ADDIS ABABA UNIVERSITY
ADDIS ABABA INSTITUTE OF TECHNOLOGY

School of Civil and Environmental Engineering
MSc. Program in Construction Technology and Management

Investigation on Construction planning and Scheduling Methods and Tools in Case of Federal Road Construction Projects

By: Beshir Mudesir
Advisor:-Abraham Assefa (PhD)

A Thesis Submitted to the School of Graduate Studies of Addis Ababa University in Partial Fulfillment of the Requirement of the Degree of Master of Science in Civil Engineering (Construction Technology and Management)

August, 2024
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Approved Board of Examiners

Advisor	Signature	Date
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Declaration

I the under signed declared that, this Investigation on Construction planning and Scheduling Method and Tools in Case of Federal Road Construction Projects My original work and has not been presented for a degree in any other university. All the source materials used for this thesis have been duly acknowledged.

Student Name: - Beshir Mudesir

Signature:-_____

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Date:-_____

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Abstract

Any effective construction management system should have as its primary objective to completing the project within allotted budget, on schedule and within necessary quality standards. Project planning and scheduling tools and methods are important tools for Contractors in ensuring efficient and effective project planning and scheduling. Traditional planning and scheduling procedures are widely used by road contractors while establishing the work program. However, due to the growing size and complexity of construction projects, as well as rapid technological progress, a move from traditional approaches to more technology intensive ways have required. Due to this, the study looks into the present planning and scheduling methods and tools adopted by the contractors in case of federal road projects, the factors that influence their choices, and the problems encountered using the chosen planning and scheduling tools and methods are studied. Road contractors working with Ethiopian Road Administration were included in the research. The questionnaire survey and case study were used for data collection and respondents are ERA road contractors. According to the findings, the most popular planning and scheduling approach used by local and foreign contractors is the bar chart, which is followed by critical path methods(CPM) in activity on arrow (AOA). Contractors, on the other side, rarely use the LSM, PERT, or GERT methodologies. Specialized software was most commonly used to create bar charts, milestone charts, and CPM in AOA, PDM, PERT, and GERT, while computer spreadsheet systems were usually utilized to create s-curve charts and linear scheduling method (LSM) The most widely used specialty software is Microsoft Project, whereas the most widely used computer spreadsheet system is Microsoft Excel. The most important criteria determining the choice of planning and scheduling methodologies are the size and complexity of projects. The requirements for detail information, computer hardware and software, and the inability to control the project's critical path are all problems experienced when employing non-network based approaches (bar chart, s-curve chart, milestone chart, and LSM). On the other hand, time Consuming, the need for a skilled and experienced Planner, detailed information, computer skills and software, and insufficient training are all major issues with adopting this method.

Key words:-planning and scheduling, Methods, Tools, factors affecting, ERA projects.

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List of Abbreviations

ERA……..Ethiopian Road

Aait……..... Addis Aababa Institute Of Technology

LOB …….Line Of Balance

RSDP ……Road Sector Development Program

PERT……Program Evaluation and Review Techniques

CPM …….Critical Path Methods

PDM ……Precedence Diagram Methods

GERT……...Graphical Evaluation And Review Techiniques

LSM …….Linear Scheduling Methods

SPSS ……Stastical Package Software for Social Science

Rras …….....Regional Road Authorities

WRO ……Woreda Road Offices

GOE ……...Government Of Ethiopia

RCI ……..Road Construction Industry

WBS ……Work Break Down Structure

UK …….United Kingdom

EU …….European Union

NDF…..……...Nordic Development Fund

WBS ……Work Break Down Structure

GC ……...General Contractor

RII ……Relative Importance Index

EFT ……..Earliest Finish Time

EST ……..Earliest Start Time

LFT ……..Latest Finish Time

LST …….Latest Start Time

PMI …….....Project Management Institute

CHAPTER ONE

1.1Background

Project planning and scheduling is one of the most important activities for a project manager when starting and managing any types of project. One of the important process that ensure the success of the construction project is planning and scheduling (Gould and Joyce, 2000). Project planning involves the function to establish project activities, their logical relationships and interrelationship to each other and the sequences in which they are to be accomplished. Project scheduling deal with the process of assigning activities duration and identifying the start and completion times of activities. Both process is no doubt important to prepare systematic work schedule during the preconstruction stage, which is important in determining the success or failure of the project in relation to time.

Project planner work within the construction industry who are concerned with the project overall work program. They are involved in the development and construction of residential, commercial, industrial, agricultural, infrastructure work and others. Planners are commonly based at the home office but often move to the construction site during the construction stage. The planner prepare basic work program for a particular construction project, advice on the work sequencing in the construction activities, monitor job progress, coordinate subcontractors, analyze the changes and the impact of delays and solve problems (Gould and Joyce, 2000).

The traditional form of scheduling method such as Gantt chart (bar chart) is commonly use to prepare construction work program currently by the contractors. Different method of planning and scheduling used to prepare work program have their application and disadvantages. Therefore, the method of planning and scheduling to be used to prepare work schedule for project planning and control commonly depend on characteristic of the project, size of the project, knowledge and level of sophistication user as well as the level of detail information require to monitor the project (Barrie and Paulson, 1992).

Delivering projects successfully is one of the key responsibilities of construction project management, and it involves planning and scheduling of construction projects Additionally, highway projects of any magnitude have become increasingly difficult due to the highly competitive environment and

complexity of the decisions of management involved (El-Rayes,2001). As a result, each Project Manager had a different system, which usually included the use of the Gantt chart or bar chart (Hancher, 2003). However, as projects became more complex the need to develop complex tools that encapsulate the complex demand of projects became apparent. The network analysis was consequently developed. From the foregoing, it is obvious that strive to obtain undisturbed construction plans and schedules from the onset of project continues persistent. Construction planning and scheduling has been there over the years; however, the general shortage of skill has brought it into sharper focus. (Allen and Smallwood, 2008) Conferring to this, ply opined that construction planning would provide an increasingly critical role in the construction industry, and even more due to the unprecedented industry growth.

Studies have shown that more than 50% of time wasted during construction is attributable to poor management practices (Koskela, 2000).

This caught the attention of the investigator and made him curios to know what factors are critical for success concerning planning and scheduling.

The researcher was curious to know the different types of planning and scheduling tools and methods, factors affecting the choice of planning and scheduling methods and tools, problems encountered using different planning and scheduling methods and tools in road construction contractors in Ethiopian road.

1.1 Problem Statement

The fundamental issue in our nation, as well as those of the other African nations, is project delay and failure to complete as anticipated. The cost, time, and quality of a project are used to gauge its performance. Problems in the project's selection, planning, execution, or control phases are typically what cause projects to fail. Collapse in one of the phases could lead to the project's failure as a whole. According to Yardley (2002), the primary cause of project failure in developing nations is an ineffective planning procedure. Ethiopian projects' scheduling and planning procedures, like those in other developing nations, are very inadequate, and projects are frequently carried out without having prepared a suitable project plan (Mohammed, 2017).

Additionally, construction processes are becoming more complex and logistically challenging (Allen and Smallwood, 2008).

Time overruns are one of the main problems that impede the development and growth of the construction sector in developing nations, according to an analysis of the literature on the subject. This has been identified as the primary underlying cause of project delays.

One of the most frequent issues faced by Ethiopian construction, which served as the subject of this thesis' research, is project completion delays. Some of the factors that contribute to these delays in project completion have been identified through the analysis of this issue, including poor time estimation, a lack of understanding or incomplete understanding of the project requirements, the complexity and unpredictability of construction projects, inadequate and unplanned scheduling, the planning fallacy, unplanned resource allocation, and poor networking between project activities. Having identified these deficiencies, the study will aim to investigating the planning and scheduling techniques used by local and international road contractors working with the Ethiopian Road Administration.

The literature review also analyzed a number of studies within the geographical boundary of this research, and the findings from these studies showed that many construction projects have been affected by time and cost overruns. However, there is currently no clear identification that this problem is. For example, in a survey on the schedule performance of Saudi construction projects, Assaf and Al-Hejji (2006) Reported that 45 out of 76 projects investigated were delayed by more than 30% beyond the originally scheduled completion date. Another study revealed that more than 50% of the sample of construction projects in UAE Experienced varying degrees of schedule deviations and cost overruns (Faridi and El Sayegh, 2006). In Qatar, over 85% of construction projects were Subject to time and cost overruns as a result of factors such as poor design and Deficiencies in schedule and cost estimates (Jurf and Beheiry, 2012)

The Bahrain construction industry has faced the same problems, with projects delayed due to critical factors such as inadequate planning and scheduling (Altoryman, 2014). In Oman, a number of construction projects were also found to be subject to schedule delays by more than 40% beyond their original schedule plans (Alnuaimi and Al Mohsin, 2013). These studies within indicated that insufficient planning and poor scheduling of project Activities, ineffective design stages, improper coordination between project stakeholders and lack of knowledge about project requirements are amongst the most critical factors causing schedule deviations and cost overruns.

Considering the above views from the literature, a question concerning the level of understanding of current practice of project planning and scheduling seems relevant: are planning and scheduling

theories properly understood and Effectively applied in practice in Federal Road construction Contractors.

Related works

Sadik Mohammed (2017) in this study he describe An assessment of the project planning practices of Addis Ababa housing project in the sites project14, project13, kilinto and head office problems with current scenario**.** the objective of this study is to assess the project planning practices of Addis Ababa housing project in selected four sites. The study employed survey in its descriptive research design. The target population of the study was staffs of the organization in the selected four sites who are project team members and managers. The result of the analysis shows that the general project planning practice of the study organization is weak but the level of staff awareness regarding the presence of the project plan is good. On the other hand the most widely used project planning tools work break down structure, Gant chart and project management information system are applicable even if it is not in a satisfactory level.

Mulualem Desalegn (2017) in this study assessment on the practice of construction work schedule preparation and control of public building projects in Addis Ababa. Thirteen Public building projects in Addis Ababa were studied to find out the current practices by adopting the processes of project time management as a study model as well as assessing the factors affecting and improvement parameters based on researchers' suggestion. The results indicate that more than 70% of the projects are behind schedule, due to low practices in establishing procedures to schedule preparation and control, and limited Project Management software application for performance analysis. Factors that mainly affect schedule performance are unrealistic estimates for effort and duration, limited knowledge in performance evaluation and design changes.

Nejbel mohammed (2014) in this study A study on planning and scheduling in federal road projects of Ethiopia: Causes of non-excusable delay in selected projects. In order to achieve its objectives, case study of ten projects, desk studies concerning the subject matter on the current trends of Ethiopian roads authority, and 26 interview responses of professionals from Ethiopian Roads Administration, consulting firms and contractors have been analyzed.

Accordingly the findings from the research show that there is a need to improve planning and scheduling trends because risk factors associated with non excusable delays have been triggered due to lack of proper planning and scheduling in execution of works.

in the above thesis works the researchers try to identify the planning and scheduling practice and trends mainly building projects and non excusable delays.However,in this research try to identify the different planning methods and tools used planning and scheduling methods, the different modern application or computer spread sheets used to road construction planning and scheduling technique's and methods used both local and international road contractors working in Ethiopian Road Administration .Inaddtion the major factors affecting the choice of and uses of modern planning and scheduling tools and methods.

1.2 Basic Research Questions

a) What approaches and instruments for planning and scheduling have road contractors used to create work schedules?
b) What are the barriers that influencing their choice of planning and scheduling methods and tools in preparing work program?

1.3 Objective of the Research

1.3.1 Genera Objective

The main objective is to investigate the planning and scheduling techniques and tools used by road construction contractors of ERA projects**.**

1.3.2 Specific Objective

- To investigate various construction planning and scheduling techniques and methods used for preparing work programs by road contractors.
- To assess the challenges/barriers that influencing the selection and investigation of planning and scheduling techniques and methods of road contractors of ERA projects.

1.4 Significance of Study

This study is significant because it raise awareness of the planning and scheduling techniques now used by construction contractors to create work schedules, as well as the challenges associated with such techniques. In order to determine the criteria for preferred planning and scheduling methods to use for creating work programs, variables affect the choice of planning and scheduling methods are also discussed. The findings of this study can be used as a foundation for advancing work program, planning and scheduling techniques in the future. In order to help them get ready for the actual industrial

practices, it also gives construction management professionals and students' knowledge of the current planning and scheduling techniques used by Ethiopian Road contractors in ERA projects.

1.5 The Scope and limitation of the Study

The study will geographically be limited to federal democratic republic of Ethiopia focusing on Ethiopian road contractors participating five regions and they active project sites in western southern, central eastern and north regions. This study mainly focuses on the **Study on Construction planning and scheduling methods and tools in local and international Road construction contractors in Ethiopian road administration.** Especially contractors participating federal road construction projects in the case of Ethiopian road administration in different regions. However, this paper focuses on contractors that grouped in all regions. The all parts of construction planning and scheduling practices and methods covered under this study. In addition, since construction project managers and planners are usually the major personnel involved in construction planning, they are the focus for data collection based on expert opinion.

1.6 Organization of the Research

The study's organizational scheme describes how the content is divided into chapters. There are five chapters throughout the entire text. The framework of the study, background, research questions, problem statement, study objective, significance, scope, and organization are all described in the first chapter, which is the introduction. Then moves on to Chapter 2's literature review. The third chapter discusses research methodology and shows how data analysis is done. Chapter 4 discusses research findings. The chapter ends with a conclusion and a recommendation.

CHAPTER TWO LITERATURE REVIEW

2.1 Introduction

Construction industry continually tries to achieve accuracy and attempt to overcome the traditional cost and time overruns associated with construction delivery, it is usually to seek for innovative ways of achieving these objectives. As result, achieving these objectives requires the utmost planning and scheduling of construction activities (Chau, Anson and Zhang, 2003). Since planning and scheduling impacts on all other tasks (Li *et al.*, 2012). In spite of these assertions, construction planning and scheduling can be very daunting, owing to its complex nature. Construction plan and schedule is a management tool that enables planners, schedulers or other related construction profession to direct the accomplishment of construction projects to complete them in a timely and cost-effective manner (Hutchings, 2003).Traditional planning and scheduling methods unable to fulfilled the need of modern project scheduling. Thus, there is a high demand on hiring professional project scheduler with knowledge in computerized scheduling to handle complex projects (Hutchings, 2003).To put the study in the right context or perspective and clarify construction planning and scheduling, this chapter is committed to reviewing existing literature on the topic and other similar or related topics.

2.2 Road Construction Industry Ethiopian Road Construction

The Road Construction Industry (RCI) is necessary for momentous development of an economy. According to (Assefa, 2008) the earliest modern roads in Ethiopia connecting Addis Ababa to Addis - Alem and Harar to Dire Dawa date back to the first half of the twentieth century. These roads were part of Emperor Menelik's attempt to modernize Ethiopia, however much has not been done until the time of the Italian occupation (1936 – 41). In the context of Ethiopia, road is the most important infrastructure that provides access to rural and urban areas in the country. Road plays crucial role to reduce transportation cost and support economic growth in the country. However, in the late 1990‟s; the road network coverage was limited to major urban areas and some rural areas. Most areas in the country were isolated from economic centers, market and basic social services. The existing road network was largely deteriorated and in poor condition (ERA, 2016).

The Government of Ethiopia has well recognized that limited road network coverage and poor condition of the existing road network has been an impediment to economic recovery and economic

growth. Therefore, to address the problems in the road sector; the Government has launched the Road Sector Development Program (RSDP) in 1997. then, four phases of RSDP were implemented over the period of 1997 - 2015 and the fifth phase; RSDP V has been implemented since July 2015 (ERA, 2016).Over nineteen years of RSDP, physical works consisting of rehabilitation and upgrading of trunk and link roads, construction of new link roads, rural roads & district roads and maintenance of federal and regional roads have been carried out by Ethiopian Roads (ERA), Regional Roads Authorities (RRAs) and Woreda Road offices (WRO) and the community and municipalities. Series of policy and institutional reforms have been implemented in the sector, which have enhanced implementation capacity of road projects and effectiveness of Road Asset Management (ERA, 2016).

2.3 Planning and Scheduling

The scheduling phase begins after completing the project planning process and constructing the planning diagram. The definition of project planning has been considered across broad front by both construction researchers (Andrew Baldwin and Bordoli, 2014). For example, project planning is define as a set of established processes used to decide on what tasks must be performed to achieve the projects set objectives within schedule and cost (Pierce, 2013). In their hand book (Andrew Baldwin and Bordoli, 2014) state that regardless of the definition chosen for project planning, it has the objective of achieving a number of common factors including the production of realistic schedules and costs, the completion of a project to defined standards of quality, design criteria, project resources, health and safety, and meeting project stakeholders' expectations.Depending on the observer or author, scheduling is regards as either an integral part of, or output from, project planning. A schedule is a representation of project activities identified by the work breakdown structure (WBS), as part of the definition of the project scope (Andrew Baldwin and Bordoli 2014)). In addition, the concept of project scheduling deals with the logical sequencing of activities and the addition of activity durations. It includes related concepts such as resource loading and tracking progress during project execution (El Naqa et al., 2007).More recently, it has been argued that planning and scheduling should be recognized as two separate, but closely related, activities that should not be performed concurrently in practice (Baldwin and Bordoli 2014). According to (Baldwin and Bordoli 2014) planning may be an iterative process but the tasks of planning and scheduling should not be attempted concurrently. Planning should precede scheduling. Scheduling should never precede planning. It is not a good practice to plan whilst scheduling. Planning and scheduling therefore requires timing, organization and discipline. On larger

projects, where planning and scheduling will be separate tasks undertaken by different people, it is easier to differentiate between the two tasks, and the tendency to confuse the roles of planning and scheduling is less likely to arise. “Based on the distinction between planning and scheduling as two separate tasks, (A Baldwin and Bordoli, 2014) simplified the objective of planning and scheduling as follows: “the main objective of planning is to ensure that things happen successfully. This requires objectives to established, tasks identified and progresses monitored. The project schedule provides the basis for measuring progress, the basis for regular review and an updating of the plan” (Baldwin and Bordoli, 2014). From project management perspective, project planning and scheduling involve interrelated inputs and detailed deliverables that are implements according to their assigned objectives. These objectives must effectively define and controlled early in planning and during execution for successful project performance. Figure 2.1 presents an overall view of planning and scheduling inputs and related functions (objectives) of each assigned input (or project activity).

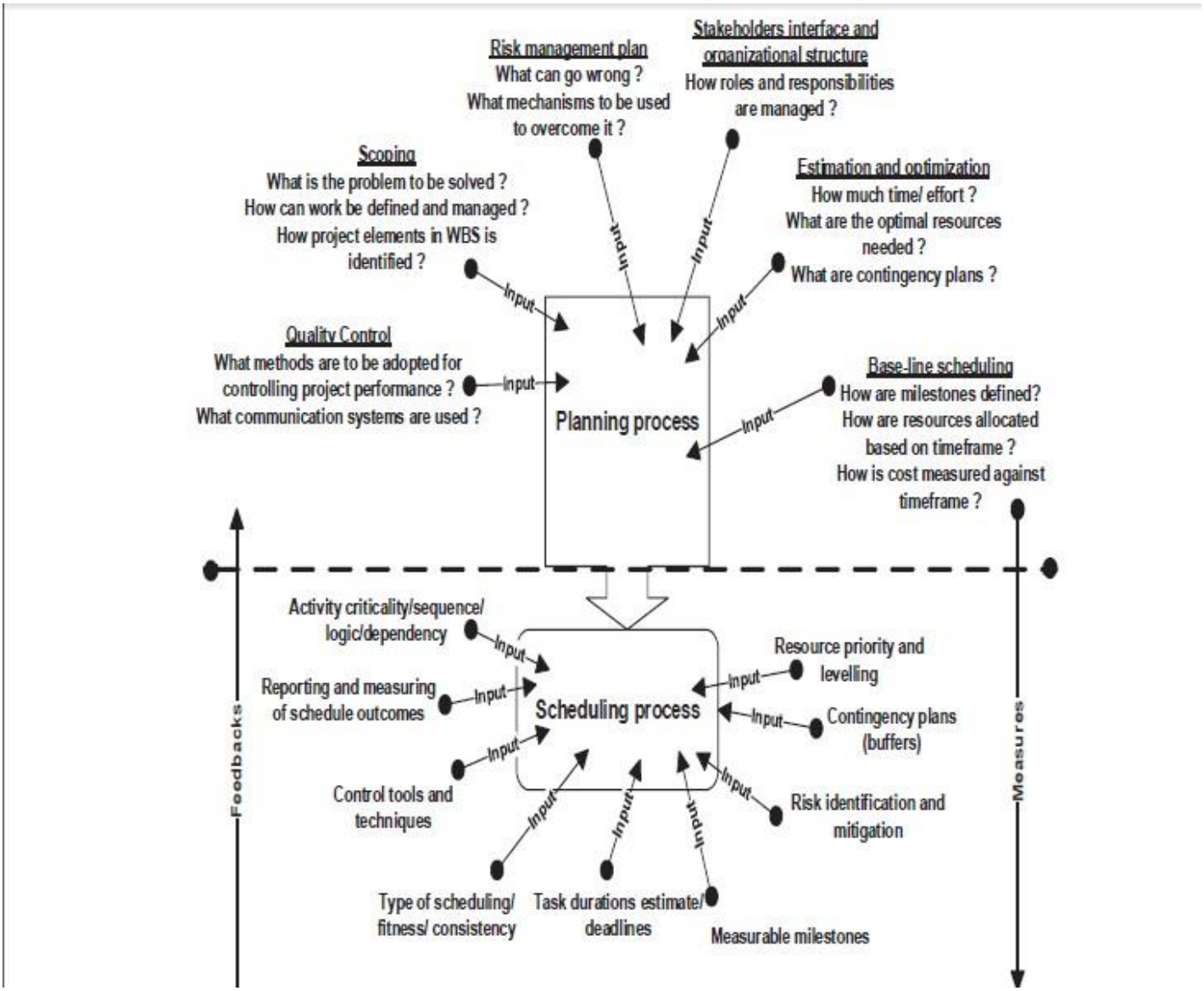


Figure 2.1 Typical planning and scheduling systems based on (Winch, 2006),(PMI 2008) and (Kerzner, 2017)

According to (Heesom and Mahdjoubi, 2004) and (Chau, Anson and Zhang, 2003) the last two decades have seen a growing interest in technological advancement (e.g. four-dimensional computer aided design, 4-D CAD) for construction planning and scheduling. According to Hitherto, construction planning and scheduling was mundane involving basic tools and practices. There was no generally accepted formal procedure to help in the management of projects (Hancher 2003). The procedure varied from project to project and from manager to manager. However, there was one thing peculiar to

all projects or sites. Construction professionals on a typical project communicated through paper- based working drawings, and the planning staff formulated their schedules in the same way involving paper-based working drawings (Hancher, 2003). This presented the planning team with an unenviable and herculean responsibility of formulating project schedules. The arduous task was the consideration of resource requirements for human, plant, materials, etc. Not only that, planners also faced the challenge of incorporating in their minds logical construction sequence, and economic resources utilization (Hancher, 2003,). The construction industry is multifarious, and involves huge number of resources. Achieving the desired results using 'human intuition' was bound to fade out. The increasing complexity of construction fueled the obsolescence of the heavy reliance on 'human intuition' in planning and scheduling.

This development led to the adoption of computer-based tools for planning and scheduling. Chau et al. (2003) argued that where computer-based tools are utilizes they were utilized as bar charts or critical path networks. This was limited in that they were not able to show spatial construction features as well as the detailed resource and workspace requirements. This had to be envisioned in the minds of the planners (Chau, Anson and Zhang, 2003).So although there have been improvements in the form of computer-based tools, the critical tasks were still left to the intuition of the planners. Moreover, their intuition was only limited to the extent of information that can be gleaned from the design documents. As a result, Chau et al. (2003) concluded that the computer has not explored enough. Exploiting the optimal assistance from computers fueled the upsurge of concerted research efforts on the concept of visualizations (i.e. 4-dimensional models). The fourth dimension has to do with time. As aforementioned, the research focus in the last two decades has been on the development of more stringent approaches to effective construction planning and scheduling. For instance, (Retik and 1990.) Developed and outlined possible features of tools for construction scheduling using computer graphics. In addition, Williams (1996) graphically represented construction plan with a 4-D Planner to improve project visualization, simulation and communication needs. In the same way, McKinney et al. (1996) developed a 4-D CAD tool that also enhances visual communication, but was limited to the construction design process.

According to (Adjei-Kumi, 1997) using a library-based 4-D model, PROVISYS, for planning reported visualization of construction plan in a virtual reality. Moving on, Kamat and Martinez (2001) proposed a general-purpose 3D visualization system on construction operations.

In spite of the fact that there have been improvements, incorporating visualizations of construction processes to aid planning and effective decision making, the developments are often limited to building level. Chau et al. (2003) argued that the application lacks pragmatic site management features. They consequently proceeded to furnish a 4-D graphical visualization capability for construction planning purposes. Currently, 4-D CAD has been founding to have a profound impact on communication in construction. It allows a more comprehensible intuition of the construction processes than the traditional 2-D drawings and schedule information (Heesom and Mahdjoubi, 2004). Surprisingly, the construction industry in developing countries including Ethiopia has historically neglected modern practices in planning and scheduling methods and tools. This is evident in the conventional cost and time overruns, and lack of literature and previous researches on the discipline in advanced planning and scheduling tools and methods in these areas.

2.3.1 Significance of Project Planning and Scheduling

The significance of project planning recognizes in early construction studies (Laufer and Tucker,1987), in which it argues that project planning needs to improve by considering more efficient management strategies in planning. According to Dvir et al. (2003), there is a strong correlation between successful project planning and the success of a project from the perspective of project stakeholders. These authors also indicated that clear definitions of functional and technical specifications in project planning can lead to more effective execution of projects. They also found a strong correlation between successful implementation of planning procedures and benefits to project stakeholders. Such findings are confirmed in a later study which indicated that project success can be measured in view of the quality of project planning; whereas poor planning means uncontrolled alterations in the planning variables of time, cost and quality (Dvir & Lechler, 2004). Zwikael (2009) argued that many construction projects are more likely to be subject to the risk of poor project planning when compared to projects in non-construction sectors.

Zwikael assessed the significance of project planning in construction projects and found that the extent of use of proper project planning by project managers and other project stakeholders was not at the optimal level of project requirements. He further argued that a strong emphasis should place on defining the project scope, project activities and costs (or budgets).

Regarding project scheduling, the development of a good project schedule is vital to an understanding of project performance and control (Ahuja & Thiruvengadam, 2004). Good scheduling represents a

roadmap for project managers, planners and schedulers in monitoring and tracking critical activities and milestones during the progress of a project (Andrew Baldwin and Bordoli, 2014).They indicated that good project planning and scheduling can provide tangible benefits for key project stakeholders. According to Andrew Baldwin and Bordoli (2014), important benefits include:

- The ability to forecast resource requirements and costs;
- The ability to develop realistic schedules with clear time deadlines;
- The ability to communicate with clear and reliable information to project stakeholders;
- Providing reliable information for risk and opportunity assessment;
- Providing good information for monitoring and control;
- Minimizing materials wastage; and
- Providing a strong basis for team coordination and assisting in the negotiation of contractual claims.

As (Andrew Baldwin and Bordoli, 2014) point out, these benefits cannot achieved without strong commitment and knowledge on the part of project managers and other project stakeholders on how to manage planning and scheduling most effectively. Despite these theoretical discussions on the significance of project planning and scheduling, little empirical research has attempted to understand the effectiveness of its application in construction projects.

According to Mubarak,(2015) claimed that planning and scheduling are important for following reasons:

- To calculate the project completion date
- To calculate the start or end date
- To expose and adjust conflict between work activities
- To predict and calculate cash flows and asses resource requirements
- To evaluate the effect of changes
- To improve work efficiency
- To resolve delay claim
- To serve as an effective project control tool and means of communicating work plans
- To Compare performance

2.3.2 Knowledge Requirements for Successful Planning and Scheduling

In construction projects, the maturity of the project management body of knowledge is a key issue for the successful achievement of project objectives (Morris, 2013).

It can argue that such knowledge should focused on, and prioritized for, specific management areas in order to improve the probability of a successful project outcome. According to (Kerzner, 2017), project planning requires effective skills and knowledge about the collection and analysis of information, communication with project stakeholders, resource negotiations, commitment and the involvement of top management, and definition of measurable milestones. Such planning knowledge and skills on the part of project stakeholders, however, needs to understood and assessed in practice.

Construction Planner in construction creates the plan and figures out how to build project in the most efficient ways (Von Brown, 2011). In construction, a project planner must have a full understanding of what they are planning to build, where the project is going to be built and the parameters that control the site (site condition) (Von Brown, 2011).

Scheduler is knowledgeable and familiar with all the techniques and practices of proper scheduling which involve the proper use of durations, scheduling relationship, lags, constraints and logic to derive the critical path (Von Brown, 2011).

The planning discipline grow concurrent with the scheduling discipline. Therefore, an effective scheduler is also an effective planner. A planner and scheduler must know the plan and how the activities work in what sequence in order to related to others the impacts of delay to a schedule and create with some other way to recover the lost time (Hutchings & Christofferson, 2004). Hence, project planner and scheduler is a sunrise career opportunity on the threshold of a bright and profitable future because the construction is an ever-demanding industry and professionals involve on the project production planning and scheduling (Hutchings, 2003).

The basic service provided by the construction planner and scheduler in the construction project are preparing the master work schedule, advice on the work planning and sequencing in the construction activities, monitor job progress, coordinate subcontractor and analyze changes and the impact of delays and solve problem on the delay by come out with some alternatives (Gould and Joyce, 2009)

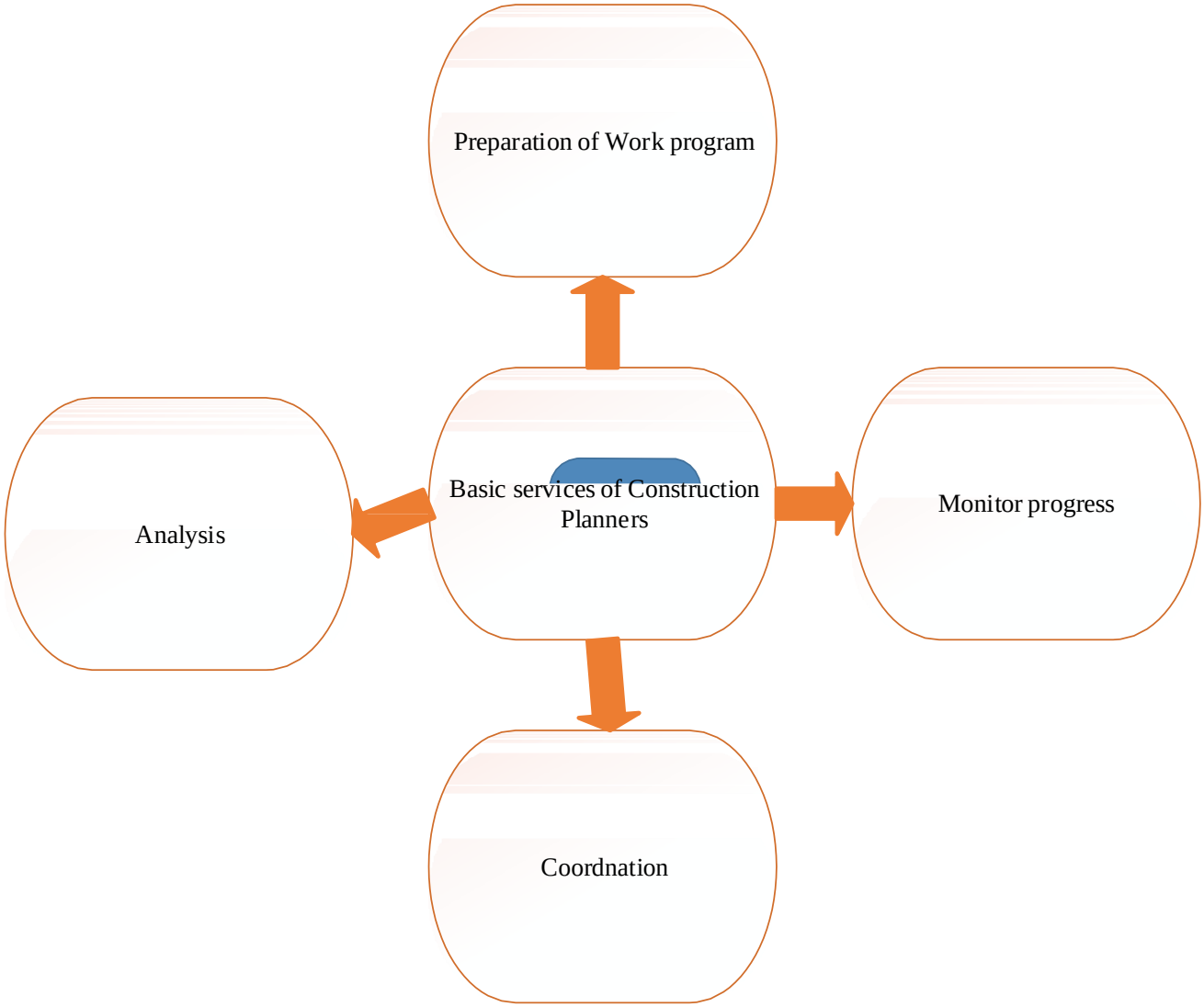


Figure 2.2 *Basic services of Construction planner and scheduler. (Gould and Joyce 2009 p,43)*

The professional skill that includes theoretical knowledge on building construction and civil engineering, knowledge in working the construction sequences in advance such as CPM, PDM, PERT and other methods and advanced computer software as well as experience on actual construction work are required for planning and scheduling engineer.

2.3.3 Project Planning and Scheduling Fundamentals

Recently, it was argued that a higher level of management and competency is required for the development of project plans, which can be used as a reliable basis for controlling project (Andrew Baldwin and Bordoli, 2014). The competence of project stakeholders (i.e. owners, project managers, designers and contractors) in providing a high level of reliable and detailed inputs and deliverables in the

early planning stages is crucial for the implementation of project planning in construction projects (Johansen and Wilson, 2006).

In view of the relevant literature mentioned earlier, an understanding of scheduling concepts should also involve important aspects and issues, such as resource loading and trade-offs, risk identification and mitigation, control techniques, activity criticality and dependencies, and contingency plans or buffers. Snoo et al. (2011) asserted that the application of scheduling concepts could be evaluated based on two main criteria: (1) uncertainty regarding resource loading and levelling in the development of the schedule; and (2) uncertainty regarding schedule execution and control.

2.4 Construction Planning and Scheduling Techniques and Tools

2.4.1 Traditional Construction Planning and Scheduling Techniques

Traditional methods is also known as non-network based methods (Arun, 2005). Non-network based planning and scheduling methods such as bar chart, s-curve chart, milestone chart, linear scheduling method (LSM) commonly lack of interrelationship between activities, thus it is often difficult to control the large and complex project (Hinze, 2004).The era of traditional planning techniques dates back to the time of Henry Gantt‘s Work, Wages and Profits ‘in 1916. The following will discuss four types of traditional planning and scheduling method to prepare work program.

2.4.1.1 Gantt Chart

Bar chart is a graphical representation of project activities shown in a time scaled bar line with no links shown between activities (Popescu and Charoenngam 1995, 1996) (Cited by Mubarak, 2005). It is the most familiar methods for presenting the work plan by listing activities and identify a time for each activity to start and a time for activity to finish (Baldwin and Bordoli, 2014). The bar chart was originally developed by Henry L. Gantt in 1917 and is alternatively called a Gantt chart (Mubarak, 2005; Patrick, 2004). Bar chart can easily show the important facts of the project that includes the planned overall length of the project, the planned duration of each project component and the calendar start and finish dates for each project phase (Gould, 2002). Thus, bar charts method still important and best used with network based method such as CPM in preparing work program (Mubarak, 2005).

Advantages of using bar chart method are simplicity and ease preparation of the bar chart, easy for understanding on the project scheduling as bar chart are uncomplicated and simple to interpret and bar chart particularly appeal to persons who do not have technical background. Therefore, bar charts have become the accepted method for communication of the project plan for over 100 years (Baldwin and

Bordoli, 2014). Disadvantages of using bar chart in planning and scheduling to prepare work program are bar chart does not automatically show the effects of changes, bar chart does not show the critical activities that determine the completion date of the project and as well as it is very difficult with bar chart to see the effects of a change, and whether or not a potential change will affect the project completion date (Newitt, 2005; Baldwin and Bordoli, 2014). The major limitation of the bar chart is that interdependencies between activities cannot be shown and thus bar charts cannot be used to determine specific project activity start dates, completion dates and available float time (Gould, 2000; Baldwin and Bordoli, 2014; Patrick, 2004).

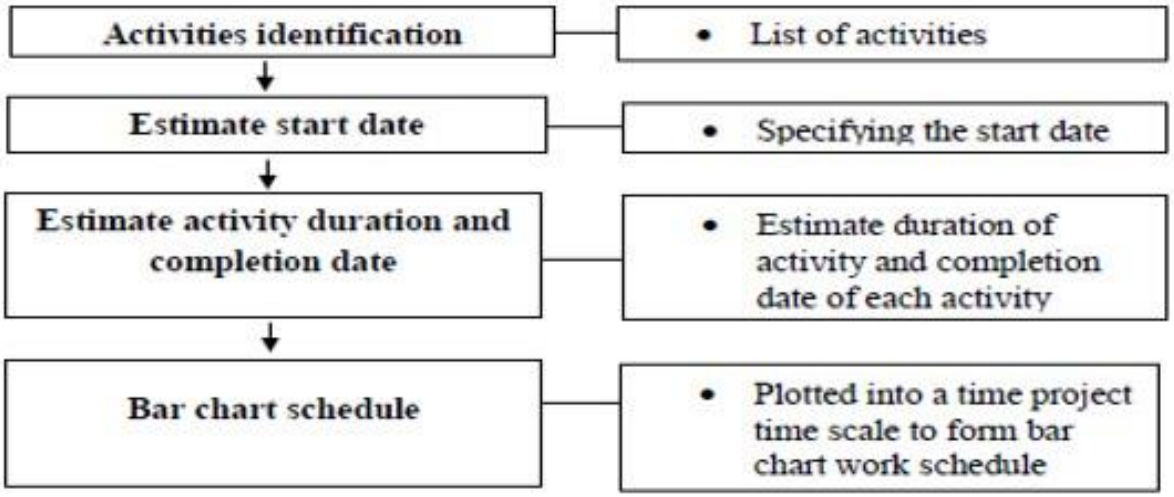


Figure 2.2 Steps to prepare bar chart schedule (source: Baldwin, 2014, P55-56)

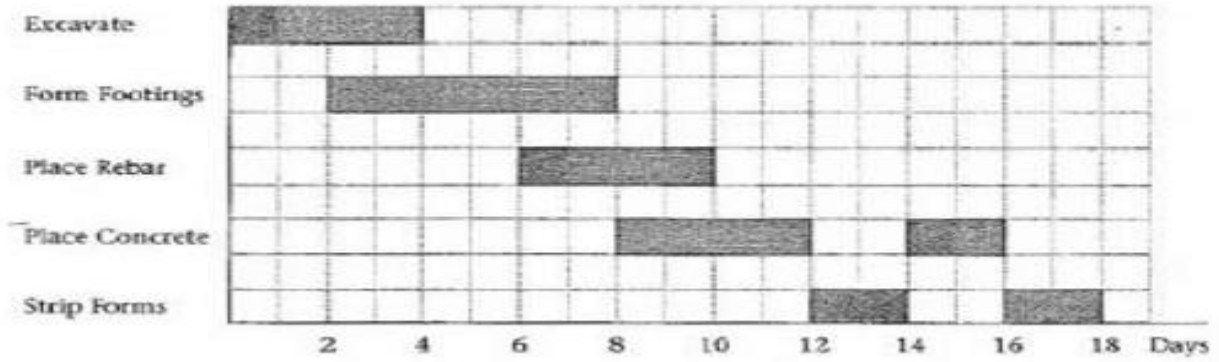


Figure 2.4 Simple bar chart (Source: Saleh Mubarek, 2005, p11)

2.4.1.2 S-Curve Chart

S-curve chart is the extension to the traditional bar chart system that lack of interrelationship float capability by adding the timeline momentum to the bar charts (Hutchings, 2004). This chart also known

velocity chart. It is a scheduling method that shows the relationship between time and output of a construction project in a Straightforward and simple way (Fisk, 1982). S-curve chart with two lines show the established schedule of total tasks and activities graphically with the actual work progress along the project progress (Hutchings, 2004). The slope of the production line from traditional S curve allow user to determine at a glance whether a project proceeding on schedule or whether it is behind schedule but catching up or falling further behind schedule (Fisk, 1982). S-curve chart more advantageous than the bar chart by providing more scheduling control over subtasks within activities because S-curve charts are structured with a one-week timeline that open up the detail of the subtask for better control (Hutchings, 2004). Moreover, the chart show interrelationship of sequential and parallel activities more clearly than traditional bar charts (Hutchings, 2004). However, the S-curve chart only suitable for smaller construction project linear in nature and it does not provide time-scale manipulation (Hutchings, 2004; Fisk, 1982).

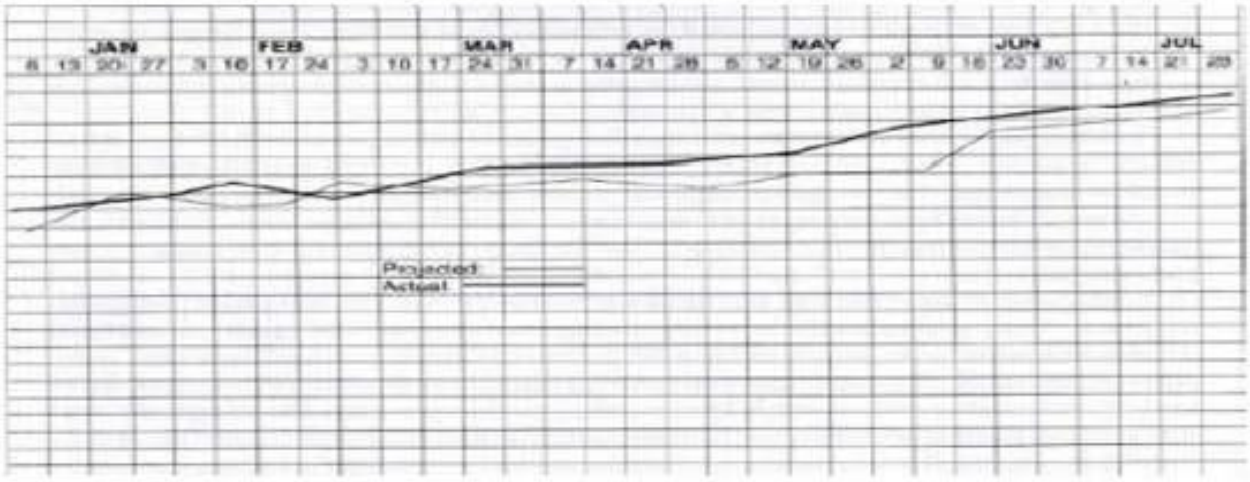


Figure 2.5 S-Curve chart (source. Hutching, 2004, P100)

2.4.1.3 Milestone Charts

Milestones are points in time that have been identified as being important intermediate reference points during the accomplishment of the work (Clough et. al, 2000). The milestone event is referred to either the start of an event or completion of event (Clough et. al, 2000; Rajiv Gupta, 2008). The managers find difficulty to keep track of all details of the construction task especially on large complex project that involved hundreds and even thousands of activities (Rajiv Gupta, 2008). Therefore, on large projects, contractors frequently establish a series of milestones extending throughout the project and use these as reference points for project monitoring (Clough et. al, 2000). Milestones can indicate on

bar chart or project network using any symbol desired (Clough et. al, 2000; Rajiv Gupta, 2008). Milestone chart important to be developed in order show to the top management on the important events (Rajiv Gupta, 2008).

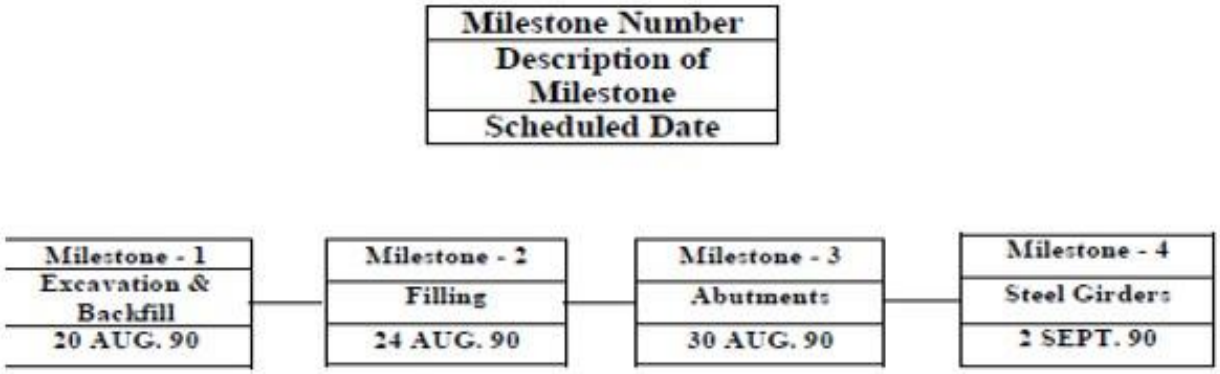


Figure 2.6 Milestone Symbol and Milestone chart (source: Adapted from Rajiv Gupta, 2008,p 102)

2.7.4 Linear Scheduling Method (LSM)

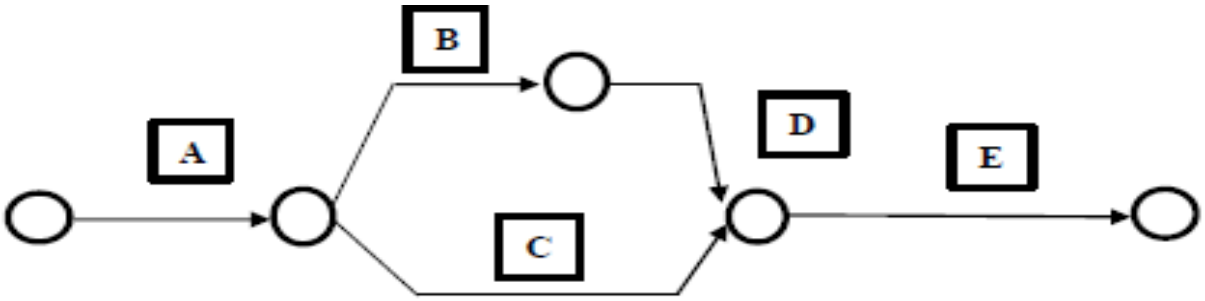
Linear scheduling method (LSM) have not been applied widely to construction projects even though they have been identified as very useful (Thiruvengadam, 2004). LSM is a method of planning and scheduling that is very effective for repetitive work that involve tall buildings (floors are identical), housing projects (identical houses or buildings), highway construction (projects are divided into sections) and others (Roslan Amiruddin, 2012). LSM also known as line of balance (LOB) method which commonly used in manufacturing industry to prevent delays or bottleneck (Hinze, 2008).The principles of using the LSM for construction project work schedule are the method summarize a group of similar activities onto one line, the method shows the rate at which the work that makes up all of the activities has to be undertaken to stay on schedule and lastly the method show the relationship of one group of activities to the subsequent group and if one group is running behind schedule, it will impact on the following group (Roslan Amirudin, 2012).LSM require the planner and scheduler to understand the rate of handover of the construction unit to clients and work gang production rates. It is less complex that the CPM (Baldwin and Bordoli, 2014). Harmelink and Rowings (1998) (Cited by Thiruvengadam, 2004) however have explained the shortage of LSM computer applications is that LSM typically has been regarded as a visual technique lacking the analytical qualities of CPM.

2.8 Network Based Diagramming

Network logic based diagram is the graphical representation of a detailed project plan where it is illustrated the job logic and basic sequencing (Hildreth and Munoz, 2005). In general, a network logic based diagram shows the 'big picture', what is going to happen and in what order (Hildreth and Munoz, 2005). It is an accurate, efficient and reliable method to prepare work schedule (Hildreth and Munoz,2005). Willis (1986) claimed that the two basic types of logic network diagrams used in prepare the network based schedule are Activity-On-Arrow (AOA) and Activity-On-Node (AON).

2.8.1 Activity-On-Arrow (AOA) Network

Activity-on-arrow (AOA) network is a network showing activities on arrows between nodes which are events representing instants in time (Willis, 1986; Patrick,2004; Mubarak, 2005). The activities description is located on the arrow. Used to model that one activity cannot start until other have finished (Mubarak, 2005).



Notes:

A predecessor to B and C B and C successor to A

B predecessor to D D successor to B

Figure 2.7 Simple Activity on Arrow Network (Source: Mubarak, 2005, p 21)

There are dummies activities which an activity inserted in an arrow network to maintain proper logic or distinguish activities identities (Willis, 1986; Patrick, 2004).However, the dummies complicate the schedule which main disadvantages on arrow network. Willis (1986) further stated activity-on-arrow network is redundant.

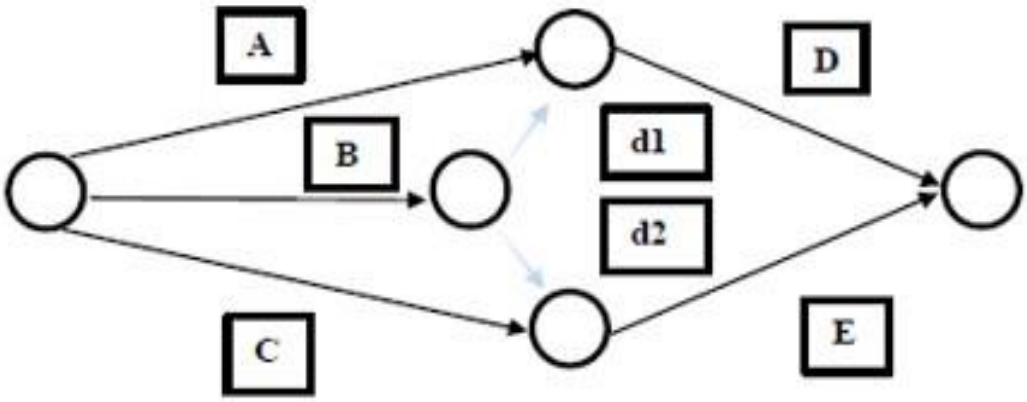


Figure 2.7 Dummies Activities in Activity-on-Arrow network(Source:Mubarek,2005,p26)

2.8.2 Activity-On-Node (AON) Network

Activity-on-node (AON) network is a network shows activities in boxes (or nodes) linked together with arrows representing the logical relationships between activities (Willis, 1986; Patrick, 2004; Mubarak, 2005). The activities description is located at the activity box. Basic node network often start with one node (project start) and end it with one node (project finish). The network form the basis for precedence diagramming method (PDM) (Mubarak, 2005).

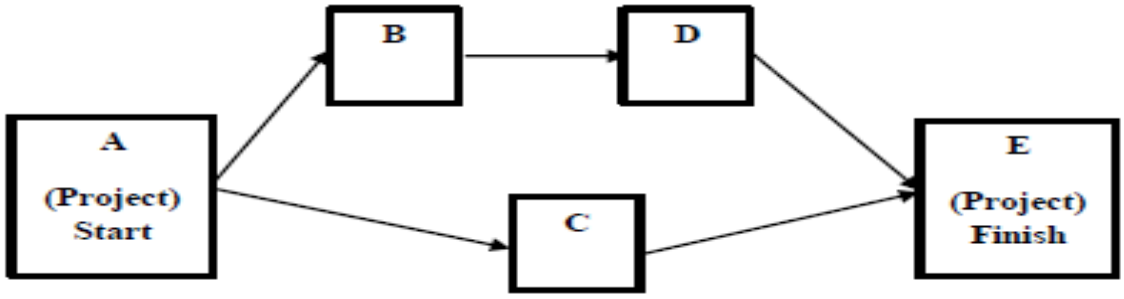


Figure 2.10 Simple Activity on Node Network
(Source: Mubarak, 2005, p 29)

2.7. Non-Traditional Planning and Scheduling Techniques.

2.6.2 Critical Path Method

With the Gantt chart relationships between activities could not be displayed, they were only implied (Hancher and 2003). Hancher further noted that the complexity of the project even makes the displaying of the relationship virtually impossible. So the development of the Critical Path Method (CPM) provided a more formal and systematic way to project management (Hancher,2003). Additionally, the critical activities could be determined using the Critical Path Method (CPM). The Critical Path is the longest path through the project, and that determines the project‘s duration. In a CPM network, events represented by circles and activities are showed as arrows (Bokor et al 2011). They sometimes referred to as Activity-on-the-arrow diagrams.

Events represent the finishing and starting times of activities directed to and from them. For instance in the Figure 2.2 the numbers in the nodes show the early and late occurrence of the events. The red line also indicates the critical path of the project. Bokor et al. (2011) contend that the CPM is capable of storing logic that created, and in consequence allows easy modifications to the original plan. The CPM has implemented successfully on several projects. Hancher (2003) noted that the success was not only peculiar to the construction industry, but project management in other disciplines. In summary, Hancher (2003) concluded that Today‘s construction manager who ignores the use of critical path methods is ignoring a useful and practical management tool‖. Surprisingly, Bokor et al. (2011) had a different view about the CPM. They noted its deficiency in handling multiple relationships.

2.6.3 Program Evaluation and Review Technique (PERT)

Program Evaluation and Review Technique (PERT) works the same way as the CPM and in fact evolved about the same time i.e. in the late 1950. However, the task durations, unlike, the CPM are determined stochastically (Bokor et al., 2011). Today, as in the past, project managers and planners have been preoccupied with PERT (Ika, 2009). Academics argue that uncertainties abound on projects and that is the major advantage of the PERT, and the difference between the PERT and CPM – details of PERT not known with certainty. In PERT the duration of the project is assume to have a beta probability distribution given by the formula given by $\frac{O + 4M + P}{6}$ Where O= the Optimistic duration M=

the Most likely duration P= the Pessimistic duration Precedence Diagramming Method It developed in response to the deficiencies arising out of the Critical Path Method. Precedence Diagramming Method

(PDM) offers the users the flexibility of more than one and complex dependencies between activities (Bokor et al., 2011).

2.7.1 4-D Cad Visualization Techniques

Conventional project planning techniques such as CPM, PERT, Gantt chart, etc. are disadvantaged in terms of adequate communication of the conceptual planning of the modern manager (Allen and Smallwood, 2008) (Allen and Smallwood, 2008), Koo and Fisher, 1998). Additionally, relating information through these conventional techniques is more difficult and mistake prone. The result is that some problems remain inherent and elude the project planning stage. This phenomenon explains why variations or changes are commonplace in construction (Koo and Fisher, 1998). If project information could visualized, there is high possibility that most of these elusive problems would detected at the planning stages. Advancing this principle evolved the theory of visualization techniques in project planning and scheduling in construction. Of particular importance in the 4-D CAD Visualization Techniques is the fact that the benefits cuts across the board. Designers and builders are able to communicate through design and construction information, which enhances collaboration and improves communication between the two entities (Koo and Fisher, 1998). In Contrast to the conventional techniques, users can also use the 4-D.CAD to assess the cost, health and safety issues, or allocation of resources even before the completion of the facility. Below are the under listed types of 4-D CAD Visualization techniques:

2.7.2 Schedule Simulator

The software emerged from the technology developed by Jacobus Technologies. The 4-D CAD combines 3D graphic of the construction process with schedule data from either Primavera or Microsoft Project. According to (Heesom and Mahdjoubi, 2004), the fusion of the data from these packages is done with OLE (Object linking and embedding) Automation, dynamically linking schedule data. A unique feature of the tool is that any variation to the schedule is immediately reflect and thus visualized in the 4D environment. The greatest disadvantage is perhaps the inability to link or connect tasks to the 3D objects automatically (Heesom and Mahdjoubi, 2004).

2.7.3 Smart Plant Review –Intergraph Incorporated

Advancing the Schedule Simulator evolved Smart Plant Review. The tool contains a Schedule Review, an engine that allows a 4D simulation through linking tasks (information from the project schedule) to the 3D CAD. Though it has similar functions with the schedule simulator, it however, allows the automatic connection of tasks and 3D objects (Heesom and Mahdjoubi, 2004).

2.7.4 4-D Viz Balfour Technology

Virtual reality display of objects allows the creation of visual scenes. As a result, a real time environment is created which can be manipulated by the user through any direction of the visual scene (Heesom and Mahdjoubi, 2004).

2.7.5 Common Point 4 D

This tool develops by the Center for Integrated Facility Engineering at Stanford University, USA. The project ended in 1998. The limitations of the conventional planning and scheduling tools may have stimulated this work, since the authors compare this tool with the conventional tools (cf. Koo and Fisher, 1998). This tool, as in the tools aforementioned, also relies on AutoCAD; specifically
3D IFC complaint models (Heesom and Mahdjoubi, 2004). As in the case of the Schedule Simulator, the linking of tasks to 3D CAD objects done manually. However, a unique feature of the software is that it allows the grouping of objects manually and attached to one or group tasks (Heesom and Mahdjoubi, 2004).

2.8 Benefits of Construction Planning and Scheduling Techniques

Throughout this study, it has demonstrated that planning and scheduling is indispensable to project success, and ultimately the profit of construction companies. As a result, interest in construction planning and scheduling techniques has grown considerably over the years, with academics and practitioners alike developing interest in the discipline. Surging interest in the discipline further reflected in the plethora of construction planning and techniques tools evolved over the years – from conventional to modern tools. The continuing trend toward the improvement of the available tools and techniques suggests many inherent and clear benefits. Under this section, the benefits highlighted. These benefits include but not limited to the following.

2.8.1 Allows Visualization of Information

Construction planning and scheduling techniques, particularly the 4D models, allows the information to visually interview in advance before construction (Heesom and Mahdjoubi, 2004). This benefit is not only peculiar to the construction industry, but to other industries as well. Evidence exists in other disciplines such as sales and operation where planning and scheduling techniques provided a similar benefit (see Ivert and Jonsson, 2010). Due to the relatively large number of semi-literates on construction sites, it is important that information is visually presented to the understanding of all; and this is what planning and scheduling techniques offer. One site engineer, during the piloting of 4DSMM

is reports to have accounted the importance of visualization in construction: locating equipment, analyzing carnage etc. (Chau, Anson and De Saram, 2005).

2.8.2 Easy Access to Information

To some extent, mental model possesses advantages over computer or graphical model in terms of its flexibility and processing of wide range of information presented in any form (Sterman, 1992). Nevertheless, mental models suffer from great disadvantages, particularly the interpretation of the mind. This is where graphical presentation of construction plans is imperative in particular projects of high complexity. Construction planning and scheduling tools like Gantt chart, CPM, etc. present the construction idea into forms that are easily appreciated by the teams (Barati et al.,2013). in the absence of any of team members, information about the project may be accessed and in consequence ensure workflow.

2.8.3 Makes It Possible To Identify Unexpected Future Outcomes

The traditional forms of construction planning and techniques made it difficult to discover problems at the initial stages and therefore variations are pervasive on construction projects (Koo and Fisher, 1998). However, recent advances in planning and scheduling make it possible to identify the inherent problems from the onset of the projects (Heesom and Mahdjoubi, 2004). For instance with the visualization tools such as the 4D CAD highlights minutes inconsistencies and problems that could have inherently been hidden from the experts.

2.8.4 Makes It Possible to Analyze Unexpected Future Outcomes

This benefit is inseparably linking with the benefit immediately aforementioned. The identification of the unexpected future outcomes precedes the analysis of the outcome. Unlike the conventional planning tools that leaned much towards imagination and intuition, modern planning and scheduling tools provide users with interactive manipulation that enable the easy analysis of unexpected future outcomes that erupts (Chau, Anson and De Saram, 2005); Koo and Fisher, 1998).

2.8.5 Results in Reliable Delivery Plan

The success of a project inevitably relies on a very realistic project plan (Heesom and Mahdjoubi, 2004). Corroborating to this, (Heesom and Mahdjoubi, 2004) argued that planning is a critical task in a project. That is to say, chances are that a reliable delivery plan would lead to a successful project. It is of no

secret that competent and experienced personnel are needed for the development of effective plans (Heesom and Mahdjoubi, 2004). Experienced managers are able to visualize the process in their heads (Koo and Fisher, 1998). However, they further argued that there is always a missing link from conveying the visualized information to second parties i.e. planners and other artisans. This is where planning and scheduling tools fit into the problem. The experience and conceptualization of such information carried out using planning and scheduling tools.

2.9 Planning and Scheduling Tools in Construction Works

2.9.1 Manual (Free Hand) For Planning and Scheduling Works

Implementation of traditional and non-traditional method to prepare work program were manually prepared by handwritten approach before introduction of computer spreadsheet system and specialist software in the preparation of work schedule (Hutchings, 2003). As project become complex, manual approach with methods to prepare work schedule is time consuming and often- difficult (Hinze, 2004).

However, manual approach in planning and scheduling works is still widely used although there is computer applications to job management. Manual approach in planning and scheduling work rely on hand methods for limited portions of a project to carry out computations for making quick checks, to determine the effect of changes, or to study a specialized portion of the work. The objective of manual approach in planning and scheduling works involve developing a thorough understanding of the procedures involved and the significance of the project time data generate (Clough et al., 2000).

In term of CPM and PDM network-based schedule computation, the approach involved repeatedly performing manual computation calculation of several kinds of network based planning and scheduling tools such as CPM, PDM, PERT, GERT and others by hand (Clough et al., 2000). It involves the use of tabular calculation sheets before replace by computerized spreadsheets and the calculation moved from one calculation to another, making subjective decisions and modifying data when required (Naylor, 1995). However, as the project increase in size and complexity, the manual calculation effort can be time consuming and lack of accuracy (Hinze, 2004). Manual approach for planning and scheduling works to prepare work program involve manual process by free hand to identify project activities, determine activity sequence, determine activity duration, perform schedule calculation, draw and prepare the work program. In conclusion, use manual (free hand) approach in preparing bar chart,

s-curve chart, milestone chart, LSM, CPM in AOA, PDM, PERT and GERT for planning and scheduling work.

2.9.2 Computer Spreadsheets System for Planning and Scheduling Works

A spreadsheet display is a grid of horizontal rows and columns set up on the screen. The grid locations may refer to by row numbers and column letters and may termed 'cells' (Cooke & Balakrishnan, 1985). In preparation for the work program, computer spreadsheet program such as Microsoft Excel is an excellent spreadsheet program that will help in the creation of bar charts. From figure 5 below, enter the dates across the top of the spreadsheet. Next, enter activity names down the left column of the spreadsheet. Format the cell and shade them to show the bars on the dates. The activities could be double-spaced, leaving room to mark the schedule with a highlighter showing the actual start and finish dates so that performance can measured and reported (Newitt, 2011).

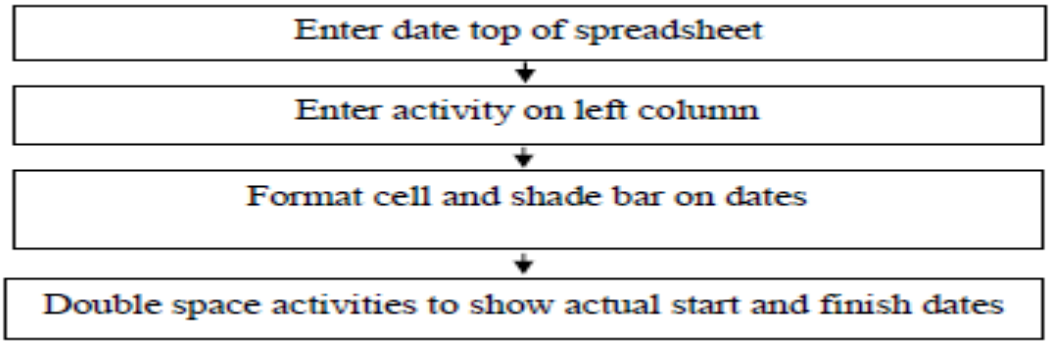


Figure 2.10 simple bar chart schedule using computer spread sheet.

Project milestone chart in tracking milestone and report progress to the team at large can be done main by spreadsheet (Excel) based core system (Hardin, 2011). S-curve chart commonly can prepare using computer spreadsheet that speed up the work of preparing work schedule (Muhammad et.al, 2007). For LSM, the spreadsheet model was mainly built by Al Sarraj (1990) for scheduling larger group activities and present the schedule automatically. The model developed based the linear scheduling assumptions with adaptions into its logic (Mendes, et.al., 1998). The use of spreadsheets provides a natural interface for model building, are easy to use in terms of inputs, solutions and report generation, and allow users to perform what if analysis. CPM, PDM and PERT scheduling method in preparing the work program using computer spreadsheet such Microsoft Excel can achieved by using four worksheets. The first worksheet used for the input of data. The second worksheet used to calculate the Earliest Start Time (EST) and the Earliest Finish Time (EFT). The third worksheet used to calculate the Latest Start Time (LST) and the Latest Finish Time (LFT) of the activities. Lastly, the fourth worksheet

used for reporting the critical path as well as for calculating the project completion period and the project variance. Two additional worksheets used after solving the problem for displaying CPM, PDM or PERT schedule in the form of network diagram other for the project and the range names used in the spreadsheet (Seal,2001).

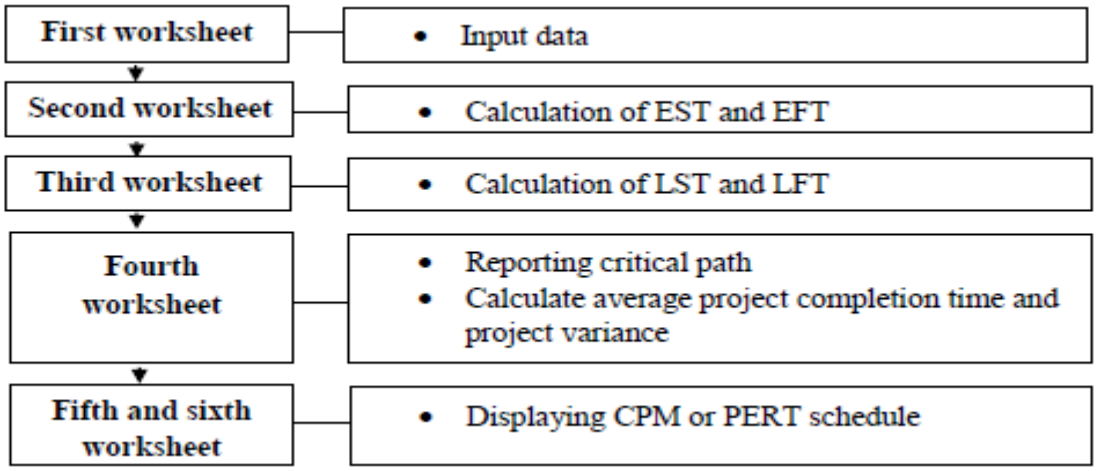


Figure 2.11 Network Based Schedule Using Computer Spreadsheet

In summary, computer spreadsheet system can used in preparing bar chart, s-curve chart, milestone chart, LSM, CPM in AOA, PDM, PERT and GERT for planning and scheduling work. The available spreadsheet systems are including excel Spreadsheet, Gnumeric, K Spread, Lotus 1-2-3, Microsoft Excel and OpenOffice (Wikipedia Spreadsheet, 2014).

2.10 Specialist Software for Planning and Scheduling Works

Specialist software is a program that' arranged to suit the needs of the users. To be specific, specialist software tools for preparing the work program are based on network analysis and scheduling methods, a schematic display of the logical relationship of the project activities (McGonigle, 1992) (Cited by Bani Ali and Anbari,2004). That specialist software for planning and scheduling works, also known as project management software. In this technological era, there are many computer scheduling specialized software on the market that essentially perform the same principal task namely to assist in the development and management of schedules.

Project Management Institute (PMI) is a large project management body to evaluate different types of planning and scheduling software and compare the strength and weakness to help project professionals to choose appropriate tools that suit their needs (Bani Ali and Anbari, 2004).

Factors enhance the use of planning and scheduling software in project management categorized into software characteristics that include ease of use, information quality and functionality, user characteristic that include level of experience, training and level of education and lastly project characteristics that include organization size, project size and project complexity (Bani Ali and Anbari, 2004). (Hinze, 2004) further claimed the factors that to be considered when choosing an appropriate construction planning and scheduling specialized software program are the specialized software program's features and cost, along with needs, resources, types of work performed by the contractor and characteristic of the projects.

In conclusion, specialist software can used in preparing bar chart, s-curve chart, milestone chart, LSM, CPM in AOA, PDM, PERT and GERT for planning and scheduling work.

2.10.1 Microsoft Project

Microsoft Project is an extremely popular project management software especially in planning and scheduling used by all types of project manager (Newitt, 2011). Many construction firms prefer Microsoft Project due to its ease of use and similarity to other Microsoft programs. Microsoft Project provide most of the functions and features as other, more expensive programs and allows a maximum of 10, 000 activities. It includes an interactive assistant, pop-up screen tips and context sensitive help information. The screen tips appear when changes made to the schedule to alert the user of alternative scheduling options or verify that the information is input correctly. Twenty predefined reports and graphic representations are included. The program layout and operations designed to be user friendly (Hinze, 2004). Main advantages of the Microsoft Project are that it designed to interface with other Microsoft programs. This feature allows easy transferring of information between programs and creation of scheduling reports containing both text and graphics along with the schedule. Additionally, task entered in Microsoft Outlook can displayed in Microsoft Project to maintain assigned activities in one convenient location (Hinze, 2004).

2.10.2 Primavera Project Planner

Primavera Project Planner is one of the most popular computer scheduling software programs used in the construction industry. Its popularity has led to continued development of additional features and functions to make it a full-service program. Main advantages of using Primavera Project Planner are that the software has a maximum capacity of 100, 000 activities on a single project, the ability to group an unlimited number of projects together and used on virtually any project. Which lead the user through

the input of specific data or the use of program features. Moreover, schedule development can speed up by writing subroutines to automatically input or modify the activity information.

Primavera Project Planner offers over 150 predefined reports and related graphic representations of the schedule. However, generally used by large firm that are able to absorb the initial investment and work on large projects requiring the greater capabilities and additional features provided (Hinze, 2004).

2.10.3 Sure Track Project Manager

Sure, Track Project Manager by Primavera Project Planner little brother. Sure, Track Project Manager provides most of the same functions as Primavera Project Planner at much lower price. However, Sure Track only allowed a maximum of 10, 000 activities on a single project and it does allow the projects to group. These features essentially allow much larger project to represent as a group of smaller projects. In term of presentation, Sure Track Project Manager provides 40 pre- programmed reports and related graphic representations (Hinze, 2004).

2.10.4 Artemis

Artemis originated from Artemis Project Management System developed by Métier Management Systems in 1978. Artemis is a major product lines to support project planning and scheduling, earned value management (project performance measurement, portfolio management, resource management, and time reporting (Artemis Wikipedia, 2014). The two Artemis software currently used in project planning and scheduling are Artemis 7000 and Artemis Schedule Publisher. Both software are able to show multiple calendars, control material and costs, perform resource scheduling and produces resource scheduling report, show resource loading conflict and mark critical path. Artemis 7000 able to handle 999, 999 tasks per project while Artemis Schedule Publisher only able to handle 12, 000 tasks per project. Thus, Artemis 7000 is commonly used in sophisticated project compare to Artemis Schedule Publisher only used in smaller project (Retik and 1990).

2.10.5 Open Plan

Open Plan is an enterprise-wide management software system that substantially improves the ability to manage and complete multiple projects on time and within budget. It was developed by Well come Software. It highly integrated, comprehensive system that users able to customize to fit their specific requirements (Soft Scout, 2014). It is the most technically advanced planning and scheduling system on the market because the Open Plan software has unlimited activities handling capabilities and able to control 1, 430 resources per project (Retik and 1990).

2.10.6 Micro Planner X-Pert

Micro Planner X-Pert is a project-management software package in continuous development since 1979. The main purpose of Micro Planner X-Pert is to produce critical path method (CPM) and PERT schedules for major, complex, and long-term projects. It is one of the few packages still fully supporting the activity-on-arrow (AOA) project network process. Moreover, it supports the full cycle of project management through multi-level work breakdown creation, transition to multiple projects using critical path diagrams and Gantt chart presentation. It has the ability to handle 15, 000 tasks per project and 500 resources per project 20 per operation (Wikipedia, 2014).

2.10.7 Fast Track Schedule

FastTrack Schedule is a project management software used for planning, tracking and reporting project goals. It developed by AEC Software, Inc. The application enables users to organize tasks into project plans, assign resources to tasks, use effort driven scheduling, and view project details in Gantt charts, monthly calendars, and others. In addition, it suited for project management beginners as well as experienced project manager. In term of information exchanging, FastTrack Schedule also exchanges data with spreadsheets including Microsoft Excel, databases, organizers including Microsoft Outlook and other project management software including Microsoft Project (Wikipedia, 2014).

2.10.8 Primavera Engineering and Construction Web Based Programs

Several software companies offer computer-scheduling capabilities via web-based programs. Primavera Engineering and Construction, for example, is an online version of Primavera Project Planner. The main advantages of Primavera Engineering and Construction Web Based Programs is it provides integrated team communication and collaboration, coordinated, schedule-based procurement and project planning and control to ensure successful design, construction and facility management projects. The web based Primavera on-line version of Primavera Project Planner provide scheduling capabilities for projects with up to 2, 000 activities.

Moreover, the web-based programs provide the convenience of access to schedules and project management information from any computer via the internet (Hinze, 2004).

2.11 Factors Influencing the Choice of Planning and Scheduling Methods and Tools

The type of method to prepare work program depend upon the nature of the project (Williams, 1996). To be specific, factors to be considered to make the choice on planning and scheduling method in preparing work program are listed and elaborated below. However (Andrew Baldwin and Bordoli, 2014) stated the selection of the method to prepare work program depend upon the type of project, the degree of development of the project and the client requirement.

2.11.1 The Size of Project

The size of the project is one of the important factors to be consider when choosing a suitable method for preparing work program. Which planning and scheduling method to uses for the project, it depends on the size the project. The size of the project would divided into three main category which small project, medium project and large project. The project's size commonly based on total financial resources available, number of team members involved, number and size of deliverables to be produced, complexity of deliverables to be produced and timeframes involved in delivery (MMPM, 2015).

2.11.2 The Complexity of Project

The complexity of the project affects the choice of planning and scheduling method used. Complex construction project consists dozens of crafts and subcontractors simultaneously working on as many or more different elements of the project. The progress of one party may affect the rate of other party and very difficult for the main contractor to take in account of all the interrelationships between the tasks. Non-network-based method include bar chart and others not actually depict this relationship and not apparent for revision if changes occur. Network based method that include CPM, PDM, PERT and GERT could be more appropriate for complex project as it allow scheduler to depict the relationships between tasks. Thus, a more sophisticated project requires a more sophisticated method to prepare the complex work program for the sophisticated project (Newitt, 2011).

2.11.3 The Type of the Project

Thirdly, the type of the project will influence the choice of method used to prepare work program. The different types of project in construction industry: - which are residential, buildings, institutional and

commercial, industrial, specialized industrial construction, highway construction and heavy construction (Gould and Joyce, 2011). Different method of planning and scheduling have their own application in nature and disadvantages when used for different types of the project. Bar chart method is more appropriate for smaller project such as building project as budget is lower. LSM is however more suitable to be used to schedule the project linear in nature such as highway construction. CPM allow better control on the complex construction project that involve variety of works as the method allow determining the impact of changes in the project (Galloway, 2006).

2.1.4 The Duration of the Project

Construction duration can define as the period given by the owner for the contractor to complete the project under normal work conditions, normal practice of construction, and based on the minimum costs (Barrie and Paulson, 1992). Different duration of the project requires different use of planning and scheduling methods to prepare work program. Non-network planning and scheduling methods such as bar chart and others are more suitable to prepare work program for shorter duration project. Longer duration project involving project with high complexity require sophisticated network based planning and scheduling methods such as CPM and others to prepare work program for an effective project monitoring and controlling (Galloway, 2006).

2.11.5 The Experience of User

The experience of user will determine the type of method to use to prepare work program. The sophistication user involve using the scheduling system as factor to determine the use of scheduling method so that the users are comfortable and familiar with the scheduling method to prepare work program (Hutchings, 2003).The level of detail in the work schedule depend on the level of experience of the planner and scheduler where a less experience team will need more detailed schedule than an experience team (Newitt, 2011).

In term of flexibility, planning and scheduling method to prepare work program must be flexible because they likely changes to made during the construction process (Newitt, 2011). The use of CPM to generate work schedule often not precisely, as estimation are used to calculate times and it could upset the implementation of the project if the estimate is followed blindly and changes not addresses promptly. However, the CPM allow the variance from the original schedule to measure to analyze the specific cause and impacts between the planned and actual work program (Wikipedia, 2014).

2.11.6 The Type of Method Used to Prepare Work Program

The type of method used to prepare work program also depend on the availability of software for the planning and scheduling method to assist in the development and management of schedules. Each types of specialized software have different scheduling capabilities, functions and features (Hinze, 2004).The management of project time is depending more and more on specialized software to prepare work program. The use of specialized software allows the prime contractor to effective management their project especially managing the construction project that consist hundreds of activities. Eventually, prime contractor might have more than one projects per year. The used of specialized software speed up their process in preparing their work program and effectively to control their (Bell, etal.2009).

2.11.7 The Client Preferences

The client preferences (specification) will also influence the method for planning and scheduling to prepare work program. Client will commonly specified their preferences scheduling method to prepare work program (Galloway, 2006). (Galloway, 2006) on his study stated that 47.6% of the client specified CPM scheduling as their preference scheduling method to prepare work program due to the flexibility to make changes on the work schedule if the project behind schedule or there is a change of order in work.

2.11.8 The Level of Detail Information for a Particular Project

The level of detail information for a particular project to prepare the work schedule. There are always some uncertainty concerning the factors that affect progress of the project. Weather conditions, labor, and material availability will become the uncertainty and act as factor that determine the method to prepare work program. Used of CPM work program for high uncertainty information project enable the contractor to determine the impact of the uncertainty on the project progress and take corrective action to minimize the impact (Willis, 1986).When we are choosing the planning and scheduling method to prepare work program. Consider the following criteria's size and complexity of project, the type and duration of the project, comfortable and experience of sophisticated users, flexibility of the planning and scheduling method, the availability of the planning and scheduling method software, client preferences (specification), organization standard method and level of detail information for a particular project.

2.12 Problems Encountered in Using the Chosen Planning and Scheduling Methods and Tools

Non-network-based method that involve bar chart and others inadequate in controlling large project with many activities because of their lack of interrelationship float capability, thus result lack of control on the critical path that determine the project duration (Hutchings & Kristofferson, 2004) . Non-network schedule such as bar chart inherent graphic limitation which thus unable to show activities dependencies (Gould and Joyce, 2011).

The use of s-curve chart only a better scheduling method for smaller and linear project where the method does not able control the critical path as well as provide an impact analysis of the work changes on the schedule. This is because the method does not provide time scale manipulation which a control domain of the project (Hutchings, 2003). Thus, this method is not suitable to control vertical project such as high-rise building because of the complex dependencies of the project (Fisk and Reynolds, 1988).

Another method to prepare work program is preparing the milestone chart. Milestone chart, which show only key performance activities, has difficulty to clearly visualize the relationship, dependencies and constraint among the construction activities (Hutchings, 2003).

Network based method able show the relationship between activities and ability to control the critical path of the project. However, the network based method that include CPM, PDM, PERT and GERT will increase the overall contract price which professional planner/scheduler must be hired to develop and manage the complex network schedule instead of project manager (Hutchings, 2003).

Construction professional such as project manager is difficult to devote the time necessary to proficient with CPM and other network based method, which are very complex to learn especially in large project (Newitt, 2011). The thorough preparation of the network-based schedule may take several weeks and consume tremendous resources. Moreover, network-based schedule requires detailed project detailed information to update and monitor the project. Lastly, availability of computer hardware and software as well as technical training must be provided in order to use the non-traditional method effectively to prepare work program (Gould and Joyce, 2011).The problems of the use for traditional planning and scheduling method (non-network based) is inability to control the critical path of the

project that lead to high cost of the project, not flexible to make analysis on the changes and technical training requirement for LSM.While the problems encountered from the non-traditional planning and scheduling method (network based) are time consuming, high complexity and difficult to learn, detail information requirement, availability of computer hardware and software, technical training requirement as well as planner/scheduler specialist requirement to create and maintain the planning and scheduling method.

2.13 Challenges in the Practice of Construction Planning and Scheduling Techniques

Construction planning and scheduling techniques present mouthwatering potentials (Azhar, 2011). Surprisingly, the construction industry in Ethiopia is lagging behind in terms of construction and planning techniques. For instance, many experts and academics in the construction industry do not know 4D CAD. Many factors account for this slow adoption of construction and planning techniques. That is the purpose of this section. In consequence, the succeeding subsections discuss the challenges that impede the successful integration of construction planning and scheduling techniques.

2.13.1 Complexity of Tools

Complexity of the planning and scheduling tools serves as an impediment to the successful integration of planning and scheduling tools. Extensively many authors have studied this problem and indeed the problem is prevalent in any identified challenges studies across the world. For instance, (woo, 2006) Observed the difficulty students especially beginners faced in the use of similar construction planning tools. This barrier is not peculiar to the class alone, it transcends to sites. The difficulty in inputting data and the time involved in handling data are some effects of the complexity of tools (Chau, Anson and De Saram, 2005).

2.13.2 Unable to Consider Spatial Planning

Existing project planning and scheduling tools do not take into consideration the spatial needs of the construction sites (Winch, 2006). As a result, (Heesom and Mahdjoubi, 2004) argued that these planning and scheduling tools are considered one-dimensional. In research, integration of site-related practices of planning and scheduling has received little attention (Retik and 1990, no date). Over a decade, development in this field is still in the preliminary stages. This development led to the heavy reliance on intuition and personal experience of the professionals.

2.13.3 Technological Challenges

In order to fully exploit the benefits of construction planning and scheduling tools interoperability is indispensable (Thurairajah & Goucher, 2013). Interoperability refers to the smooth exchange of information across all disciplines. However, the fragmented and solitude nature of the construction industry (Arayici and 2012) impede this integration and inconsequence such incompatibility aggravate the adoption of modern construction planning and scheduling tools including 4D CAD (Olatunji, 2011). The conventional nature of the road industry makes it more difficult to implement these practices.

2.13.4 High Computer Illiteracy Rate (High Skill Is Required)

Skill is relevant in the accurate and realistic development of construction plans and schedules using visualization (Chau, Anson and De Saram, 2005). Modern construction planning and scheduling techniques require much knowledge in the manipulation of the tools. In the Ethiopian Construction Industry, most professionals are not used modern construction tools practically because the computer has not fully integrated in the course. More so, there are limited reference materials on the discipline.

2.13.5 Fragmented Nature of Construction Industry

Today, as in the paste, construction projects experience major conflicts that in most cases plunge the project into delays and cost overruns. (Khosrowshahi & Arayici, 2012) explained that the fragmented nature of the construction industry is partly a contributing factor. Although, this characteristic of the industry cuts across all countries there have been attempts to successfully integrate collaboration in the construction industry of the developed economies. This has fueled the implementation of many sophisticated planning and scheduling techniques. Surprisingly, the industry in developing countries is still battling with the issues of collaboration and fragmentation.(Khosrowshahi & Arayici, 2012) argued that technology alone is not capable of changing the widespread problem in the industry. Collaboration is indispensable in the adoption of these techniques.

2.13.6 Traditional Tools Forces Minds Visualizations

A greater challenge with the conventional planning and scheduling tools is the heavy reliance on mind modeling (Chau, Anson and De Saram, 2005).Although cognitive processes and intuition are indispensable in construction site co-ordination, situations. Such as complexity and multi-interrelated factors limit the capabilities of human in cognitive, reflective and analytical skills (Chau, Anson and De Saram, 2005) Pervasive cost and time overruns, the 90% syndrome among others are some of the

highlights of the disadvantages of mental visualization (Sterman, 1992) To overcome this construction planning and scheduling tools evolved. However, those employed in the Construction Industry of Ghana has not been the solution to the problem but the problem itself. The reason is that the industry relies on conventional tools such as Gantt chart, etc. that is one-dimensional (Heesom and Mahdjoubi, 2004) and in consequence forces mental visualization.

2.13.7 Cost of Modern Planning and Scheduling Tools (Cost of Software)

Software and hardware upgrades are considering as significant barriers to planning and scheduling techniques, particularly for (McGraw-Hill, 2012). Thurairrajah and Goucher (2013) observed that considerable resources expended on the implementation of these techniques in the form of strong training requirement, which in some situation turn out to be time-consuming.

2.14. Planning and scheduling methods in road construction.

Massive cost involvements and large construction periods make construction planning critical for the long-term success of road construction projects. Poor construction planning is the biggest reason of incompetent construction in highway projects due to delays and cost overruns (Doloi, 2013).A good construction plan ensures timely completion of work within budget through efficient utilization of resources (Choi and Minchin, 2006). It should also ensure feasibility, identify conflicts in the beginning, and be readily understandable to all stakeholders. Highway construction projects fall into the category of linear repetitive projects due to their linear geometry and the involvement of repetitive tasks. As most work in (Doloi, 2013) highway construction projects is carried out by heavy machinery, any crew idle time is costly.

Construction planning methods used in highway projects broadly categorized into bar charts, network-based, and linear scheduling methods. The simplest tool of construction planning is bar chart. However, apart from representing the construction activities on a time scale, bar charts do not provide much help with respect to location breakdown, continuous resource utilization, and cost optimization. Along with bar charts, network-based methods like Critical Path Method (CPM) are commonly used methods in the planning of highway construction projects. However, network- based methods have limitations when applied to repetitive projects:

(1) Continuous crew engagement is not ensuring,

(2) Multiple crew Strategies are difficult to implement,

(3) There is no information about work location, progress direction, and task production rates at any point of time during project execution, and

(4) The network becomes relatively large and complicated when applied to a repetitive project (Mattila, 2003); (John Harmelink and John, 1995).

Since early 1950, a number of alternative methods were developed specifically for repetitive projects with different names depending on the particular application for which each method was developed (John Harmelink and John, 1995).These methods represent project progress in linear graphical format, hence, grouped under linear scheduling methods. These are more suitable for repetitive projects like highways due to:

(1) Relatively small number of repetitive tasks are neatly represented on a graph and easily read and understood by the field staff,

(2) Graphical representation provides instant information on work location, progress direction, and task production rates to maintained,

(3) Helps in ensuring work continuity and detecting space and time conflicts, and

(4) Takes less time and effort to develop (John Harmelink and John, 1995). Literature however suggests that most linear scheduling methods have focused only on developing the concept rather than implementing it on live projects. This is the main reasons why linear scheduling methods have not become popular among project planners.

2.15-Chapter Summary

Planning and scheduling is a process of identifying and sequencing the activities in preparing the work program. There are various types of planning and scheduling methods categorized into two main categories. That, are non-network-based methods that include bar chart, s-curve chart, milestone chart and linear scheduling method (LSM) and network-based methods that include CPM in activity-on-arrow (AOA) network, PDM, PERT and GERT can used by the construction contractor in preparing the work program. The various planning and scheduling methods adopted by contractors can be prepare using three approaches either by prepared manually, by computer spreadsheet system or by specialist software. The literature review also highlighted the factors influencing the choice of planning and scheduling methods in preparing work program and the problems encountered in using the chosen planning and scheduling methods to prepare work program. The following chapter will discuss about

the research methodology that consists of the type of research method, research instrument and methods of data analysis.

CHAPTER THREE

3. Research Methodology

3.1 Introduction

The preceding chapter went over earlier study topics that were connected to the chosen issue. This chapter's goal is to outline the methods used to accomplish the research's goal and produce findings for the case studies and research questions. The following steps were used to categorize the research process: Issues' identification and a problem statement, Review of Literature, Methodology, Discussion and Analysis of Data, Conclusion, and Recommendation.

3.2 Research Design

The research design is a strategy for achieving the study's goals. Quantitative research is an investigation into a social or human issue that is based on testing a hypothesis or a theory made up of variables, measured with numbers, and analyzed using statistical techniques to see if the hypothesis or theory is true. Quantitative data are hard and reliable measurements.(Naoum, 2007). In order to examine respondents' opinions, views, or perceptions of a given issue subjectively, qualitative research places an emphasis on meanings, experiences, and descriptions. Because it is possible to obtain sufficient information from research questions that are relevant to the respondent's attitude, opinion, and view along with an evaluation of the actual practices, both quantitative and qualitative types of data are used in this study

3.3. Methods of Data Collection

In research, there are two categories of data: primary and secondary. Both are taken into account in this study. The field survey provided the primary data, while a literature review provided the secondary data. Initially, both sets of data covered all aspects of the research. Neville (2007) argued that research should contain empirical research data. He views empirical data, which are crucial to any research project, as primarily field survey or primary data. The information acquired from the experts mentioned in this study is one of the main data sources in this research. Scientific data gathering techniques predominate in the field of evaluation throughout literature (Taylor-Powell and Steele, 1996) primarily because they provide quantifiable information and show cause-effect links. Information gathered by a targeted questionnaire survey of these experts. Closed-ended questions were part of the questionnaire's response format. Due of their simplicity and simplicity in analysis, closed-ended questions were

included in view of the fact that it is possible to get adequate information from research questions that are related to the respondent's attitude, opinion and view coupled with desk study review of actual program. The purpose of the questionnaire was to determine how local and foreign road construction contractors who work with the Ethiopian Road Administration schedule and plan their projects.

Desk Study

In order to have enough information three road projects were carefully selected based on the current project progress and different data's were investigated. The sources of data's were masterwork schedule, weekly, monthly and annual progress report and different formats used at project site. Depending on the data and information gathered the cases discussed regarding the preparation and implementation of planning and Scheduling methods and tools practiced in ERA road projects.

3.4.2.1 Interviews

Interviews are a type of survey where questions are delivered in a face-to-face with the interviewee asking questions selected individuals. In this study semi-structured interview were conducted with senior counterpart engineer, resident engineers, project managers and senior office engineer for seeking information regarding how construction works program are prepared and implemented, challenges in preparation and implementation in ERA road projects. Improvement methods in preparation and implementation works program were also asked.

3.4 Population and Sampling Methods

Population, generally, refers to a group of units of interest within the same geographic location of interest (Taylor-Powell, 1998). The preliminary searches revealed that most of these firms are in Ethiopian Road administration, but their operations covered across the country.

The population in this study as aforementioned were professionals that in their line of operation plan and schedule projects. These include Planners, Project Managers, Construction Managers, contract administrators, claim experts, quality controllers, office engineers etc. To get the total population, currently, the Ethiopian road administration has five regional project management directorates namely, eastern region, northern region, Western region, southern region and Central region project management directorates with 141 road projects. Accordingly, the Ethiopian Road Administration distributes the overall active projects for both local and foreign contractors currently. The population of this research were 36 local and 26 foreign contractors' total 62 road contractors participating the current projects in the five project management directorates in Ethiopian road administration.

3.4.1 Sampling

3.4.1.1 Sampling Technique

Probability sampling is used to obtain a sample that is representative of the population. However, probability sampling largely depends on a precise estimate of the population size. Probability sampling, especially simple random and was challenging due to the population's less precise characteristics. Thus, non-probability sampling method was employed to this research. The study used purposive sampling to draw samples from the population.to select 52 contractors among 62 contractors based on the current work progress reported in Ethiopian Road Administration. Accordingly contractors included this research are their current work progress is less than 80% of over all projects.Using the sampling technique known as "purposeful sampling," the researcher selects the participants for the study 52 contractors their physical status is below. It was chosen for the benefits attributed to its use, including the ability to include information-rich issues that are crucial to the study and the emphasis on specifics rather than generalizations. (Tuuli *et al*., 2007; Taylor-Powell, 1998). The professionals involved in the study guided the decision. Therefore, considering planning and scheduling methods and procedures within the road construction industries.

3.4.2 Questionnaires Development

The study uses a semi-structured questionnaire due to the large scope of the issue, the requirement for structure, and the necessity for respondents to be adaptable when answering some of the questions. In this study, only domestic and foreign contractors were given consideration; client ERA, consultants, and financiers are not included in the survey. Only further information needed for the contractor's planning and scheduling methods were obtained from these parties. As a result, this study was used questionnaire's "closed" version. It is simple to ask, quickly to react to, does not require written responses from the respondent, and requires minimal analysis. In this regard, a draft questionnaire was given to and tested among a limited group of respondents. Both factual and subjective questions are included in the design questionnaire. A rating scale and a Likert scale are used in the questionnaire's format for the opinion items. The rating scale is selected as the framework for asking respondents because it is a typical structure for asking respondents about their thoughts or opinions about an object, event, or attribute and also allows the respondents to express their level of agreement or disagreement on a specific scale. Because the questions include an attitude statement, the Likert scale is also chosen as a format for interviewing responses. (Naoum, 2007).

There are 36 domestic and 26 foreign contractors participating in ERA. Among this 52 contractors were selected based on their physical progress and questionnaire was distributed to the contractors. Numbers of questionnaire were distributed to professionals related to the topics in five regional directorates. The designed questionnaires were divided into the following main sections, which are -

Part A: The three components of general information are: company background, use of construction projects schedule management tools and procedures, and respondents' educational background and employment history in the construction industry. The data analysis conducted utilizing the questionnaire included the data collected through document reviews (Annexed).

Part B: Local and international road construction contractors use planning and scheduling techniques to create work schedules. This section lists the planning and scheduling techniques used by local and foreign road construction companies in Ethiopia, the methods used to create the different planning and scheduling techniques, the kinds of computer spreadsheet systems, and the kinds of specialized software used to create work schedules.

Part C: The selection of planning and scheduling techniques while creating a work program. This section will outline the variables affecting local and foreign road construction contractors' decisions about planning and scheduling techniques while creating work programs for the Ethiopian Road Administration.

Part D: Challenges in Creating a Work Program Using the Selected Planning and Scheduling Methods. This section identifies the issues that local and foreign road contractors, as well as the Ethiopian road administration, have while preparing work schedules utilizing the planning and scheduling techniques they have chosen.

Part E: - Challenges in the Practice of Construction Planning and Scheduling Techniques and tools.

3.5 The Research Scope and Limitation

The local and international contractors working on road projects managed by ERA are the study's target demographics. Even while diverse factors affect how each group of contractors chooses and uses planning and scheduling methods and tools for road projects, the difficulties vary in nature, severity, and root cause.

Even if there are issues that make it difficult for contractors to perform well on road projects, the impact of the elements that have been identified on both the contractors and the projects has been properly analyzed.

3.6 Methods of Data Analysis

Because it is the most straightforward form of analysis and offers a broad summary of the findings, descriptive statistics were chosen as the approach for data analysis in this study. The technique also conveys a sense of what is occurring. In most cases, the descriptive statistic will examine the data as either percentages or actual figures. (Noam, 2007). In order to meet the research objectives, the data collected from the questionnaire are processed using SPSS and Microsoft Excel 2019 to convert the raw data into informative tabulations, graphs, or charts. Frequency distribution and assessment of central tendency and RII are the methods employed in the research to explain the feature of group data.

3.6.1 Frequency Distribution

A significant amount of raw data was summarized using frequency distribution. It is used to categorize the data and calculate the number of people or cases that fall within each group. The answer that was selected as being the most desired by the listed respondents is shown by the highest percentage, or frequency, of the actual number. The research's findings can be displayed graphically, tabulated, or as a bar chart, pie chart, or graph. The ratio of the overall frequency of the chosen responses to the total respondents can be multiplied by 100 percent to determine the percentage or frequency computation. (Noam, 2007). The percentage or frequency calculation is as the following:

$$\text{Percentage (\%)} = \frac{\text{Frequency of Selected Answer}}{\text{Total Respondents}} \times 100\%$$

(Sources: Naoum, 2007)

Equation (1).

3.6.2 Measurement of Central Tendency (Mean Analysis)

The Likert scale question was examined using the mean. According to the Likert scale, responses range from strongly disagree to strongly agree and from never to very frequently or from not significant to very important. (Noam, 2007). First, the questionnaires' raw data were collated for later analysis. The mean approach was then used to evaluate the data. The research's goal in employing the mean score approach is to look at-

• The extent to which planning and scheduling techniques are applied;

• Variables affecting the decision on which planning and scheduling techniques to use when creating a work program; and Issues that arise while employing the selected planning and scheduling techniques. By combining and then dividing by the total number of values, the mean score can be computed. First, the mean range will be calculated using the formulas below.

Mean Range= (Largest Scale)-(Smallest Scale)/4 =4-1/4=0.75 ……Equation (2)
(Sources:-Lvin et al., 1998)

The first division of the mean range for section B is into the following four categories: never, sometimes, often, and very continuously. To make the data analysis results in Section B more understandable, the following scale of the mean range will be utilized to illustrate the results.

For Section D, the mean range is divided into four categories as well are strongly disagree, disagree, agree and strongly agree.

Mean Value

The method used to analyze the findings of Section **B, C and D** of the questionnaire is mean score. The mean score will be based on the respondent agreement on the problem statement. The result of mean score can calculated by ***using the formulae below:***

Mean Value, χ = ΣaiXi/ΣXi
Equation (3)
Where: χ = Mean Value

ΣaiXi = Sum of all scores in the set

ΣXi = Number of scores or observations in the set

(*Sources: Adapted from Abdul Majid and McCaffer, 1997, p 1)*

Relative importance index

The Relative Importance Index Standard Deviation was used in the examination of the degree of agreement among respondents regarding the use of the tools and procedures. The goal was to determine how the various elements should be used. Each tool or technique's score is determined by adding the ratings that respondents gave it based on (Waris et al., 2014; Badu et al., 2013; Fugar and Agyakwah-Baah, 2010). RII generates a value between 0.2 and 1.0 for a five-point response item (cf Badu et al., 2013; Ugwu and Haupt, 2007). The Relative Importance Index (RII) was calculated using the formula shown below (Badu et al., 2013).):

In the case of 5 point, Likert scales RII=$\sum \frac{W}{A} * 100 \frac{a+b+c+d+e}{5}$, $(0 \leq RII \leq 1)$ Equation (4)

Where:-

W is given each items by the respondents range from 1 to 5 such that one for

N_5 is no of respondents for always use these methods

N_4 is no of respondents for Often use these methods

N_3 is no of respondents for Sometimes use these methods

N_2 is no of respondents for neutrally to use these methods

N_1 is no of respondents for Never use these methods

A (highest weight) =5

N= Total No of Respondents=24 local contractors and 16 for international contractors.

Hence, the following derived usage from RII are used:-

High (H) 0.8<RII< 1.0

High-Medium (H-M) 0.6<RII<0.8

Medium (M) 0.4<RII<0.6

Medium-Low (M-L) 0.2<RII<0.4

Low (L) 0.0<RII<0.2

When two variables have the same RII values, the variable with the lowest standard deviation is given the highest ranking, according to Ahadzie (2007). The respondents' reported level of results were consistently agreed upon when the standard deviation was smaller than 1.0. (Field, 2005). The transformation matrix suggested by Chen et al. (2010), as seen in Waris et al., is used to compare RII with the relevant level of utilization (2014). Here, the transformation was modified to compare the degree of utilization to the researcher's proposed level of relevance. Types of Planning and Scheduling Methods in part A.

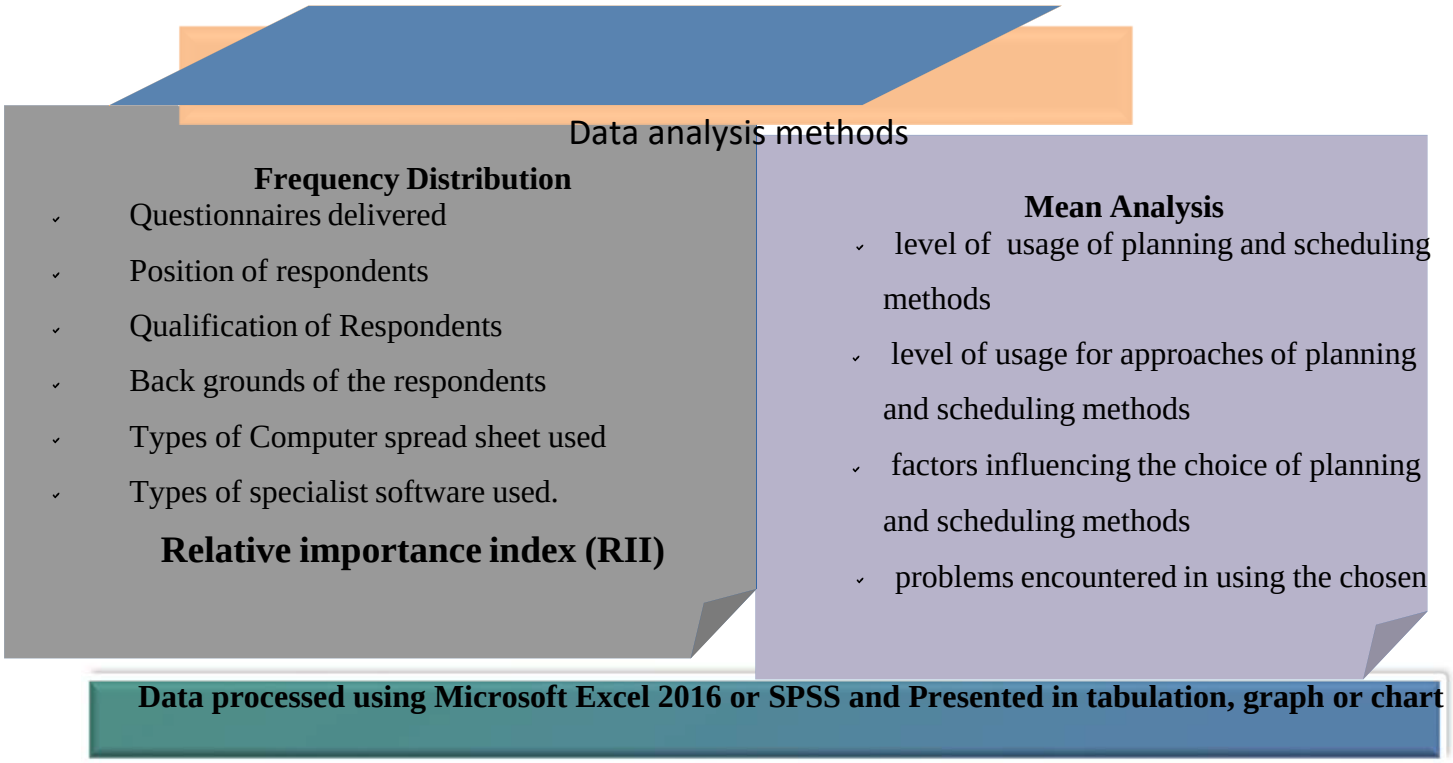


Figure 3. 1 Data Analysis Adopted for Research

CHAPTER FOUR

4. Data Analysis and Findings

4.1 Introduction

According to the previous chapter, respondents to the questionnaire were asked about planning and scheduling the projects they were involved in for ERA road construction project, including both local foreign contractors. In respect to the study's goals, this chapter discusses the analysis's findings and findings from the questionnaire surveys and selected project studies. Based on this, a questionnaire was created to gather information from experts with sufficient knowledge on potential difficulties faced by local and foreign contractors on road projects managed by the Ethiopian Roads Administration.

There are six main sections in this chapter. The demographic background of the respondents is covered in the first section. The second section examines evaluations and levels of planning, scheduling, and approaches for various scheduling techniques. The third section discusses factors influencing the selection of planning and scheduling methods and tools, the fourth section discusses challenges encountered using the selected planning and scheduling methods, and the fifth and final sections, respectively, discuss challenges in the application of planning and scheduling methods and tools as well as the advantages of using them.

4.2 Distribution and Response Rate

A total of 52 questionnaires were distributed to local and foreign road contractors working on ERA road projects in five regional directorates. From the total number of distributed surveys, 40 were returned, or 77 percent. The study's foundation was an analysis of all the information gathered from the surveys.

Table 4.1 questionnaires distributed and response rate

No	Questionnaire Status	Frequency	Percentage
1	Returned Questionnaires	40	77
2	UN-returned Questionnaires	12	23
	Total	52	100

4.2.2 Category of the contractor

40 replies were received from the 52 surveys that were given out, including 24 (60%) from local contractors and 16 (40%) from foreign companies. According to Table 4.2, the overall response rate was 77 percent. According to an analysis of each respondent's specific experience, 85% of all respondents have worked on road projects for more than five years, and of those, 45% have experience working on projects for more than ten years.

Table 4.2 contractor's category

No	Contractors category	No of questionnaires distributed	No of questionnaires respond	% of Distributed	% of Response
1	Local contractors	28	24	100	86
2	International Contractors	24	16	100	67
		52	40	100	77

4.3 Positions of Respondents in the Company

Table 4.3 in the questionnaire surveying referenced below highlights the various roles of respondents in the organization, including both local and international contractors. The majority of the positions were related to the positions of planning and scheduling in projects. From this survey, the respondents the highest percent hold positions as project managers, contract administrators, office engineers and project coordinators in both local and international contractors. The lower no of respondents holds in positions in planner and schedulers in local contractors and contract managers and office engineers in international contractors. This is in line with the findings of Heesom and Mahdjoubi (2004), Allen, and Smallwood (2008), who noted that both domestic and foreign contractors working with ERA generally lack staff and knowledge in construction planning and scheduling. On the other hand, the bulk of respondents roughly 95% work in direct planning and scheduling responsibilities. Therefore, the responders are the type of individuals the survey was looking for.

Table 4.3 position of the respondents.

No	Position of Respondents in the organization				
		International contractors	Local Contractors	International contractors	Local Contractors

1	Project Manager	8	15	50	62.5
2	Office engineer	1	3	6.25	12.5
3	Project Planner/Scheduler	3	1	18.75	4.16
4	Contract manager	1	3	6.25	12.5
5	Project coordinator	3	2	18.75	8.33
TOTAL		16	24		

4.4 Qualification of Respondents Local and International Contractors

From a TVET diploma to a master's degree, the highest level of education is available. The majority of respondents (75 percent and 58.33) had a master's degree in a field relevant to construction, whereas 25% of respondents in both local and international contractors have a bachelor's degree in a related field. Some of the respondents have also earned further degrees (such as master and bachelor's); 4 percent and 16.67 percent, respectively, have master's degrees in different subjects. This shows that the respondents had adequate academic credentials and sufficient knowledge to contribute to the survey's findings for both domestic and foreign contractors.

Table 4.4 Qualification of Respondents

	International Contractor	Local Contractor	International Contractor	Local Contractor
Master’s degree	12	14	75	58.33
bachelor’s degree	4	6	25	25
others	0	4		16.67
Total	16	24	100	100

4.1 Assessment of the level of usage of planning and Scheduling Methods in local and international road Construction Contractors.

Table 4.5 below shows a summary of the assessment of the usage of planning and scheduling techniques in the road construction contractors. For each of the planning and scheduling techniques the respondents' scores ranged from 1 (Never) to 5. (Always). The relative importance index standard deviation was used in the examination of the degree of the agreement among respondents.

Discussion

This section discusses the planning and scheduling methods adopted by local and international road contractors to implement their work program. Most respondents in table 4.5 below agreed that simple bar charts or Gantt charts were the most common planning and scheduling techniques used in road construction projects by both domestic and foreign contractors. However, foreign contractors as different

to local contractors, use different planning and scheduling methods. This discussion highlights the need for greater knowledge and approach in alternative planning and scheduling techniques. The majority of local contractor professionals agreed that the Gantt chart is the best and simplest scheduling and planning tool with RII 0.87 and standard deviation .76. This is reliable with both the analysis of Bokor et al., (2011) and Hakeem Nyarko Twumasi (2015).

Gantt charts are common, particularly in developing nations, for the same reason as the suggestions for this questionnaire; the difficulties with other planning and scheduling tools necessitate the use of more sophisticated skills and techniques, according to the survey, and this accounts for the participants' low usage of the tool. The technology is rarely employed on road construction projects, despite Bokor et al. (2011) argument that it is useful for such projects. According to the respondents, who included both local and foreign contractors, the Critical Path Method was the second most popular scheduling method after the Gantt chart. The tool's success in the field of project management may be responsible for its rising popularity. In the sense that Hancher (2003) came to a conclusion about the fundamental nature of the instrument and consequently suggested using it in construction. Thus, the findings support Hancher's (2003) claims that the tool is widely used in the construction sector. Amazingly, despite having access to modern scheduling technologies, the Ethiopian road construction industry is still not fully utilizing their potential. These tools display scheduling in 4-D, common point 4D, schedule simulator, and smart plan evaluation. The companies involved never employ the BIM visualization, advanced smart simulation, or 4-D CAD approaches or technologies. The responders' responses make this clear. The Table below shows that the 4-D CAD, schedule simulation, 4-dviz Balfour technologies, and common point 4D tools all had poor rankings. The fact that such procedures or techniques necessitate a high degree of information technology expertise, which is lacking in the road construction industry in developing countries like Ethiopia, may be the cause of the low level of adoption (Chau et al., 2005).

Table 4.5 usage of level of planning and scheduling Techniques in International and local contractors

Planning and Scheduling Methods	Local Contractors			International Contractors		
	RII	**Mean**	**Rank**	**RII**	**Mean**	**Rank**
Simple bar chart(Gantt chart)	0.87	4.33	1	0.86	4.31	1

Planning and Scheduling Methods	Local Contractors			International Contractors		
	RII	**Mean**	**Rank**	**RII**	**Mean**	**Rank**
Velocity diagram(S-curve)	0.68	3.42	4	0.69	3.44	4
Mile stone chart	0.53	2.67	8	0.34	1.69	11
Linear Scheduling methods	0.61	3.04	6	0.53	2.63	6
Critical path methods(CPM)	0.77	3.8	2	0.80	4.00	2
Critical path methods on Arrow network	0.69	3.46	3	0.76	3.81	3
Program evaluation and Review	0.56	2.79	7	0.61	3.06	5
Graphical evaluation and review techniques	0.63	2.63	5	0.38	1.88	9
4-D Cad Visualization Techniques	0.24	1.21	8	0.36	1.81	10
Schedule simulator	0.24	1.21	8	0.2	1.00	14
Smart Plant Review	0.23	1.13	9	0.4	2.00	7
-D Viz Balfour Technology	0.23	1.17	10	0.4	2.00	8
Common point 4D	0.21	1.04	11	0.21	1.06	13
BIM	0.23	1.17	10	0.25	1.25	12

4.2 Approaches for using Planning and Scheduling Methods

This section will go over how frequently local and foreign road contractors use planning and scheduling techniques when working on projects for the Ethiopian Road Administration Professionals were asked to rate the effectiveness of various scheduling and planning techniques. For this section analysis, four-point Likert scale surveys were employed, with 1 denoting "Never" and 4 denoting "Always." To

determine the level of usage for each type of planning and scheduling approach, the mean score for each method was computed. The average score and usage category were described in Chapter 3. Table 3.2 shows the overall mean value of approaches used in preparing the various planning and scheduling methods.

Table 4.6 shows the mean values for three approaches used for planning and scheduling method by local contractors.

Methods	Approach	frequency 1	2	3	4		Total	Mean	Level of usage
Simple bar chart(Gantt chart)	manual (free hand)	16	2	4	2		24.00	1.67	
	computer spread system	1	5	10	8		24.00	3.04	
	Specialist soft ware	2	1	15	6		24.00	3.04	
Velocity diagram(S-curve)	manual (free hand)	19		2	3		24.00	1.54	
	computer spread system	15	2	3	4		24.00	1.83	
	specialist soft ware	21		1	2		24.00	1.83	
Mile stone chart	manual (free hand)	18	3				21.00	1.14	
	computer spread system	18	2	1			21.00	1.19	
	specialist soft ware	16	1		4		21.00	1.62	
Linear Scheduling methods	manual (free hand)	17	3	1	2		23.00	1.48	
	computer spread system	17	2	2			21.00	1.29	
	specialist soft ware	17		1			18.00	1.11	
	manual (free hand)		1	1	2		4.00	3.25	
Critical path methods (CPM)	computer spread system		2	1	1		4.00	2.75	

Methods	Approach	frequency 1	2	3	4		Total	Mean	Level of usage
	specialist soft ware	1		18	2		21.00	3.00	
Critical path methods on Arrow network	manual (free hand)	2	1		2		5.00	2.40	
	computer spread system	1	2	6	1		10.00	2.70	
	specialist soft ware	2		18	1		21.00	2.86	
Program evaluation and Review Techniques (PERT)	manual (free hand)	2	1	10	1		14.00	2.71	
	computer spread system	2	2	1			5.00	1.80	
	specialist soft ware	2	1	10			13.00	2.62	
Graphical evaluation and review techniques (GERT)	manual (free hand)	1	2	1	1		5.00	2.40	
	computer spread system	1	2	1			4.00	2.00	
	specialist soft ware	3	1				4.00	1.25	

Table 4.7 shows the mean values for three approaches used for planning and scheduling method by international contractors.

Methods	Approach	*frequency* 1	2	3	4	Total	Mean	Level of usage
Simple bar chart(Gantt chart)	manual (free hand)	9	1	4	2	16	1.94	

Methods	Approach	*frequency*				Total	Mean	Level of usage
		1	**2**	**3**	**4**			
	computer spread system	0	3	9	4	16	3.06	
	specialist soft ware	2	2	8	4	16	2.88	
Velocity diagram(S-curve)	manual (free hand)	11		2	3	16	1.81	
	computer spread system	9	2	3	2	16	1.88	
	specialist soft ware	10	2	2	2	16	1.88	
Mile stone chart	manual (free hand)	10	5	1		16	1.44	
	computer spread system	13	2	1		16	1.25	
	specialist soft ware	12	1	1	2	16	1.56	
Linear Scheduling methods	manual (free hand)	10	3	1	2	16	1.69	
	computer spread system	9	2	5		16	1.75	
	specialist soft ware	6	5	5		16	1.94	
	manual (free hand)	10	2	2	2	16	1.75	
Critical path methods (CPM)	computer spread system	2	2	10	1	15	2.67	
	specialist soft ware	1		18	2	21	3.00	
Critical path methods on Arrow network	manual (free hand)	2	2	10	2	16	2.75	
	computer spread system	1	3	10	2	16	2.81	
	specialist soft ware	2		18	1	21	2.86	
Program evaluation and	manual (free hand)	2	1	12	1	16	2.75	

Methods	Approach	*frequency*				Total	Mean	Level of usage
		1	**2**	**3**	**4**			
Review Techniques (PERT)								
	computer spread system	2	2	1		5	1.80	
	specialist soft ware	2	1	13		16	2.69	
Graphical evaluation and review techniques (GERT)	manual (free hand)	3	11	1	1	16	2.00	
	computer spread system	1	1	10	4	16	3.06	
	specialist soft ware	3	1	12		16	2.56	

Table 4.6 and 4. 7 shows the mean values for three approaches used for planning and scheduling method by contractors. From the analysis, specialist software were the most used approach used in preparing bar chart, CPM in CPM in AOA and PERT while computer spreadsheet system were the most used approach used in preparing s-curve chart and LSM.

Both specialist software and computer spreadsheet system was the most approach used in preparing PERT. For bar chart, majority of the respondents prepare bar chart with specialist software with mean value of 3.91 that fall under category of frequent use, followed by computer spreadsheet system with mean value of 3.30 that fall under category of frequent use and lastly manual (free hand) with mean value of 2.03 that fall under category seldom use. For s-curve chart, majority of the respondent prepare s-curve chart with computer spreadsheet system with mean value of 3.41 that fall under category of frequent use, followed by specialist software with mean value of 2.97 that fall under category of medium use and lastly manual (free hand) with mean value of 1.47 that fall under category never use.

For milestone chart, majority of the respondent prepare milestone chart with specialist software with mean value of 3.63 that fall under category of frequent use, followed by computer spreadsheet system with mean value of 3.00 that fall under category of medium use and lastly manual (free hand) with mean value of 1.63 that fall under category never use. Meanwhile, for LSM, majority of the respondent prepare LSM with computer spreadsheet system with mean value of 2.41 that fall under category of

seldom use, followed by specialist software with mean value of 2.24 that fall under category of seldom use and lastly manual (free hand) with mean value of 1.65 that fall under category never use.

For CPM in AOA, majority of the respondent prepare CPM in AOA with specialist software with mean value of 3.32 that fall under category of medium use, followed by computer spreadsheet system with mean value of 1.88 that fall under category of seldom use and lastly manual (free hand) with mean value of 1.68 that fall under category never use. For PDM, majority of the respondent prepare PDM with specialist software with mean value of 3.37 that fall under category of medium use, followed by computer spreadsheet system with mean value of 1.80 that fall under category of seldom use and lastly manual (free hand) with mean value of 1.53 that fall under category never use.

For PERT, majority of the respondent prepare PERT with specialist software and computer spreadsheet system with mean value of 2.31 each respectively that fall under category of seldom use and followed by manual (free hand) with mean value of 1.69 that fall under category of never use. Lastly for GERT, majority of the respondent prepare GERT with specialist software with mean value of 2.27, followed by computer spreadsheet system with mean value of 2.18 and lastly manual (free hand) with mean value of 1.91. This reflect that all three approach used for GERT fall under category of seldom use.

To conclude this section, the specialist software is the most frequently used in preparing bar chart and milestone chart, medium usage for s-curve, CPM in AOA and PDM; and seldom being used for preparing the other planning and scheduling methods. This is probably because of that majority of the specialist software such as Microsoft Project use by contractor in preparing work program are user friendly in preparing bar chart, milestone chart, CPM in AOA and PDM. However, those specialist software which commonly used by contractors has limited function in preparing LSM, PERT and GERT. The preparation of s-curve and bar chart had frequently use the computer spreadsheet system. Apart from milestone chart with medium usage of computer

Spreadsheet system, the preparation other methods seldom use computer spreadsheet system. The computer spreadsheet system frequently used in preparing s-curve chart by contractors because due to that majority of the contractors are more convenient on using computer spreadsheet system and at the same time still lack of knowledge on using specialist software in preparing s-curve chart. Across all the planning and scheduling methods, contractors seldom or never prepare them manually. This indicates that the contractors have move with the shift in technology used in preparing their work program. This

is probably due to that preparing various planning and scheduling methods manually is time consuming and lack of flexibility to analyze changes on the project. In contrast, computerized planning and scheduling by using the computerized spreadsheet system and specialist software for planning and scheduling will speed up the process in preparing the various planning and scheduling methods and at the same time more flexible to analyze the changes on the project.

4.3 Types of Computer Spread sheet used

Table 4.8 shows the type of computer spreadsheet system used by contractors. Based on the analysis as illustrated in Table 4.7, *Microsoft Excel is the most common computer spreadsheet systems used by both local and international contractors* with 100 % because of the fact that Microsoft Excel is very common in the country and easy to acquire. Table 4.8 also indicates that not all the computer spreadsheet system are familiar to contractors in Ethiopia. While OpenOffice.org is the second highest, which is 37.5% % and followed by K spread Access, 18.75 % in international Contractors. G numeric, S Suit spread and Lotus 1-2-3 were not used spreadsheet system used by both local and international contractors with 0.00 % each respectively. Hence, Microsoft Excel is the most used computer spreadsheet system by local and international road construction contractors in preparing work program.

Table 4.8 type's computer spread sheet used by the contractors

Computer Spread sheets	International Contractors	Local Contractors	International Contractors	Local Contractors
Microsoft Excel, /2019	16	24	100	100
Open office org	6	0	37.5	0
K Spread	3	0	18.75	0
Lotus-1-2-3		0	0	0
G numeric		0	0	0
Total			16	24

4.3.1 Level of Usage of Computer Spread Sheet

This section discusses the level of usage for each type of computer spreadsheet systems used by contractors. Respondents were asked to rate the level of usage for each type of computer spreadsheet systems. Five point Likert scale was used for this section analysis, where "1" represented "Never Use" and "4" reflected "Always Use". The frequency for each computer spreadsheet systems was calculated

to identify the level of usage for each type of computer spreadsheet systems. The frequency distribution was explained in Chapter 3. Table 3.2 shows the overall frequency for the computer spreadsheet systems.

Table 4.8 level of usage of computer spread sheets in local contractors

Types of computer spread sheets	Frequency for Liker t Scale				
	Never	Some times	Often	always	Total
Microsoft Excel, 2019	0	0	11	13	24
Open office org	24	0	0	0	24
K Spread	24	0	0	0	24
Lotus-1-2-3	24	0	0	0	24
Gnumeric	24	0	0	0	24
Total	24	0	0	0	24

Table 4.9 level of usage of computer spread sheets in international contractors

Types of computer spread sheets	Frequency for Liker t Scale				
	Never	Some times	Often	always	Total
Microsoft Excel, 2019	0	0	5	11	16
Open office org	10	2	4	0	16
K Spread	14	2	0	0	16
Lotus-1-2-3	24	0	0	0	16
Gnumeric	16	0	0	0	16
Total	16	0	0	0	16

Discussion

Table 4.8 and 4.9 show the usage of computer spreadsheet systems shows that Microsoft Excel isvery frequently used with 54.16 % and 68.75% local and international contractors respectively and followed secondly by Open Offce.org with 0% and 25 % local and international contractors respectively. Hence, it can be concluded that the most very frequent use computer spreadsheet **system by both local and international contractors in preparing work program is Microsoft Excel.**

4.4 Types of Specialist Software Used

Table 4.9 show the type of Specialist Software used by Contractors. Based on the analysis from Table 4.9 the most popular specialist software used by both local and international contractors is Microsoft Project with 100.00 % because of the fact that Microsoft Project is the most user friendly and well known specialist software. The second highest are Primavera Project Planner with 75 % and 41.7% international and local contractors respectively and followed by Primavera Engineering and Construction Web Based Programs with 62.5 % used by international contractors. Sure Track Project Manager is fourth highest with 12.5 % for international contractors and not used at all for local contractors. Other specialist software are not well known and used both local and international contractors to prepare work programs. This indicate that not all the planning and scheduling software are familiar to contractors in Ethiopia. Hence, it can be conclude that the most used Specialist Software by both local and international contractors in preparing work program is **Microsoft Project and medium use of primavera project planners and schedulers**.

Table-4.10 Types of specialist soft wares used in local and international contractors

Types of Specialist Software	Frequency		Percentage	
	International Contractors	Local Contractors	International Contractors	Local Contractors
Microsoft office project	16	24	100	100
Primavera project planner	12	10	75	41.7
Sure track project manager	2	0	12.5	0
Artemis	0	0	0	0
Open plan	0	0	0	0
Micro Planner X-Pert	0	0	0	0
Fast Track Schedule	0	0	0	0
Primavera Engineering and Construction Web Based Programs	10	0	62.5	0
Total	16	24		

4.4.1 Level of usage of specialist computer software's

Table 4.11 level of usage of specialist software in local contractors

Types of Specialist software's	Frequency for Liker t Scale				
	Never	Some times	Often	always	Total
Microsoft office project	0	3	11	10	24
Primavera project planner	4	15	4	1	24
Sure track project manager	24	0	0	0	24
Artemis	24	0	0	0	24
Open plan	24	0	0	0	24
Micro Planner X-Pert	24	0	0	0	24
Fast Track Schedule	24	0	0	0	24
Primavera Engineering and Construction Web Based Programs	24	0	0	0	24
Total	24				

This section will discuss about the level of usage for both local and international contractors use each type of specialist software. Respondents were asked to rate the level of usage for each type of specialist software. Five point Likert scale was used for this section analysis, where "1" represented "Never Use" and "5" reflected "Very Frequent Use". The frequency for each specialist software was calculated to identify the level of usage for each type of specialist software. The frequency distribution was explained in Chapter 3. Table 4.10 showed the overall frequency for the specialist software.

Types of Specialist software's	Frequency for Liker t Scale				
	Never	Some times	Often	always	Total
Microsoft office project	0	3	2	11	16
Primavera project planner	3	10	3	0	16
Sure track project manager	8	7	1	0	16
Artemis	16	0	0	0	16
Open plan	16	0	0	0	16
Micro Planner X-Pert	16	0	0	0	16
Fast Track Schedule	16	0	0	0	16
Primavera Engineering and Construction Web Based Programs	12	4	0	0	16

Total	16					

Table 4.12 Level of usage of specialist software for planning and scheduling in international contractors

Discussion

Table 4.11 and table 4.12 shows the usage of specialist software. Based on the analysis, Microsoft Project has the highest percentage in very frequent usage with 45.83 % and 68.75% local and international contractors respectively. Primavera Project Planner has the second highest percentage in very frequent usage with 4.2% and 18.5% and followed thirdly by Primavera Engineering and Construction Web Based Programs with 6.03 % in international contractors. Therefore, it can be concluded that the most very frequent specialist software used by contractors in preparing work program is **Microsoft Project and Primavera project planner.**

4.5 Factors Influencing the Choice of Planning and Scheduling Methods in Preparing Work Program.

This section discuss the factors influencing the choice of planning and scheduling method. Respondents were asked to rate the level of importance for each of the Nine factors both local and international contractors given that influence the choice of the planning and scheduling methods. The mean range is divided into five categories which are not important, slightly important, important, very important and most important. The mean score for the factors was tabulated and then ranked from the highest to the lowest, as shown in Table 4.13. Table 4.13 also identifies the mean value for each factor. The category for level of importance is as explained in Chapter 3.

Table:-4.13 factors influencing the choice of planning and scheduling methods and tools in local contractors.

	Frequency				TOTAL	Mean	Ranking	category	
Factor	1	2	3	4	5				
Size of the project	1	2	2	8	11	24	4.08	2	Very important
Complexity of the project	2	4	6	4	8	24	3.5	6	Very important
Types of project	0	3	6	8	7	24	3.79	3	Very important

Duration of the project	0	4	5	10	5	24	2.17	9	slightly important
Experience of the users	0	5	7	6	6	24	3.54	5	Very important
Flexibility of the chosen methods	1	1	10	7	5	24	3.58	4	Very important
Availability of planning and scheduling Soft wares in the market	2	3	6	10	3	24	3.38	7	important
Clients preference	1	4	9	7	3	24	3.29	8	important
Level of detail information available For particular project.	0	0	5	8	11	24	4.25	1	Most important

Table:-4.14 factors influencing the choice of planning and scheduling methods and tools in international contractors

	Frequency					TOTAL	Mean	Rank	category
Factor	1	2	3	4	5				
Size of the project	1	2	2	5	6	16	4.4	1	Very important
Complexity of the project	0	2	4	4	6	16	3.88	3	Very important
Types of project	0	3	6	3	4	16	3.5	5	Very important
Duration of the project	0	0	5	6	5	16	2.75	8	important
Experience of the users	0	2	3	5	6	16	2.63	9	slightly important
Flexibility of the chosen methods	1	1	5	4	5	16	3.69	4	Very important
Availability of planning and scheduling Soft wares in the market	2	3	2	6	3	16	3.31	6	important
Clients preference	1	7	3	2	3	16	2.94	7	important
Level of detail information available For particular project.	0	0	3	5	8	16	4.31	2	Most important
Others (specify									

Table 4.13 &14 portrays the overall mean value for the importance level for nine factors influencing the choice of planning and scheduling methods to be used. The Representation shows that most of the factors were found to be in the range of very important (3.40 – 4.20) for both local and international contractors. One of the factors were in the range of most Important (4.20 – 5.00). Meanwhile, only one of the factors fall into the category of slightly important (1.80 – 2.40). This show that all the respondents think that suggested factors are important.

Majority of the respondents think that the size of the project the complexity of the project, types of the project experience of the user flexibility of the chosen methods and detail information are the very important factors that influence the choice of planning and scheduling methods. In addition, the size of the project, complexity of the project and detail information available for particular project is most important factor for both local and international contractors. This probably because in larger size construction project with high complexity that consists of various subcontractor simultaneously working on as many as or more different element on the project. The progress of one party may affect the rate of other party and difficult for the main contractor to take in account of all the interrelationships between the tasks. Meanwhile, the others five factors that influence the choice of planning and scheduling methods fall under category very important. Level of detail information is important due to some uncertainty that can affect the progress of the project. The information include weather record and labor and material availability important to the main contractor for their planning and scheduling work. The type of project such as residential, building, institutional and commercial, industrial, heavy construction and others will consider by the contractor when choosing the suitable method for planning and scheduling due different characteristic for each methods. Moreover, the experience and skill of the contractor on the methods important to be considered to ensure an effective planning and scheduling. Besides that, the method used must flexible for any changes on the project and availability of advanced software help the contractor to speed up the planning and scheduling process and making changes on their schedule if there are any changes on the project. The contractor will also consider client preferences although contractor have the choice to decide their own preference methods for planning and scheduling. Cost of the project, lead time for deliveries good and equipment, cash flow of developer and construction drawing availability are not important factor where each of those problems have only one respondent.

In conclusion, majority of the respondents agreed that the size of the project and the complexity of the project are the most important factor that influence the choice of their planning and scheduling method. Thus, this shows that the complex planning and scheduling method commonly used for large size and high complex project.

4.6 Problems Encountered in Using the Chosen Planning and Scheduling Methods to Prepare Work Program.

This part examines and discusses the objective's findings, which point up issues with the selected planning and scheduling techniques. The problem with each of the eight categories of planning and scheduling systems are covered in this section. The level of agreement for each of the eight problems was requested of the respondents. We utilized a five-point Likert scale, with 1 denoting "Strongly Disagree" and 5 denoting "Strongly Agree." The average mean values of the local and international contractors were tallied for the difficulties and then ordered from highest to lowest. The level of agreement category were described in Chapter 3.

4.7 Summary of Problems Encountered in Using the Various Planning and Scheduling Methods

Table 4.21summary of problems encountered in various planning and scheduling methods.

Problem	*Mean Value*							Overall average mean value
	Bar chart	Velocity diagram	Milest one chart	LSM	CP M	PER T	GER T	
Time consuming	2.92	3.39	3.25	3.38	3.71	2.96	3.17	3.25
Not flexible to analyze changes on the project	2.28	3	3.13	3.33	3.13	3.17	3.17	3.03
High complexity and difficult to learn	2.25	2.46	2.63	2.67	3.5	3	3	2.79
Specialist and experienced planner/scheduler	2.96	2.71	2.96	2.92	3.54	3.13	3.08	3.04
Detail information requirement	3.38	3.79	3.88	3.29	3.63	2.79	3.17	3.42
Computer hardware and software requirement	3.21	3.42	3.5	3	3.54	3.33	3.24	3.32
Sufficient training requirement.	3.08	3.17	3.21	3.21	3.54	3.08	2.63	3.13
Inability to control critical path of the project	3.71	3.38	3.33	3.33	2.58	3.08	3.33	3.25
Overall average mean value	2.97	3.17	3.23	3.14	3.4	3.07	3.1	3.15

This section discusses the overall summary for problems encountered in using the chosen planning and scheduling methods. Table 4.20 shows problems encountered in using the various planning and scheduling methods. It can be summarized that the problems encountered in using the non-network based methods (bar chart, s-curve chart, milestone chart and LSM) include the requirements for detail information, computer hardware and software, and the inability to control the critical path of the project.

Time consuming; requirements for specialist and experienced planner/scheduler, detail information, computer hardware and software and sufficient training were the problems in using network-based methods (CPM in AOA, PDM,PERT and GERT). In general, majority of respondent agree that detail information requirement with average mean value of 3.3 and computer hardware and software with average mean value of 3.28 as the common problems for planning and scheduling.

E. Challenges in the Practice of Planning and Scheduling Techniques and tools.

Table 20 Challenges in the Practice of Construction Planning and Scheduling Techniques and tools in local contractors

Descriptive Statistics					
	N	Mean		Std. Deviation	
	Statistic	Statistic	Std. Error	Statistic	Ranking
unable *t*o take into account spatial planning	24	2.625	.1571	.7697	4.00
Technological challenges	24	2.833	.1433	.7020	2.00
High Computer Illiteracy Rate (High Skill is required)	24	2.625	.1682	.8242	5.00
Fragmented Nature of the construction Industry	24	2.917	.1896	.9286	1.00
Traditional tools Forces minds Visualization	24	2.750	.2272	1.1132	3.00
Cost of modern planning and Scheduling Tools(Costs of Soft wares)	24	2.333	.1772	.8681	6.00
Valid N (list wise)	24				

Table 21 Challenges in the Practice of Construction Planning and Scheduling Techniques and tools in foreign contractors.

Descriptive Statistics				
	N	Mean	Std. Deviation	Rank
Cost of modern planning and Scheduling Tools(Costs of Soft wares)	16	2.375	.7188	6

High Computer Illiteracy Rate (High Skill is required)	16	2.563	.9639	5
unable to take into account spatial planning	16	2.750	1.0646	4
Technological challenges	16	3.32	.8062	1
Traditional tools Forces minds Visualization	16	2.938	1.2894	3
Fragmented Nature of the construction Industry	16	3.000	1.0328	2
Valid N (list wise)	16			

Table 4.21 & table 4.22 summarizes the challenges confronting the application of modern scheduling and planning techniques in the local and international road contractors. The ratings of the challenges ranged from 1 (i.e. Not Severe) to 5 (i.e. very Severe). Altogether, the respondents agreed that complexity of the tools or technological challenges and fragmented natures of construction industry are the major challenges hindering planning and scheduling in international and local road construction contractors with a mean rate of 3.32 and 2.917 (Std. Dev = .802 &.9286) respectively. Similarly, the aggregated ratings indicated that cost of modern planning and scheduling tools (cost of softwares) is the least challenge with a mean rating of 2.37 and 2.33 (Std. Dev. =.718 & .868) international and local contractors respectively. From Table 4.21 & 22 the standard deviations are less than 1.00 and very small when compared with the mean rating indicating that there is less variability in the responses of the respondents. More so, they mean the data are fit for the study (Field, 2005 cited from Manu, 2012).

Discussion

As aforementioned, the major challenge is complexity of tools or technological challenges and fragmented nature of construction industry in local and international contractors. The challenge cuts across the learning divide, and also both practice and academia. Woo (2006) identified the challenge in the classroom as impeding the operation of planning and scheduling tools. Conversely, Chau et al. (2005) identified the challenge among practitioners. It would therefore not to be farfetched to conclude that the challenge is prevalent in the industry. The finding therefore corroborates the studies of both authors – Woo (2006) and Chau et al. (2005), and by extension, the problem is also persistent in the Road Construction Industry.

Complexity of tools is an association of technological challenges. It was therefore not surprising that the respondents ranked the challenge second after complexity of tools. Generally, the construction industry was considered to be fragmented and it is even worse in the developing countries. The finding largely concurs what is in literature that technological challenge is a major issue to deal with in planning and scheduling (Olatunji, 2011).

Surprisingly that the cost of modern planning and scheduling tools is not such a challenge facing planning and scheduling in the Road Construction Industry. This partially explains the over reliance of the traditional planning and scheduling tools that are not highly sophisticated and thus not expensive.

NO	Project Name	Contract Amount	Total Length(KM)	Contract Duration	Contract signing date	commencement date	Completion date	Time Elapsed (%)
1	Construction Works of Kessa-gimjabet-azena-ambela Road Project	380,204,197.21	71.756	1080.00	July 14, 2021	November 18,2021	November 17,2024	86%
2	Construction Works of Kunzila Junction-Horticultural –Zegetown Road Project	554,487,294.1	21.8	910	November,15/2017	November,15/2017	May,13/2020	100%
3	Construction Works of Motta mekane Iyesus-Gessay Road Project	1,618,179,826.58	139.5	1278	May,23,2017	August1,2020	January,18/2021	100%

Table 4.9.1 List of selected Road projects from Ethiopian Road Administration for case Study:-

4.9 Analysis of data from the desk study

During the study period three (3) asphalt road projects which have more time elapsed were selected for desk study in order to identify the practices, challenges in preparation and implementation of construction works program and to suggest the improvement methods. The construction of roads are being undergoing by two foreign and one local contractors. The list of selected road projects are as shown in **Table 4.9.1**.

Case Study 1:-

The project road is located in the northern part of the country in Amahara national region. The total length of the project is 71.756 km Asphalt Concrete standard with contract amount ETB 380,204,197.21(Original).The original contract duration is 1080(Original) calendar days and the original completion date is November 17, 2024. The construction is being undergoing by foreign contractor china civil engineering Corporation. From the current physical progress during the january, 2023 report the total to date executed km about 86.14 (86 %).

The progress in the execution of all activities is unsatisfactory as compared to the schedule and to the time elapsed so far.

In the table above shown the time elapsed from original duration is an extremely high an extension of time was granted to contractor. As observed from the document, the contractor prepared the master schedule using Ms-Project and primavera project planner also they used planning and scheduling methods like bar chart CPM and daily log book also used but the implementation is not as planned.

Case Study 2:-

The project road is located in the northern part of the country in Amahara national region. The total length of the project is 21.8 km Asphalt Concrete standard with contract amount ETB 554,487,294.1 (Original).The original contract duration is 910(Original) calendar days and the original completion date is November 17, 2024. The construction is being undergoing by foreign contractor china civil engineering Corporation. From the current physical progress during the January 2023, report the total to date executed km about 86.14 (86 %).

Case Study 3:-

The project road is located in the northern part of the country in Amahara national region to connect southern Gondar zone with the areas of Eastern Gojam zone. The total length of the project is 139.5 km Asphalt Concrete standard with contract amount ETB 1,618,179,826.58 (Original).The original contract duration is 1278(Original) calendar days and the original completion date is January,1/2021.

4.3 Findings from the Case Study

The document study was applied to three selected road projects in order to know the planning and scheduling methods and tools to implement construction works program done. In addition to know the assessment of the level of usages of planning and scheduling methods and tools, approaches for using planning and scheduling methods, types of computer spread sheet types of Specialist Software Used, factors influencing the choice of planning and scheduling methods in Preparing Work Program and, Problems encountered in using the chosen planning and scheduling methods to Prepare Work Program. From the document and document reviews. The study of document referred Master schedule, monthly schedule, weekly schedule, site logbook, monthly and annual physical and financial progress report and other additional documents on project referenced.

4.2 Assessment of the level of usage of planning and Scheduling Methods in local and international road Construction Contractors.

The summary of the level of usages of planning and scheduling methods for both local and foreign contractors shown below in the Table 1, which used in planning and scheduling methods and tools of construction works program as found from the document referenced and on selected three road projects. From the study found twenty (20) planning and scheduling methods used in preparation and planning of construction works program in answering the objective of the research. Most of them were identified in literature review.

This section discusses the planning and scheduling methods adopted by local and international road contractors to implement their work program. From document reviews and data referenced Most respondents in table 4.5 below agreed that simple bar charts or Gantt charts were the most common planning and scheduling techniques used in road construction projects by both domestic and foreign contractors.

Gantt charts are common, particularly in developing nations, for the same reason as the suggestions for this questionnaire; the difficulties with other planning and scheduling tools necessitate the use of more sophisticated skills and techniques, according to the survey, and this accounts for the participants' low usage of the tool. According to the respondents, who included both local and foreign contractors, the Critical Path Method was the other most popular scheduling method after the Gantt chart. These tools display scheduling in 4-D, common point 4D, schedule simulator, and smart plan evaluation are not commonly use. The companies involved never employ the BIM visualization, advanced smart simulation, or 4-D CAD approaches or technologies. And also the document review shows three approaches used for planning and scheduling method by contractors. From the document reviews from selected road projects, specialist software were the most used approach used in preparing bar chart, CPM in CPM in AOA and PERT while computer spreadsheet system were the most used approach used in preparing s-curve chart and LSM.

Both specialist software and computer spreadsheet system was the most approach used in preparing work programs, the specialist software is the most frequently used in preparing bar chart and milestone chart, medium usage for s-curve, CPM in AOA and PDM; and seldom being used for preparing the other planning and scheduling methods. This is probably because of that majority of the specialist software such as Microsoft Project use by contractor in preparing work program.

Planning and scheduling methods manually is time consuming and lack of flexibility to analyze changes on the project. In contrast, computerized planning and scheduling by using the computerized spreadsheet system and specialist software for planning and scheduling will speed up the process in preparing the various planning and scheduling methods and at the same time more flexible to analyze the changes on the project due to that manual planning and scheduling method is not used.

Table:-4.9.2 *Assessment of the level of usage of planning and Scheduling Methods in local and international road Construction Contractors.*

Simple bar chart(Gantt chart)
Critical path methods(CPM)
Mile stone chart
Linear Scheduling methods
Critical path methods on Arrow network
Program evaluation and Review
Graphical evaluation and review techniques
4-D Cad Visualization Techniques
Linear Scheduling methods
Critical path methods on Arrow network
Program evaluation and Review
Graphical evaluation and review techniques
4-D Cad Visualization Techniques
Schedule simulator
Smart Plant Review
-D Viz Balfour Technology
Common point 4D
BIM

4.3 Types of Computer Spread sheet used

From the document referenced the most type of computer spreadsheet system used by both contractors is micro soft excel because of the fact that Microsoft Excel is very common and easy to acquire.

Table:-4.9.3 Type's computer spread sheet used by the contractors

Computer Spread sheets
Microsoft Excel, /2019
Open office org
K Spread
Lotus-1-2-3
G numeric

Types of Specialist Software Used

From the document reviews, that shows the usage of specialist software Microsoft Project has the highest percentage in very frequent usage with local and international contractors respectively. Primavera Project Planner has the second highest percentage in very frequent usage.

Table:4.9.4 Types of specialist software used for planning and scheduling

Types of Specialist Software
Microsoft office project
Primavera project planner
Sure track project manager
Artemis
Open plan
Micro Planner X-Pert
Fast Track Schedule
Primavera Engineering and Construction Web Based Programs

4.6 Factors Influencing the Choice of Planning and Scheduling Methods in Preparing Work Program.

From the document review importance level for nine factors influencing the choice of planning and scheduling methods to be used. Majority of the respondents think that the size of the project the complexity of the project, types of the project experience of the user flexibility of the chosen methods and detail information are the very important factors that influence the choice of planning and scheduling methods. In addition, the size of the project, complexity of the project and detail information available for particular project is most important factor for both local and international contractors. This probably because in larger size construction project with high complexity that consists of various subcontractor simultaneously working on as many as or more different element on the project. The progress of one party may affect the rate of other party and difficult for the main contractor to take in account of all the interrelationships between the tasks. Meanwhile, the others five factors that influence the choice of planning and scheduling methods fall under category very important. Level of detail information is important due to some uncertainty that can affect the progress of the project. The information include weather record, labor, and material availability important to the main contractor for their planning and scheduling work. The type of project such as residential, building, institutional and commercial, industrial, heavy construction and others will consider by the contractor when choosing the suitable method for planning and scheduling due different characteristic for each methods. Moreover, the experience and skill of the contractor on the methods important to be considered to ensure an effective planning and scheduling. Besides that, the method used must flexible for any changes on the project and availability of advanced software help the contractor to speed up the planning and scheduling process and making changes on their schedule if there are any changes on the project. The contractor will also consider client preferences although contractor have the choice to decide their own preference methods for planning and scheduling. Cost of the project, lead time for deliveries good and equipment, cash flow of developer and construction drawing availability are not important factor where each of those problems have only one respondent.

From the document review the size of the project and the complexity of the project are the most important factor that influence the choice of their planning and scheduling method. Thus, this shows that the complex planning and scheduling method commonly used for large size and high complex project.

Table:-4.9.5 factors influencing the choice of planning and scheduling methods

Factor
Size of the project
Complexity of the project
Types of project
Duration of the project
Experience of the users
Flexibility of the chosen methods
Availability of planning and scheduling Soft wares in the market
Clients preference
Level of detail information available For particular project.

Problems Encountered in Using the Chosen Planning and Scheduling Methods to Prepare Work Program.

It can be summarized that the problems encountered in using the non-network based methods (bar chart, s-curve chart, milestone chart and LSM) include the requirements for detail information, computer hardware and software, and the inability to control the critical path of the project. Time consuming; requirements for specialist and experienced planner/scheduler, detail information, computer hardware and software and sufficient training were the problems in using network-based methods (CPM in AOA, PDM, PERT and GERT). In general, majority of the contractors used that detail information requirement and computer hardware and software as the common problems for planning and scheduling.

Table:-4.9.6 problem encountered in using the chosen planning and scheduling methods.

Time consuming
Not flexible to analyze changes on the project
High complexity and difficult to learn
Specialist and experienced planner/scheduler
Detail information requirement
Computer hardware and software requirement
Sufficient training requirement.

Inability to control critical path of the project
Overall average mean value

4.8 Chapter Summary

This section summarized the overall findings of the research. The research intended to identify the planning and scheduling methods adopted by local and international contractors in preparing work program, to determine the factor influencing their choice of planning and scheduling methods as well as problems encountered in using the chosen planning and scheduling methods. The research analysis and findings revealed that the planning and scheduling methods used by contractors in preparing their work program is dominated by the traditional or the non-network based methods.

Specialist software were the most used in preparing the various planning and scheduling methods followed by the computer spreadsheet system. Across all the planning and scheduling methods, both local and international contractors seldom or never prepare them manually.

The size and complexity of projects are the most important factors influencing the choice of planning and scheduling methods. Problems encountered in using the non-network based methods (bar chart, s-curve chart, milestone chart and LSM) include the requirements for detail information, computer hardware and software, and the inability to control the critical path of the project. On the other hand, time consuming; the requirements for specialist and experienced planner/scheduler, detail information, computer hardware and software and sufficient training were among the problems identified in using the network-based methods (CPM in AOA, PDM, PERT and GERT). Thus, the common problems encountered across all methods centered on the requirements for detail information, as well as for computer hardware and software.

CHAPTER FIVE

5. CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The overall study finding about planning and scheduling methods used by local and foreign contractors working with the Ethiopian road administration planning and scheduling methods and tools, factors influencing their choice of planning and scheduling methods, problems encountered using the selected planning and scheduling methods were concluded in this section**.**

5.2.1 Type of planning and scheduling methods adopted local and international contractors in preparing work programs

It can be concluded that the planning and scheduling methods used by both local and international contractors is dominated by traditional planning and scheduling methods and tools. bar chart method is used with the most popular specialist software's were the most used in preparing the various planning and scheduling methods, both local and international contractors followed by the computer spread sheet system across all the planning and scheduling methods both contractors seldom or never prepare work program manually. Microsoft office excel is the most adopted and frequently used computer spread sheet system used by both local and international contractors in preparing work programs while Micro soft project is the most adopted and most frequently used specialist software by both local and international contractors in addition to Microsoft project primavera project planner is frequently used by international contractors to prepare work programs.

5.2.2 Factors influencing the Choice of Planning and Scheduling Methods in Preparing Work Programs.

There are two most important factors that influence the choice of planning and scheduling methods which are the size of the project and the complexity of the project. It can therefore be concluded that these two factors are main factors influencing the choice of planning and scheduling methods to be used by contractors for planning and scheduling in preparing work program.

5.2.3 Problems Encountered in Using the Chosen Planning and Scheduling Methods to Prepare Work Program

The main problems in using the bar chart is inability to control critical path of the project. Meanwhile, the main problems in using the s-curve chart are detail information requirement, computer hardware and software requirement and inability to control critical path of the project. Moreover, the main problems in using milestone chart is detail information requirement and computer hardware and software requirement. For both CPM in AOA and PDM, the main problems encountered are time consuming, specialist and experienced planner/scheduler requirement, detail information requirement, computer hardware and software requirement and lastly sufficient training requirement. There are no problems reflected for LSM and PERT mainly due to the respondent not familiar with methods. Lastly, the problem encountered in using GERT is time consuming and sufficient training requirement.

Hence, problems encountered in using the non-network based methods (bar chart, s-curve chart, milestone chart and LSM) include the requirements for detail information, computer hardware and software, and the inability to control the critical path of the project. On the other hand, time consuming; the requirements for specialist and experienced planner/scheduler, detail information, computer hardware and software and sufficient training were the common problems in using network based methods (CPM in AOA, PDM, PERT and GERT).

5.3 Limitation of the Research

Throughout the entire process of the research, the problems encountered include the following:

Low rate of response from the respondents (52 sets of questionnaire have been distributed to the respondents but only 40 sets of questionnaire were returned) and Lack of commitment by Respondents to fill questionnaires and some respondent’s did not participate because they were busy in filling questionnaires. Therefore, shortage of time for waiting until getting the responses promised from the respondents and they are not responsible to give detail information.

5.4 Recommendations for Future Research

- The research has revealed that advanced scheduling and planning tools and methods are not well integrated into the Ethiopian Road Construction Industry. It is therefore recommended that further studies should be conducted into the integration of such tools in planning and scheduling.

- Detail study on the specialist software used for planning and scheduling work m Ethiopian construction industry.

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8. APPENDIX

8.1 Questionnaire Survey

ADDIS ABABA UNIVERSITY

ADDIS ABABA INSTITUTE OF TECHNOLOGY (AAIT)

SCHOOL OF CIVIL AND ENVIRONMENTAL ENGINEERING

Program:-MSc in Construction Technology and Management

Research questionnaires

Dear Sir/ Madam

This questionnaire is prepared to gather the necessary information for a study aimed to ***Study on Construction planning and Scheduling Methods and Tools in Local and International Road Construction Contractors Working with Ethiopian Road Administration*** considering the experience of road contractors in Ethiopian Road Administration The information you provide will be used only for academic purpose (only for the study under consideration) and will be kept confidential; hence; you are kindly requested to provide only thoughtful and honest responses that will give the most valuable information for the Study. Your cooperation is highly appreciated.

Thank you!

Beshir Mudesir
Tel +251-912285738
Email address :(beshirm2015@gmail.com)

Part A: - general Information

1. Name of Organization (optional):_____

Local Contractor ☐ International Contractor ☐

2. Category of your organization:

☐ General Contractor ☐ Building Contractor ☐ Road Contractor

☐ Water works contractor ☐ Special Contractor ☐ Consultant

Others (Please specify) _____

3. Please select your position in the organization:

☐ General Manager ☐ Operation manager ☐ Construction (coordinator)

☐ Commercial Manager ☐ Bid expert ☐ Quantity surveyor

☐ Senior office engineer ☐ Contract Engineer ☐ Project planner/scheduler

Other (please specify) _____

4. Experience (please tick one):

☐ Less than 5 years ☐ 5 to 10 years ☐ 10 years and above

5. Demographic Information

Age: ☐ 20-30 ☐ 31-40 ☐ 41-50 ☐ 51-60 ☐ Over 60

Gender: ☐ Male ☐ male

Education: Please specify all that apply to you.

☐ Master's Degree ☐ Bachelor's Degree ☐ College Diploma

☐ Others specify_____

Your educational Background /Field of study _____.

Part B: Planning and Scheduling Methods Adopted by local and international road Construction Contractors in Preparing Work Program.

The approaches used in preparing the various planning and scheduling methods, the types **computer spreadsheet system** and the **types of specialist software** used in preparing work program

Please tick (√) relevant appropriate choice for your work

1. Which types of planning and scheduling methods used to prepare work program in your organization and your frequency of uses.

Planning and scheduling Techniques	always	often	Sometimes	neutral	never
	5	4	3	2	1
Simple bar chart (Gantt chart)					
Velocity diagram(S-curve)					
Mile stone chart					
Linear Scheduling methods					
Critical path methods (CPM)					
Critical path methods on Arrow network					
Program evaluation and Review Techniques (PERT)					
Graphical evaluation and review techniques (GERT)					
4-D Cad Visualization Techniques					
Schedule simulator					
Smart Plant Review					
4-D Viz Balfour Technology					
Common point 4D					
BIM					
Others, please specify					

2. How the previous (question #1) methods are used to prepare work program in your organization. Select more than one.

Planning and scheduling tools / Planning and scheduling techniques	Manual (free hand scheduling)				Computer spread sheet system				Special software used to plan and schedule			
	always	often	sometimes	never	always	often	Sometimes	never	always	often	sometimes	never
Simple bar chart(Gantt chart)												
Velocity diagram(S-curve)												
Mile stone chart												
Linear Scheduling methods												
Critical path methods (CPM)												
Critical path methods on Arrow network												
Program evaluation and Review Techniques (PERT)												
Graphical evaluation and review techniques (GERT)												
Others, please specify												

3. Indicate which computer spreadsheets used by your organization preparing work program and level of usage.

Types of computer spread sheet	Level of usage			
	1	2	3	4
	never	sometimes	Often	always
Microsoft Excel, 2010,2013/2016/2019				
Open office org.				
KSpread				
Lotus-1-2-3				
Gnumeric				
Others(please specify)				

4. Indicate which planning and scheduling software used by your organization for preparing work program and level of usage.

planning and scheduling software	Level of usage				
	never	sometimes	Often	always	
Microsoft office project					
Primavera project planner					
Sure track project manager					
Artemis					
Open plan					
Micro Planner X-Pert					

FastTrack Schedule					
Primavera Engineering and Construction Web Based Programs					
Others(please specify)					

Part C:-Factors influencing the choice of Planning and Scheduling methods to prepare work programs in Local and International Road Contractors.

1. Which factors influence the choice of planning and scheduling methods? Please indicate their priority order. Please select the appropriate priority circle

   Rating Scale:-

   1 =neutral 2 =strongly disagree 3= disagree

   1 4= agree 5= strongly agree

(1)	1	2	3	4	5
(2) Size of the project					
(3) Complexity of the project					
(4) Types of project					
(5) Duration of the project					
(6) Experience of the users					
(7) Flexibility of the chosen methods					
(8) Availability of planning and scheduling					
Soft wares in the market					
(9) Clients preference					
(10) Level of detail information available					
For particular project.					
Others (specify)……					

Part E: - Challenges in the Practice of Construction Planning and Scheduling Techniques and tools.

1 = strongly disagree 2. =disagree 3. =agree 4. = strongly agree

1) Unable To Take Into Account Spatial Planning	1	2	3	4
2) Technological Challenges				
3) High Computer Illiteracy Rate (High Skill Is Required)				
4) Fragmented Nature of Construction Industry				
5) Traditional Tools Forces Minds Visualizations				
6) Cost of Modern Planning and Scheduling Tools (Cost Of Software)				

Thank you for your time and cooperation.

9. Appendix 2:- Basic Data of Case Study Projects

1.

S.No	Project	Construction Works of Kessa-gimjabet-azena-ambela Road Project	
	Funding	Federal Democratic Republic of Ethiopia	
	Client	Ethiopian Road Administration	
	Consultant		
	Contractor's origin	Foreign	
	Project length	71.756	
	Types of Contract	Admeasurement	
	Condition of contract	Fidic based Condition of Contract	
	Construction Type	Asphalt	
	Notification of Award		
	Contract signing date	July 14, 2021	
	Commencement date	November 18,2021	
	Original Completion date	November 17,2024	
	Original contract period	1080 calendar days	
	Maintenance period	365 calendar days	
	EOT		
	Progress	86%	
	Revised Completion Time		
	Actual Completion time		
	Financial Data	**Foreign**	**Local**
	Contract Amount		380,204,197.21
	Liquidated Damage		
	Advance Payments		20% of contract Amount

2.

S.No	Project	Construction Works of Kunzila Junction-Horticultural –Zege town Road Project
	Funding	Federal Democratic Republic of Ethiopia
	Client	Ethiopian Road Administration
	Consultant	Markan Trading PLC
	Contractor	
	Contractor's origin	Domestic
	Project length	21.8km
	Types of Contract	Admeasurement
	Condition of contract	Fidic Based
	Construction Type	Asphalt
	Notification of Award	
	Contract signing date	November,15/2017
	Commencement date	November,15/2017
	Original Completion date	May,13/2020
	Original contract period	910 calendar days
	Maintenance period	365calendar days.

	EOT		
	Progress		
	Revised Completion Time		
	Actual Completion time		
	Financial Data	**Local**	**Foreign**
	Contract Amount	554,487,294.1	
	Liquidated Damage	0.1% of Final Contract Amount.	
	Advance Payments	20% Contract Amount	

3.

S.No	Project	Construction Works of Motta mekane Iyesus-Gessay Road Project	
	Funding	Federal Democratic Republic of Ethiopia	
	Client	Ethiopian Road Administration	
	Consultant	Core Consulting Engineers PLC	
	Contractor's origin	Foreign	
	Project length	139.5km	
	Types of Contract	Admeasurement	
	Condition of contract	Fidic Based	
	Construction Type	Asphalt	
	Notification of Award	April,17,2017	
	Contract signing date	May,23,2017	
	Commencement date	August 1,2020	
	Original Completion date	November,18/2021	
	Original contract period	1278 calendar days	
	Maintenance period	365cal.days	
	EOT		
	Progress		
	Revised Completion Time		
	Actual Completion time		
	Financial Data	**Local**	**Foreign**
	Contract Amount	1,618,179,826.58	
	Liquidated Damage	0.1% of contract Amount	
	Advance Payments	20% Contract Amount.	