy of the overall project estimate. This technique requires the project team to decompose the work into very small work packages. Generally, the smaller the project activity, the easier it is to estimate because the work scope is very small. All of these estimates of small activities are added up into subgroups and finally into the project total. The advantage of this technique is that the estimate is usually more accurate since the work is better understood. The disadvantage of this technique is that, it is very time consuming, and it may be impossible to decompose activities that cannot be easily defined, (http://www.projectmanagementguru.com).

Duration Estimation Procedure

According to Chitkara (2011) the various stages in duration estimation of construction activity can be identified as follows:

1. Decide the method of execution.
2. Estimate the quantity of work involved.
3. Identify the resource required.
4. Assessing the effective employment of the resource.
5. Estimating the activity completion period using estimated resources.

$$Completion\ Period = \frac{Quantity}{Output\ per\ unit\ of\ resourceX\ Resource\ earmarked} \quad \ldots [3.2]$$

6. Rounding off the completion period to nearest value after making reasonable contingency allowance
7. Use three- time PERET or a nonlinear estimate, where it is not possible to predict reasonable activity duration by one-time method, and then convert it into one time estimate.

During the estimation of duration there is one important thing to be consider, As Fisk (2000) noted, the duration estimate for each activity shall be computed in working days, converted to calendar days, and shown on the construction schedule is calendar days, and shall represent the single best estimate considering the scope of the work and resource planned for the activity. Except for certain non-labor activities, such as curing concrete, paint drying, procurement, or delivering of materials, activity duration shall not exceed 10 working days (14 calendar days) nor be shown as less than one working day unless otherwise accepted by the engineer.

3.2.2 Activity Resource Estimation

The construction activity accomplishment process combines physical resources like men, material, and machinery. The duration of an activity and the resource required are interlinked. For example, the activity of placing concrete in the foundation of a large building can be done manually or using crane and bucket arrangement, or pumping by concrete pumps or transporting by a conveyor system. The time and cost for each of these methods will differ considerably. Similarly, the time and manpower required for wall shuttering will depend upon the type of shuttering used from the available choices of custom-built steel wall forms and conventional timber-plywood steel props support system. In Short, It is the method of production and the time available that dictates the resource required for accomplishment of activity, (Chitkara, 2011). Hendrickson (2003) also described that from the planning perspective, the important decision in estimating resource requirement are determine the type of technology and equipment to employ and the number of crew to allocate the task.

PMBOk guidelines (2013) defined estimating activity resource is the process of estimating the type and quantity of materials, human resource, equipment, or supplies required to perform each activity. As Hendrickson (2003) states more detailed definitions of required resources would include the number and type of both workers and equipment required by an activity as well as the amount and type of materials. Since the work activities defined for a project are comprehensives, the total resource required for the project are the sum of the resource required for various activities. By making resource requirement estimate for each activity, the requirement for particular resource during the course of the project can be identified.

Chitkara (2011) emphasized that the preliminary estimate of resources needed to accomplish an activity can be made by using the planning norms developed from past experience of companies or the published literature, suitably modified to conform to project environment. The resource planning norms include the following:

a) Workers output norms
b) Plant and machinery output norms
c) Material quantity estimation and wastage norms

3.2.3 Construction Manpower Planning

In this research construction manpower planning answers the questions who are the workers (list of labor), how many are the workers (crews)? How much they can do the workers per hour (Workers' productivity)? When they can do the work or provided (schedule)? According to Chitkara (2011) the project construction manpower planning is primarily concerned with estimating the workers' productivity, scheduling manpower employment, and structuring it into workers' team and work-groups according to the task requirement. It is mandatory to have realistic estimate of expected labor productivity in order to plan the physical resource, to plan direct cost and to meet its targets. According to Humphreys of all resources that make up a capital estimate for construction project, labor is the most illusive and affords much latitude for error and difficult to es-

timate because of the difference in productivity in various geographic areas. Labor will constitute 25-40 % of the total project cost. Also Elbeltagi describes labor cost on large projects constitutes approximately 50 to 60 % of the total project cost. In Ethiopia material cost accounts about 40-70 % of the contract price (Asteway, 2008). According to Chitkara (2011) the basic equation for determining the workers required for accomplishing a specific activity or work–item is given by:

Manpower estimation

$$Workers\ required = \frac{Work\ quantity \times workers^{'} productivity\ stsndards}{copmpletion\ period} \ldots [3.3]$$

$$Workers^{'} productivity\ standard = worker\ out\ put \times production\ efficiency\ factor. . [3.4]$$

Where

- Workers' productivity standard (workers production planning norms or planning data) is the effort in man-days or man- hours needed to accomplish a unit of work. It can also be stated in terms of quantity of work done per man-days or man- hours, while working efficiently but allowing for normal delays and wastage.
- Work quantity expressed in standard work units.
- Completion period is working days or hours planned or earmarked to accomplish the task/activity.
- Workers'' production norms in the above equation are in man-days or man-hours required for accomplishing the unit work.
- Production efficiency factor is the multiplayer used to convert production norms into productive standards depending on the job condition of the site.

Improvement of workers'/labor productivity should be a major and continual concern of these who are responsible for cost control of constructed facility (Hendrickson, 2003). According Chitkara (2011) the experienced estimator or planner compiles the workers' production planning norms for estimating the manpower requirement. In the absence of such planning data, appropriate norms can be developed using one or a combination of the following methods:

a) Analyzing the past performance data

   Construction firms will have their own daily output data records for the past executed activity of each projects, compiling these basic production norms by analyzing the past performance data of similar works by averaging the historical data using statistical techniques .

b) Abstracting data from published norms.

   A planner or estimator can drive production norms for a project by relating them with published production norms of professional institutions. The production norms for this project or other areas can be assessed using published relative productive index or experience from the production norm of one of the area (project) base.

c) Work-studying the actual work process.

   This is carried out by professionals using the method study and time study techniques, aim at finding the optimum method of production with specified resources and time required to perform the production tasks, so as to establish the production norms of workers and production of capacity of machine

   The concept of work study has found wide acceptance in manufacturing industries, but in the construction fields it is not so effective because projects have unique tasks and, which are affected project work conditions.

3.2.4 Construction Material Planning

According to Chitkara (2011) Construction materials planning involves identifying materials, estimating quantities, defining specifications, forecasting requirements, locating

sources for procurement, getting samples of material approved, designing material inventory, developing procurement plans, and monitoring flow of materials till the connected construction works are completed.

According to Chitkara (2011) in construction projects, materials accounts for more than 40% of the project cost. A small saving in materials cost, say even 5%, through efficient management of materials, can result in a large contribution specially, when competitive bidding is for small profit margins. Also Linden (2008) States that the direct cost of construction materials varies from 28% up to 50% of the total project cost, depending on what is being built.

Efficient materials management in project environment calls for integrated approach covering numerous functions such as material planning, Purchasing, inventory control, store keeping and warehousing, handling and transportation, codification and standardization, and the disposal of surpluses. Material planning, which is the key function of materials management, is closely linked with project planning and control set-up. Both these work together to develop a plan for procurement and stocking of construction materials so as to provide at the site materials of the right quality in the right quantity at the right price from the right sources at the right time.

Constriction material planning includes not only activity material estimation, material quantity estimation and assigning material estimated for each activity but also it includes material purchasing, material transportation, material deliver, and material handling in warehouse as well as on site and so on. However activity material estimation, material quantity estimation and assigning material estimated for each activity is the basic and first step of for construction material planning and these are mutually dependent. As we have explained in the above material planning is broad, since the time given to complete master's thesis is to short and, I only include estimation resources needed by each activity, assigning the resource to each activity and finally controlling

the resources assigned, while controlling will be see in last chapter others can take for further research study.

Material quantity estimation

As we described in the above we have already define the activity, which is the lowest level of the WBS and the smallest functional area tracked in the project. The Work quantity takeoff of an activity is calculated from the drawings accurately, and according the method of work /choice of technology determined above, we estimate the material needed for a single unit of work by each activity, as we described in the above activity resource estimation. According to Chitkara (2011) Material quantity estimates are based on the abstract of quantity of work calculated by the quantity surveyors from the contract drawings. The work quantities when multiplied by respective estimated materials required for a unit item of work, given the quantity of materials required for the activity. In particular, material estimates must include wastage percentage, which occur during execution of work. The final material quantities especially, of the A and. B items which constitute the major portion of the materials cost, are then compared with the preliminary material estimate prepared at the time of tendering, so as to know the variations from the original estimate.

$$Material\ to\ be\ provisioned = theoretical\ quantity\ of\ material \times \frac{\{100 + standard\ wastage(\%)\}}{100} \ldots [3.4]$$

Depending up on the choice of technology or the method of execution the standard wastage also various, for this reason the standard wastage can best be specified from experience. (Chitkara, 2011).

3.2.5 Construction Equipment and machinery Planning

According to Chitkara (2011) Construction equipment planning aims at identifying the construction equipment for executing project task, assessing equipment performance capability, forecasting the date wise requirements of numbers & types of equipment

based on the select method of production or execution and finally participating in the selection of the equipment to be acquired. In mechanized building projects, the equipment costs can vary from 5 % to 10 % of the direct costs depending upon the nature of the project and the method of production selected.

Equipment selection and estimation

After we decide the method of execution of the work package or activity, the third step in resource activity estimation is selecting what type of equipment? , And how many (crews)? Can be employed by considering the site constraints and making cost benefit analysis of alternatives. According to Hendrickson (2003) the selection of the appropriate type and size of construction equipment often affects the required amount of time and effort and thus the job-site productivity of a project. It is therefore important for site managers and construction planners to be familiar with the characteristics of the major types of equipment most commonly used in construction.

Also Chitkara (2011) lists below some consideration to be taken during selection of equipments but not necessarily limited to these:

1. Task considerations
    - Nature of the task and specification.
    - Daily/hourly forecast of planed production.
    - Quantity of work and time allowed for completion.
    - Distribution of work at site.
    - Interference and expected and interdependence with other operations.
    - Task considerations
2. Site constraints
    - Accessibility to location.
    - Working space restriction.
    - Altitude and working weather conditions.
    - Working season and working hours.

- Availability of local resources of manpower, materials and equipment.
- Availability of equipment hiring, repair and maintenance facilities, locally.
- Availability of fuel, oil and lubricants.

3. Equipment suitability
    - Type of equipment suitable for the task.
    - Make, model and size of special purpose, and general purpose equipment available that can handle the task.
    - Production capability, serviceability condition and delivery time of each equipment available
    - Equipment already owned by the contractor.
4. Commercial considerations
    - Buy second –hand or new equipment
    - Rent equipment
    - Hire-purchase equipment
    - Purchase or lease

Chitkara (2011) ,defined that the output planning data of the equipment considered during the planning stage can be derived by multiplying the ideal output by correction factors and the equipment performance factor (operating condition).

Planned output/hr = Ideal output/hr X correction factor X performance efficiency factor… [3.5]

3.3 Construction Direct Production Cost and Project Budget Planning

Once we have assigned the resource like labor, material, equipment and time to each activity the fourth step is to change these resources to cost for budgeting of the project. According to Hendrickson (2003) for contractors the bid estimate is usually required as budgeted estimate; which will be used for control purpose as well as for planning construction financing. The budgeted cost should be also updated periodically to reflect the

estimated cost to completion as well as to insure adequate cash flow for the completion of the project, because cost and time varies when method of execution vary .

According to Chitkara (2011), direct costs are costs that can be correlated to a specific activity or a work-item, which is being done or produced based on the method of production selected.

Direct costs breakdown components are shown below:



According to Chitkara (2011), the direct material costs generally includes

- Purchase cost, ex-factory cost or specified deliver location.
- Transportation costs including freight by rail, ocean, custom clearance, insurance and handling charges till arrival at site.
- Site manufacturing and fabrication costs to transform raw materials into products for use in permanent works.

Finally, Chitkara suggested that it is not must to have detailed costing of all types of material that go into the production of an item of work. Minor materials items like screw, nail and trade men's tools can be best grouped under the indirect costs.

According to Chitkara (2011), the Labour cost generally includes;

- Basic wages
- Overtime & allowance
- Procurement expenses including recruitment and conveyance at site
- Benefits and statutory regulation compensation expense such as earned leave, provident funds, gratuity, bones, insurance, medical, etc.

Here, Chitkara gives another option for evaluating direct labor cost including only salary and wages under direct cost and the reaming expense under indirect cost.

Direct equipment and machinery costs are costs that are consumed by the project and specifically required by the project. This item could include items that are purchased, leased or rented.

According to Chitkara (2011), other direct expenses generally include;

- Special purpose plant and machinery cost, such as owning and operating costs of concrete production, transportation and placing equipment.
- Sub-contracted activities
- Hired resources costs for execution of specified permanent work, like excavator for trench.
- Temporary activity required for specific work like erecting scaffolding plate form plastering work.

According to Chitkara (2011), the identification and unit rate costing of the physical resources, the needed quantity, and the schedule requirement of the resources are directly linked to the expected cost of the project work. Generally the cost of the physical resources that are utilized to complete the work can be computed in terms of hourly cost as:

Activity labour cost

$$= Labour\ effort\ in\ man - hours \times Standard\ labour\ hourly\ rate \quad \text{... [3.3.1]}$$

Activity equipment utilization cost

$$= Equipment\ utilization\ hour \times Standard\ equipment\ hourly\ rate \quad \text{... [3.3.2]}$$

Activity material cost

$$= material\ consumption\ quantity \times Standard\ material\ unit\ price \quad \text{... [3.3.3]}$$

According to Chitkara (2011), the direct production cost standard of a work package in a standard work-unit can be estimated as following:

$$Direct\ cost\ production\ standard = Direct\ labour\ cost\ standard + Direct\ material\ cost\ standard + Direct\ plant\&\ equipment\ expenses\ standard + othere\ direct\ expenses\ standard \quad \ldots [3.3.4]$$

Where:

$$Direct\ labour\ cost\ standard = Work\ quantity \times Workers'\ productivity\ standard \times Labour\ standard\ hourly\ rate \quad \ldots [3.3.5]$$

$$Direct\ material\ cost\ standard = Work\ quantity \times Material\ consumption\ standard \times Material\ standard\ unit\ price \quad \ldots [3.3.6]$$

$$Direct\ plant\ \&\ equipment\ expenses\ standard = Work\ quantity \times Equipment\ output\ standard \times Equipment\ standard\ hourly\ employment\ costs \ldots [3.3.7]$$

$$Other\ direct\ expence\ standards = Remaing\ direct\ expence\ not\ coverd\ in\ the\ above \quad \ldots [3.3.8]$$

In the above activity resource estimation we have already shown that, how can compute labour effort in man-hours, equipment utilization hour and material consumption quantity. Chitkara (2011) describes the techniques to develop standard labour hourly rate, standard equipment hourly rate and standard material unit price as following:

$$Labour\ hourly\ standard\ rate = \frac{Annual\ estimated\ labour\ cost}{Annual\ productive\ hours} \quad \ldots [3.3.9]$$

$$Equipment\ hourly\ standard\ rate = Owning\ cost\ per\ hour + operating\ cost\ per\ hour \quad \ldots [3.3.10]$$

$$Material\ standard\ price = price\ at\ source + transportation\ cost + taxes \quad \ldots [3.3.11]$$

$$Site\ manufactured\ material\ standard\ unit\ price = Variablecost\ per\ unit + \frac{Fixed\ cost}{quanity\ delivered} \quad \ldots [3.3.12]$$

3.4 Resource scheduling

Scheduling is putting of the allocated or assigned physical resources and costs of activity in time table with chronological order and relation. Scheduling the activities by hand is difficult because building construction have money activities involved other construction type. There for to put these activities in diagrams and to calculate the critical path is tedious and longtime taking. Now's a day there are many software that can ease way of life. From these Micro soft Project 2000-2007 & Primavera project planner (P3) to (P6) are commonly used project management software. The main focus of P3 is a single project, standalone environment where as P6 is for multi-project, multi-user environment of an enterprise. As we know Ethiopian contractors have multi-projects, different or similar projects at different places. There for I selected the P6 release 6.0 to use throughout my research. We use primavera p6 v6 software not only for scheduling but also for planning, and controlling.

3.5 Project Control System

The primary reason for doing a project plan (including the schedule) is to achieve control of the project. If you have no plan, you can't possibly have control by definition! So now we are ready to deal with how control is actually achieved in a project. (P. Lewis, 2011). According to Chitkara (2011),an efficient integrated project control system generates information that can improve the productivity of men and materials; economies the employment of resources; enable understanding of time and cost behavior; provide early warning signals of ensuring dangers; update resources planning and costing norms; prevent pilferages and frauds; and assist in formulating bonus/incentive scheme for motivating people. A project needs an effective control system to continuously monitor the deviations from planning path, and to apply corrective measures.

In addition to the need of control system Chitkara (2011) stated the steps in the control process are:

Step 1: Define the parameters to be controlled.

Step 2: Establish baselines for measuring performance.

Step 3: Account performance feedback date by

- Measuring performance
- Recording performance
- Reporting performance deviations

Step 4: Monitoring performance by

- Consolidating reported performance feedback data.
- Analyzing performance variations.
- Forecasting performance trend.

Step 5: Communicate information.

Step 6: keeping data records up-to-date

According to Chitkara (2011), in construction project, the typical parameters that may be controlled are as follows:

- a) work scope control
- b) Time progress control
- c) Resource procurement management
- d) Resource productivity control
- e) production direct cost control
- f) Earned value control

Also, as Chitkara (2011), stated that the parameters required to be controlled, listed above are inductive not expansive. Depending upon the nature of the project, there can be additions and alterations in these parameters. For example, in a simple project direct cost control can be combined with resource productivity control or budgeted cost control. In complex projects, new parameters such as investment (portfolio) control may have added to evaluate the economics of, 'make or buy' and 'hire or purchase' deci-

sions. Further, in case of projects being executed in a foreign country, mobilization control become necessary so as to ensure the timely induction of resources. The control parameters are not mutually exclusive. They are interrelated as well as interdependent.

3.5.1 Project Work Scope Controlling

Work scope control aims at ensuring that the project includes all the works conforming to stipulated WBS, design, drawings, specifications and BOQ, and is concerned only with authorized works required to complete the project success fully. In the interest of the project purpose; the project scope may undergo some changes from the original scope of work. In case of changes, the necessary change control system must bring out the implication of change on project time, resource and cost objectives prior to the approval of its implementation, (Chitkara, 2011). As Fisk (2000) noted, an important part of scope change control is to determine what is causing the variance and to decide the variance requires corrective action.

Any document that alters the terms of the original contract in any way must be considered as a change order. As such, the document must either be signed by the owner or by someone with the power of attorney to act for him. A change order must be clear, concise and explicit. It must tell the contractor what is to be done, where or with in what limits, whom the work is to be performed, if the order of the work is affected, how the contractor will be paid, and what consideration will be given to contract time (extension), (Fisk, 2000).

Finally, any alteration on the contract document (on the special condition of contract, on the drawing, on the specification, on Bill of Quantity and any other document listed in the special condition of contract as forming part of the contract) will have been an effect on original contract price and intended completion time. Hence, the contractor should be clearly recorded on its own format to control the scope change orders by showing the effect both on the original contract price and intended completion time and distributed to the owner and engineer.

Figure/Table-Scope change order format

3.5.2 Resource Productivity and Direct Cost Controlling

Since cost overruns increases project costs and diminish profits, it is easy to see why both project management and upper –level management must become sensitive to the cost of project activities, (Halpin). Direct cost control and resource productivity control are inseparable. The aim of direct cost control is to minimize expenditure through the cost variance analysis, and this mainly depends upon minimizing wastage in the employment of resources, (Chitkara, 2011). In the above two chapters we have assigned both the physical resources and costs to each activity and we put them in a time table called schedule, and then we made a baseline for these cost and work scope. According to Chitkara (2011), the project work done value and cost baselines includes the time phased forecast of earned value, planned production cost and cash-flow. These baseline estimates are prepared during planning stage. Now we will control the variance made from the baseline by using controlling techniques' during the work executions.

Earned Value Management is a commonly used method for planning and controlling of performance measurement for projects. It integrates the scope baseline, with the cost baseline along with the schedule baseline, to form the performance baseline, which helps the project management team asses and measure project performance and progress, (Chitkara, 2011).

3.5.1.1 Direct Cost controlling

We have defined well direct costs & direct cost production standards in the above chapter, now we will identify the difference occurred between the direct standard costs and direct actual costs and applying corrective measures. Direct cost control aims at improving productivity by minimizing the wastage of input resources, developing standards for costing future works, and accounting all direct costs for <contribution control> and <budgetary control>, (Chitkara, 2011).

Direct cost variance break down

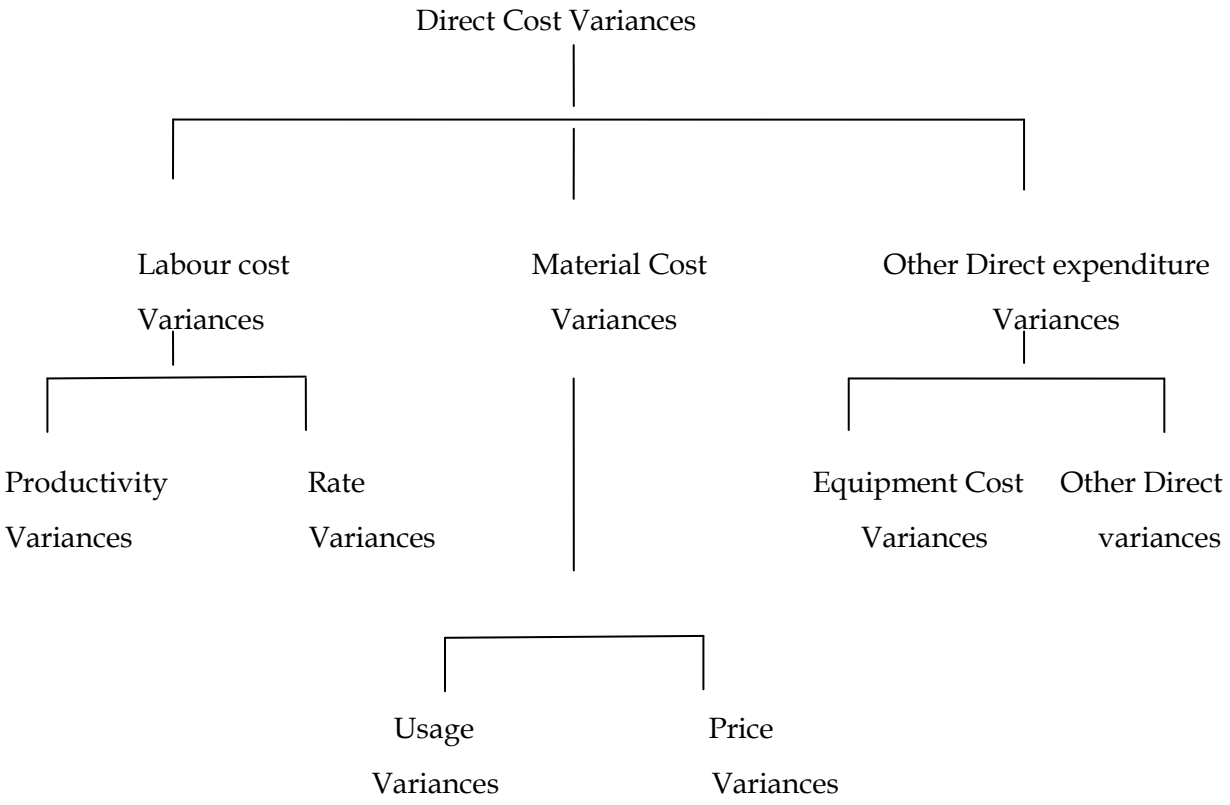


Figure 3.2 Direct Cost Variance Break down

The first step to control the direct cost is that identifying the variance, do we have variance? Is it favorable or unfavorable?

According to Chitkara (2011), $\text{Direct Cost Variance} = \text{Standard direct cost} - \text{Actual direct cost}$

Where:

Favorable variance (F) ≥ 0

Unfavorable variance (U) < 0

Direct cost variance involves the evaluation and analysis of the following variances:

a) Direct Material Cost Variance

$$Direct\ Material\ Cost\ Variance = Standard\ material\ cost - Actual\ material\ cost.. [3.5.1]$$

Or

$$Direct\ Material\ Cost\ Variance = Material\ usage\ variance + Material\ price\ variance.. [3.5.2]$$

Where,

$$Material\ usage\ variance = Standard\ rate(standard\ quantity - Actual\ quantity) \ldots [3.5.3]$$

$$Material\ price\ variances\ Actual\ quantity(Standard\ rate - Actual\ rate)..[3.5.4]$$

b) Direct Labour Cost Variance

$$Direct\ Labour\ Cost\ Variance = Standard\ labour\ cost - Actual\ labour\ cost \ldots [3.5.5]$$

Or

$$Direct\ Labour\ Cost\ Variance = Labour\ Productivity\ cost\ variance + Labour\ rate\ variance \ldots [3.5.6]$$

Where,

$$Labour\ operating\ or\ productivity\ cost\ variance = Standard\ rate(standard\ time - Actual\ time) \ldots [3.5.7]$$

$$Labour\ rate\ variance = Actual\ time(Standard\ rate - Actual\ rate) \ldots [3.5.8]$$

c) Direct Equipment Cost Variance

$$Direct\ Equipment\ Cost\ Variance = Standard\ equipment\ cost - Actual\ equipment.. [3.5.9]$$

or

$$Direct\ Equipment\ Cost\ Variance = Equipment\ productivity\ cost\ variance + Equipmentrate\ variance \ldots [3.5.10]$$

Where,

$$Equipment\ operating\ or\ productivity\ cost\ variance = standard\ rate(standard\ time - Actual\ time) \ldots [3.5.11]$$

$$Equipment\ rate\ cost\ variance = Actual\ time\ (Standard\ rate - Actual\ rate) \ldots [3.5.12]$$

d) Other Direct Cost Variance

$$Othere\ Direct\ Expenses\ Variance = Standard\ cost - Actual\ cost \ldots [3.5.13]$$

The second step is that making an appropriate analyzing to the variances. The earned value analysis method is also called simply variance analysis. Variance analysis allows the project manager to determine through spots in the project and to take corrective action, (P. Lewis). According to Chitkara (2011), Earned value analysis have two main purposes:

a) To analysis the cost changes resulting in time and cost over-runs or under-runs for taking timely corrective action such as modifying cash flow, and updating financial forecasts and project profitability expectations.
b) To update key personnel on anticipated cost changes in their field of responsibility, so as to create cost consciousness for exploring means of minimizing wastage and reducing costs.

According to PMBOk guidelines (2013) & Chitkara (2011), the parameters which form the foundation of the ''earned value'' concepts are three these are:

- **BCWS or PV**: Budgeted Cost of Work Schedule or Planned Value respectively. Is the value of the base line at a given time or it is the cumulative planned value of the authorized work, scheduled for completion to date at contract rate. Or the budgeted cost of work schedule to be done in a given time period, or the level of effort that is supposed to be performed in that period.
- **BCWP or EV**: Budgeted Cost of Work Performed or Earned Value respectively. It is the budget associated with the authorized work that has been completed or it is the cumulative value of the authorized work completed to date at contract rate.
- **ACWP or AC**: Actual Cost of Work Performed or Actual Cost respectively. It is the total cost incurred in accomplishing the work that the EV measured.

Whereas Halpin, adds three more parameters to Chitkara (2011) & PMBOk guidelines (2013) these are:

- **BCAC**: Budgeted cost at completion. Is the total planned value or contracted total cost for the work package.
- **AQWP**: Actual Quantity of Work Performed.
- **BQAC**: Budgeted Quantity at Completion. Value of the quantity baseline as the project at a given point

3.5.2.1 Threshold Parameter definitions and formulae for earned value analysis

A threshold consists of parameters, type, and a lower and/or upper threshold value the module generates an issue automatically when a threshold parameter is below or equal to the lower threshold or equal to or above the upper threshold value.

Formulae for Earned Value Analysis

Variance Formulae

- Cost Variance (CV)

  $CV = BCWP - ACWP$ ...[3.5.14]

If CV =+Ve indicates a cost Under-run / within Budget

CV=0 indicates according to the budget

CV=-Ve indicates overrun/Over budget

- Schedule Variance (SV)

  $SV = BCWP - BCWS$ ... [3.5.15]

If SV =+Ve indicates a cost overrun/Over Budget

SV=0 indicates according to the budget

SV=-Ve indicates overrun/Over budget

Indices Formulae

If CPI ≥ 1 Favorable performance

- Cost Performance Index (CPI) (Cost efficiency)

CPI< 1 Unfovorable performance

$$CPI = \frac{BCWP}{ACWP} \dots [3.5.16]$$

- Schedule Performance Index (SPI) (Schedule efficiency)

If SPI ≥ 1 Favorable performance

SPI< 1 Unfovorable performance

$$SPI = \frac{BCWP}{BCWS} \dots [3.5.17]$$

Status in percentage Formulae

- Schedule variance as a percentage of schedule achievement (SV %)

$$SV\% = \frac{BCWP - BCWS}{BCWS} \times 100 \dots [3.5.18]$$

- Cost variance as a percentage of the earned value (SV %)

$$= \frac{BCWP - ACWP}{BCWP} \times 100 \dots [3.5.19]$$

- Percentage completed on data date

$$= \frac{ACWP}{BAC} \times 100 \dots [3.5.20]$$

- Percentage of project scheduled to be achieved on data date

$$= \frac{BCWS}{BAC} \times 100 \dots [3.5.21]$$

Trends Formulae

- Estimated Cost At Completion with the present trend (EAC) is the estimated final cost of the project

$$EAC = ACWP + \frac{BAC - BCWP}{CPI} \ldots [3.5.22]$$

- Variance At Completion (VAC)

$$VAC = BAC - EAC \ldots [3.5.23]$$

3.5.3 Time Schedule Controlling

As explained by Chitkara (2011), Construction projects are time bounded and all project activities are directed towards the achievement of project time objectives. Delay can alter the planned level of resource and their mobilization. Time over runs increases overheads, reduces planned revenue from sales and create cash flow problem. Delay in contracted projects can result penalties, and adversely affect the reputation of the company. Delays cause confusion and conflicts.

If time over run or delay creates all the above listed problem contractors should have develop project time control system for their projects. According to Chitkara (2011), project time control aims at the timely execution of work according to the project planned schedule and applies corrective measures in case of time deviation.

In Ethiopia delay in construction project is not uncommon, this is because the contractor could not know well the cause for the delay clearly and also have no recorded documents. Even if the contractor had a recorded document the document is not detailed with cost and time.

The first thing the contractor should have to do is that set schedule base line for the project and from starting the execution of the work record the actual start and end of the activity. When he sees the variances he should have to ask what causes for this. The cause for the variance may be from the contractor, from the client or from the engineer (consultant).

The following listed below are some of the causes for variance:

1. Duration estimation wrong (it may be optimistic estimator)
2. Late issue of complete drawings
3. Delay of site handover
4. Delay payment on advance payment (depends on the agreement)
5. Delivery problem

1.1 Material
1.2 Manpower
1.3 Equipment & machinery
1.4 cash

6. Change scope of work
7. weather
8. Differing site conditions
9. Change in method of work/technology from the baseline planned one.
10. Subcontractor performance
11. Late inspection for the work
12. Material/sample approval
13. Delay payment for complete works
14. Late approval of payment certificates
15. Late payment release after certification
16. Strike on the project place (because of accident or late daily labor payment).

We have listed the causes for the variance; however these causes may not lead to claim for time extension or penalty to the contractor. From the above listed some of are due to the contractor and others are due to the contractor or the engineer. If delay occurs we have only two responses either claim for time extension or penalty. The first one is nice for the contractor, however the variance my not lead to time extension if the variance did not lied on critical path. As Chitkara (2011), explained in certain cases, the claim of the contractor for the delay due to reasons beyond his control may be accepted, but no extension is awarded no logical reasons are assigned to it. For example, a delay in the commencement of non critical activity, which is completed before its latest finish time (may be due to any reason), does not entitle a contractor to claim for extension of time. But delay in critical activities due to non-supply of materials under the client's supply, or due to reasons beyond the contractor, need consideration for extension time.

The second one never the contractor wants to be happened, so the contractor chooses other opinions to compensate to time lost (that did not allow him to time extension). The only two options the contractor has are the following:

1. Time compression of critical path. (Process of reduction of project completion time without any appreciable change in cost of activities).
2. Time crashing of the critical path. (Keeping the increase in cost of speeding up the project from its optimal completion period to its minimum. In other words buying time with lest price).

   However after doing cost benefit analysis the above options and time compression is not applicable and the penalty cost is less than the time crashing .The contractor may be decided to enter the penalty.

4. RESEARCH DESIGNE AND METHODOLOGY

4.1 Overview of the Research Process

Owing to the researcher's desire to undertake an applied research, which aims at contributing knowledge towards solving a practical problem, the research started by investigating a practical problem. Experience, observation and results of previous studies from the ground for formulating the research problem statement and case study: Based on the problem statement, first an extensive review of literature on the subject was undertaken. Next, an investigation on the selected project construction operation planning and controlling of Crafts Construction Plc projects was carried out with the view of discovering whether it matches what has been discussed in the literature or not. Results of the investigation gave a clear picture of existing practice and assisted in identifying the gap and limitations of the practice, which were used to propose the improvement interventions

4.2 The Study Approach and Research Instrument

As described earlier, the motivation for the research originates mainly from observations and experience of the researcher serving as the office engineering department head of Crafts Construction Plc. But the need for proving the existence of the problem demands a methodology approach for collecting, analyzing and interpreting data related to the subject under consideration. Accordingly case study was selected as the research instrument owing to its suitability to the level of information required and during the case study the necessary data were collected for the active projects from the organization.

Sources and Collected Data

1. Literature surveyed
2. Using the internet websites to find relevant information.

3. Primary data collection through a Survey at selected active (under construction) on site data collection and conducting interviews of Crafts Construction Plc for three months.
4. Secondary data collection from crafts construction plc of selected active projects.
    2. Drawings, Bill of quantity & Contract documents from the Office engineering Dept.
    3. Labour, Equipment & Machinery, and material output data from the commercial Dept.
    4. Wedge of salary of persons from HRM Dept.
    5. The unit price of each material needed by the project is collected from the logistics Dept.
    6. Rental Cost of Equipment and Machinery from Equipment and Machinery Dept.
    7. Baseline cost (tender cost breakdown) is collected from the Commercial Dept.
    8. Monthly plan and evaluation of projects from commercial Dept.
    9. Monthly report and work progress from the construction Dept.

5. ANALYSIS AND DISCUSSION

Analysis model used in this research

Crafts Construction Plc Documents are analyzed using Primavera P6 release 6.0. Comparing the practice of the previous planning, scheduling & controlling of the previous technique with the new one, as mentioned earlier the case study was undertaken for all active projects of Crafts Construction Plc.

Initially, the analysis of the survey data was grouped by monthly planned work to be executed, monthly work executed, monthly planned material cost, monthly actual material cost, monthly planned labour cost, monthly planned equipment cost, monthly equipment cost, monthly utilized time and profit without considering the overhead of the head office and the project.

Finally, identify the gaps or variance created between the planned and the actual, and how the organization analyzed the variance. And how did it control the variances? And give corrective actions. The detailed planning and controlling practices of the survived projects are compared with the findings from the literature review.

Tabele 5.1

5.1 Scope of work Definition

The actual practice, the framework of the project work breakdown structure is not suitable for physical resource, cost, and schedule control. That means the tasks are not subdivided until the point is easier to estimate how long the small task will take and how much it will cost to perform than it would have been to estimate these factors for higher levels. The WBS does not provide the basis on which resource assignments are made.

According to the second rule of thumb, no activity or group of activities at the lowest level of data in the WBS should be longer than a single reporting period. For example, if the project team is reporting progress monthly, then no single activity or series of activities should be longer than one month.

According to (P.Lewis 2011), Guidelines the WBS should be followed by individuals who are knowledgeable about the work different parts of the WBS will be developed by various. Then the separate part will be combined. The first rule of the project planning is that the people who will ultimately do the work should develop the plan. However The WBS was approved and followed by persons in head office which does not have enough knowledge about the work without participating the person who will do the work.

5.2 Method of Execution of the Activity

According to Chitkara (2011), Method of statements described in details the sequence and the manner in which the work is to be executed. In order to produce a quality work, it is necessary that the method is participated by executing agency and approved by the client engineer.

In order things get right first time during construction, it is necessary that all the parties involved in construction arrive at an agreed approach in the method of execution.

Method of statement will vary with the nature of activity for which the method statement is prepared; however its format can be in tabular descriptive text, graphs/charts or a combination of these.

Good quality of method of work or statements reduces complaints, production cost, and production time.

According to the case study, the organization did not produce a detailed method of work/statement for each activity. It only uses the method of statement used bid pricing without considering , the site layout, resources in stock, and the remaining resources that will be purchased, leased, hired, or manufactured, the time duration given to accomplish, the quality of work that is described in the contract document, degree of work complexity.

The project manager, the project engineer, and the general foreman did not get involved in the preparation of the method of statements; the people participating in the execution of the work used their own technology that did not match the planned one without any approval or cost-benefit analysis.

5.3 Construction Resource estimation

As shown in Table 5.1, the planned amount for the revenue is 69% of the contract value; this means resources were estimated only for the 69% of the contract amount. In addition, as I described above, the methodology used in planning and execution varies, the resources estimated are incomplete and incorrect in quantity and amount and the resources are delivered to the site. Because of this incomplete or incorrect amount it causes the project cost overruns or time overruns or both.

5.4 Activity Duration Estimation

The duration of an activity and a resource are interlinked. From the case study result duration estimations of the projects were not interlinked with the resource. They only use duration estimation by commonsense/guess there is no duration estimation procedure or method. They did not use past experience data because the daily productivity data recorded is not well documented, organized, summarized, revised and standardized for the organization.

5.5 Direct Cost Estimation

Once we have assigned the resources like labour, material, equipment, and time to each activity, the next step is to convert these resources to cost for budgeting of the project. The findings of the survey indicated that the planned amount for the revenue is 69% of the contract value; this means direct cost was estimated only for the 69% of the contract amount. Finally, the Total direct cost estimated was not completed because, as described earlier some activities are not breakdown enough to estimate how much it will cost and how long to perform the task.

5.6 Direct cost Controlling

As shown in Table 5.1, the organization identifies the direct cost variance of (labour, material and equipment), however it does not go deep through the cause of the direct cost variances like for Labour (productivity variance and rate variance), for material (usage variance and price variance) and for equipment (rent/ purchase price variance and productivity variance).

5.7 Organization Performance with respect to Profit

Regarding organization performance with respect to profit, the survey findings revealed that the organization faces serious challenges with regard to the expected profit amount from most of its projects. The survey result, as shown in Table 5.1, indicated that the organization obtained 30% of the amount planned.

5.8 Organization Performance with respect to Time

Regarding organization performance with respect to time, the survey finding revealed that the organization faces serious challenges with regard to completing the project on its completion time. The survey result, as shown in Table 5.1, indicated that the organization executed the work below 50% of the contract amount until the completion time has elapsed.

5.9 Planning and Controlling Tools

As shown in the Appendix, Crafts Construction Plc used ms-Project software for scheduling purpose only. Using software for planning and controlling is not common in Crafts construction

PLC. Lack of well trained staffs in planning and controlling software made the organization challenge in planning and controlling the project.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

As it is to be recalled, the main objectives of the research were to investigate the existing project construction operation planning and controlling practice of Crafts Construction PLC, to identify the gap or the drawbacks with the practice, and to forward recommendations which can assist in overcoming or minimizing the consequences of the problems. The need for undertaking a detailed investigation on the existing practice was mainly due to the fact that previous studies conducted on the area, apart from reporting the incompetence of the practice in general, have not pointed out particular areas that need interventions. In this research detailed assessments were made on work scope definition, activity definition, resource planning (labour, material, equipment, and time), and these resource cost controlling practices and, consequently, particular issues that demand improvement interventions were clearly pointed out. Moreover Crafts Construction Plc's performance with regard to securing adequate profit from the projects we also explored and completing the project on its completion time.

1. Scope of work Definition

The actual practice, the framework of the project work breakdown structure is not suitable for physical resource, cost, and schedule control. That means the tasks are not subdivided until the point is easier to estimate how long the small task will take and how much it will cost to perform than it would have been to estimate these factors for higher levels.

The WBS does not provide the basis on which resource assignments are made. The WBS was approved and followed by persons in the head office who do not have enough knowledge about the work without participate the person who will do the work.

2. Method of Execution of the Activity

According to the case study, the organization did not produce a detailed method of work or statement for each activity. It only used the method of statement from the bid

pricing stage, without considering the site layout, resources in stock, reaming resources that would be purchased, leased, or hired, or manufactured, the time duration given for accomplishment, quality of work described in the contract document, and degree of work complexity.

The project manager, the project engineer, and the general foreman were not involved in preparing the method of statements. Consequently, the people executing the work used their own technology which did not match the planned approach without any approval or cost-benefit analysis.

3. **Construction Resource estimation**

As shown in Table 5.1, the planned amount for the revenue is 69% of the contract value; this means resources were estimated only for the 69% of the contract amount. In addition, as I described above, the methodology used in planning and execution varies, the resources estimated are incomplete and incorrect in quantity and amount and the resources are delivered to the site.

4. **Activity Duration Estimation**

From the case study result duration estimation of the projects was not interlinked with the resource. They only use duration estimation by commonsense or guess there is no duration estimation procedure or method. They did not use past experience data because the daily productivity data recorded is not well documented, organized, summarized, revised & standardized for the organization.

5. **Direct Cost Estimation**

The findings of the survey indicated that the planned amount for the revenue is 69% of the contract value; this means the direct cost was estimated only for the 69% of the contract amount only. Finally, the Total direct cost estimated was not completed because, as described earlier some activities are not breakdown enough to estimate how much it will cost and how long to perform the task.

6. **Direct cost Controlling**

As shown in the table 5.1, the organization identifies the direct cost variance of (labour, material & equipment), however it does not go deep through the cause of the direct cost variances like for Labour (productivity variance & rate variance), for material (usage variance and price variance) and for equipment (rent or purchase price variance and productivity variance).

7. Organization Performance with respect to Profit

Regarding organization performance with respect to profit, the survey findings revealed that the organization faces serious challenges with regard to the expected profit amount from most of its projects. The survey result, as shown in Table 5.1, indicated that the organization obtained 30% of the amount planned.

8. Organization Performance with respect to Time

Regarding organization performance with respect to time, the survey finding revealed that the organization faces serious challenges with regard to completing the project on its completion time The survey result, as shown in Table 5.1, indicated that the organization executed the work below 50% of the contract amount until the completion time is elapsed.

9. Planning and Controlling Tools

As shown in the Appendix, Crafts construction Plc used ms-Project software for scheduling purposes only. Using software for planning and controlling is not common in Crafts construction PLC. Lack of well trained staffs in planning and controlling software made the organization challenge in planning and controlling the project.

6.2 Recommendations

This section presents the research's practical recommendations that are targeted at minimizing the consequences of the challenges and problems that contractors face with regard to planning and controlling of construction projects. Preparing a detailed good, realistic & applicable plan and controlling the plan helps them to get adequate profit and to complete the project on its completion time with the specified quality.

1. **Work Scope Definition**

As discussed in the literature review part, the work scope definition is important in identifying what is going to be done. The major goal of scope management is to ensure that the required work and only the required work-is included and performed in the project. One of the basic tools used to define work scope is WBS. The work breakdown structure of your project makes the project smaller and more manageable pieces.

According to the literature review maximum level can be used 20. AWBS should be developed before scheduling and resource allocation. Identify the task first, and then come back and decide how to do them and estimate how long they will take.

Stop breakdown the work when you reach a point where you can estimate time and cost to a desired degree of accuracy or the work will take an amount of time equal to the smallest unit you want to schedule. And a WBS does not have symmetrical all paths have to go down to the same level. See the appendix for the sample HTTC project.

2. **Method of Execution of the Activity**

You have to decide the technology you will use to execute the work by considering the resources (material, labour, equipment, money & time) you have in your stock and the reaming resources that can be purchased leased hired, or manufactured, and the site layout plan with the specified quality. Finally, make cost-benefit analysis for the options you have to decide. See appendix.

3. **Activity Definition**

Based on your technology or decided construction /production method define your activity by asking what needs to be done for the task, based on the technology decided or the database. The activity needs time, physical resources (manpower, material & equipment), subcontractor (labour, equipment, and material), or a combination, and money (cost for the physical resource).

4. **Total Resource Estimation**

After identifying the resources needed for the single activity calculate the total resource needed to complete the project for the estimated volume of work or quantity.

5. **Duration estimation**

As we discussed in the literature review resources and duration are interlinked, there for by considering the completion time given and the ''80 hour rule'' estimate the duration needed to execute the activity.

6. **Resource assignment**

After defining the activity through data base is to allocate or assign the physical resources and their costs, and duration to each activity from the activity data base we have.

7. **Resource Scheduling**

After allocating or assigning the physical resources & their costs and duration, we develop a work program called scheduling. A project planning is not completed until all the activities are schedule and forecast of major resources is developed.

8. **Planning, scheduling & controlling tools or Software's**

The project management software can aid in the speedy development of the network and project schedule, planning, and controlling. Use Primavera P6 Enterprise project portfolio management software to plan schedule and control your project in one.

9. **Baseline the scope of work, work done value, physical resource & their costs & duration**

After completing project planning and scheduling through Primavera P6 making a baseline of the plan which consists of the scope of work, work done value, physical resources, their costs, and durations. This step is the last preparation for the comparison of the actual with the planned one.

10. **Controlling**

The last most important step is controlling the deviated parameters from the planned one and Appling appropriate corrective measures.

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APPENDIX

Appendix A

Row data of Crafts Construction PLC's previous planning and scheduling techniques.

1. Project Performance Evaluation of Holy Trinity Theological College of Multipurpose Building
2. Budget Summary /Analysis sheet for Holy Trinity Theological College

Appendix B

New planning and scheduling techniques were developed as part of this research and were subsequently applied as a case study to project with crafts Construction PLC to evaluate their effectiveness.

1. The Work Breakdown Structure (WBS) for Holy Trinity Theological College (Work Scope Definition) Using Primavera P6.
2. Work Methodology /Method of Statements Selection for Holy Trinity Theological College.
3. Planning the Construction Resources of Holy Trinity Theological College
   3.1 Activity Resource and Duration Estimation Sheet.
4. Manpower Assignments, Material Delivery, Equipment/ Cash out forecast Schedule using Primavera P6.
5. Work Plan and Revenue/ Cash In forecast Schedule using Primavera P6.
6. Time Schedule using Primavera P6

SIGNED DECLEARATION SHEET

I hereby declare that the work which is being presented in this Project entitled **"PROJECT CONSTRUCTION OPERATION PLANNING and CONTROLLING of BUILDING PROJECTS A Case Study on Crafts Construction PLC"** is my original work and has not been presented for a degree of any university and that all sources of materials used for this project have been dually acknowledged.

Submitted By:

_____	_____	_____
Student	Signature	Date

Approved By:

1. _____	_____	_____
Advisor	Signature	Date

2. _____	_____	_____
Chairman, Dept's Graduate committee	Signature	Date

3. _____	_____	_____
Chairman, Faculty's Graduate committee	Signature	Date

4. _____	_____	_____
Dean, Graduate School	Signature	Date