Addis Ababa University

Addis Ababa Institute of Technology (AAiT)

School of Civil and Environmental Engineering

(Construction Technology and Management)

Analysing the Planning and Scheduling of 40/60 Saving Houses Development Enterprise

By

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A thesis submitted to the School of Graduate Studies of Addis Ababa University in partial fulfilment of the requirement of the degree of Master of Science in Civil Engineering (Construction Technology and Management)

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Declaration

I, Hassina Oumer, declare that this paper is a presentation of my original research work on the topic entitled "Analysing the Planning and Scheduling of 40/60 Saving Houses Development Enterprise)" in partial fulfilment of the requirements for Masters of Science degree at Addis Ababa University. This work has not been submitted for a degree to any other university. All the references are also duly acknowledged as listed in the references.

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Abstract

One of the major challenges of Addis Ababa city is lack of shelter and unemployment as identified by city administration of Addis Ababa, which needs an urgent remedy. In order to solve these challenges, the city administration has established an integrated housing development program which has to be planned to change the image of the city, to modernize the life style of the society, and to promote the construction industry.

In Addis Ababa slum upgrading, public-private partnership for housing production, and direct government low-cost housing are undertaken with varying degrees of success. However, the vast majority are uncoordinated, small in scale compared with demand, and often do not reach the target low income beneficiaries. There is a critical problem in the construction of these saving houses in Addis Ababa that had limited the timely delivery of the houses. The objective of this research was to investigate the planning and scheduling phases of saving houses development enterprise construction projects by identifying the project planning elements and the project resource requirements by to comparing and contrasting the resource constrained and unconstrained schedules. To identify the resource availability the scheduling is done by as resource constrained schedule.

This exploratory study applied an inductive approach with the use of both qualitative and quantitative case studies, by collecting and analysing textual data through document analysis, interviews, observations and resource determination using MS Project. To effectively evaluate a project planning and scheduling the schedules submitted by the contractors were collected and evaluated. The best contractor schedules were identified using a schedule goodness index. A resource driven schedule was also proposed and developed, and was compared with contractor's submitted schedule to identify the resource gaps. The research results showed that the lacks of planning in saving houses development enterprise are due to: lack of technical knowhow, poor institutional arrangements, and weak legal frameworks. The gaps are identified and recommendations are forwarded for both the client and contractors.

Key words: Project management, Housing, Planning, Scheduling

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List of Abbreviations

AASHDE	Adds Ababa Saving Houses Development Enterprise
CCPM	Critical Chain Project Management
CPM	Critical path method
EVM	Earned Value Method
GERT	Graphical Evaluation and Review Technique
IHDP	Integrated Housing Development Program
PERT	Performance Evaluation and Review Technique
PM	Project Manager
SHDE	Saving Houses Development Enterprise
TOC	Theory of Constraints
WBS	Work Breakdown Structures

CHAPTER ONE: INTRODUCTION

1.1 General

According to the Human Development Report (2014). Ethiopia ranks number 173 out of 187 countries in the world. This low ranking reflects the poverty and harsh living conditions of the vast majority of the people, but also highlights a great need for improvement and development. To improve this situation, a number of important measures must be taken. One isto give the Ethiopian people the opportunity to get better housing. The need for this can be identified over large parts of the country; both rural and urban. This need has to be seen in relation to the larger and more general problems which the country is currently facing.

One of the major challenges of Addis Ababa city is lack of shelter and unemployment as identified by city administration of Addis Ababa, which needs an urgent remedy. In order to solve these challenges, the city administration has established an integrated housing development program which has to be planned to change the image of the city, to modernize the life style of the society, and to promote the construction industry.

Residential construction is a sector that plays a vital role in any country‟s development. Hence, proper and systematic management of this sector should be applied and implemented by the parties involved, particularly the builders or the contractors. Construction covers both small and big projects.

The massive housing needs are unlikely to be met by the small scale housing cooperative, government, and upgrading approaches prevailing from the late 1970s until the mid-2000s, especially considering the high demand by the low-income sector of the population for affordable housing. In response to this challenge, the Ethiopian government outlined an ambitious vision for low-income urban and housing development, formulated as the Integrated Housing Development Program (IHDP), for all slums to be cleared within ten years‟ time and for Ethiopia to be a middle-income country by 2025. In particular: “The IHDP envisages…the utilization of housing as an instrument to promote urban development, create jobs, revitalize the local urban economy through MSE development, encourage saving and empower urban residents through property ownership, and develop the capacity of the domestic construction industry.”

Since 2005, Ethiopia has been implementing an ambitious government-led low and middle income housing program. In 2013/14 the 40/60 saving houses development was launched by Addis Ababa city administration saving houses development enterprise (AASHDE). Currently,

the housing construction is under going on 13 sites with eight topologies, i.e., B+G+7,B+G+8, B+G+9, B+G+10,2B+G+12, 2B+G+13, 2B+G+15 and 2B+G+18,which will have a total of 38,925 houses. According to AASHDE, from those sites, only two sites which are located in Senga Tera and Crown Hotel (Kality), which have 1,992 units, are completed and will be transferred to home owners this year. The construction in Bole, Meri-Ayat and Ehel Nigid site which are expected to be completed in this year have only executed 80% of the total work. The other remaining sites have commenced there work last year but they are still in poor progress, which is around 10%.the progress of the projects are poor relatively, this is due to design change, shortage of material, resource shortage, capacity of the MSE‟s is not compatible with the projects and the commencement of the projects are at the rainy season. This is due to poor planning and scheduling practice.

The middle and low income societies can benefit through direct participation in the construction work and take care of the overall construction management by themselves. This can be proved by providing sufficient training for self-help housing cooperatives and assigning technical personnel for group of cooperatives.

1.2 Statement of the Problem

In Addis Ababa slum upgrading, public-private partnership for housing production, and direct government low-cost housing are undertaken with varying degrees of success. However the vast majority are uncoordinated, small in scale compared with demand, and often do not reach the target low income beneficiaries. In 40/60 saving house development the beneficiaries pay the 40% of the cost before they get the house and most of the population is living in the rented houses. There is a problem in the construction of these saving houses in Addis Ababa that deems special attention for delivering the houses on the time.

The significance of the research is therefore, to provide significant ideas to the plan makers who set out rules and regulations that need to be practiced by homebuilders. The findings of the research will help to improve the quality of project management elements in integrated house construction.

1.3 Research Objective

The aim of this study is to examine the suitability in applying and implementing project management elements focusing on project planning and project scheduling in 40/60saving house projects. Therefore, the following specific objectives are studied:

- To identify the elements of project planning and scheduling,
- To compare and contrast the schedules with unconstrained, constrained and contractors submitted schedule, and
- To establish the application and implementation of project management methods in the construction of house project.

1.4 Scope and Limitations

The aim of this study is to analyze the planning and scheduling in 40/60 saving houses development enterprise projects. However, assessing the situation covers wide concepts and since it will be very difficult to cover all the concepts in a single study, the study focused to the planning and scheduling of those project‟s by conducting both clients and contractors resource.

The study has the following specific limitation:

- Lack of up-to-date information on planning from the client and Ministry of work and Urban Development, and
- Non-availability of clients material schedule data.

1.5 Significance of the Research

The outcome of this research will be of immense value to the success of Addis Ababa 40/60 housing projects, as well as a contribution to the literature. Perhaps, the information obtained from this research can be used by the government policy maker and regulators and thus develop better understanding of the application and implementation of modern project management of construction of 40/60 saving house development.

This research empirically lends significant general knowledge of proper project management in residential constructions project to homebuilders. The homebuilders will realize that applying and implementing modern methods and techniques of construction in house projects such as project planning, project scheduling and project control acts as a guidance to improve work performance and increase productivity. For other researchers, the findings of this study could provide a source of references.

CHAPTER TWO: LITERATURE REVIEW

2.1 General

The purpose of this chapter is to present the main research topics and establish the foundation of this study. The theoretical framework is organized to address the following issues:

- Fundamental aspects of project/construction management,
- How construction projects are planned and scheduled, and
- How such plans and schedules are evaluated.

Accordingly, this section defines a project, how a construction project is defined, what project management is and what aspects of construction management are fundamental for planning, scheduling and control.

2.1.1 Project

A project can be defined in many ways. A project is "an endeavor in which human, material and financial resources are organized in a novel way, to undertake a unique scope of work, of given specification, within constraints of cost and time, so as to achieve beneficial change defined by quantitative and qualitative objectives". (Turner & Müller, 2003) "Projects exist to produce deliverables. A project can be considered to be any series of activities and tasks that:

- Have a specific objective to be completed within certain specifications
- Have defined start and end dates
- Consume human and nonhuman resources (i.e., money, people, equipment)
- Have funding limits (if applicable)
- Are multifunctional (i.e., cut across several functional lines)".(Kerzner, 2013)

Every project creates a unique product, service, or result (PMI [Project Management Institute, Inc.], 2013). Projects can thus be classified into types and typologies. The three primary types are: Business projects, Development projects and Change projects. The four factors influencing the typologies are: size, institutional/industry context, organizational condition, and task features (Morris, Pinto, &Söderlund, 2010).

The theoretical lifecycle phases of a project can be defined as: Conceptual, Planning, Testing, Implementation, and Closure (Kerzner, 2013).

2.1.2 Construction Project

Construction is one among many types of project-based production systems (Ballard & Howell, 2003). According to Chitkara (1998), construction project refers to a high-value, time bound and

special construction mission with predetermined performance objectives. He further explains that the project mission is accomplished within complex project environments, by putting together human and non-human resources into a temporary organization, headed by a project manager.

The major construction projects can be grouped into Building Construction, Infrastructure Construction, Industrial Construction, and Special-purpose projects. Due to the limited scope of this research, only Building Construction will be further addressed.

Building construction constitute the largest segment of the construction business. Building works include residential and commercial complexes, educational and recreational facilities, hospitals and hotels, warehouses and marketing facilities. The building business serves mankind by providing shelter and services for its habitation, educational, recreational, social and commercial needs. The Building works are mostly designed by the Architect/Engineering firms, and are financed by public and private sector and individuals (Chitkara, 1998).

2.1.2.1 Project Lifecycle

Construction projects, just like other projects, have a predetermined duration with a beginning and an end. The starting point of a project is the time when the project idea is conceived by the client. The end marks the time when the mission is accomplished. The time span between the start and completion of a project represents the project life cycle. According to Chitkara (1998), the life cycle of a typical construction project can be broadly divided into the following phases: formulation phase, mobilization phase and construction phase. The details of each phase as discussed below:

- The formulation phase includes the conception of the project idea, feasibility studies, investment appraisal and project definition.
- The mobilization phase covers the preparation of the project preliminary plan, designs and drawings, contracts, resources mobilization and earmarking funds, and
- The construction phase includes planning and controlling execution, inducting resources, construction and commissioning, and finally, handing over to the client.

2.1.3 Project Management

2.1.3.1 What is Project Management?

Project management as a term seems to first appear in 1953, arising in the US defense-aerospace sector (Johnson, 2006). Since then project management has been defined in many ways, depending on industries, organizations and individuals. The Project Management Institute

describes project management as: "the application of knowledge, skills, tools, and techniques to project activities to meet the project requirements" (PMI, 2013).

Wysocki (2011) describes project management as: "an organized common-sense approach that utilizes the appropriate client involvement in order to deliver client requirements that meets expected incremental business value." Kerzner (2013) states that project management is designed to manage or control resources on a given activity, within time, cost, and performance. He further explains that time, cost, and performance are the constraints on the project. If the project is to be accomplished for an outside customer, then the project has a fourth constraint: good customer relations.

Project management is not a one-person operation; it requires a group of individuals dedicated to the achievement of a specific goal. Project management team includes: a project manager, an assistant project manager, a project (home) office and a project team (Kerzner, 2013).

2.1.4 Construction Management

In this section some of the fundamental ideas of construction management are presented as well as the major management tasks. Also, some important concepts regarding the design and construction processes are presented. But first, the main construction participants and stakeholders are presented.

2.1.4.1 Construction Participants

The five main agencies actively associated with the execution of major works with in design and construction projects are listed in the table below (Chitkara, 1998):

Table 2.1 Construction Participants

Agency	Description of participants
Business promoter	The business promoter, also called the client, is the potential owner of the construction project. He sponsors the construction works and ultimately utilizes them. A client can be a government body, a public or private enterprises, or some private individual. It is the client who sponsors the works, finances their construction, and utilizes the facility constructed.
Construction management consultants	The consultants are hired by the client for carrying out certain services on contract basis, often for the entire

Agency	Description of participants
	life of the project. The nature of tasks assigned to the consultants vary, but may include but are not limited to: feasibility and cost estimates, soil investigation, coordination of designs, tendering and awarding contracts to bidders, develop detailed construction plans and supervising works.
Architect and engineering associates	Architect and engineering associates are the firms employing the architects and engineers. An architect is an individual who designs the buildings, landscapes and other artistic features. The engineers associated with architects develop structural, electrical, mechanical and other specialist systems and designs.
Input suppliers	Input suppliers within the construction industry exist in the form of men, materials, machinery and money. The workforce connected with construction includes architects, engineers, managers, technical and non-technical staff, highly skilled operators, and skilled and unskilled manpower.
Construction contractors	Construction contractors form the backbone of the construction business as they execute most of the construction works. In the competitive construction business, which requires special resources for different types of construction work, the contractors generally tend to specialize in a particular area of construction.

2.1.4.2 Design and Construction Processes

Koskela divides construction projects into two main processes, i.e. design process and construction process. Based on his description these processes are defined as follows (Koskela, 1992):

(1) The design process is a theoretically knowledgeable clarification of specifications where needs and wishes are transformed into requirements and later to detailed designs. Also, this is a process of detecting and solving problems.

(2) The construction process consists of two types of flows:

- The material process which consists of the flows of material to the site, including processing and assembling on site.
- The work processes of construction teams. Koskela explains that the temporal and spatial flows of construction teams on site are often closely associated with the material processes.

Koskela explains that the following three processes control or support the main processes of design and construction (Koskela, 1992):

- Project management process by the owner.
- Design management process by the design project manager.
- Construction management process by the project manager. In this process the detailed design is transformed into a construction plan. This means daily coordination and control of the processes on site.

2.1.4.3 Fundamental Ideas for Planning, Scheduling and Control

Since construction projects are in many ways similar to other enterprise projects many of the general principles of management also apply to construction management. To understand what principles are useful in managing construction projects one should look at basic general definition of management. Pierce (2013) defines management as: "the process of planning, organizing, directing and controlling". The definition of these well-known concepts can be further extended by looking at the specific concepts contained within it. The ideas that are most important for the purposes of schedule and control construction projects are: goals, process, planning and control. These ideas are further (Pierce, 2013):

(1) First, one recognizes that goals are always involved. From a philosophical perspective one could state that without a set of goals, there is no point in even taking actions. From a construction company"s perspective it is obvious that the company must have profit as an overall goal, and completing the work on time is essential part of meeting profit goals.

(2) Second, defining process as a set of continuing systematic actions over time. The management must be executed in a systematic way, continually throughout the life of the project.

Management also means that rational decisions must be made in order to achieve the goals. The systematic method of management is namely set up to deliver accurate, timely information to the decision makers, so they can plan and control the project.

(3) Third, defining planning as deciding what tasks must be performed to accomplish the goals of the project. This means establishing realistic schedules and budgets, coordinating resources and making sure everyone knows what the plan of action is.

(4) Fourth, controlling is the final action in the management process. To achieve and maintain control, the project manager must monitor the progress of the project.

2.1.4.4 The Major Project Management Tasks

These fundamental ideas form a basis for the management practices within construction projects. The following tasks, based on the concepts above, are defined by Pierce as the three major project management tasks (Pierce, 2013):

(1) First, establishing and focusing on goals that will be general at first, then increasingly specific and job oriented as the work is planned. The project manager should set intermediate goals for the construction process, goals that meet the ultimate requirements of cost and time.

(2) Second, establishing an effective management process that will operate in a systematic way. The management system should be designed to address the following elements:

- **Time**: Establishing a plan of action to ensure the work is done in the correct order and within the time allowed.
- **Cost**: The work must be performed efficiently.
- **Resources:** Determine how much, when and where the required resources are needed (resources such as labor, equipment, or materials).
- **Finances:** Predicting the amount of funds needed to support all the work.

(3) Third, using this systematic management process to make the best possible decisions coordinating the work of the project and then continue planning and controlling the work throughout the project lifecycle. Feedback is a key to manage and control a construction projects, however, to do so the project manager must perform the following tasks (Pierce, 2013):

- **Plan:** Establishing realistic and usable schedules and budgets.
- **Communicate:** The plans must be communicated clearly and effectively to the people who will be executing them.
- **Monitor and control:** Ensure that the project goals are met and take action if necessary.

2.1.5 Traditional Construction Management Methods

In this section the traditional approach to construction management is presented. First, the underlying philosophy is addressed, and then some of the main characteristics of traditional construction management are explained.

2.1.5.1 Traditional Production Philosophy

The traditional understanding of production is to view it as a conversion process. The traditional production philosophy is described below.

A production process is a conversion of an input to an output. The conversion process can be divided into sub-processes, which also are conversion processes. The cost of the total process can be minimized by minimizing the cost of each sub-process. The value of the output of a process is associated with costs (or value) of inputs to that process (Koskela, 1992).

Figure here below illustrates the traditional view of a production process as a conversion process (Koskela, 1992):

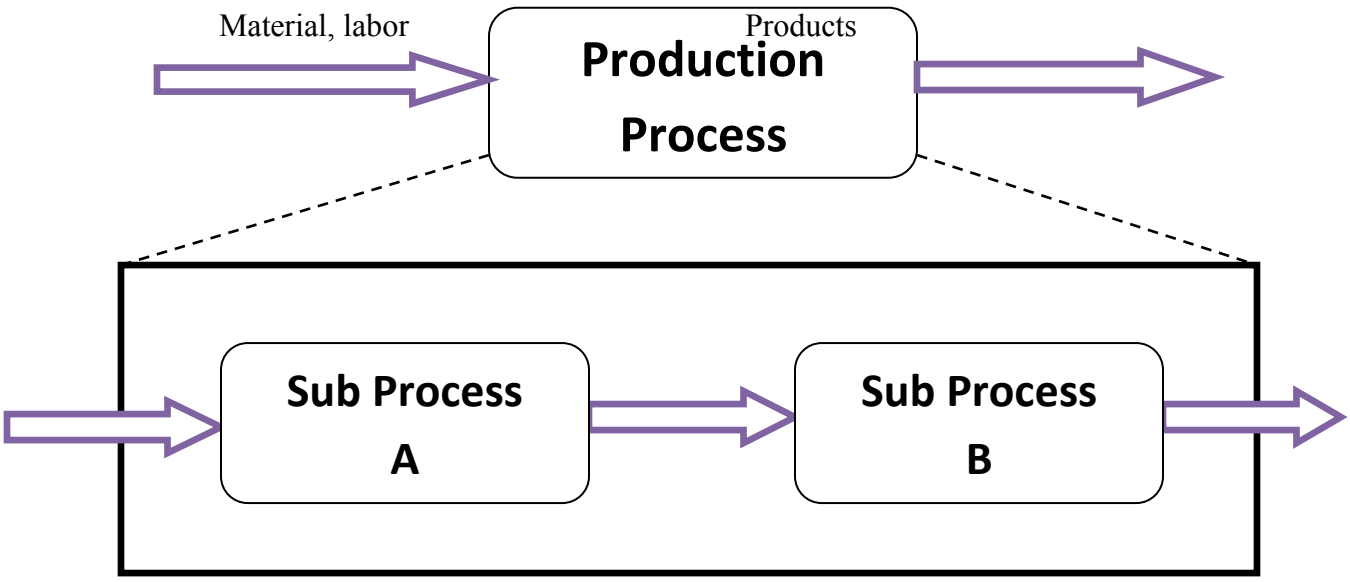

Figure 2.1 Traditional view of a production process

This model is ideal for measuring productivity, for example the ratio of output to the input in a given time period. Koskela notes that value is not of great importance in this production philosophy. He further explains that the value of the output can only be raised by using better material and more skilled specialists, the costs of which are higher.

This view of production also applies to how traditional management and organization is practiced; in fact several disciplines have used this idea as basis for understanding production (Koskela, 1992).

2.1.5.2 The New Production Philosophy

Production is a flow of material and/or information from raw material to the end product. In this flow there are four kinds of inherently different activities; the material is processed, it is inspected, it is waiting and it is moving. Processing represents the conversion aspect of production whereas inspecting, moving and waiting represent the flow aspect of production. The flow processes can be characterized by time, cost and value, where value refers to the fulfillment of customer requirements. Generally, the processing activities are the only value-adding activities. For material flows, processing activities are alterations of shape or substance, assembly and disassembly (Koskela, 1992).

Figure 2.2 graphically explains production as a flow process. The shaded boxes represent non value-adding activities whereas the white boxes value-adding processing activities (Koskela, 1992).

This new approach implies a dual view of production that consists of both conversions and flows. While all activities expend cost and consume time, only conversion activities add value to the material and/or information being transformed to a product.

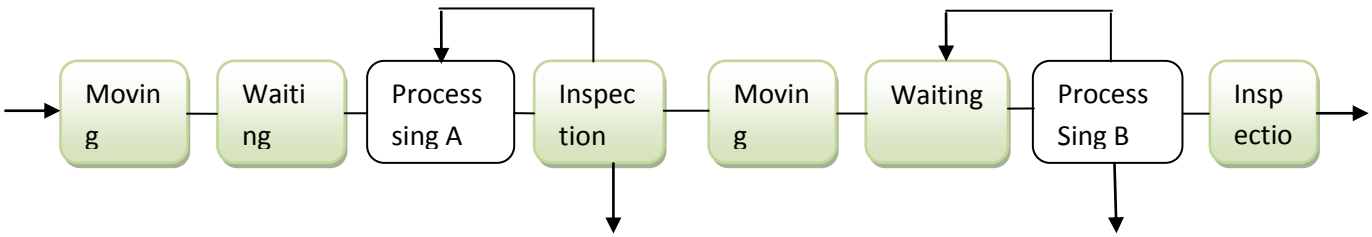

Figure 2.2 Production as a flow process (Koskela, 1992)

Therefore, the flow activities of inspecting, moving and waiting should be reduced or eliminated, whereas the conversion activity made more efficient.Lean construction has at least two foci that distinguish it from traditional construction management. One focus is on waste and the reduction of waste. The other focus is on managing flows (Alarcón, 1997).

"Lean Construction is like driving on a highway. If everybody drives at the same speed we all get there on time and a lot of traffic flows through. But if anybody goes either too fast or too slow it's those cars that mess everything up." - Greg Howell at an AGC meeting in 1993

2.2 Planning, Scheduling and Control

Mubarak (2010) explains that even though planning, scheduling, and project control are extremely important functions of construction management, it also includes components such as cost estimating and management, procurement, project and contract administration, quality management, and safety management. However, due to the limited scope of this research only planning and scheduling will be addressed in this review.

2.2.1 Planning

To begin with it is appropriate to refer to one of Kerzner‟s sayings: “Failing to plan is planning to fail” (Kerzner, 2013). In this section planning is defined.

2.2.1.1 What is planning?

Project planning can be defined in many ways. Pierce (2013) defines “Planning can be defined as deciding what tasks must be performed to accomplish the goals of the project. This means establishing realistic schedules and budgets, coordinating resources to get the work done, and most importantly, make sure everyone knows what the plan of action is.” According to Kerzner (2013) “Planning, in general, can best be described as the function of selecting the enterprise objectives and establishing the policies, procedures, and programs necessary for achieving them. Planning in a project environment may be described as establishing a predetermined course of action within a forecasted environment. The project‟s requirements set the major milestones.”

Kerzner (2013) explains that planning is determining what needs to be done, by whom, and when. Mubarak (2010) adds that planning also covers answering how, how much, why and where. Kerzner‟s nine major components of planning are:

- Objective: a goal, target, or quota to be achieved by a certain time.
- Program: the strategy to be followed and major actions to be taken in order to achieve or exceed objectives.
- Schedule: a plan showing when individual or group activities or accomplishments will be started and/or completed.
- Budget: planned expenditures required to achieve or exceed objectives.
- Forecast: a projection of what will happen by a certain time.
- Organization: design of the number and kinds of positions, along with corresponding duties and responsibilities, required to achieve or exceed objectives.
- Policy: a general guide for decision-making and individual actions.

- Procedure: a detailed method for carrying out a policy.
- Standard: a level of individual or group performance defined as adequate or acceptable.

The four basic reasons for project planning are to eliminate or reduce uncertainty, improve efficiency of the operation, obtain a better understanding of the objectives, and to provide a basis for monitoring and controlling work (Kerzner, 2013)

2.2.1.2 The Planning Process Group

The PMBOK defines the Planning Process Group as those processes performed to establish the total scope of the effort, define and refine the objectives, and develop the course of action required to attain those objectives (PMI).

The main focus area for this study is the Project Time Management. The processes within Project Time Management seek to ensure the timely completion of the project. This includes defining activities, sequencing activities, estimating activity resources, estimating activity durations, developing the schedules and controlling the schedules. The most relevant processes for this study are developing schedule and control schedule. These processes are defined as follows (PMI):

- Develop Schedule: is the process of analyzing activity sequences, durations, resource requirements, and schedule constraints to create the project schedule.
- Control Schedule: is the process of monitoring the status of the project to update project progress and managing changes to the schedule baseline.

2.2.1.3 The Project Plan

A project plan is fundamental to the success of any project (Kerzner, 2013). It is a formal, approved document that defines how the project is executed, monitored and controlled, and closed (Project Management Institute, Inc., 2013). The main purpose of applying a project plan is to document planning assumptions and decisions, facilitate communication among stakeholders, and document approved scope, cost, and schedule baselines. The project plan serves as a guideline for the lifetime of the project and may be revised as often as needed. The project plan is a standard from which performance can be measured by the customer and the project team (Kerzner, 2013). All appropriate stakeholders should be involved when planning the project and developing the project management plan and other project documents (Project Management Institute, Inc., 2013).

2.2.1.4 Successful Planning

Project planning must be systematic, flexible to handle unique activities, disciplined through reviews and controls, and capable of accepting multifunctional inputs (Kerzner, 2013). Successful project management requires planning and commitment form executives throughout the project, not just at the start (Jugdev& Müller, 2005). The project manager is the key to successful project planning. It is desirable that he/she is involved from project conception through execution (Kerzner, 2013).

No matter how hard one tries, planning is not perfect, and sometimes plans fail. Typical reasons include (Kerzner, 2013):

- Corporate goals are not understood at the lower organizational levels.
- Plans encompass too much in too little time.
- Financial estimates are poor.
- Plans are based on insufficient data.
- No attempt is being made to systematize the planning process.
- No one knows the ultimate objective.
- No one knows the staffing requirements.
- No one knows the major milestone dates.
- Project estimates are best guesses, and are not based on standards or history.
- Not enough time has been given for proper estimating.
- No one has bothered to see if there will be personnel available with the necessary skills.
- People are not working toward the same specifications.
- People are consistently shuffled in and out of the project with little regard for schedule.

In this context it is worth mentioning that the main reasons why projects are not completed on time and within cost are behavioral rather than quantitative problems. This may be due to poor morale, poor human relations, poor labor productivity and lack of commitment by those involved in the project (Kerzner, 2013).

2.2.1.5 Planning Methods and Tools

The construction culture and many of its methods have their roots in periods before explicit scientific analysis. However, various developments occurred after the Second World War, leading to strategic initiatives like industrialization, computer integrated construction, and total quality management. This also lead to improvements in operational and tactical techniques such

as project planning and control tools, organizational methods, project success factors, and productivity improvement methods (Koskela, 1992).

After the technological developments after the Second World War project management has been epitomized by tools such as Performance Evaluation and Review Technique (PERT) and Critical Path Method (CPM), Work Breakdown Structures (WBS), and Earned Value Method (EVM) (Morris, Pinto, &Söderlund, 2011). These methods are briefly explained below.

PERT is a network planning technique that applies critical path analysis to reveal interdependencies and problems that are not obvious with other planning methods. In that way, PERT determines where the greatest effort should be made to keep a project on schedule (Kerzner, 2013).

The **CPM** calculates the theoretical early start and finish dates, and late start and finish dates, for all activities without regard for any resource limitations. This is done by performing a forward and backward pass analysis through the schedule network. The resulting early and late start and finish dates indicate the time periods within which the activity could be scheduled, given activity durations, logical relationships, leads, lags, and other known constraints (Project Management Institute, Inc., 2013).

The **WBS** breaks the work down into smaller elements. It is a product-oriented family tree subdivision of the hardware, services, and data required to produce the end product. It is structured in accordance with the way the work will be performed and reflects the way in which project costs and data will be summarized and eventually reported. When preparing the WBS one also considers other areas that require structured data, such as scheduling, configuration management, contract funding, and technical performance parameters (Kerzner, 2013).

The **EVM** is a method of performance measurement. It integrates project scope, cost, and schedule measures to help the managers assess and measure project performance and progress. It requires the formation of an integrated baseline against which performance can be measured for the duration of the project. EVM develops and monitors three key dimensions for each work package and control account, namely: Planned Value, Earned Value and Actual Cost (Project Management Institute, Inc., 2013).

These tools and techniques were developed by and for practitioners who needed them to improve the efficiency of project implementation (Morris et al., 2011). These so called traditional tools

and techniques are widely recognized in the field of construction management and are applied to manage construction projects up to professional standards (Pierce Jr. 2013).

CCPM

Critical Chain Project Management (CCPM) was first introduced by EliyahuGoldratt as a new method of managing projects at the International Jonah Conference in 1990 (Bevilacqua et al., 2009). It remained unexplored until he decided to repeat his success in writing "The Goal" business novel in 1984, this time with "Critical Chain" in 1997. In his book, Goldratt extended the principles of the Theory of Constraints (TOC) to project management. TOC was based on the principle that every system has a constraint that prevents it from reaching higher levels of performance and the only approach to improve the system performance is to enhance the capacity of that constraint. With regard to CCPM, this unique constraint in single project environments is the longest chain of activities in the project network, taking into account both activity precedence andresource dependencies (critical chain) and in multi-project environments is the resource impeding projects‟ earlier completion. Goldratt (1984, 1997) provides a 5-step procedure for the process of ongoing improvement (identify the constraint, exploit the constraint, subordinate other non-constrained entities to the constraint, elevate the constraint, return to step one if the constraint is changed). CCPM also suggests estimating activity durations to their 50% probability of being completed on time and consider a buffer (project and feeding buffers) at the end of each chain of activities to allow for uncertainties. There are also some other buffers, namely resource buffer, drum buffer, capacity buffer and cost buffer. Some other characteristics are that it is completely against multitasking, does not consider activity due dates and schedules non-constraint activities to their latest start.

CCPM is not a holistic approach towards managing projects and is more a scheduling method addressing schedule-related aspects of projects. It only includes human aspects in terms of scheduling activities and not related to leadership, project governance and communication. These aspects should be addressed through TOC philosophy or Lean principles, as explained in the TOC Handbook (Cox and Schleier, 2010). As it is outside the scope of this study to explain in more detail the principles of CCPM, readers are encouraged to read the CCPM classic book by Leach (2014) for a comprehensive explanation.

Graphical Evaluation and Review Technique (GERT), one of the intriguing techniques used for network-based management.It is a stochastic network technique and has many advantages

over the conventional Critical Path Method (CPM) and Program Evaluation and Review Techniques used for project management. The formulation of the GERT network for linear situation can be development by analytical techniques (such as signal flow graph theory); thus for a non-linear and other complex conditions, the Q-GERT (included Queuing Concepts) is used.

2.2.1.6 The (40/60) Construction Planning Process

The planning process of 40/60 projects are based on experiences from other similar projects, such as the Lideta site condominium project. However, from this experience the planners did only the change of the typology of the projects and did not have sufficient data and scope of the project. The optional cost and the project completion time is decided by the client (AASHDE). The contract type is fixed unit prices contract with registered eligible contractors.

2.2.2 Scheduling

2.2.2.1 What is Scheduling?

The two terms, planning and scheduling, are often thought of as synonymous. However, they are not. Scheduling is just one part of the planning effort. Mubarak explains that schedules are the result of asking "when" during planning (Mubarak, 2010). Scheduling is part of the Project Time Management process and defined"…the process of analyzing schedule activity sequences, schedule activity durations, resource requirements, and schedule constraints to create the project schedule". (Project Management Institute, Inc., 2013). "Scheduling is the determination of the timing and sequence of operations in the project and their assembly to give the overall completion time." (Mubarak, 2010)

The purpose of scheduling is to provide a "roadmap" that represents the delivery of the project scope over time as defined by the project team (Project Management Institute, Inc., 2013). Kerzner explains that a schedule is a plan showing when activities or accomplishments will be started and/or completed. The primary objective of scheduling is to coordinate activities to complete the project with the: best time, least cost and least risk (Kerzner, 2013).

2.2.2.2 Developing Schedules

This subsection describes the process of developing a schedule, based on a practice standard developed by The Project Management Institute. The initial steps are selecting a scheduling method and a scheduling tool. The schedule model is formed as specific project data is inserted

into the scheduling tool. The model is then used to generate (print) project schedules. These aspects are explained separately below:

The scheduling methods provide the framework which schedule models are developed. The scheduling tool provides the means of adjusting various parameters and components that are typical in a modeling process.

The scheduling tool includes the capability to:

- Select the type of relationship, such as finish-to-start or finish-to-finish,
- Add lags and leads between activities,
- Apply resources,
- Add constraints,
- Capture a specific schedule as a baseline or target schedule,
- Change various parameters within the schedule model such as imposing a different project completion date in an attempt to shorten the overall project duration to analyze the impact that these changes would have on the project schedule, and
- Compare the most recent schedule against the previous one or against a target or baseline to identify and quantify trends or variances.

By inserting specific project data, such as activities, durations, and resources into the scheduling tool the schedule model is created. The schedule model then produces project schedules, which contains the planned dates for completing project activities. In this way the schedule model provides a tool for analyzing alternatives. Once this model is developed, it should be updated on a regular basis to reflect progress and changes (Project Management Institute, 2007). This practice standard refers to the scheduling engine populated with project data as the schedule model. However, in general practice the printed schedule and the schedule model are both referred to as the schedule (Project Management Institute, Inc., 2013).

2.2.2.3 Types of Schedules

There are different types and formats of schedules. Examples of schedule formats are milestone charts, bar charts and project schedule network diagrams. These formats are briefly described as follows (PMI):

- A milestone chart is similar to bar charts, but it only identifies the scheduled start or completion of major deliverables and key external interfaces.

- A bar chart represents activities by applying bars which show activity start and end dates, as well as expected durations. Bar charts are relatively easy to read, and are frequently used in management presentations.
- A project schedule network diagram with activity date information, usually show both the project network logic and the projects critical path schedule activities.

2.2.2.4 The Tripod of Good Scheduling

Mubarak"s tripod of good scheduling system describes three important factors to consider when scheduling. He states that if anyone of the three "legs" is missing, the system will fail. The tripod of good scheduling system is defined as follows (Mubarak, 2010):

(1) The Human Factor: A proficient scheduler or scheduling team that understands the concepts, definitions, and applications or project scheduling.

(2) The Technology: A good scheduling computer system (software and hardware) along with IT support.

(3) The Management: A dynamic, responsive, and supportive management that believes in the use of scheduling as part of the management effort.

Kerzner explains that every scheduling technique has its advantages and disadvantages. However, there are some scheduling problems that can impact all scheduling techniques. These include (Kerzner, 2013):

- Using unrealistic estimates for effort and duration,
- Inability to handle employee workload imbalances,
- Having to share critical resources across several projects,
- Overcommitted resources,
- Continuous readjustments to the WBS primarily from scope changes, and
- Unforeseen bottlenecks.

Moosavi and Moselhi (2012) developed a schedule assessment criteria based on best practices for construction scheduling, which was developed using extensive review of schedules and expert input from scheduling professionals. The list of criteria was compiled under three categories as shown in figure 2.3.

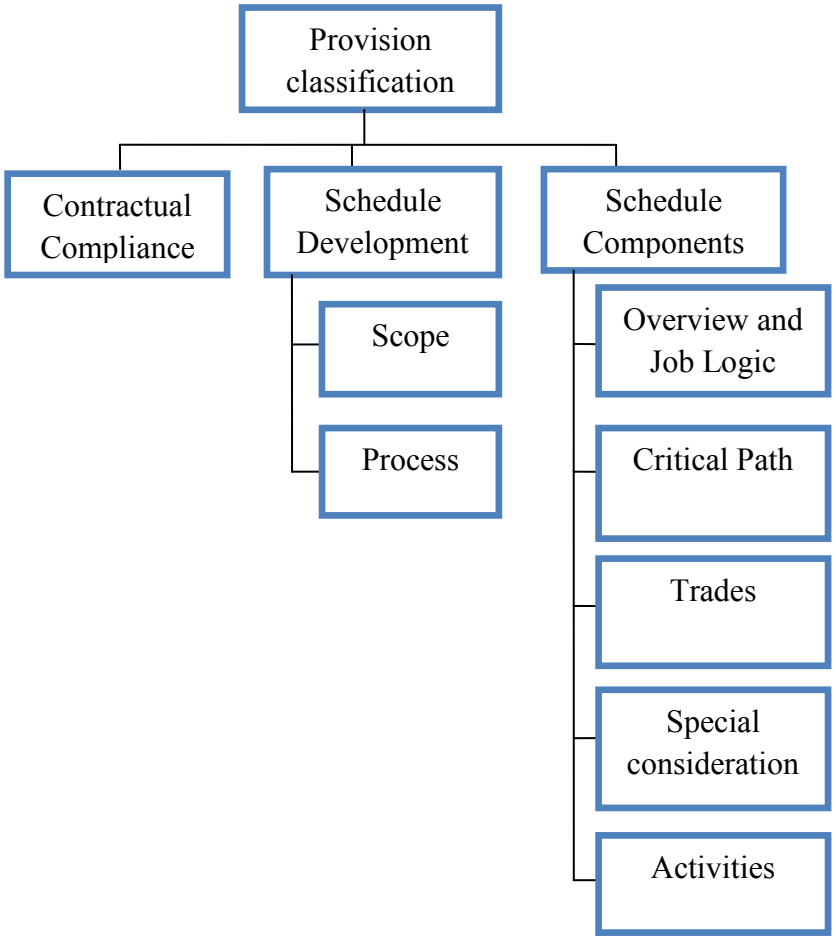

Figure 2.3 Criteria classification

Contractual compliance

The most important criteria each schedule should satisfy are contractual provisions. These provisions could be considered as obligatory criteria because if submitted schedules are not in conformity with the contract, whether or not other criteria are satisfied, the schedule should not be accepted. Although such criteria seems obvious, it is the basic reason for rejection of many schedules (Li and Carter, 2005; Zartab and Rasmussen, 2001).

Schedule development

This category encompasses the criteria that are directly related to the process of schedule development. Five provisions have been divided into two different sub categories; scope and process. Applying these provisions help users to assess the process of schedule development. These provisions are frequently overlooked although they were highlighted and stressed in several publications. For instance, a criterion which is called “Subcontractors Participation” was indicated in various references (De La Garza, 1988; Zack Jr., 1991). Even some references

suggested a provision in some contracts requiring subcontractors to sign off on the schedule as verification of their commitment to the scheduled dates (Li and Carter, 2005). The same provision was suggested in another reference intended to prevent contractors from elimination of certain activities and from using unrealistic durations to submittals for review (Zack Jr., 1991). This kind of repetition for a single provision in different references has been noticed for numerous criteria.

Schedule components

The last category is schedule components covering thirty five provisions, divided into five sub categories. Schedule components category encompasses all quantitative provisions that pose some thresholds on numeric schedule components. These criteria are described subsequently in the developed computer application. Importance of quantitative criteria, such as threshold values, lies in its speedy processing using the developed computer application. Some part of schedule review knowledge is generic and some part idiosyncratic. Although the thresholds of quantitative provisions are retrieved from published material, they are not cast in stone. They can be considered as initial suggested values. Therefore firms are encouraged to develop their own database of projects in order to modify the proposed thresholds to suit their idiosyncrasies of their specific needs. A complete list of extracted provisions is presented in table 2.2.

Table 2.2 Schedule assessment and evaluation criteria (Moosavi and Moselhi, 2012)

No.	Element	Explanation	References
i. Contractual Compliance			
1	Milestones & Project Duration	Milestones & project duration must be in line with related contractual provisions.	Spencer and Lewis 2006, De La Garza 1988
2	Phasing and Sequencing	Phasing and sequencing must be in line with related contractual provisions (if applicable).	Li 2005
3	Number and Duration of Activities	Number and duration of activities must be in line with related contractual provisions (if	Li 2005

No.	Element	Explanation	References
		applicable).	
4	Activity Code	Activity code must be in line with related contractual provision (if applicable).	Li 2005
5	Schedule Submission Date	Schedule submission date should be in compliance with related contractual provision.	Zack 1991
6	Scope Coverage	Scope of the project should be covered by schedule	Douglas 2009-b, GAO 2009, PMI 2007, Li 2005
1.2 Job Logic			
7	Job Logic	Job logic must be rational.	O'brien and Plotnick 2010, Douglas 2009-b , GAO 2009, De La Garza 1988
1.3 Duration			
8	Activity Duration (reasonability)	Activity duration must be reasonable.	O'brien and Plotnick 2010, Douglas 2009-b, GAO 2009
ii. Schedule Development			
2.1 Scope			
9	Project Scope Definition	All aspects of project scope should be adequately defined before scheduling	PMI 2007
10	WBS Verification	Scheduling should be based on an approved WBS	PMI 2007

No.	Element	Explanation	References
2.2 Process			
11	Scheduling Process	Schedule should be developed by participation of parties associated with the project	Li 2005
12	Subcontractors Participation	Subcontractors responsible for considerable parts of project should become involved in schedule development having their work integrated and coordinated.	Li 2005, Zack 1991, De La Garza 1988
13	Verification of Subcontractors‟ Scope of Work	The schedule should reflect the start and completion dates for prime contractors involved	Douglas 2009-b, De La Garza 1988
iii. Schedule Components			
3.1 Overview			
14	Verification of Project Duration	Project duration should conform with parametric scheduling results	Moselhi 2010
15	Minimum Milestones	At least two milestones, start & end, should be included in each schedule	PMI 2007
16	Verification of Project Performance	Generated S-Curve should be in compliance with typical S-curves	De La garza1988
17	Phase Duration	Each phase duration (Engineering, procurement, ...) should be in compliance with historical average data according to Total Installed Cost	Madl 2010
18	Phase Overlap	Engineering should not overlap construction by more than a	Madl 2010

No.	Element	Explanation	References
		percentage	
19	Calendar Verification	Non-working days should be indicated in the project calendar	Douglas 2009-b, Li 2005
20	Working Hours Schedule-Estimate Compliance	Basis of scheduling should be in compliance with basis of estimate as regards working hours	Madl 2010
21	Congestion Index (labor density)	Maximum number of workers per square meter should be limited to avoid congestion (25 to 30 sqm/man) (200sqf/person, Kerridge and Vervakin, Bent)	Russell and Udairpurwala 2000, Bent 1996, Kerridge and Vervakin 1986
3.2 Critical Path			
22	Critical Path	Each critical activity should have a predecessor reflecting a physical dependency	O'brien and Plotnick 2010
23.1	Schedule Criticality rate.1	Number of critical activities/ total number of activities should be limited	O'brien and Plotnick 2010, De La Garza 1988
23.2	Schedule Criticality rate.2	Duration of critical activities / total duration of activities should be limited	Spencer and Lewis 2006
24	Near criticality rate	Number of near critical activities/total number of activities should be limited (near critical activities: TF<5 to 10)	O'brien and Plotnick 2010
25	Project Effort Ratio	Project critical path effort(number of laborers)/ total project effort should be within a min/max range	Spencer and Lewis 2006

No.	Element	Explanation	References
26	Project Cost Ratio	Project critical path cost/ total project cost should be within a min/max range	De la Garza 1988
3.3 Resources			
28	Resource Loading	Schedule should be loaded with resources	Madl 2010, Griffith 2005, Glenwright 2004, Zack 1991
29	Responsibility Assignment	A responsible party/person should be assigned to each activity	PMI 2007, De la Garza 1988
30	Schedule Leveling	Schedule should be leveled	GAO 2009, Douglas 2009-b
31	Trades' Peak Resource Loading	Compliance of peak resource loading of each trade with historical average data according to total installed cost and phase duration	Madl 2010
32	Trades' Peak Resource Loading relation	The relationship between various trades' peak resource loading should follow the historical average trend according to total installed cost and phase duration	Madl 2010
33	Trades' Rate of completion per week	Compliance of each trade‟s progress curve with historical (typical) average Data according to total installed cost and phase duration	Madl 2010
34	Peak to average labor ratio	Peak to average number of laborers for each trade should comply with the average historical	Madl 2010

No.	Element	Explanation	References
		data according to total installed cost and phase duration	
3.4 Special Considerations			
35	Permits & Environmental Remediation	Permits & environmental remediation should be included in the schedule (if applicable)	Nabros 1994, De La Garza 1988
36	Startup and Testing Activities	Start up and testing activities should be included in the schedule (if applicable)	Douglas 2009-b, Zack 1991
37	Submittal Activities	Material and/or methods requiring prior approval must have their submittal activities in the network	De la Garza 1988
38	Submittals Review Activities	Submittal reviews to be reflected in schedule as an activity	Fredlund and king 1992, Zack 1991, De La Garza 1988
39	Procurement Activities	Procurement activities should precede special installation tasks	De la Garza 1988
3.5 Activity Attributes			
40	Number of Constraints	Number of constraints on activities start and finish should be limited	GAO 2009, Spencer and Lewis 2006, Dzeng et al. 2005
41	Lag Duration	Should not be greater than the duration of Predecessor or Successor activity	Winter 2010

No.	Element	Explanation	References
42	Relationship Ratio	Total number of relationships/Total number of activities, should be limited	O'brien and Plotnick 2010, Spencer and Lewis 2006
43	Activity without Affiliation	No open ended activity is allowed(activity without predecessor or successor)	Madl 2010, Li 2005, Winter 2010, Berg et al. 2009
44	Number of Activities	If number of activities has not been indicated in the contract, it has to be within a min/max range	O'brien and Plotnick 2010, De La Garza 1988
45	Activity Float	Activities with excessive Total Float should be avoided	Li 2005, Dzeng et al. 2005, Berg et al. 2009, De La Garza 1988
46	Negative Float	No activity with negative float is allowed	Madl 2010, GAO 2009, Berg et al. 2009, Winter 2008
47	Weather Sensitive Activities	Special measures should be taken for this type of activities (e.g., Adjusting productivity according to seasonal conditions)	Douglas 2007, Li 2005, Dzeng2004, De La Garza 1988
48	Activity Duration (rules of thumb)	Activity duration should be limited to certain days	Berg et al. 2009, PMI 2007, De La Garza 1988

2.2.2.5 Baseline and Constrained Scheduling

A baseline is a complete copy of a project plan that you can compare to the current schedule to evaluate progress.The simplest baseline plan is a complete copy or "snapshot" of the original schedule. This snapshot provides a target against which you can track a project"s cost, schedule, and performance. The as-planned schedule, or the *baseline schedule*, outlines a contractor"s original understanding and plan of action for a project. To provide a complete overview of the project scope, the "baseline" should include all aspects of the project, including all subcontracted work. Detail must be enough to measure progress and quantify impacts, but operations are often generalized at a summary level. Placing too much emphasis on minute detail in this stage of scheduling may result in large concepts being missed (Clough et al. 2000).

The constraints can be either external, such as required phase and contract completion dates, or internal, such as one activity may not begin until another activity is complete. External constraints can be considered those restrictions placed on a project from outside the project management organization or the project itself. One typical example of an external constraint would be a required delivery date or contract completion date. Internal constraints are considered to be those imposed by the project manager for business reasons or as a result of professional judgment. Examples of these types of constraints are how many people to assign to a particular task, or the order in which to accomplish tasks.

2.2.2.5.1 Time Constrained Resource Scheduling

Time constrained resource scheduling is one of the two basic resource scheduling procedures performed by the majority of scheduling software. The starting point for time constrained resource scheduling is a CPM network of a project for which the forward and backward passes have been completed. Each activity is then assigned its required resources based on unlimited availability of the required resources. Each activity can then be moved or slid within its available free and total float in order to minimize the changes in required resource levels between time periods. The process is carried out for each non-critical activity in the project for the simple reason that the critical activities have no float. Any change in the scheduling of a critical activity would either violate the relationships between the activities or delay the early finish of the project. In time constrained resource scheduling there are no set limits on the amount of resources available. The only hard criteria are that the fixed completion of the last activity not be delayed (Seibert and Evans 1991).

2.2.2.5.2 Resource Constrained Resource Scheduling

The second basic resource scheduling procedure, as with the procedure for time constrained resource scheduling discussed above, resource constrained resource scheduling begins with a resource loaded CPM diagram with the relevant calculations of early and late, start and finish, and free and total float completed. For resource constrained resource scheduling the early finish of the last activity is not fixed or locked. Rather the total amount of a resource or resources available is given a set maximum amount available per time period. Hence the terminology, resource constrained resource scheduling. The maximum available limit of a resource may be constant over the duration of a project, or in some cases, variable with time. The limits imposed may be the result of actual resource availability or management decisions. Once the resource limits are set the project is rescheduled one activity at a time. When there are insufficient available resources to accomplish a given activity it must be postponed until the resources are available. There are two basic variations on these rules which should be considered. The first allows for an activities total duration to be adjusted without changing the total required resources to complete the activity. This is commonly referred to as effort driven scheduling. The name derives from the fact that the anticipated effort and available resources determines activities duration. The second variation is to allow activities to be temporarily suspended or interrupted to accommodate resource requirements in other, more critical activities. This is commonly referred to as splitting an activity (Drexl and Gruenewald 1993; Oguz and Bala 1994).

2.2.2.6 An As-Built Schedule

As new schedules of record are updated and modified, they are forming the basis of what will be referred to as the *as-built* schedule a final documentation of actual starts and finishes of activities, any delays, change orders, extra work, weather, and other factors that affected project completion. As-built activities should correspond to those of the baseline schedule, although it may be necessary to account for changes in activities and logic. The as-built is an accurate historical representation of the actual sequence of construction and how it was completed. Project timing, sequence, and logic are developed through daily recording of various information, coming from an array of sources such as contract agreement, weekly report, monthly reports and by site observation decide which work is done, on progress and unfinished. Further, developing a list of problems, disputes, changes, and delay causing events, along with accompanying dates, can be arranged in chronological order and then plotted on the as-built in

order to visualize the delaying events in the context of project history (Bramble et al. 1990). Changes and delays are incorporated into the as-built through addition or alteration of appropriate activities.

2.3 Scheduling Tools

Most construction contracts for construction projects require periodic schedule updates. A schedule update is an assessment of the project status and prediction of how and when the project will be completed. Proper updating of the work schedule is an integral part of project management and a critical communication tool between the parties. The schedule update should reflect the current plan to reach project completion and an accurate record of the past performance. The major steps in updating a schedule involve (Paul E. Harris):

1. Setting a baseline
2. Updating the schedule
3. Comparing schedule updates.

These steps are common to every software package and considered a regular course of business for construction schedulers. Microsoft Project Planner, Primavera, Project.net, Basecamp, Gantt Project, Genius Inside, Liquid Planner, Micro Planner X-Pert, Naval Plan, Open Proj, Open Workbench, Etc.. this all are used for scheduling purposes but in our context the Microsoft Project is used. Microsoft Project Planner (MSP) has many unique features specifically designed to make using the software simple. However when it comes to updating a schedule using MSP, construction schedulers often find MSP extremely confusing. This is mainly due to the MSP"s „ease of use features" getting in the way of reflecting the consequences of the current status. It gets even more complicated if you ever have to do a forensic delay analysis on a MSP schedule. A clear understanding of how MSP calculates a schedule will make it possible to properly use MS Project in place of a Primavera product, if needed.

Microsoft Project is a project management software program developed by Microsoft. The first commercial version of Project was released for DOS in 1984 and the first Windows version-was released in 1990. Microsoft Project can do:

- Designed to assist project managers in developing plans, assigning resources to tasks, tracking progress, managing budgets and analyzing workloads. They can also help to schedule a project"s resources,

- The application creates critical path schedules, and critical chain which can be visualized in a Gantt chart.

Based on data entry and once configured, user enters data and MSP can automatically:

- Computes all times and costs
- Identifies Critical Path, computes late & early start dates, slack
- Computes % complete on a task and project level
- Identifies areas of over-tasking of resources
- Draws a wide ranges of charts and graphs specific to the project
- Creates a wide range of reports specific to the project

2.4 Common Problems with Project Schedules

A project schedule typically is intended to model the execution plan of a contractor in performing a scope of work for an owner over a specified period of time. In order for a project schedule to model the execution plan, it must accurately reflect the scope of work, have a sufficient detail to monitor progress, and contain activity delays have been incorporated into the schedule. It is the completion date forecasting and delay monitoring capability of a properly prepared project schedule that makes it such a valuable tool, allowing management insight in to the effect of delays. Management can then make timely decisions to address and mitigate the delays.

Therefore, it is important when evaluating the quality and reasonableness of project schedules to look for deficiencies in the areas of work scope, activity durations, and activity sequencing. The schedule quality assurance procedures described below can help to identify potential schedule deficiencies and correct common problems. (Andrew Avalon, P.E., and Curtis W.Foster, 2010)

2.4.1 Schedule Quality Assurance Procedures

First, the project schedule should be reviewed to ensure that the complete scope of work is represented in the schedule. Next, schedule metrics should be calculated and compared to industry norms. Then, the schedule logic should be reviewed in detail to ensure that the logic is reasonable and complete. Lastly, the project schedule critical path should be identified and reviewed in detail. The findings from each of these examinations can then be compiled in a report to serve as a guide for schedule improvement or correction if necessary.

The comparison of a completed or in-progress schedule to an earlier progress update or baseline schedule will reveal changes made to the schedule. These changes can identify adjustments in

the plan, changes in the scope, or mitigation efforts to overcome a delay, which should be reviewed when evaluating the quality of a schedule.

2.4.1.1 Scope of the Project Schedule

To effectively evaluate a project schedule to determine if it accurately reflects the project scope of work, the reviewer must understand the project scope. The project contractual scope of work is usually identified in project documents such as the project contract, drawings, and specifications. Large complex projects are generally divided up into areas or units. The reviewer should be familiar with the industry sector for the project to ensure a complete work scope review. A list or work breakdown of the activities or tasks required to achieve the contractual scope of work should be compiled.

2.4.1.2 Schedule Metrics Comparison

Schedule metrics can be compiled and calculated from a review of the individual schedule activities and activity characteristics. The process for this type of analysis starts with the export of all activities and activity data to a database or spreadsheet. A table of activity characteristics is created where one record or row in the spreadsheet contains all relevant information about an individual schedule activity. This table should at a minimum contain the following activity data for each activity:

- Activity ID
- Activity Description
- Activity duration information
- Activity type
- Activity status
- Activity percent complete
- Activity dates
- Activity float
- Activity constraints
- Activity resources
- Activity codes

This table can then be reviewed and analyzed to generate various schedule metrics. A listing of several of these schedule metrics along with an explanation of the procedure used to compile each metric from the activity data follows below.

- Activity type summary

Proper evaluation of project schedule metrics requires knowing what type of schedule activities are being reviewed, compiled, and tabulated. Schedules generally have a mix of task activities, start and finish milestones, and hammock activities. This metric sums the total number of task, milestone, and hammock activities. Hammock activities are generally not used in the calculation of other schedule metrics. In fact, most schedule metrics are calculated using only the task type of activity.

- Activity status summary

Various schedule metrics calculations are made on groups of activities depending on the status of the individual activity. Whether or not that activity is complete, in progress, or not-started can determine if the activity is included in the calculation of a particular metric. This metric sums the total number of complete, in-progress, and not-started activities.

- Number of activities per month cycle time

To compile this metric, the span of the schedule is documented from the start of the first task activity to the completion of the last task activity. Analysis of this metric involves totaling the number of task activities in progress during each month of the project, based on actual and early activity dates. This information can then be grouped by project phase or other pertinent factors, reviewed, and presented graphically to reveal if the activity detail balanced over the course of the project. Sometimes projects have a tendency to be more detailed in the beginning, the more general and less detailed in the later stages of project.

- average activity remaining duration (days)

The average activity remaining duration metric excludes completed work. The remaining duration for all tasks is summed and divided by total number of tasks activities that are in-progress or not started.

- Number of activity calendars

The schedule calendar definitions are reviewed and then activity table is evaluated to identify which calendar is applicable to each activity. Evaluation are made of the calendar usage as to whether the calendar assignment is reasonable based on where each task is performed and which project resource or resources are assigned to complete the work.

- Number of constrained activities

The activity table should be reviewed for information relating to activity dates and float constraints that can affect the forecasting ability of the schedule. Activities are identified that have constraints and the type of constraints, this information is tabulated and analyzed. The improper use of constraint may affect total float values and potentially and analyzed. The improper use of constraints may affect total float values and potentially distort the critical path of the project. Constraints can also control which activities are impacted by delays or changes. Mandatory start or finish constraints prevent the schedule from responding to change or delays. The reasoning for the use of these constraints should be explored and other constraints or logic ties considered that are not restrictive to float calculations.

- Resource loading

The project schedule is reviewed to determine whether activities have been resource loaded. If resources have been used in the schedule, there are a number of metrics that can be calculated and reviewed. For example, the review can tabulate the different resources? Has resources leveling been utilized in the schedule?

- Metrics for in-progress schedules

If the project schedule reviewed is a status update, there are additional metrics that can be calculated to reveal potential problem. Two of these are described below.

  - Planned duration vs. actual duration check

This metric review completed task activities. A review of the planned duration compared to the actual duration of individual activities reveals activities that were delayed in completion. A review of how many of the completed activities in an area of phase of the project can reveal problems that should be investigated. The calculation of the average activity actual duration divided by the average activity planned duration may a trend regarding the forecasting accuracy of the schedule.

  - Percent complete vs. remaining duration analysis

This metric reviews in-progress task activities. The percent complete versus remaining duration check is used to activities that may show incorrect progress reporting. Typically, the percent complete value is linked arithmetically to the remaining duration value, where: percent complete = (OD-RD) / OD *100.1 A review of these value in the activity table will identify activity where percent complete or the remaining duration is not consistent with this calculation.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

This chapter explains the choice of research methodology for this research. It begins with an overview of the general approach and methods used in the research. The focus of the research is identifying major elements of construction management practices in the city government of Addis Ababa 40/60 saving houses of construction projects. The choice of the mixed research method is justified as an appropriate research strategy.

3.2 Fundamental Concepts

Progress in almost every field of science depends on the contributions made by systematic research; thus research is often viewed as the basis of scientific progress. Broadly defined, the purpose of research is to answer questions and acquire new knowledge. Research is the primary tool used in practically all areas of science to expand the limits of knowledge ((Marczyk et al., 2005) quoted in Getaneh (2011)). Besides, Kumar (2011) described research as one of the ways to find answers to questions, whereas, Abiy*et al* (2009) described research methods as specific research tools (surveys, interviews and case studies) that are used in research projects to gain full understanding of phenomena.

In the other hand, research methodology is a way to systematically solve the research problem and it shall identify the research basis, research questions and research analysis (Kothari, 2004).Abiy*et al* (2009) described research methodology as "the theory of how inquiry should precede"that "involves analysis of the principles and procedures in a particular field of inquiry." This involves the researcher‟s assumptions about the data collection methods and analysis strategy.

This research was conducted and inquiries were made to identify major elements of project planning and scheduling of the major construction parties in the case of city governance of Addis Ababa 40/60 saving houses of construction projects. Accordingly, this chapter covers the research methodology followed to achieve the ultimate goal of the research to draw up findings in a way to make conclusions and to forward recommendations.

3.3 Research Design, Approaches and Methods

Kumar (2005) described a research design as a procedural plan that is adopted by the researcher to answer questions validly, objectively, accurately and economically. According to Kumar (2005), the following two objectives need to be fulfilled in a research design:

1. To conceptualize an operational plan and to undertake various procedures and tasks required to complete the study.

2. To ensure that these procedures are adequate to obtain answers to the research questions. Research strategies can be broadly categorized as either quantitative or qualitative. Quantitative research is objective in nature (Johnson and Harris, 2002). It usually requires respondents to record their attitudes, opinions, or beliefs on different-point scale measured with numbers (Krosnick and presser, 2010). Three main approaches were suggested to collect the data: asking questions of respondents by means of questionnaires and interviews, undertaking experiments and performing extensive reviews of the relevant literature (Johnson and Harris, 2002). On the other hand, qualitative research is subjective in nature (Naoum, 2007). It relies on observing people in their own environment, communicating with them in their own language, and on their terms. Case studies are the major types of qualitative study. In addition, a research study using both qualitative and quantitative approaches can be called a "mixed-methods" approach (Creswell, 2009).

Creswell and Borrego describe three research approaches: qualitative, quantitative and mixed methods (Creswell, 2013; Borrego, Douglas, &Amelink, 2009). The following definitions are based on their description:

Qualitative research is an approach for exploring and understanding the meaning individuals or groups ascribe to a social or human problem. It"s fitting for inductive approaches to data analysis. Olsson &Sörensen (2003) explain that inductive reasoning is based on discoveries from reality which then leads to laws and theories.

Quantitative research is an approach for testing objective theories by examining the relationship among variables. It"s fitting for deductive approaches, where a theory or hypothesis justifies the purpose statement and the direction of the narrowly defined research questions. Olsson &Sörensen explain that deductive reasoning is based on a theory, but presents an assumption about reality in a hypothesis (Olsson &Sörensen, 2003).

Mixed methods research is an approach to inquiry involving collecting both qualitative and quantitative data, integrating the two forms of data.

After careful consideration a mixed approach was evaluated as the best fitting approach for this research, based on the nature of the research questions. The reason for this decision is better explained in the next sections.

3.4 Research Methodology Employed in This Study

3.4.1 Selected Research Approach Type

This research concerns both qualitative and quantitative characteristics, which are explained below:

1. Quantitative aspects of this research:

- The objective of this research is concerned with the identification of major project management problems among the major construction parties in the City government of Addis Ababa 40/60 saving houses of construction projects using different-point scale measured with numbers.

2. Qualitative aspects of this research:

- Investigation on project management problems in the Addis Ababa 40/60 saving houses of construction projects using the case study. These are featured with qualitative elements. Interviews and case studies appear to be more appropriate for capturing such relevant information in this study.
- The project management problems among construction parties can be identified by selected case studies of Addis Ababa 40/60 saving houses of construction projects. This again depends on an overall understanding of the project planning and scheduling in the whole process of a construction projects.

Therefore, in this research, mixed-method research seems to be appropriate and is helpful in gaining a better understanding through an in-depth study of the new phenomenon based on its qualitative and quantitative aspects of the study.

3.4.2 Selected Research Methods

The approach to data collection should be based primarily on the nature of the investigationand on the type of data and information that are required. The objective of this study is toidentify the elements of the project planning and scheduling of contractors submitted by the contractors, consultants, clients and regulatory body. This could be met by employing a diverse range of methods tocollect applicable data. This included observation, interviews, and case studies.

3.4.2.1 Case Study Designs

As the case study aimed to identify potential challenges towards the elements of project management n 40/60 saving houses development enterprise, specifically taking project planning and project scheduling, an in depth analysis of the how they plan and schedule, how they asses

the plans and schedules submitted by the contractors". The case study can be described as being of revelatory character, meaning that the researcher got a special opportunity to investigate the problem within the organization while participating in daily work. The researcher thus got access to a wide range of documents and information that elsewhere wouldn't have been accessible and was furthermore able to learn more about, and observe the problem from within the researched context. The case study was supported by interview, document collection and participatory observations.

3.4.2.2Data Collection

As previously mentioned, case studies do not need to be limited to a single source of evidence. In fact, good cases studies usually rely on a variety of sources. Yin (2009) mentions six sources case study evidence may come from, i.e., documents, archival records, interviews, direct observation, participant-observation, and physical artifacts. This study applies three sources in data collection, namely: interviews, direct observations and documents.

3.4.2.2.1 Interviews

Interview is one of the primary data collection methods which are flexible and adaptive way of investigating underlying motives of a subject in a way that visual observation cannot (Odur, 2005). This type of interview has a predetermined set of questions (generalized form of questionnaire) with a flexible order depending on what the interviewer perceives the subject matter by looking at the respondent capability and exposure or experience. The interview undertaken for this thesis was based on study of the problems on

The semi-structured approach to the interviews and the open ended questions were chosen because they would allow the individuals to discuss and share their own opinions, while the researcher will adapt the questions to the interviewee"s relative level of understanding of the investigated topic. The conversation was always started with the researcher defining the concept of project management in construction industry. The researcher recorded the conversation and also took notes. Whenever there were additional questions or a need for clarification, the researcher got in contact with the interviewees directly in person.This gave the interviewees the chance to go outside of the investigators line of questions, if they felt the need to come across information they weren't directly ask for. An interview guide was made for each interview. A summary of the interview guides can be found in appendix. Key personnel form the client and contractors were interviewed at each project.

3.4.2.2.2 Direct Observations

The researcher participated in daily work by working as an intern within the researched organization and thereby was able to observe situations meaningful for the research. The participation lead to informal talks about the topic as well as showed examples of real time challenges related to project planning and scheduling.

Direct observations are when the investigator has the opportunity to observe a "case" in its natural setting within a case study. The advantage of using observational evidence is that it often provides additional information about the topic being studied. The observations can be so valuable that one may even consider taking photographs at the site. Unfortunately the resources did not permit multiple observers in this study. Both formal and casual observations were applied in this research, formal observations during various meetings and casual observation throughout the field visits, during and in between the interviews and meetings.

3.4.2.2.3 Documentation

The collected documents adopted for conducting this research include steering documents, presentations, minutes of meetings, action lists, progress plans, decision plans, and other documents were made accessible by the project managers and used as a source for evidence in this case study. The collected documents were derived from organizational sources and have been used in order give multiple evidences. Archival documents, correspondences and other related documents have been reviewed to understand the background of contract provisions, problems and practices in construction works. These secondary sources provide a general understanding of the subject area by presenting a wide range of ideas in the field which help to supplement other specific information obtained from the primary data sources.

3.5 Data Analysis

Data analysis consists of examining, categorizing, tabulating, testing, or otherwise recombining evidence, to draw empirically based conclusions. Every case study analysis should follow a general analytic strategy, defining priorities for what to analyze and why. Yin‟s four analytic strategies are as follows:

- Relying on theoretical propositions.
- Developing case descriptions.
- Using both quantitative and qualitative data.
- Examining rival explanations.

3.5.1 Schedule Assessment

First, the goodness of the schedules submitted by contractors will be assessed using the schedule evaluation criteria developed by Moosavi (2012). The complete list of the schedule assessment criteria is shown in Table 3.4. Each evaluation criterion will be scored on a scale of 1 – 10, where 1 represents not well done and 10 represents well done. Then, the evaluation score of each criterion will be added resulting in the total evaluation score. As the list includes 48 criteria, the maximum total score will be 480 and the overall schedule goodness index will be calculated as shown below:

$$Overall\ schedule\ goodness\ index\ (OSG) = \frac{Total\ evalaution\ score}{480} \qquad (3.1)$$

Using the evaluation criteria each schedule will be evaluated and the overall schedule goodness index will be determined for the evaluated schedules. Additionally, shortcomings of the submitted schedules will be identified based on the low scoring schedule evaluation criteria, and further commonalities among schedules will be recognized.

3.5.2 Schedule Analysis by using MS Project

To develop the proposed schedules of the 13 sites of 40/60 housing projects, data will be collected from branch offices and client‟s representative consultants to collect the baseline schedules approved by the consultants. As there was a design change in all cases (all project sites), the data to be collected will be based on the revised schedule due to the effect of design change to the baseline schedule. The hard copy of the schedules from the consultants will be collected.

To compare the base line schedule and the proposed schedule that will develop both schedules. The contractor‟s submitted schedules are the original as planned schedule, steps for creating the baseline schedules are as follows:

- Creating the projects,
- Defining the calendar,
- Defining the project breakdown structures,
- Adding the activities, and
- Adding the logic links

To develop the constrained schedule first we should collect the information about the sites such information are collected by direct site observation by identifying finished and unfinished works,

and analyzing the monthly reports done by the consultants, after getting those information same steps are done as baseline schedules but w we add only constraints

- Creating the projects
- Defining the calendar
- Defining the project breakdown structures
- Adding the activities
- Adding the logic links
- Adding the constraints

CHAPTER FOUR: DATA COLLECTION

4.1 Interviews

The following table gives an overview of the interviews that were conducted during the several site visits. The site name and roles of the interviewees are listed, as well as the purpose of the interview, when it was conducted and the duration of the interview.

Table 4.1 Interview overview

Interviewee	Role	Purpose of interview	Date	Duration
At branch 4	Representative of the client on branch office	Gather detailed information of the planning and scheduling process from the client‟s perspective.	July 25/2016	45 minutes
Head office of SHDE	Vice manager of saving houses development enterprise	Gather detailed information of the planning and scheduling process from the client‟s perspective.	July 18/2016	30 minutes
Bole Beshale project	Project coordinator (Consultant)	Gather detailed information about the project strategy, the project and the planning, scheduling and control process from the consultant‟s perspective.	July 15/2016	30 minutes
Summit project	Project coordinator (consultant)	Gather detailed information about the project strategy, the project and the	July 13/2016	30 minutes

		planning and scheduling process from the consultant‟s perspective.		
MeriLoke project	Project coordinator (Consultant)	Gather detailed information about the project strategy, the project and the planning, scheduling and control process from the consultant‟s perspective.	July 18/2016	25 minutes
Bole Bulbula lot 4 project	Project coordinator (Consultant)	Gather detailed information about the project strategy, the project and the planning, scheduling and control process from the consultant‟s perspective.	July 20/2016	30 minutes
Asco project	Project coordinator (Consultant)	Gather detailed information about the project strategy, the project and the planning, scheduling and control process from the consultant‟s perspective	July 22/2016	20 minutes

The interviews persons are limited due to unavailability of the clients and consultants were not available. The duration of the interview is short due to short answers of the interviewers and there was a gap of how they plan and scheduled the projects.

4.2 Observations

The different observations that were made at project sites during the site visit. To obtain basic information about the project and make a plan for the research procedures during the visit Percent of the completed works and the remaining works are identified during the site observation.

Table 4.2 project current status

No.	Project Name	Typology	Percent Complete
1	SengaTera	2B+G+12	96.62%
2	Crown	2B+G+12	96.01%
3	Asco	2B+G+13	57.18%
4	EhilNigid	2B+G+12	92.27%
5	HintsaAkrabi	2B+G+13	77.07%
6	MeriLoke	2B+G+13	63.92%
7.1	Bole Bulbula Lot 1	B+G+7	93.29%
7.2	Bole Bulbula Lot 1	2B+G+13	82.18%
8.1	Bole Ayat Lot 1	B+G+8	59.52%
8.2	Bole Ayat Lot 2	B+G+8	53.21%
8.3	Bole Ayat Lot 2	B+G+10	54.56%
8.4	Bole Ayat Lot 3	B+G+8	53.27%
8.5	Bole Ayat Lot 3	B+G+10	56.65%
8.6	Bole Ayat Lot 4	B+G+8	50.05%
8.7	Bole Ayat Lot 4	B+G+10	42.34%
8.8	Bole Ayat Lot 4	2B+G+13	47.91%
9.1	Bole Ayat 2	2B+G+13	56.71%
9.2	Bole Ayat 2	2B+G+15	54.67%

10.1	Bole Bulbula Lot 2	B+G+9	28.61%
10.2	Bole Bulbula Lot 2	2B+G+13	29.91%
10.3	Bole Bulbula Lot 2	2B+G+15	33.56%
11	TuristNigid	2B+G+18	56.21%
12	Summit	B+G+8	45.55%
13.1	Bole Beshale	2B+G+13	15.56%
13.2	Bole Beshale	2B+G+15	17.23%
13.2	Bole Beshale	B+G+9	14.89%

4.3 Documents

The table below gives an overview of the documents that were provided for the study by the project managers. The table gives a brief description of the project sites.

Table 4.3 project general information

No.	Project Name	Typology	Project Duration	Contract Amendment	Collection of schedules
1	SengaTera	2B+G+12	540	October 10/2012	In all cases the schedule is collected from branch office of the projects and from the consultants. In current case the schedules are revised due to design change only, not including the other delays caused by the client. However
2	Crown	B+G+9	455	May 28/2013	
3	Asco	2B+G+13	807	October 25/2013	
4	EhilNigid	2B+G+12	807	October 3/2013	
5	HinsaAkrabi	2B+G+13	807	January 5/2013	
6	MeriLoke	2B+G+13	540	March 28/2014	
7.1	Bole Bulbula Lot 1	B+G+7	390	March 27/2014	
7.2	Bole Bulbula Lot 1	2B+G+13	540	March 27/2014	
8.1	Bole Ayat Lot 1	B+G+8	621	May 20/2014	
8.2	Bole Ayat Lot 2	B+G+8	621	May 20/2014	
8.3	Bole Ayat Lot 2	B+G+10	693	May 20/2014	
8.4	Bole Ayat Lot 3	B+G+8	628	May 20/2014	
8.5	Bole Ayat Lot 3	B+G+10	693	May 20/2014	
8.6	Bole Ayat Lot 4	B+G+8	621	May 20/2014	
8.7	Bole Ayat Lot 4	B+G+10	693	May 20/2014	

8.8	Bole Ayat Lot 4	2B+G+13	918	May 20/2014	the schedules are revised but they still use as a baseline or master schedule of the project.
9.1	Bole Ayat 2	2B+G+13	675	May 23/2015	
9.2	Bole Ayat 2	2B+G+15	730	May 23/2015	
10.1	Bole Bulbula Lot 2	B+G+9	520	July 7/2015	
10.2	Bole Bulbula Lot 2	2B+G+13	540	July 7/2015	
10.3	Bole Bulbula Lot 2	2B+G+15	720	July 7/2015	
11	TuristNigid	2B+G+18	852	March 18/2015	
12	Summit	B+G+8	440	May 26/2015	
13.1	Bole Beshale	2B+G+13	520	May 21/2015	
13.2	Bole Beshale	2B+G+15	670	May 21/2015	
13.2	Bole Beshale	B+G+9	730	May 21/2015	

CHAPTER FIVE: RESULTS AND DISCUSSION

5.1 General

This chapter presents the results from the 13 case studies. The results are sorted according to the methods used in data collection, i.e. interviews, observations and document analysis. The investigator tried to remain neutral when presenting the findings and only report what was observed during the investigation.

5.2 Description of the Cases

The 40/60 housing projects are built for registered residents in different packages. The first package includes the SengaTera and Crown sites, which are high rise buildings located in Mexico-SengaTera and Kality, respectively. The second package includes the Asco, Ehilnigid, HinsaAkrabi, Meriloke, Bole Bulbula lot 1, Boleayat lot 1- lot 4 sites and has totally different sizes, typologies, and site condition. The third package includes Bole Ayat 2, Bole Bulbula lot 2, TuristNigid, Summit and Bole beshale which are located at the back of Mekedoniya, Bole Bulbula, HayaAratMazoria, infront of Moha and on main road of Bole Arabssa, respectively. Nonetheless, the third package site benefit from similar technical specifications and have many features in common.

The proposed schedule represents a 2B+G+18, 2B+G+13 and B+G+12 story building. This schedule was merely used to compare and contrast the schedules that are submitted by the contractors as planned and these schedules are approved by branch consultants and client representatives. As indicated in the previous chapter, the schedule assessment conducts the job logic assessment for a set of commonly used activities in saving houses development enterprises of building construction. Also, this schedule assessment evaluates job logic, schedule development and schedule components, for all of projects.

In the proposed schedule the duration of projects slightly increases with compared to the contractor‟s submitted schedule. This is due to the resource constrained schedule. The proposed schedule was mainly used to compare and contrast the contractors submitted schedules assessment. The schedules of the all actual projects were not that detailed, thus a detailed proposed schedule was selected in order to test and validate the schedule assessment.

5.2.1 Documents and site observation

In construction management the detailed design is transformed into a construction plan. This means daily coordination and control of processes on site in 40/60 projects are in many ways

similar and repetitive and many of the general principles of management also the same. From construction companies‟ perspective it is obvious that the company must have profit as an overall goal, and completing the work on time is essential part of meeting profit goals. The management must be executed in a systematic way, continually throughout the life of the project.

Planning covers answering how, how much, why and where the project is executed. In the planning phase objective of the project, scope definition and goal of the project should be defined. The planning process includes defining activities, sequencing activities, estimating activity durations, developing the schedules and controlling the schedules, in AASHDE the planning process is done by the client and the scheduling is done by the contractors it leads to uncontrolled delay. The main construction materials such as cement, reinforced bars, pre-cast beam, slab hallow blocks, wall hallow blocks, electrical and sanitary fixtures are supplied by the client such materials are not delivered on time and contractors performance is on question.

A delayis an event that prevents the contractor from completing the work within the contractually specified performance period, a slowing down of the work without stopping it entirely, triggered by something other than a formal directive from the owner to stop work. Simply put, a delay is a loss of time. Any party involved in the project can cause delays, however most claims involve alleged delays caused by the owner in 40/60 saving houses development.

Damages from pure delays are those resulting from an extended performance period, including increased overhead and job site costs, equipment standby costs, wage escalation, and financing costs.

A disruptionalso has an impact that alters the contractor‟s planned work sequence or flow of work expected at the time of bidding, which results in increased difficulty, cost, and/or time. When this occurs, the contractor cannot perform work in the manner anticipated during bid preparation, thus resulting in a schedule impact. As opposed to delays, damages associated with disruption are likely to be increased labor costs due to inefficiency, the activation/deactivation of increased manpower, and additional equipment costs.

Another major type of potential schedule impact involves in 40/60 saving houses project was changes of work and design. When a contractor takes on any type of work that deviates from the original contract, or from the scope of work or plan of action reasonably anticipated under the contract, that results in an increase in performance time, the contractor may seek an adjustment. Before determining the impact of the change on the schedule, the change must be identified as

truly being a change from the original contract or merely a situation that should have been anticipated by the terms of the original agreement. That is clearly beyond the general scope of the contract, so extensive as to change the entire character of the work required under the contract.

Additional Quantity:Another source of schedule impact is the case where additional quantityof work is required on existing activities the same scope, but more of it. The increase in quantity of an activity directly affects the duration of the activity, consequently impacting the schedule. If greater quantities of work are needed to fulfill the contract, the contract time limit may be increased.

Differing Site Conditions: The first two sources of impact reflect the adding of scope and quantity to activities, whereas this section addresses a change in the conditions encountered on a job site, or differing site conditions. To be considered a Differing Site Condition (DSC), there must be a material, significant difference from the conditions reasonably anticipated to be encountered on site.

5.3 Analysis and Evaluation

The twenty-six actual schedules were reviewed based on the developed method. In the first step schedule are developed with respect to contractor‟s original schedule which is mainly concerned with the quantitative provisions. There were a set of deficiencies common among all cases that caused these schedules not to be labeled as good. These schedules were unable to satisfy the criteria regarding “Resource Loading”, “Responsibility Assignment”, “Trade‟s peak resource loading”, “Peak to Average Labor Ratio”, “Duration of Critical Activities”, “Project Cost Ratio”, “Project Effort Ratio”, “Activities Float” Critical Path”, „Constraints”, “Permits and Environmental Remediation”, “Relationship Ratio”, “Submittals Review”, and so forth. These deficiencies indicated that limitations of the submitted and approved schedules.

5.3.1 Schedule goodness index comparison

The schedule goodness index is presented as follows by dividing in to three main categories this are contractual compliance, schedule development and schedule component.

5.3.1.1 Contractual Compliance

Contractual compliance focuses on the clients need and it includes milestone, project duration, schedule submission date, scope coverage, job logic and activity duration repeatability. The contractual compliance score is calculated for all projects and the results are shown in Figure 5.1,

where the maximum score is 80. Accordingly, Bole Ayat lot 4 with a typology of 2B+G+13 has a highest score (41) and project Bole Bulbula lot 1 with a typology of B+G+7 has least score (24). The main cause is the duration of the project have main difference. When we see Bole Ayat Lot 4 (2B+G+3) total duration is enough to delivered the project so the scope of the project is well defined, activity duration also reasonable, job logic is good but in the case of Bole Bulbula Lot 1 (B+G+7) the project duration is very short so the items are not well defined. In all cases the evaluation of the schedule submission date and job logic was satisfactory, as it was a requirement for receiving an advance payment. However, the milestone and project duration was decided by the client before the scheduling process started and the schedules were prepared to fit that project duration. In contractual compliance the main cause of failure is due to project duration plan is decided by the client.

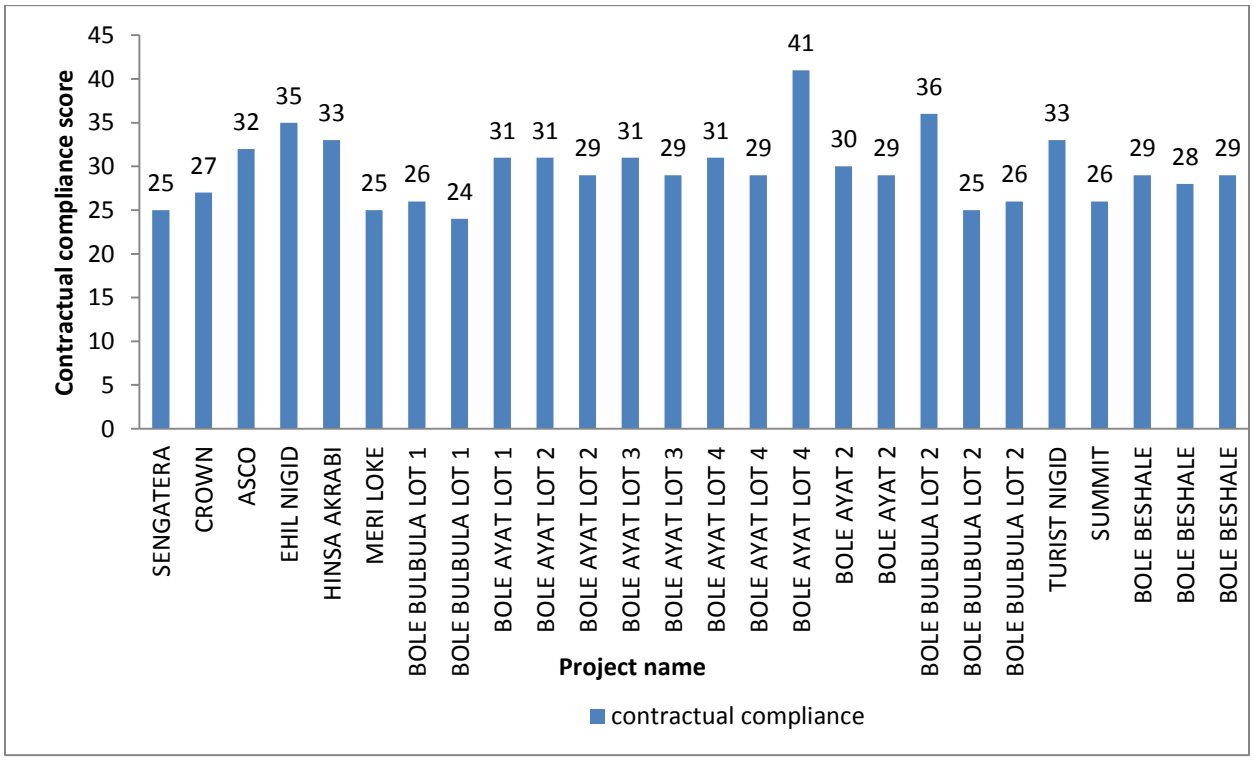

Figure 5.1comparisons of schedules with respect to contractual compliance score (between contractor submitted schedules)

5.3.1.2 Schedule Development

Schedule development includes project scope definition, WBS, scheduling process, subcontractor participation and verification of subcontractors‟ scope of work. Before scheduling the scope should be adequately defined and scheduling should be based on an approved WBS.

The scope coverage of the project has direct relationship with schedule development, these leads to uncontrolled conflict between the duration of the project and scope in project schedule development. Schedules have to be developed by participation of parties associated with the project. Subcontractors responsible for considerable parts of project should become involved in schedule development having their work integrated and coordinated and also verification of subcontractors‟ scope of work should be approved. HinsaAkrabi, EhilNigid and Bole Ayat lot 1 to lot 4 and Bole Ayat ranked one to three respectively and the least is SengaTera and Bole Bulbula lot 1 (B+G+7) respectively. The project of HinsaAkrabi 56.21% is completed now and the remaining duration is enough to complete the project with in a limited time delay. But when we see SengaTera site the delay is 250% of the project duration. The comparison schedule goodness index of the schedule development is shown below with the help of figure.

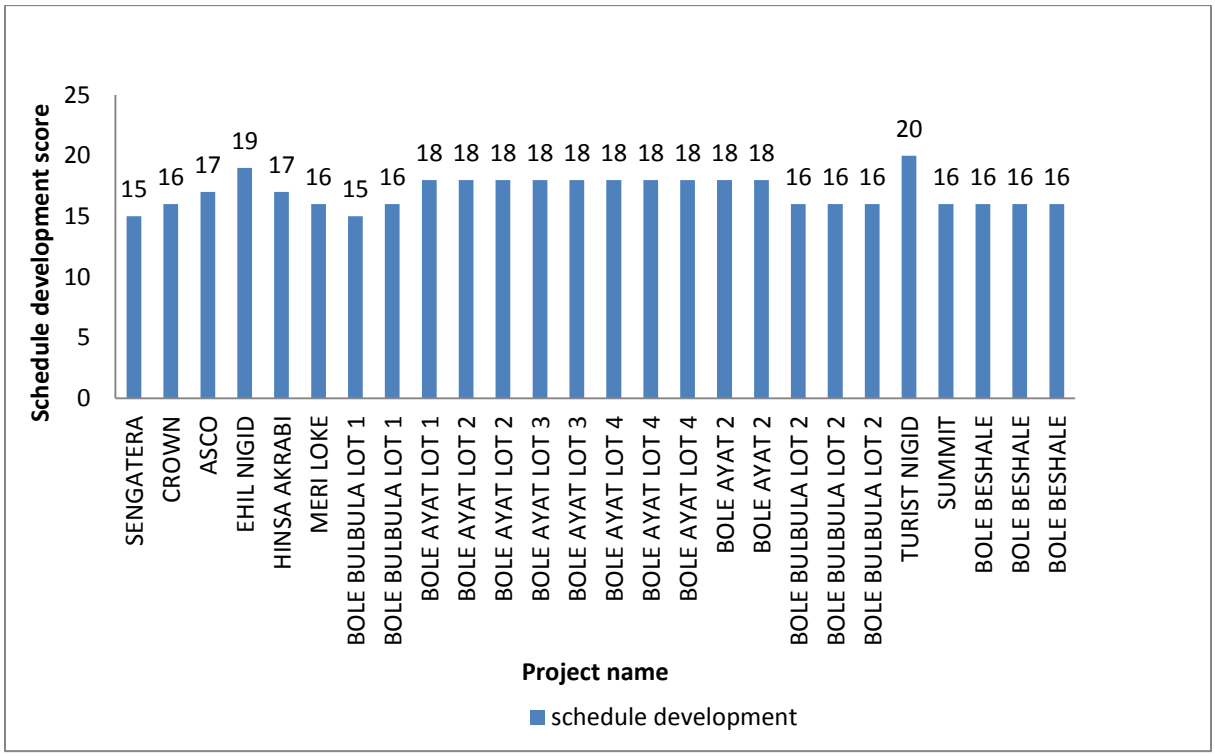

Figure 5.2comparisons of schedules with respect to schedule development score (between contractor submitted schedules)

5.3.1.3 Schedule Component

Schedule component includes phase duration, phase overlap, resource loading, number of constraints and weather sensitivity activities this are affects the duration of the project. Main delay of project duration is caused by the components of the schedule that are included in the

schedule. Schedule components mainly affected by verification of project duration confirm parametric scheduling results. Phase overlap is repetitive in all projects and each phase overlap should be in compliance with historical average data according to total installed cost. Resource loading, responsibility assignment is very important aspects on scheduling of the project. With proper resource loading the actual duration of the project can be estimated and the delay of duration can be minimized also it can be predicted on the starting of the planning stage. The projects are repetitive then the startup and testing activities can be included in the schedule to improve the next projects. Negative float, open ended activity and lag duration is done properly with related to other components of the schedule. TuristNiged has highest score and Bole Bulbula lot 2 (2B+G+15) and Bole Ayat 2 (2B+G+15) comes second respectively. The lest score is recorded on project of SengaTera and Crown sites this is due to phase duration and phase overlap was not limited. The results of the score are presented on the figure below as follows.

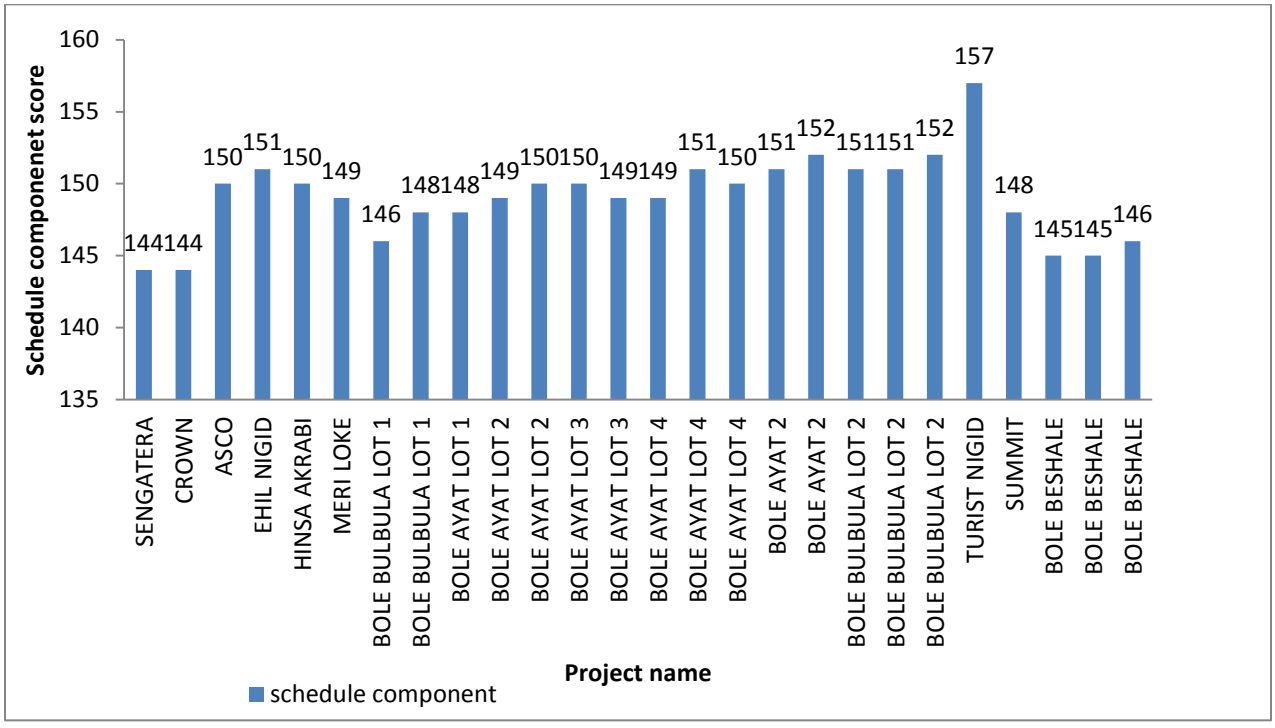

Figure 5.3 comparisons of schedules with respect to schedule component score (between contractor submitted schedules)

CHAPTER SIX: ANALYSIS OF THE PROPOSED SHEDULE

6.1 The 40/60 SHDE projects Scheduling

In 40/60 SHDE the project‟s duration is decided by the client so the schedule prepared by the contractor is time constrained resource scheduling. The starting point for time constrained resource scheduling is a CPM network of a project for which the forward and backward passes have been completed. Each activity is then assigned its required resources based on unlimited availability of the required resources. Each activity can then be moved or slid within its available free and total float in order to minimize the changes in required resource levels between time periods. The process is carried out for each non-critical activity in the project for the simple reason that the critical activities have no float. Any change in the scheduling of a critical activity would either violate the relationships between the activities or delay the early finish of the project.

In time constrained resource scheduling there are no set limits on the amount of resources available. The only hard criterion is that the fixed completion of the last activity not be delayed. In the case of the 40/60 housing projects the resource is not completely defined and scope of the project is changed in other way. The scheduling process should have included the resource allocation to minimize the delay of the next activities. The contractors are assumed that the resources are available but, the execution phase the materials are not delivered on time, the quantity of the work and the contract quantity of the work is less, design change is common this cause the phase overlap and phase duration is goes up, and the material is delivered when the activity is already started due to these reasons the duration of the project is delayed. Time constrained resource scheduling is considered necessary as fluctuations in resource levels "are very undesirable because they often present labor, utilization, and financial difficulties to the contractor." (Easa 1989)

The methods of time constrained resource scheduling can generally be categorized as either heuristic or optimization. The heuristic approach uses the application of various rules of precedence to decide which of several activities will be scheduled first and which will be postponed when an undesirable change in resource requirements occurs. An optimization approach on the other hand examines all possible scheduling scenarios and then chooses the best solution based on a given measure or metric.

The principle advantage to a heuristic approach is that significantly less calculation time is required. Conversely, the principle disadvantage of an optimization approach is that each possible scheduling scenario must be evaluated. The number of calculations required and the associated time for this approach typically limits its applicability to desktop computers, even for short simple networks. For this reason, the majority of scheduling software products utilizes a heuristic approach to time constrained resource scheduling.

The principle disadvantage to a heuristic approach can best be described as the approximate nature of the result. A heuristic method, by its very nature will not necessarily find the one best solution. Rather, it uses the application of various rules to decide which activities should be scheduled and which should be postponed. The choice of priorities in scheduling activities can significantly affect the outcome. On the other hand, the optimization approach can choose which scenario provides the "best" solution by evaluating each and every scheduling scenario.

6.2 Resource Constrained Resource Scheduling (the proposed scheduling)

As with the procedure for time constrained resource scheduling discussed above, resource constrained resource scheduling begins with a resource loaded CPM diagram with the relevant calculations of early and late, start and finish, and free and total float completed. For resource constrained resource scheduling the early finish of the last activity is not fixed or locked. Rather the total amount of a resource or resources available is given a set maximum amount available per time period.

Resource constrained resource scheduling methods can also be classified into the same two general categories of heuristic and optimization methods discussed for time constrained resource scheduling. The heuristic method follows preset rules and priorities to determine the order in which activities are rescheduled. The optimization method examines all possible scheduling scenarios and then chooses the best solution.

Similar advantages and disadvantages apply for resource constrained resource scheduling as do for time constrained resource scheduling. Optimization is calculation and memory intensive while the heuristic approach offers only an approximate solution. Oguz and Bala (1994) provide a good description of just how calculation intensive the optimization method is.

One point which must be stressed for the heuristic method of resource constrained resource scheduling is that the order, or priority, in which activities are rescheduled can significantly

affect the outcome. For example, the election to schedule a non-critical and resource intensive activity ahead of a critical activity may significantly delay the early finish of the last activity.

For either the heuristic or optimization method of resource constrained resource scheduling the typical metric of performance is the overall delay in the completion of the project as compared to the unconstrained early completion.

A shorter scheduling delay being preferred over a longer one due to the relatively high daily overhead costs associated with most projects. The analysis in this thesis uses the metric of the overall delay in the project expressed as a percentage of the original duration. The one drawback to this metric is, again, that the results cannot be compared between two different networks. This is even true when the overall delay in completion is expressed as a percentage of the original duration. The reasons for this lack of comparability are the same as for time constrained resource scheduling.

The literature on resource constrained resource scheduling is much more plentiful and varied than that for time constrained resource scheduling. This is probably a direct result of the much more troublesome problem of not having enough resources as compared to the somewhat idealistic problem of minimizing variations in resource requirements. Moder et al. (1983) provide an excellent and thorough discussion of the theory and methodology of resource constrained resource scheduling. Shanmuganayagam (1989), and Drexl and Gruenewald (1993) provide some innovative approaches to the mathematical aspects of resource constrained resource scheduling using optimization methods. Finally, Russell and Caselton (1988) discuss the application of resource constrained resource scheduling to projects with a highly repetitive series of activities.

In 40/60 SHDE projects are highly repetitive series of activities due to this reason the resource constrained resource scheduling is developed. The proposed schedule is developed by adding the resources that are supplied by the client and also the contractors, from the contractors submitted schedule the proposed schedule is developed. The duration of the activities, job logic, is same with the contractor‟s submitted schedule. The resources are identified prior to the activities and constrained with the available resources. The duration of the project is slightly different from the original contract duration; this is due to the duration of the activities are increased due to the resource availability at the time of the work.

The benefit from resource constrained resource scheduling are the resources are identified before the project starting time, the schedule of the resources are known and to give a chance of the resource priority and minimize the delay between activities. The activity delay causes the successor activity waits to start until the predecessor activity finished then the negative lag is increased.

The proposed schedule is 2B+G+18 prototype (Appendix C) the schedule assessment is done for this.The overall schedule goodness index is calculated and compared to the contractor‟s submitted schedule presented below.

6.3 Comparison of contractors submitted schedule with proposed schedules

The schedule goodness index is done for the proposed schedule; the results are different with different aspects such as contractual compliance, schedule development and schedule components. The proposed schedule typology is only 2B+G+18 building this is selected due to the progress of the project site and the comparison of the contractors submitted schedules are already compared so, the defects are identified and the results are presented. However, the proposed schedule is prepared based on the best performers of the contractor‟s submitted schedules. Now we can see one by one.

When we see the contractual compliance the result is different on contractor‟s submitted schedule with proposed schedule. These criteria cannot be readily assessed, and the assessment of schedules was merely based on conceptual provisions and would always be susceptible to subjectivity. The main difference is due to scope coverage, milestone and project duration, job logic and activity duration is done properly. The proposed schedule is loaded with resource and constrained with resource this increases the duration of the project but it is reasonable and acceptable for the good planners (the contractor‟s submitted schedule, and proposed schedule constrained with resource is on appendix B, and C respectively). The schedule goodness index of contractors submitted schedules are score and also the proposed schedules the results are presented by graph.

The best performance is recorded by project Bole Ayat lot 4 with a typology of 2B+G+13 has a highest score (41) and project Bole Bulbula lot 1 with a typology of B+G+7 has least score (24), the score of the proposed schedule was 44 however the result is close to the contractor‟s submitted schedule. The contractual compliance shows mainly on clients need. The duration of the project is increasing in the proposed schedule so, the client satisfaction is decreases. The

contractors are doing the schedule with in the clients planed duration so what they doing was putting the contract document to the fraction of activities. This plan shows time constrained schedule so the resource is available in other words. The actual implementation is reverse, resource constrained but not limited to time of completion. The failure is in the planning stage.

In the proposed schedule the duration is relatively increased it cannot satisfy the clients need however it give reasonable finishing date than of the contractor‟s submitted schedule.

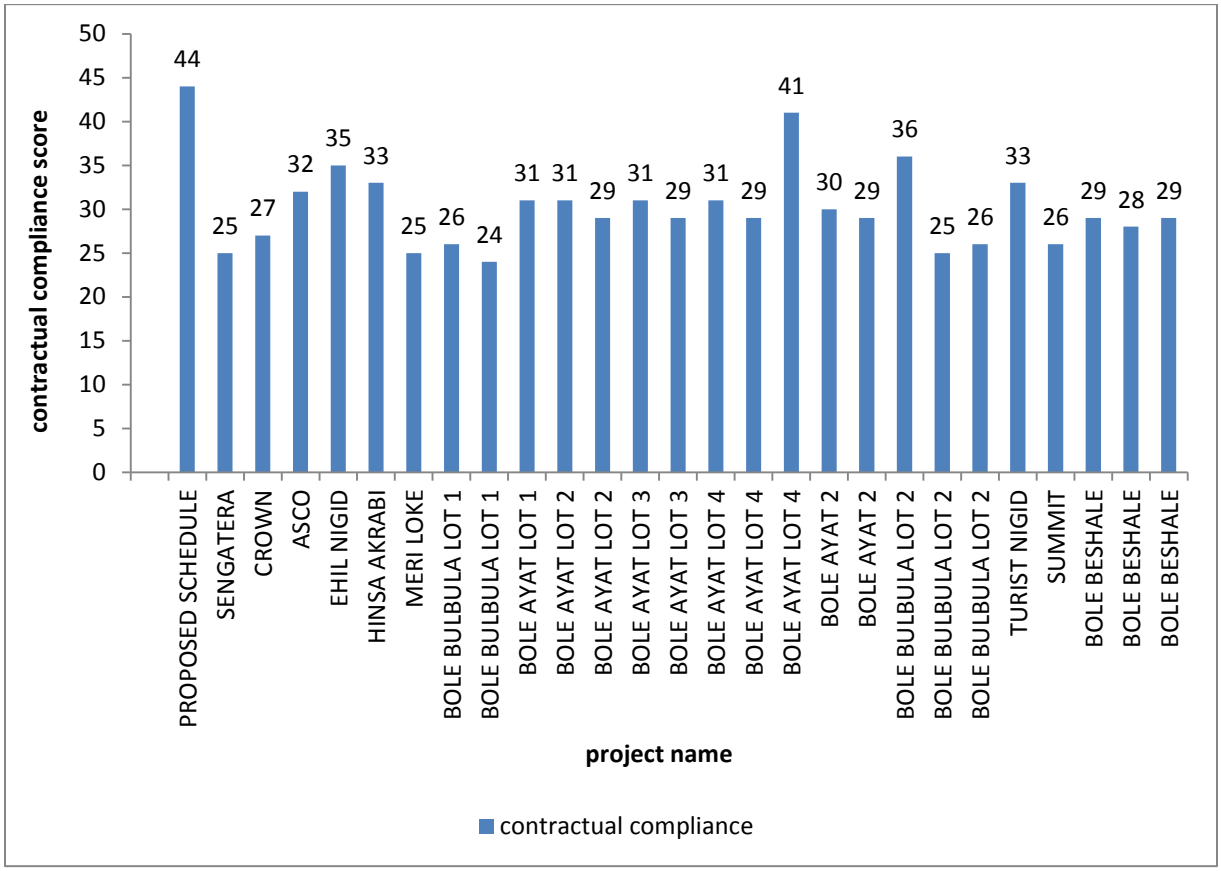

Figure 6.1 comparisons with respect to contractual compliance (proposed vs. contractor submitted schedules)

Schedule development internally related to scope and process of scheduling, the scope of the project is the same but the process of the scheduling included and presented well in proposed schedule. Participation of the subcontractors and verification of their work schedule affects the project duration directly. Tourist Nigid and EhilNigid a best performer respectively, and also the worst performer were SengaTera and MeriLoke the performance depends on project scope definition and scheduling process. In the case of the proposed schedule I put the subcontractors work as a milestone and subcontractors can make the schedule and can it be verified.

Contractor‟s submitted schedule shows only there working schedules and then includes the subcontractors work without verification of the participants at all. The schedule is not reflecting the subcontractors start and finish time definitely.

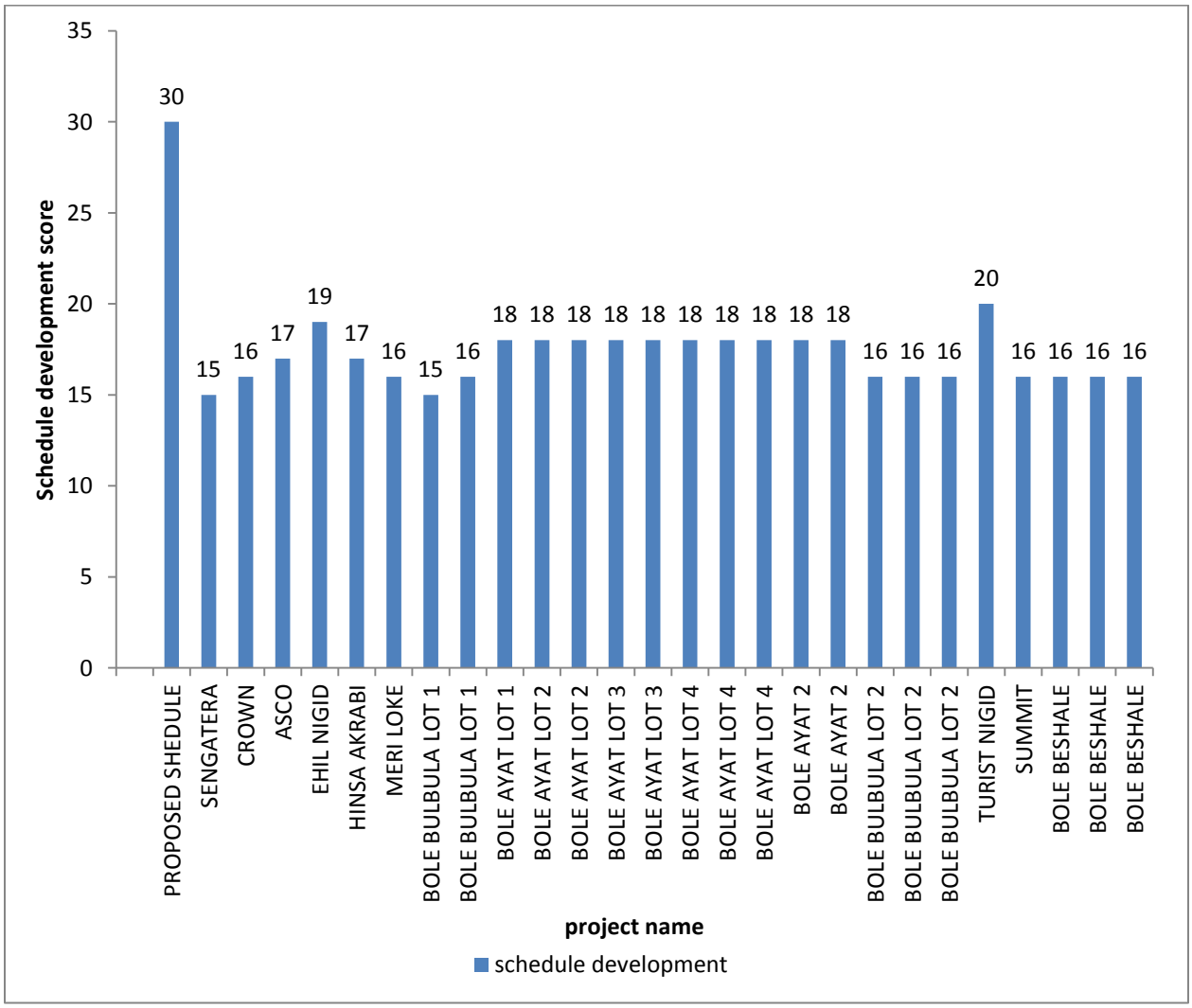

Figure 6.2 comparisons with respect to schedule development (proposed vs. contractor submitted schedules)

Critical activities, to be well manageable, should have a limited duration. There are other deficiencies associated with the application of conceptual provisions. It is not uncommon for different schedule reviewers to conclude with different, even contradictory, review results. The level of subjectivity is lower in schedule components. The main cause of the failure relay on verification of project duration, phase duration, phase overlap, resource loading, responsibility assignment, schedule leveling and number of constraints. The score of the contractor‟s submitted schedules are more or less the same, the highest score is recorded by TuristNigid, and the main

aspect is phase overlap, in TuristNigid it is relatively minimized in the project than of the other project site.

In all schedules the resource is assigned in the other sheet, not loaded in the schedule so the resource doesn‟t affect the project duration. In other word there are no constraints stipulated on the contractor‟s submitted schedule. Planning has to be covering the resources that are needed in the implementation of the project. The resource should have to be loaded on each activity and it gives the resource utilization has to be maximized to finish the activities on time.

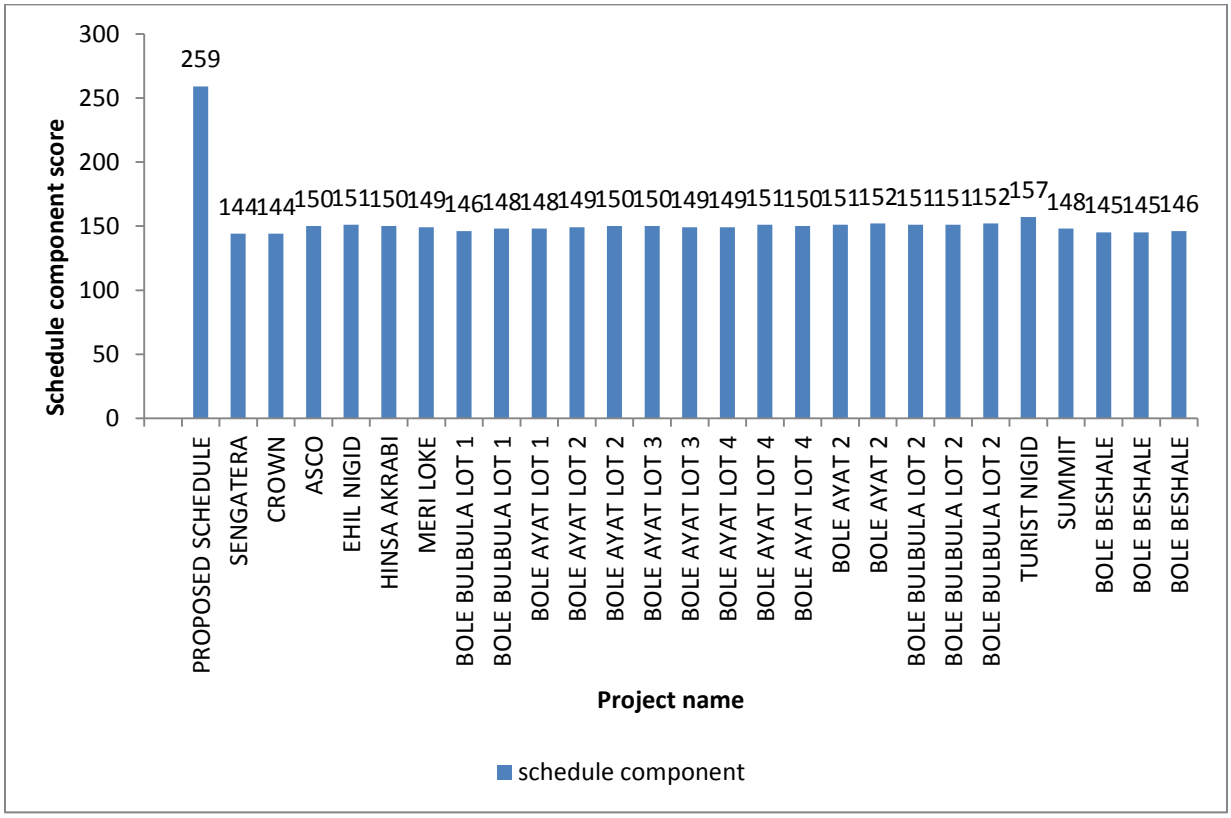

Figure 6.3 comparisons with respect to schedule components (proposed vs. contractor submitted schedules)

Cumulative score of the schedule goodness index is giving the overall assessment of the schedules submitted by the contractor‟s. TuristNiged has a higher score and Bole Ayat lot 4 with a typology of 2B+G+13 second score is recorded 210 and 209 out of 480 respectively. The projects are good with the progress. It is because of the scope coverage is good, phase overlap is less and the resource availability is good relatively from the rest of the projects. A SengaTera and Crown site has scored 184 and 187 respectively. These projects were the first projects of the

40/60 saving houses development enterprise there were problems related to the scope coverage, the drawing was not full; phase overlap was common in both project sites.

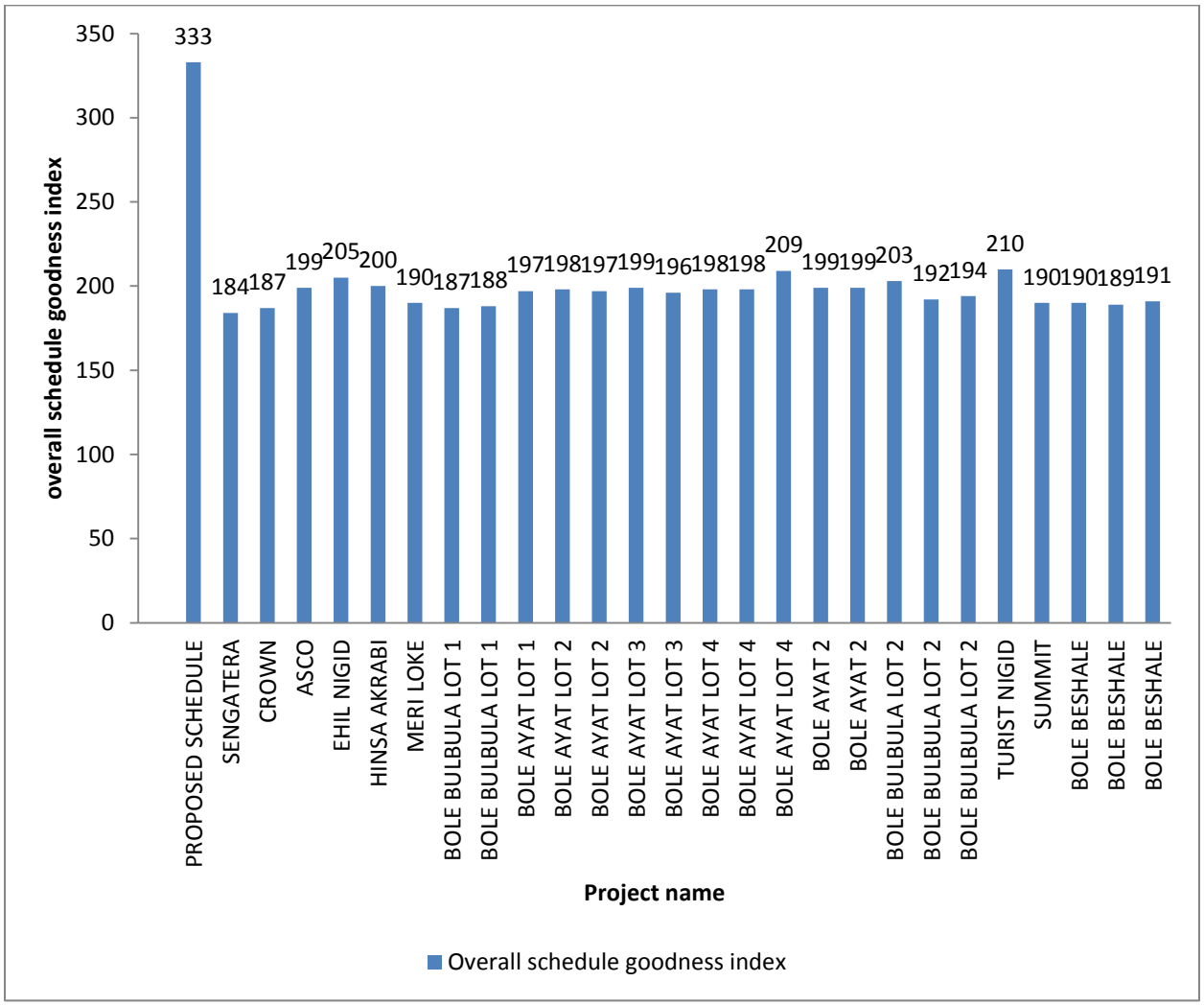

Figure 6.4 overall schedule goodness index (proposed vs. contractor submitted schedules)

6.4 Discussion of result

The Client: The vice manager emphasized the objectives regarding the project delivery (cost, time, quality and safety) and on the objectives of meeting the needs of the user and operator. He stressed the importance of involving the future users and owner/operating organization in the planning process to make sure that their needs were satisfied.

The clients vice manager explained that the main objective is to deliver the project on time and within budget. He explained that the saving houses project ambitions are high; to be one of the most solution maker on housing in the country. He further explained that the operating organization wants a building which is rational to operate. He was confident that these goals

would be achieved but there are many problems in the implementation of the planned schedule to the actual project sites. These problems are due to client, contractors and consultants.

The client‟s project representative explained that the aim is to meet the project‟s success criteria presented in the project plan. The main objective is to deliver within the constraints of time, cost and quality.

The Contractor: The contractors‟ PM also noted that they had adopted the client‟s objectives for the project, as described in the contract documents. The PM described that their main objectives were to profit from the project, but also to deliver the building within the constraints of time and quality, ensure adequate project management. The PM was mainly concerned with the time management of the project, in order to deliver the project on time. The main problems are project design change, weather condition is not considered, material delivery system is not adequate and scope of the project is not covered before the planning and scheduling process is started.

The consultant: The project coordinators in all cases agreed on the planning and scheduling process is not done properly. The main reasons are the time of planning the participants are limited (only the client), resulting in the delay and cost overrun the projects. The material delivery system, design change, scope coverage and scheduling processes are the main causes of delay. Most of the time, materials are purchased and delivered when the activity is underway, it leads to the successor activity is paused and waits the predecessor activity so the lag duration is greater than of both the successor and predecessor activities duration. Change order, additional quantity of work, unspontaneous deployment of resources and weather condition without differentiation of project sites are the main causes of the project completion date.

6.5 Challenges in 40/60 housing planning and scheduling

Completion of the projects on time is not common in SHDE, the reason behind this reports are deficiency of scope coverage, design change, material not delivered on time, performance of MSE, site condition, additional quantity and performance of the contractors are main factors for the delay.

Accurate schedule documentation should include detailed records of all events that could have potentially impacted of the planning and scheduling of the project. The idea behind gathering all the information is to be able to recreate the job on paper, ideally in its entirety, so that future projects can develop more effectively. In this research only the collected data available in the contractor side, the client‟s resource deployment is not documented clearly. However, the

sources and information listed above are not always available for analysis. Contemporaneous documentation may not exist, may contain errors, or may omit important information. The proposed schedule was prepared with the help of contractor‟s resource and compared to contractor‟s submitted schedule.

Table 6.1 Delay of the project sites

No.	Project Name	Typology	Finish Date	Current Delay (in days)	% Completed	Expected completion date
1	SengaTera	2B+G+12	Tue 11/4/14	456	96.62%	Fri 9/16/16
2	Crown	B+G+9	Mon 2/23/15	377	96.01%	Mon 9/19/16
3	Asco	2B+G+13	Mon 11/28/16		57.18%	Tue 8/28/18
4	EhilNigid	2B+G+12	Fri 11/4/16		92.27%	Wed 10/26/16
5	HinsaAkrabi	2B+G+13	Mon 2/8/16	127	77.07%	Thu 8/24/17
6	MeriLoke	2B+G+13	Thu 4/21/16	74	63.92%	Wed 11/29/17
7.1	Bole Bulbula Lot 1	B+G+7	Wed 9/23/15	225	93.29%	Fri 9/30/16
7.2	Bole Bulbula Lot 1	2B+G+13	Wed 4/20/16	75	82.18%	Thu 2/2/17
8.1	Bole Ayat Lot 1	B+G+8	Tue 10/4/16		59.52%	Tue 1/30/18
8.2	Bole Ayat Lot 2	B+G+8	Tue 10/4/16		53.21%	Tue 7/10/18
8.3	Bole Ayat Lot 2	B+G+10	Thu 1/12/17		54.56%	Fri 6/1/18
8.4	Bole Ayat Lot 3	B+G+8	Thu 10/13/16		53.27%	Fri 7/6/18
8.5	Bole Ayat Lot 3	B+G+10	Thu 1/12/17		56.65%	Mon 4/9/18
8.6	Bole Ayat Lot 4	B+G+8	Tue 10/4/16		50.05%	Fri 10/12/18
8.7	Bole Ayat Lot 4	B+G+10	Thu 1/12/17		42.34%	Thu 8/1/19
8.8	Bole Ayat Lot 4	2B+G+13	Thu 11/23/17		47.91%	Mon 12/24/18
9.1	Bole Ayat 2	2B+G+13	Thu 12/21/17		56.71%	Mon 7/23/18
9.2	Bole Ayat 2	2B+G+15	Thu 3/8/18		54.67%	Mon 11/26/18
10.1	Bole Bulbula Lot 2	B+G+9	Mon 7/3/17		28.61%	Fri 4/5/19

10.2	Bole Bulbula Lot 2	2B+G+13	Mon 7/31/17		29.91%	Tue 2/5/19
10.3	Bole Bulbula Lot 2	2B+G+15	Mon 4/9/18		33.56%	Fri 9/14/18
11	TuristNigid	2B+G+18	Thu 6/21/18		56.21%	Fri 2/15/19
12	Summit	B+G+8	Mon 1/30/17		45.55%	Tue 1/2/18
13.1	Bole Beshale	2B+G+13	Wed 5/17/17		15.56%	Fri 2/3/23
13.2	Bole Beshale	2B+G+15	Wed 12/13/17		17.23%	Fri 5/6/22
13.2	Bole Beshale	B+G+9	Wed 3/7/18		14.89%	Fri 6/9/23

The actual delay is identified and also the expected completion day can be identified. Project SengaTera is not completed yet, the delay is 83% of the contract duration. This shows that the delay is above the contract duration of the project, the cause of this delay is material delivery, scope coverage, resourcerestrictionand phase overlap was common in the execution of the project. SengaTera, Crown, Asco and EhilNigid are included in package one, they are not completed yet the problems encountered from those projects are repeated to the other three packages. The expected completions of projects are determined and average of the delay is 149% of the total duration of the projects. On package four Bole Beshale project site is late and the delay is more than 100% of the contract period. The site condition of Bole Beshale is black cotton type soil and the amendment of the contract is exactly on the rainy season, there is no special permit for weather sensitivity activities to give a chance of the schedule to revise. The scheduling process is only breaking down of the total duration in to the activities duration without considering the resource profile of both the client and contractor.

In the above cases the delay of each project is identified and shown in the table above. The development of an effective plan for schedule and control of the mass housing construction involves a number of challenging tasks mainly repetitive activities in this case. On the other hand, repetitive activities have to be scheduled by a technique that can be achieved by integrating traditional network scheduling and resource-driven scheduling in an effective. The objective of this study is to develop planning and scheduling for repetitive projects that minimize the project duration and maximize the resource utilization.

The lack of planning in saving houses development enterprise could be said to have its basis in three major areas: lack of technical knowhow, poor institutional arrangements and weak legal frameworks. The situations of Ethiopian urban centers indicate that their infrastructure, which is far from adequate in both in quality and quantity. Low funding, high rate of population growth, poor quality control, inadequate inspection and maintenance, and lack of consistency and uniformity in design, construction, and operation practices, have severely hampered housing development in AASHDE.The main challenges in 40/60 housing are listed below:

- Lack of developed schedule assessment
- The scope of the projects are not defined clearly
- Insufficient data for planning
- Not considering the working areas (infrastructure)
- Limited resource
- Non continuous resource deployment

CHAPTER SEVEN: CONCLUSION AND RECOMMENDATION

7.1 Conclusions

This research addresses identifying the elements of project management such as project planning and scheduling in 40/60 saving houses development enterprises. Planning and scheduling in a housing construction is viewed as a constraint satisfaction problem where constraints are continually being identified, checked, updated and modified until satisfactory schedules are obtained.

The planning methodology is traditional, the client only puts the project duration without logistic management (planning, purchase, delivery and control of construction material).

The main findings of planning problems are listed below:-

- There is no participation of associated parties with the project in the planning stage,
- All aspects of project scope not defined adequately,
- The resource schedule is not defined clearly,
- There is no stock of materials supplied by the client,
- There is no planning manual related to this housing system,
- The contractors are submitting the schedules for interim payment approval,
- There is no differentiation of site conditions, and
- They only focused on the price of the project, not the completion of the projects.

Optimal resources allocation at the planning stage when it comes to implementation stages the resources deployment is not matching the planned schedule. The failure to implantation is common and they are not learning from there failure. The completion date is above the planned schedule duration in all cases.

The main findings of scheduling problems are listed below:-

- The scheduling is time constrained resource scheduling,
- Scheduling is prepared by the contractor without participation of sub-contractors,
- Contractors only breakdown the project in to fraction of activities within the contract period without the project scope definition ,
- No verification of sub-contractors scope of work,
- Lack of calendar verification,
- The project cost ratio was not done,
- Resource loading to the schedule is not common,

- The schedule is done without detail drawing,.

7.2 Recommendation

In 40/60 saving houses development enterprise project the projects are continuous and they should have be learn from the failure of completing the projects on time. Based on the identified gaps in the conclusion part, here are some recommendations.

- ✓ Critical examination of submitted schedules, implementation of strict project control, proper updating and approval of schedules, should be developed.
- ✓ Proper planning is essential for the successful completion of a project; therefore, the project office has to do some adjustments in the following areas,
  - Resources have to be identified prior to the beginning of the projects (quantity and quality).
- ✓ Even though creating job opportunity for Micro and Small Enterprises (MSE) is government policy and has to be implemented, enough training has to be given, which includes
  - Continuous technical assistance,
  - Ethics related to construction work.
- ✓ It isrecommended that logistic management has to be outsourced for the following reasons:
  - Logistic work is one of the major works in construction industry, so that it has to be handled with professionals not in a traditional way. There are conflicts; the main conflict is the delay of project duration this is due to lack of knowledge to decide which is first and next.
- ✓ Proper documentation should be developed to achieve the goals of planning and scheduling for the upcoming projects.
- ✓ Accurate schedule documentation should include detailed records of all events that could have potentially impacted of the planning and scheduling of the project. The idea behind gathering all the information is to be able to recreate the job on paper, ideally in its entirety, so that future projects can develop more effectively.
- ✓ On the other hand, 40/60 SHDE projects are repetitive activities, it should have to be scheduled by a technique that can be achieved by integrating traditional network scheduling and resource-driven scheduling to minimize the duration of by an effective utilization of available resources.

7.3 Suggestion for Future Research

1. Study on the identification of delay by comparing the as-planned schedule with the as-built schedule.
2. Study on the implementation of lean project management.

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Appendix A: The interview guide applied during the interviews.

Interview Guide

Project name:			
Interviewee:			
Date of meeting:	**Time:**	**Location:**	**Minutes written by:**

Comment:

This interview guide is made for a case study research where the aim is to identify the process in planning and scheduling for the construction of saving houses development enterprise. The case study is part of a master thesis. The following questions were formed to highlight relevant issues focused on the planning and scheduling process and how they evaluate those schedules.

Project strategy:

• How was the project strategy developed?
  ➢ What is the main focus?
• Were there made any changes to the project strategy?
  ➢ If, yes, what is the main focus?

Objectives and goals in planning and scheduling:
• How are the objectives and goals identified? • How are the objectives and goals managed and achieved? • How is the next milestone and project phase reached? • How are the opportunities and options identified and managed? • How do you measure performance?
Effectiveness:
• How do you measure effectiveness in planning and scheduling?
Stakeholders:

- How do the different stakeholders affect the planning and scheduling?
  - Internal/External stakeholders
- What stakeholders are involved in the planning phase?
  - How are they involved?
- How are the needs and requirements of the stakeholder met?
- What is done to make sure that the right stakeholders are included?

Tools:

- What tools do you use for planning and scheduling?
- How do the tools for planning, scheduling and control help you in the construction projects?
- What do the tools plan and/or observe?
  - What factors are important for effectiveness when using the tools?
  - What factors are likely to cause delays, cost overrun and/or other errors?
- Who uses and manages the tools?

How do you document your data?

Motivations:

- Are there any rewards in case of successful planning and scheduling?
  - If yes, what are they?
- Are there any penalties in the case of delays?
  - If yes, what are they?
- What happens if the project goes over budget?

Other topics?

Appendix B: Complete list of schedule evaluation criteria (Moosavi, 2012)

First, the goodness of the schedules submitted by contractors will be assessed using the schedule evaluation criteria developed by Moosavi (2012). Each evaluation criterion will be scored on a scale of 1 – 10, where 1 represents not well done and 10 represents well done. Then, the evaluation score of each criterion will be added resulting in the total evaluation score. As the list includes 48 criteria, the maximum total score will be 480 and the overall schedule goodness index will be calculated as shown below:

$$Overall\ schedule\ goodness\ index\ (OSG) = \frac{Total\ evalaution\ score}{480} \qquad (3.1)$$

Using the evaluation criteria each schedule will be evaluated and the overall schedule goodness index will be determined for the evaluated schedules. Additionally, shortcomings of the submitted schedules will be identified based on the low scoring schedule evaluation criteria, and further commonalities among schedules will be recognized.

No.	Element	Explanation	Score (1-10)
1.1	**Contractual Compliance**		
1	Milestones & Project Duration	Milestones & project duration must be in line with related contractual provisions.	
2	Phasing and Sequencing	Phasing and sequencing must be in line with related contractual provisions (if applicable).	
3	Number and Duration of Activities	Number and duration of activities must be in line with related contractual provisions (if applicable).	
4	Activity Code	Activity code must be in line with related contractual provision (if applicable).	
5	Schedule Submission Date	Schedule submission date should be in compliance with related contractual provision.	
6	Scope Coverage	Scope of the project should be covered by schedule	
1.2	**Job Logic**		
7	Job Logic	Job logic must be rational.	

No.	Element	Explanation	Score (1-10)
1.3	**Duration**		
8	Activity Duration (reasonability)	Activity duration must be reasonable.	
2. 1	**Schedule Development**		
2.1.1	*Scope*		
9	Project Scope Definition	All aspects of project scope should be adequately defined before scheduling	
10	WBS Verification	Scheduling should be based on an approved WBS	
2.1.2	*Process*		
11	Scheduling Process	Schedule should be developed by participation of parties associated with the project	
12	Subcontractors Participation	Subcontractors responsible for considerable parts of project should become involved in schedule development having their work integrated and coordinated.	
13	Verification of Subcontractors‟ Scope of Work	The schedule should reflect the start and completion dates for prime contractors involved	
2.2	**Schedule Components**		
2.2.1	*Overview*		
14	Verification of Project Duration	Project duration should conform with parametric scheduling results	
15	Minimum Milestones	At least two milestones, start & end, should be included in each schedule	
16	Verification of Project	Generated S-Curve should be in compliance	

No.	Element	Explanation	Score (1-10)
	Performance	with typical S-curves	
17	Phase Duration	Each phase duration (Engineering, procurement, ...) should be in compliance with historical average data according to Total Installed Cost	
18	Phase Overlap	Engineering should not overlap construction by more than a percentage	
19	Calendar Verification	Non-working days should be indicated in the project calendar	
20	Working Hours Schedule-Estimate Compliance	Basis of scheduling should be in compliance with basis of estimate as regards working hours	
21	Congestion Index (labor density)	Maximum number of workers per square meter should be limited to avoid congestion (25 to 30 m^2/man)	
2.2.2	*Critical Path*		
22	Critical Path	Each critical activity should have a predecessor reflecting a physical dependency	
23.1	Schedule Criticality rate.1	Number of critical activities/ total number of activities should be limited	
23.2	Schedule Criticality rate.2	Duration of critical activities / total duration of activities should be limited	
24	Near criticality rate	Number of near critical activities/total number of activities should be limited (near critical activities: TF<5 to 10)	
25	Project Effort Ratio	Project critical path effort(number of laborers)/ total project effort should be within a min/max range	
26	Project Cost Ratio	Project critical path cost/ total project cost	

No.	Element	Explanation	Score (1-10)
		should be within a min/max range	
2.2.3	*Resources*		
28	Resource Loading	Schedule should be loaded with resources	
29	Responsibility Assignment	A responsible party/person should be assigned to each activity	
30	Schedule Leveling	Schedule should be leveled	
31	Trades' Peak Resource Loading	Compliance of peak resource loading of each trade with historical average data according to total installed cost and phase duration	
32	Trades' Peak Resource Loading relation	The relationship between various trades' peak resource loading should follow the historical average trend according to total installed cost and phase duration	
33	Trades' Rate of completion per week	Compliance of each trade"s progress curve with historical (typical) average Data according to total installed cost and phase duration	
34	Peak to average labor ratio	Peak to average number of laborers for each trade should comply with the average historical data according to total installed cost and phase duration	
2.2.4	*Special Considerations*		
35	Permits & Environmental Remediation	Permits & environmental remediation should be included in the schedule (if applicable)	
36	Startup and Testing Activities	Start up and testing activities should be included in the schedule (if applicable)	
37	Submittal Activities	Material and/or methods requiring prior approval must have their submittal activities	

No.	Element	Explanation	Score (1-10)
		in the network	
38	Submittals Review Activities	Submittal reviews to be reflected in schedule as an activity	
39	Procurement Activities	Procurement activities should precede special installation tasks	
2.2.5	*Activity Attributes*		
40	Number of Constraints	Number of constraints on activities start and finish should be limited	
41	Lag Duration	Should not be greater than the duration of Predecessor or Successor activity	
42	Relationship Ratio	Total number of relationships/Total number of activities, should be limited	
43	Activity without Affiliation	No open ended activity is allowed(activity without predecessor or successor)	
44	Number of Activities	If number of activities has not been indicated in the contract, it has to be within a min/max range	
45	Activity Float	Activities with excessive Total Float should be avoided	
46	Negative Float	No activity with negative float is allowed	
47	Weather Sensitive Activities	Special measures should be taken for this type of activities (e.g., Adjusting productivity according to seasonal conditions)	
48	Activity Duration (rules of thumb)	Activity duration should be limited to certain days	

Appendix C: contractors submitted schedule

Appendix D: proposed schedule