



Addis Ababa University
Addis Ababa Institute of Technology
School of Civil and Environmental Engineering

**STUDY ON PLANNING AND SCHEDULING OF CBE HEAD
QUARTER BUILDING CONSTRUCTION**

By

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A Paper Submitted To The School Of Graduate Studies Of
Addis Ababa University In Partial Fulfillment Of The
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Management)

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Declaration

I declare that this paper has been composed of solely by myself and that it hasn't been submitted, in whole or in part, in any previous application for a degree or professional qualification .All sections of the paper that use quotes or describe an argument or concept developed by another author have been referenced to show that this material has been adopted to support my paper.

Addis Ababa/ June 2018

Place/date

Derebe worku

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ABSTRACT

Planning and scheduling is very important for the efficient and effective completion of construction projects. Construction project planning is a method of determining “What” is going to be done, “How” things are going to be done, “Who” will be doing activities and “How much” activities will cost. Scheduling which address “when” includes activity schedule, material schedule, equipment schedule, financial schedule and manpower schedule. Especially in high-rise buildings, which have different interrelated activities, proper planning and scheduling is very important for the successful completion of the project. Nowadays high-rise building construction especially for banks’ and insurances’ headquarters is becoming common in Addis Ababa. Proper planning and scheduling of the project by breakdown into manageable activities and crews are important for the efficient completion of the project. For high rise building construction assigning special equipment and experienced professionals, applying duration reducing work method, using proper and economical design should be considered during the planning stage. The population of Addis Ababa or other Ethiopian cities is expected to increase significantly, due to the movement of people from the rural areas to the cities, there by requiring the efficient construction of high-rise building will be mandatory and in the future there will be a lot of high rise buildings. By taking this into account CBE head quarter building construction project was studied to establish the planning and scheduling techniques used in the project and key conclusions and recommendations are drawn for the project and for the other high-rise building construction to be constructed in the future too. By taking in to consideration the project master construction schedule and by preparing sample schedule for the structure work; recommendations forwarded to complete the project with in the contract period.

Key Words: - High-rise building, prefabrication, composite material

TABLE OF CONTENTS

DECLARATION	ii
ACKNOWLEDGMENT	iii
ABSTRACT	iv
LIST OF FIGURES	viii
ABBREVIATIONS	xi
CHAPTER ONE: INTRODUCTION	1
1.1 Background	1
1.2 Statements Of Problem.....	3
1.3 Objective Of The Research	5
1.4 Scope And Limitation	5
CHAPTER TWO: LITERATURE REVIEW	7
2.1 Project.....	7
2.1.1 Characteristics Of Project	7
2.1.2 Project Management	8
2.2 Project Planning And Scheduling	10
2.2.1 Enables And Barriers In Project Planning And Scheduling	10
2.2.2 Project Planning	12
2.2.2.1 Resource Planning	13
2.2.2.2 Planning Considerations For Construction.....	14
2.2.3 Project Scheduling	15
2.2.3.1 Elements Of Developing A Good Schedule	16
2.2.3.2 Activity And Project Duration Estimate	23
2.2.3.2.1 Duration Estimating Standards.....	25
2.2.3.3 Crashing Of Project Duration	26
2.2.3.4 High-Rise Building Scheduling	27
2.3 Reducing Construction Duration Of High Rise Building	29
2.3.1 Project Planning And Management	29
2.3.2 Construction Processes And Materials	30
2.3.2.1 Jump Form System To Construct Concrete Core Walls.....	30
2.3.2.2 Prefabrication Of Elements	31
2.3.2.3 Composite Materials	32

2.3.2.4 External Cladding	32
2.3.3 Construction Equipment	33
2.3.3.1 Special Equipment	33
2.4 Planning And Scheduling Of Commercial Bank Of Ethiopia New Head Quarter Building Construction	34
2.4.1 The Project Background	34
2.4.2 Employer’s Requirement Expressed In The Contract Document.....	35
2.4.2 Planning Of The Project	36
2.4.2.1 Overall Construction Process	36
2.4.2.2 Vertical Transport Planning	37
2.4.2.3 Steel Structure Construction	39
2.4.2.4 Tower Construction	40
2.4.2.5 Curtain Wall Construction	40
2.4.3 Organization Structure Of The Project And Related Issues	40
2.4.4 Scheduling Of The Project.....	41
2.4.4.1 General	41
2.4.4.2 The Schedule Of Typical Floor Structural Work.....	42
 CHAPTER THREE: RESEARCH METHOD	 43
3.1 Literature Review	43
3.2 Desk Study/Site Observation	43
 CHAPTER FOUR: ANALYSIS AND DISCUSSION	 44
4.1 Overall	44
4.2 Equipment And Tools	45
4.3. Safety In The Site	52
4.4. Site Lay Out And Working Condition	53
4.5. Sample Baseline Schedule Versus Updated Schedule	58
4.6. Project Progress Relative To The Master Schedule	60
 CHAPTER FIVE: CONCLUSION AND RECOMMENDATION	 62
5.1 Conclusion.....	62
5.2 Recommendation.....	63
 REFERENCES.....	 65
 Appendix A: Floor 28th Structure Work Baseline Construction Schedule Of The Project (Sample Typical Schedule).....	 67

Appendix B: Floor 28th And 32nd Structure Work Updated Construction Schedule Of The Project (Sample Schedule)	70
Appendix C: Master Construction Schedule of The Cbe Headquarter Construction Project	75

LIST OF FIGURES

figure 1 . Adapted Form Of Pmi’s Nine Project Management Knowledge Areas (Pmbok, 2004).....	9
Figure 2 Relationship Type Examples	20
Figure 3 Illustration Of Productivity Changes Due To Learning (Ch.Chowdeswari 2017).....	28
Figure 4 . Sample Portion Of A Manual High-Rise Schedule.....	29
Figure 5 . Prefabricated Concrete Manhole For Cbe Head Quarter Project	32
Figure 6 Tower Crane And Elevators	38
Figure 7 . Concrete Pump And Its Accessories	39
Figure 8 . Composite Column Structure	39
Figure 9 Organization Structure Of The Project.....	40
Figure 10 Cbe Office Tower Building Under Construction	45
Figure 11 Cranes And Elevators	46
Figure 12 Reinforcement Bar In Roll Measuring And Cutting Machine.....	47
Figure 13 Reinforcement Bar Tread Making Machine.....	47
Figure 14 Concrete Casting Using Vibrator Which Works With Electric Power	48
Figure 15 Plywood Drilling Machine For Tying By Treaded Bar.....	48
Figure 16 Concrete Drilling Machine	49
Figure 17 Dust/Wood Chips Cleaning Machine Which Works By Compressor	49
Figure 18 Bolt Fixing And Loosening Tools For Formwork Post Erection.....	50
Figure 19 Plywood Cutter For Formwork Placing	50
Figure 20 Plywood/Timber Cutter For ‘Pency’ Formwork Placing	51
Figure 21 Concrete Pump.....	51
Figure 22 Damper Used To Transport Mortar And Debris	52
Figure 23 # 3 Tower Crane Which Cover All Area Of Office Tower	52
Figure 24 Safety Warnings.....	53
Figure 25 Reinforcement Bar Preparation (Cutting & Bending) Area	54
Figure 26 Workers During Reinforcement Bar & Pipe For Electric Installation Fixing On The 29th Floor	54
Figure 27 Carpenter And Bar Bender Working On The 30th Floor Of The Tower	55
Figure 28 Contractor Project Office And Resident Building Location Inside The Site	55
Figure 29 Basement Cleaning And Make Ready For Fill	56
Figure 30 Different Class Of Concrete (For Beam & Column) Separation Using Rough Texture Sheet Metal.....	56

Figure 31 End Of Composite Steel Section (30th Floor Of The Tower)..... 57
Figure 32 Stair Case Riser Prefabricated Formwork..... 58

LIST OF TABLES

Table 1 Impact Indices And Ranks OfThe Barriers To Planning And	11
Table 2 Impact Indices And Ranks OfThe Enablers To Planning And Scheduling	12
Table 3 Plan Versus Executed For Some Activities	60

ABBREVIATIONS

AAU-AAiT = addis ababa university-addis ababa institute of technology

CSCEC = china state construction engineering corporation

CSFs = critical success factors

ETB = Ethiopia birr

FF = finish-to-finish

FS = finish-to-start

HVAC = Heat, Air Ventilation, and Cooling

HCB = hollow concrete block

ID = Identification

LOB = line of balance

RII = Relative Impact Index Factor

SF = start-to-finish

SS = start-to-start

USD = United States dollar

WBS = work breakdown structure

W/C ration = Water Cement ratio

4B+G+48 = four basement floor + ground floor+ 48 floor above ground level

CHAPTER ONE: INTRODUCTION

1.1 Background

Projects have a major role to play in the economic development of a country. In our country high-rise building construction especially in Addis Ababa is in a good start. Due to an increasingly competitive environment, construction companies are forced to be more efficient and achieve competitive operational advantage. Companies are always looking for improvements in equipment features, communication tools, efficient management techniques, and training human resources (T.Subramani et al., 2014).

Among the major problems facing technical management today are those involving the coordination of many diverse activities toward a common goal. In a large construction project management must devise plans which will tell with as much accuracy as possible how the efforts of the people representing different functions should be directed toward the project's completion. In order to devise such plans and implement them, management must be able to collect pertinent information to accomplish the following tasks:

- (1) To form a basis for prediction and planning
- (2) To evaluate alternative plans for accomplishing the objective
- (3) To check progress against current plans and objectives, and
- (4) To form a basis for obtaining the facts so that decisions can be made and the job can be done (James et al., n.d).

Construction planning and scheduling is one of the important tool in a construction project. Every construction project involve with a lot of activities which need to be planned and schedule properly to ensure the completion of the project.

Construction project planning is a method of determining "What" is going to be done, "How" things are going to be done, "Who" will be doing activities and "How much" activities will cost. By raising the question" what", "how", "who" and "how much" and answering properly those issues we can make ready resources for the successful completion of the project.

A construction project can vary from extremely profitable to barely worth it and sometimes end up costing the contractor more than what he or she is getting paid to

complete it. The profitability of a project depends heavily on the ability of the general contractor to anticipate potential problems and avoid them. Usually, a construction project will not proceed as planned due to various factors. These factors include, but are not limited to, weather conditions, city regulations and codes, differing site conditions, change in construction materials prices and most importantly workers' productivity.

Because construction is almost always conducted by humans, the productivity rate of workers will have a major impact on the project's budget and schedule. The productivity rate is the amount of work output completed in a certain period of time. There are many factors that affect the productivity rate of workers such as thermal comfort, safety issues, availability of tools and materials, length of work hours and availability of supporting facilities such as toilets and proper waste containers. The site layout and safety coordination play the major roles in controlling the productivity rate (Alshanbari and Hamzah, 2010).

The United Nations predicts that the world's population is expected to increase by 30% (of 2012) by 2050 and 75% of the population will live in cities. Such a rapid population explosion demands innovative ways to supply more living and working spaces. Skyscrapers, also called super-high-rise buildings, have become an important alternative in the urbanization process to increase vertical space and to accommodate more people. Therefore, it has become a favorite way in the last decades of accommodating a rapid expansion of population (Yangkui li.et al., 2016). In developing countries like Ethiopia the population will live in the cities increase due to industrialization because of this rate of high-rise building construction will be increased to fulfill the living and working space requirements. As we see in the case of Addis Abeba city areas which were known by their of g+0 villa (houses) demolished and construction of high rise buildings in a good start this indicates that the city plan to expand vertically rather than expanding horizontally. For the successful vertical expansion of the cities proper planning and scheduling is very important.

Scheduling is the determination of the timing and sequence of operations in the project and their assembly to give the overall completion time. To evaluate the efficiency of a project completion time, cost and quality are important criteria. In the case high-rise building; if the project isn't well planned and scheduled there will be time overrun. In high-rise buildings the equipment required is special, the activities are a lot and complex, most materials required are prefabricated, especially in our country most material and equipment are imported and in the city there is material stocking area problem in the site. Taking in to consideration those facts well planning and Scheduling

is very important for the successful completion of the high-rise building construction.

In order to avoid the time overrun of high-rise building construction

- We should list the major activities.
- Using special formwork like a climbing formwork systems [sometimes referred to as self-climbing or self-lifting) to construct the core walls has been successful in reducing construction times, primarily because the process become repetitive though the whole height of the building.
- Using special equipment to facilitate horizontal and vertical movement is one of the main tasks in the high-rise buildings construction.
- Composite construction in high-rise buildings refers to the mixed use of concrete and structural steel in major load supporting elements like columns.
- Using prefabricated elements is another method that has been successfully used to save time in the construction of high-rise buildings. The repetitiveness of many elements makes this process suitable and very effective like curtain wall cladding.

Even if in our country high-rise building construction experience is less, now a day's most financial institution head quarter buildings are high-rise. When we study the planning and scheduling of Commercial Bank of Ethiopia Head quarter building construction project, the way of planning and scheduling can be applied for the high-rise building construction in the country. The Commercial Bank of Ethiopia Head quarter building construction project has a total floor area is estimated about 165,476.4 m² which consists of office tower has floors of 4B+G+48 which includes the main departments of the Bank and low-rise buildings (4B+G+6 and 4B+G+8) are mainly conference centers, commercial center and parking garage (AAiT, 2017). In this study we will see the way of planning and scheduling of CBE head quarter in relation to theoretical one and finally from the study I will forward the conclusion and recommendation to be useful for the efficient construction of high-rise building.

1.2 Statements of Problem

In the United States Government Accountability Office examined 413 projects that failed to achieve their goals, and 79% of the causes were due to poor planning, 15% were poorly performed and 6% were both (Emblemsvag et al, 2014). If the effect of poor planning has such an effect in the developed nation like United States, in Ethiopia the effect poor planning is more than that because it is a developing nation. The Ethiopian construction industry has a widespread problem concerning cash flow in projects. As a consequence of this problem, there are a lot of half-finished buildings that are on hold

until the owner manages to finance further production. Due to the cash flow instability in projects, many sub-contractors and suppliers demand cash or check payment in advance to performed work or delivery. There are a large number of labors in projects, but old-fashioned work methods and outdated tools often make the efficiency in production low (karlsson, 2011). As stated by the researcher most contractors still using old-fashioned work methods and outdated equipment. Due to this poor plan that means using eucalyptus scaffolding rather than using steel scaffolding, and which will cause time overrun due to the old-fashioned work method; this results disappointment in the client side. Some clients when they made a contract with the contractor they worry about the advance payment because of this; that means the client not well planned their finance source due to this the project finance problem happen. When we see high-rise building construction it requires special equipment and work methods in addition to adequate finance source. Most construction projects schedule prepared at the beginning of the project because the contract forced the contractor to do so but not revised on progress without delay due to this time overrun exist on the project completion time. The contractor better prepare feasible schedule for the purpose to establish production goals, to manage change and for the communication of the construction plan.

In this study we will see how the CBE head quarter planning and scheduling was done and their progress in relation to the plan and schedule. As we observed most building construction in our country their performance at the beginning is good which include activities like earth work and concrete casting. After the completion of the structural work excessive delay of the project mostly observed; this progress continuity problem may be lack of good planning and scheduling of different activities by considering their relationship. When we schedule we should identify critical activities and assign resource for it on time for the execution of activities according to the specified time. The delay of critical activity will be the delay of a project as a whole. Especially in the case of high-rise building construction good planning and scheduling is very important for the successful completion of the project because in high-rise building a lot of activities exist as well executing the activities is difficult relative to low-rise building construction.

An accurate schedule can help better distribute construction resources, such as money, machinery, and materials, in a more efficient way. For example, a project team can arrange the project finance and cash flow in advance according to the project schedule. On the other hand, skyscrapers are commonly regarded as a symbol of urban development and economic status, so a misjudged schedule of skyscrapers may have an influence beyond

the project itself to extend to its neighboring zones or overall society (Yangkui et al, 2016).

Even though we haven't much experience of high-rise building construction due to our bad mostly observed time overrun experience that was seen even on low-rise building constructions projects; in the future clients may hesitate to give high-rise building construction contract for local contractors.

Hence in order to minimize the above mentioned problems the study will forward the good methods of planning and scheduling of high-rise building construction projects from literature review and as well by considering the good experience of CBE head quarter construction project.

1.3 Objective of The Research

In our country high-rise buildings are not common. But now a days most financial institutions like banks and insurances starting construction of high-rise head quarter buildings. Those buildings are constructed by foreigner contractors especially china's construction companies. This case happens as most clients said verbally they have not confidence about the resource capacity of local contractors; of course they have different productive and non-productive reasons to choice foreign contractors. This lack of confidence developed may be due to the time overrun of most construction project constructed by local contractors. In addition to the financial capacity problem; most cost overrun and time overrun happen may be due to lack of good planning and scheduling. So the aim of the study is to examine the planning and scheduling of CBE head quarter construction project and the under listed are the specific objectives of the study;

- To assess the CBE head quarter construction project master schedule versus executed status.
- To evaluate the CBE head quarter construction project pre-construction planning versus actually done on site.
- To evaluate the CBE head quarter construction project weakness and strong side in relation to planning and scheduling
- To identify the practical scheduling methods for high rise building construction.

1.4 Scope and Limitation

Planning and scheduling of high-rise building is very important for the successful completion of the project. This study deals with the planning and scheduling of CBE head quarter building construction especially the structural parts. The building after completion

will be the tallest building in the country and studying the planning, scheduling of this project will be a good view for the other projects to take as an experience in the future. The limitation of the study are the project will not be completed during the study period and there is also a limitation of papers like thesis, journal on the study of planning and scheduling of high-rise building construction in Ethiopia. The other limitation for this research is that even if the study is for academic purpose the contractor is not willing to give all the information requested for the purpose of this study.

CHAPTER TWO: LITERATURE REVIEW

2.1 Project

A project can be defined as a set of a large number of activities or jobs that are performed in a certain sequence determined logically or technologically and it has to be completed within a specified time and cost whilst meeting the performance standards. Another definition of a project is a temporary endeavor with the objective to create a unique product or service. It is temporary in the aspect that it has a definite beginning and a definite end. The uniqueness with a project means that the provided service or product is different from all other services and products. Many organizations use projects to response to requests that cannot be handled within the normal organizational limits. The size and length of a project can vary from one person to thousands and from a few weeks to more than five years (karlsson, 2011).

2.1.1 Characteristics Of Project

- (1) **Objectives:** A project has a set of objectives or a mission. Once the objectives are achieved the project is treated as completed.
- (2) **Life cycle:** A project has a life cycle. The life cycle consists of five stages i.e. conception stage, definition stage, planning & organizing stage, implementation stage and commissioning stage.
- (3) **Uniqueness:** Every project is unique and no two projects are similar. Setting up a cement plant and construction of a high-rise building are two different projects having unique features.
- (4) **Team Work:** Project is a team work and it normally consists of diverse areas. There will be personnel specialized in their respective areas and co-ordination among the diverse areas calls for team work.
- (5) **Complexity:** A project is a complex set of activities relating to diverse areas.
- (6) **Risk and uncertainty:** Risk and uncertainty go hand in hand with project. A risk-free, it only means that the element is not apparently visible on the surface and it will be hidden underneath.
- (7) **Customer specific nature:** A project is always customer specific. It is the customer who decides upon the product to be produced or services to be offered and hence it is the responsibility of any organization to go for projects/services that are suited to customer

needs.

(8) Change: Changes occur throughout the life span of a project as a natural outcome of many environmental factors. The changes may vary from minor changes, which may have very little impact on the project, to major changes which may have a big impact or even may change the very nature of the project.

(9) Optimality: A project is always aimed at optimum utilization of resources for the overall development of the economy.

(10) Sub-contracting: A high level of work in a project is done through contractors. The more the complexity of the project, the more will be the extent of contracting.

(11) Unity in diversity: A project is a complex set of thousands of varieties. The varieties are in terms of technology, equipment and materials, machinery and people, work, culture and others.

2.1.2 Project Management

Project management is the work methods that are used to control and manage activities in a project. Project management involves the application of knowledge, skills, tools and techniques in project activities to meet the project objectives. All management work is based on processes as: initiating, planning, executing, controlling and closing. The PMI, Project Management Institute, has defined nine categories of project management knowledge areas which are listed in the figure below (karlsson, 2011).

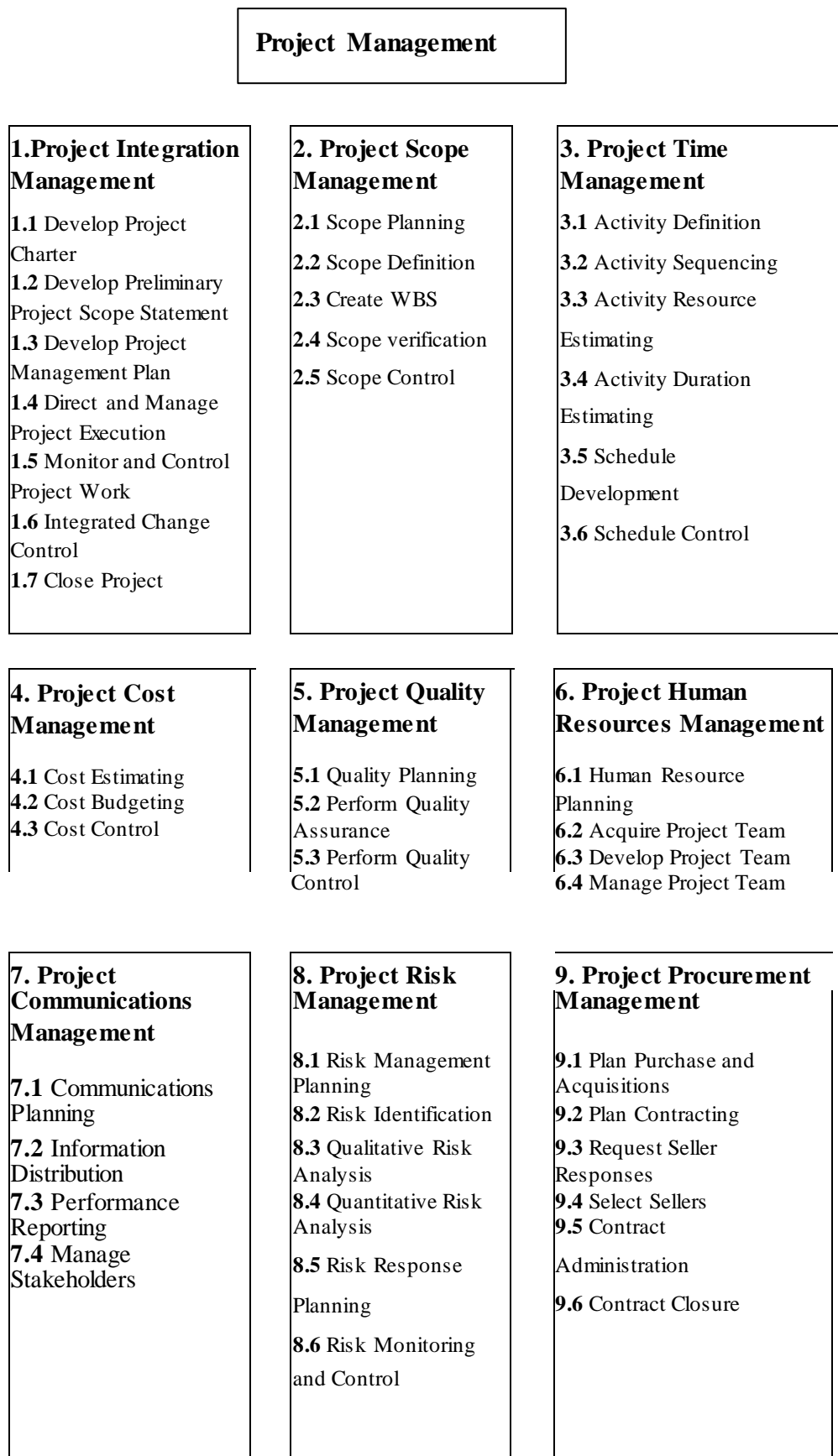


Figure 1 . Adapted form of PMI's nine Project Management knowledge areas (PMBOK, 2004).

2.2 Project Planning And Scheduling

Construction project planning is a method of determining “What” is going to be done, “How” things are going to be done, “Who” will be doing activities and “How much” activities will cost. In this sense planning does not cover scheduling, which addresses the “When”, but once planning is complete scheduling can be done. The first step in building a model of a project planning and scheduling system was to separate the functions of planning from scheduling. We defined planning as the act of stating what activities must occur in a project and in what order these activities must take place. Only technology and sequence were considered. Scheduling followed planning and is defined as the act of producing project timetables in consideration of the plan and costs.

2.2.1 Enables And Barriers In Project Planning And Scheduling

Planning and scheduling have a significant role in controlling project performance and form an integral part of project management. They are often referred to as if they were synonymous rather than two distinct stages in a process for estimating the duration of the project and for providing a workable basis upon which activities can be implemented. A prerequisite for successful scheduling is the definition of all the activities required to deliver the project's scope, the correct sequencing of those activities and the addition of resources and time to create the schedule. Hammad Al Nasser and Radhlinah Aulin study's adopted a questionnaire-based survey to measure the impact of each factor and the data were analyzed using the relative impact (or importance) index (RII). On the basis of RII rankings, the results revealed that the identified enablers and barriers were all considered significant (Hammad and Radhlinah, 2016).

Table 1 Impact Indices and Ranks of the Barriers to Planning and Scheduling

#	Barriers in Descending Order	Value	Rank	significance
B2	Insufficient support from project stakeholders in planning and the preparation of schedules	0.725	1	VS
B3	Poor decision-making regarding activity criticality	0.688	2	S
B8	Absence of resource-constrained scheduling for dealing with uncertainty problems	0.681	3	S
B9	Absence of new technology and software for planning and scheduling	0.671	4	S
B1	Lack of effective leadership	0.669	5	S
B4	Lack of education and training in planning and scheduling	0.655	6	S
B6	Absence of schedule contingency	0.646	7	S
B7	Trivial control and reporting system between management levels	0.646	7	S
B5	Incompatibility of planning methods with the project's nature (i.e., complexity and size)	0.610	8	S

Note: S- significant

V.S – Very significant

Table 2 **Impact Indices and Ranks of the Enablers to Planning and Scheduling**

#	Enablers in Descending Order	RII		
		Value	Rank	Significance
E4	Reliability of detailed schedules	0.746	1	VS
E11	Effectiveness of resource levelling in scheduling	0.740	2	VS
E12	Efficiency of managerial support for motivational and training programmes	0.740	2	VS
E7	Fast re-planning and recovery from unexpected changes in the baseline schedule	0.736	3	VS
E1	Well-documented inputs, milestones and deliverables in scheduling	0.733	4	VS
E5	Focusing on a holistic approach rather than on the completion of individual activities	0.733	4	VS
E3	Cost-efficiency in accelerating and reworking schedules and their activities	0.731	5	VS
E2	Proficiency of team in managing scheduled activities, deviations and corrective actions	0.727	6	VS
E9	Availability of alternate planning methods to overcome shortcomings with existing methods	0.727	6	VS
E6	Proper understanding of the interrelationship (alignment) between scope, schedule and budget	0.724	7	VS
E8	Effective tracking of in-progress schedule deviations	0.711	9	S
E10	Improving schedule quality control by considering unintended human operational behaviors in Scheduling	0.705	10	S

Note: S- significant

V.S – Very significant

2.2.2 Project Planning

Project planning is a general and most common term in construction management which refers to attain the expected goals and destinations. Planning is the key to bring the expected projects into reality or in existence. Therefore, the term 'Project Planning' has

been used at various platforms to get the close meaning of different things. Generally planning involves the breakdown of the undertaken whole project works into small definable, identifiable and quantifiable tasks or activities or works and then constitutes the logical interdependencies between them (Vishan and Balasaheb, 2017).

Construction planning may be said to consist of five steps:

1. A determination of the general approach to the project
2. Breakdown of the project into job steps or “activities” that must be performed
3. Ascertainment of the sequential relationships among these activities
4. Graphic presentation of this planning information in the form of a network
5. Endorsement by the project team

The segments into which a project is subdivided for planning purposes are called activities. An activity is a single work step that has a recognizable beginning and end and requires time for its accomplishment. The extent to which a project is subdivided depends on a number of practical considerations, but these eight are suggested as guidelines for use when activities are being identified:

1. By area of responsibility, where work items done by the general contractor and each of its subcontractors are separated
2. By category of work as distinguished by craft or crew requirements
3. By category of work as distinguished by equipment requirements
4. By category of work as distinguished by materials such as concrete, timber, or steel
5. By distinct structural elements such as footings, walls, beams, columns, or slabs
6. By location on the project when different times or different crews will be involved
7. With regard to owner’s breakdown of the work for bidding or payment purposes
8. With regard to the contractor’s breakdown for estimating and cost accounting purposes

2.2.2.1 Resource Planning

In planning resource requirement the following points to be considered:

- a) The total resource requirements for a project over its duration.
- b) Minimum delay in completion of the project when insufficient resources are available.
- c) Most efficient utilization of resources to carry out the project in a fixed time.

Resource planning is the process of making sure resources are available as required to execute the project according to schedule. Two types of resource planning

problems exist while preparing schedule. In one, the project faces a scarcity of resources and the activities on network must be arranged in such a way that the requirement of resources does not exceed availability. In case such an arrangement is not feasible, the one which gives the minimum additional requirement of resources is chosen. The resources are allocated among competing activities in the order of importance. In other type of resource planning problem the scarcity condition is relaxed and what is needed is to level up the highly fluctuating demand for resources at different times, primarily to facilitate project supervision and enhance efficiency (Shaik mohammad et al., 2014).

2.2.2.2 Planning Considerations For Construction

The following are some of the basic considerations required during the construction planning process.

- Statutory Obligation
- Contractual Obligation
- Social Obligation
- Site Characteristics

Statutory Obligation

Statutory obligation would include the compliance with Building Regulation / Building Ordinance and Approved Plan. It is the duty of the main contractors to provide continuous Site Supervision and to notify Buildings Department any contravention of regulations that would result from carrying out the works shown in approved drawings.

Contractual Obligation

Contractual obligation is the commitment between the Contractor and the Employer in delivering the services as accordance to the terms and conditions as laid out in the contract documents. This would also include special terms and conditions required by the Employer together with design assumptions and requirements from the Architects and Engineers.

Social obligation

Social obligation involves the care of workers on site and neighbors or public outside site boundary. For the workers, we have to provide a safe working environment together with all necessary welfare facilities for all workers working on site and to ensure they are getting paid from the respective employers in a timely manner. In taking care of the neighborhood, it has always been the concerns of main contractors in minimizing nuisance and impacts to all nearby residents and pedestrians or road users during the course of construction. Besides the care of workers and neighborhood, sustainability is also one of

the upcoming key issues in the construction industry.

Site Characteristics

Every projects are different and having its own characteristics in view of its own geographical location, nature of works, time of construction, people's knowledge and skill-set. Construction planning is somehow tailor made to suit the site characteristics or constraints and is a one-off exercise, which is not fully applicable to other identical projects although the concept may be the same (David, n.d).

2.2.3 Project Scheduling

Scheduling refers to slotting out the time duration by the thorough and explicit analysis of the planning term to each and every activity to know the final project duration and the project delivery date. In other words it governs the timing of each work activities recognized by the planning process before or during project execution. Typically it shows and signifies the sequential order or phasing various individual project activities in a systematic way to complete the project. The schedule is a tool or a technic of every project management team which is used and practiced to predict most probable project completion time and thus enabling the in/ on time resources conception which are budgeted on the particular work (Vishan and Balasaheb, 2017).

Several steps are involved in devising an efficient and workable job schedule. The next list of eight steps is offered as a procedural guide.

1. Estimate the time required to carry out each network activity.
2. Compute the time period required for overall project completion using these time estimates.
3. Establish time intervals within which each activity must start and finish to satisfy the completion date requirement.
4. Identify those activities whose expedient execution is crucial to timely project completion.
5. Shorten the project duration at the least possible cost if the project completion date will not meet the contract or other requirements.
6. Adjust the start and finish times of selected activities to minimize resource conflicts and smooth out demands for manpower and equipment using surplus or float times that most activities possess.
7. Make a working project schedule that shows anticipated calendar dates for the start and finish of each network activity.
8. Record the assumptions made and the plan's vital boundary conditions.

These will become an integral aspect of the completed baseline project schedule.

2.2.3.1 Elements of Developing a Good Schedule

Good schedule is very important for the successful completion of the project. The development of a 'good schedule' is achieved through the consistent application of sound general practices. The under listed are the practical benefits of good scheduling.

- requires managers to think the project through prior starting the work
- provides a structured approach to planning
- Means of communicating the work plan to others
- identify problems before they arise
- identify long-lead fabricated items
- assess resource requirements
- forecast cash flows
- serves as primary documentation for delay claim analysis and other time impact considerations.

To meet the above listed benefits the essential elements that must be considered by the project team when developing a good schedule.

A) Developing the Scheduling Framework

1 Determining How the Schedule Model will be developed

At the outset, the project manager, in conjunction with the project team, should determine a development plan for the schedule model. If the schedule model can be developed in its entirety, and determining the stakeholders whose input will be required as part of the schedule development process. The schedule model describes the work to be done (what), the resource(s) required to do it (who), and the optimum sequence (activity starts, finishes, and relationships) in which the work should be undertaken (when).

2 Understand the Full Scope of the Project

The scheduler needs to review and understand the project's scope documents with particular emphasis given to the WBS. These documents provide the back ground, information, and understanding needed to develop the schedule model. The goal of this process is to ensure that all aspects of the project scope have been adequately defined and included in the schedule model.

Activities in the schedule model represent the work that produces the deliverables or work packages identified in the WBS; thus, all work elements in the WBS should be directly traceable to a schedule activity or group of activities. The researchers found that the seven most important variables affecting the time schedule of high-rise type of structure were: (Maria, 2000)

- (1) Area of external cladding;
- (2) Height of the building;
- (3) Ratio of total gross floor area to the number of stories;
- (4) Type of foundations;
- (5) Information flows between architect/engineer and contractor;
- (6) Presence/absence of precast facades; and
- (7) Type of scheme [rental/purchase).

Managers are or should be alerted to the relevance of these factors whenever they have time constraints. The more accurate the information about these areas, the more reliable is the schedules.

3 Identify the Project and Schedule—Project Schedule ID

Every schedule model needs to have a unique name and identification number to identify the project. Each version of the schedule model needs to have a unique version number or ID number. This is essential to allow the proper archiving of project documents and audit processes.

4 Establish Project Calendars and Work Periods

The scheduler will determine, in concert with the project team, the work periods which will be selected for the project. These work periods may be different for specific activities or portions of the project including resources. Some of the calendar issues to consider include:

- Number of working days in a week
- Number of shifts to be worked each day
- Number of hours to be worked each shift or day
- Any periods of scheduled ‘overtime’ work or non-working time (e.g., holidays).

These elements play a major role in determining the number and structure of the project calendars required for the schedule.

Generally accepted practice is to use a default project calendar which is adequate and reasonable to perform the work, based on the project’s normal working times.

5 Establish the Optimum Project Update Cycle

The project management team, using the expertise of the scheduler, should determine the appropriate frequency for performing updates and status against the schedule. This includes determining at what point in the cycle the update will occur and how often the status will be reported. The optimum update cycle will vary with industry and project intent from hourly updates for planned out age projects for manufacturing/production facilities to weekly or monthly updates for major

construction or software development projects. The chosen update cycle has a direct relationship or bearing on the activity durations contained within the schedule.

6 Designing an Effective Activity Coding Structure

A reasonable and useful code structure should be developed so that selecting, sorting, and grouping of the schedule data to facilitate the development and maintenance of the schedule model, as well as meeting the project reporting requirements, is easily accomplished. A structured activity ID/numbering scheme may form part of the overall coding design. Using a structured numbering system may allow the users of the schedule to have a better understanding of how a particular activity fits into the bigger project picture by grasping the significance of the activity number itself. At a minimum, an activity number must be unique, and follow a scheme appropriate to the project.

7 Determining Resource Planning Requirements

If the schedule is to take resource availability into account, the resource pool available to the project needs to be determined together with any special resource calendars, skill sets, and availabilities. Resources used for scheduling purposes may be the same or a subset of the resources used for cost estimating. Just as activity codes can be used to classify and organize activities, resource codes can be assigned to resources to classify resources according to organization, skill level or type, reporting structure, etc. And, just as Activity IDs should be structured into a meaningful scheme, Resource IDs should be similarly structured (PMI, 2007).

B) Developing the Baseline Schedule

1 Define Milestones

Once the scheduler has a feel for the overall structure of the project data discussed previously, he or she can begin to lay out the project's milestones. Milestones will have zero duration, will be used as bench marks to measure progress against, and can also reflect the start and finish points for various project events or conditions. Generally, a milestone will represent the start or completion of a part of the project and/or may be associated with external constraints, such as the completion of a deliverable or the receipt of an external input. As a minimum, each project must have a start milestone and finish milestone.

2 Design the Project's Activities

The scheduler, in conjunction with the individuals responsible to perform the work of the project, can begin to create the list of activities that will need to be performed to complete the project. The characteristics of a well-designed activity include:

- The activity is a discrete element (or block) of work that is a tangible element of the project scope
- A single person should be responsible for performing the activity. This does not preclude the idea that multiple resources may be required to accomplish the activity, but it does require that a single entity is responsible for its performance. That person should be the same one who will report progress on the activity.
- Activities describe the work that must be accomplished. As such the description for each activity must start with a verb and contain a unique object. Adjectives may be helpful to clarify ambiguities. Each activity description should be unique and leave no room for confusion, that is, it can be identified without ambiguity.
- The work represented by an activity should, once started, be capable of proceeding to completion without interruption (except for naturally occurring non-work periods in the calendar). If the work on an activity is suspended or delayed, it is often beneficial for the activity to be split into two or more activities at natural break points.
- The work contained in an activity should be scoped so that the activity's duration will be less than two times the update cycle (ideally never more than three times the update cycle). This allows the reporting of the start and finish of an activity within one or two update cycles, allowing management to focus on performance and corrective action if needed. Exceptions to this general rule are continuous activities, (e.g., summary activities such as boring a 2-mile long tunnel or paving several miles of highway).

3 Design the Project's Logic

Connecting the activities and milestones together with 'sensible' logic is the bedrock of any schedule model. The method of connection is defined as a relationship. Every activity and milestone except the first and last must be connected to at least one predecessor and one successor.

For most instances, each activity would finish prior to the start of its successor activity (or activities) (known as a finish-to-start (FS) relationship), but that is not always possible. If it is necessary to overlap activities, the scheduler may elect to use start-to-start (SS), finish-to-finish (FF) or start-to-finish (SF) relationships. Figure 2 provides examples of the four relationship types in CPM methodology. Whenever possible, the FS logic relationship should be used. Ideally, the sequence of all activities will be defined in such a way that the start of every activity has a logic relationship to a predecessor and the finish of every activity has a logic relationship to a successor.

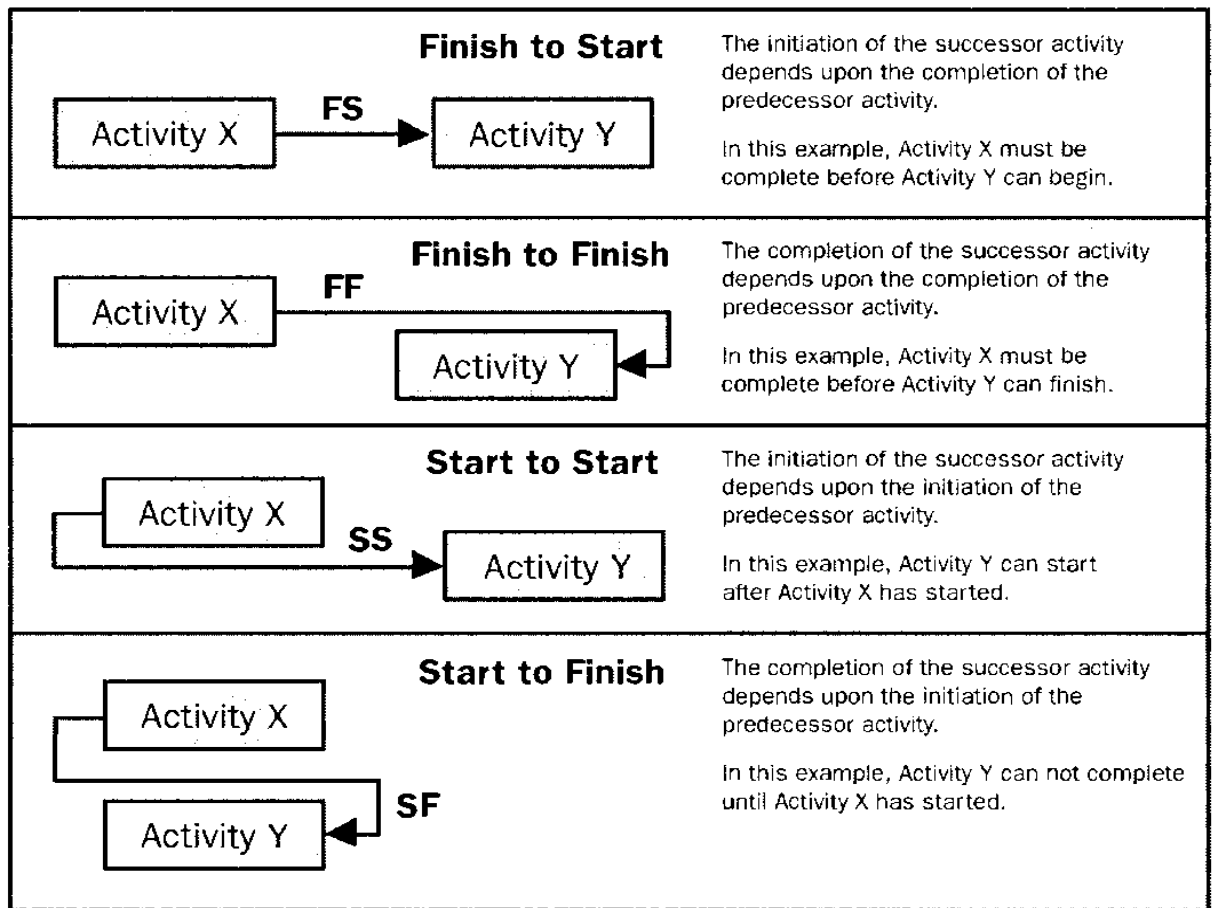


Figure 2 Relationship Type Examples (PMI, 2007)

The scheduler may also assign lag(s) to some relationships. A lag imposes a delay between the preceding and succeeding activity. It is also possible to assign constraints to activities and milestones which require the activity or milestone to start or finish at specific points in time.

4 Determining the Duration for Each Activity

Activity duration estimating is the process of estimating the number of work periods needed to complete individual schedule activity. A very important thing you need to be aware of and highlight during the assessment description. The concept of ‘project or activity run time’ describes the amount of working hours needed to spend for the project or activities execution. While, the number of work periods needed, must add to run-time issues such as resource availability, weekends and holidays, lunch breaks, etc. In many cases, the number of resources that are expected to be available to accomplish an activity may determine the activity’s duration. An increase or decrease to a driving resource allocated to the activity will have a direct effect on the duration (but this is not a simple ‘straight line’ relationship). Other factors influencing the duration are the type or skill level of the resources

available to undertake the work, resource calendars, and the intrinsic nature of the work. While it is feasible to determine a duration for an activity at any time, generally accepted good practice recommends defining the activity first, then tying it logically into the overall schedule sequence and then focusing on how long it will take to accomplish the work. At this time, the relationship between the activity and other work in the schedule will be more easily appreciated; and resource flows, activity team sizes, and the like can begin to be determined.

5 Analyzing the Schedule Output

Once complete, the schedule model will be comprised of a number of unique activities of varying durations with defined logic relationships. It provides the project team with information on what must be accomplished and the sequence required to accomplish the project deliverables. However, it still does not indicate when to do what. In order to acquire that information, the scheduling tool is activated to calculate the dates and other values within the schedule model according to the chosen scheduling method. Despite the speed of many computer programs, the scheduling function always requires three distinct processes for 'time analysis' and a fourth if resource smoothing or leveling is being used. The discrete steps are:

- A start date is assigned to the start milestone. Then moving throughout the network from activity to activity (from left to right) and in the sequence defined by the logical relationships, start and finish dates are assigned to each activity and milestone, as determined by the defined durations. This is called the forward pass. The start and finish dates on each activity are called the early dates and when the analysis reaches the end of the network it establishes the earliest possible finish date for the project.

- Next, a finish date is assigned to the end milestone. This could be the same date as the one calculated by the forward pass or a different date applied as a constraint. The analysis process then works back through the network from right to left until it arrives back at the start milestone, and another set of start and finish dates is assigned to each activity. This is called the backward pass and establishes the late dates for each activity and milestone.

- Float values are calculated by comparing the early and late dates as follows:

Total float is calculated by subtracting the early finish date from the late finish date (start dates can be used instead). Free float is calculated by subtracting the early

finish date of the activity from the earliest start date of the closest of its successors. Free float is never negative.

- Once the float values have been calculated, resource smoothing and/or leveling may be carried out to minimize resource over allocations or reduce the fluctuations in resource demand. If this process is to be done automatically, the scheduler needs to determine the processes and algorithms to be used.

6 Approving the Schedule

The project team should be actively involved in reviewing the results of this initial scheduling process. The review should consider the analyzed project end date, milestone completion dates, and resource requirements (compared to resource availability) to determine the acceptability of the schedule. Where alterations are required, variations are made to the schedule logic, resource allocations and/or durations, and then the schedule is reanalyzed. The most often pursued alteration involves actions to reduce the overall duration of the schedule. The key techniques used to compress the schedule are ‘crashing’ and ‘fast tracking’. These iterations continue until an acceptable project schedule is developed, one that all of the project stakeholders can agree with.

7 Baseline the Schedule

Once agreed upon, the first version of the schedule that is developmentally complete to be approved for capture or copied for future reference is called the project baseline schedule. This baseline becomes the benchmark against which project performance may be measured. It is a generally accepted practice that every project should have a baseline schedule in place before the execution of the project work commences. Once the baseline has been approved, reports are distributed in accordance with the project’s communication plan and changes are monitored and controlled through the integrated change control process.

8 Maintaining the Schedule

Change is inevitable and every project will experience it. The last major component needed to ensure successful project execution is effective change control. The key is to determine how the project will approve and track change as it occurs throughout the project’s life cycle. Change can occur simply by work progressing more quickly or slowly than planned, as well as when changes in other elements of the project occur (e.g., scope changes) and/or whether the project team decides to modify its approach to the project work.

The status/update process occurs on a regular basis determined during the project

planning process. The steps involved in maintaining the schedule at each status/update are:

- Collect and record the actual status of the work at a predetermined date/time for the project. The information collected should include the actual start dates for all activities that have commenced and actual finish dates for all activities that have been completed during the reporting cycle. Where an activity is in progress, the amount of work accomplished and the time needed to complete the remaining work should be determined. Other information gathered at this time may include data on resource utilization and costs incurred.
- Enter status information into the schedule model and re-analyze the remaining work to determine the project status. All incomplete work will be rescheduled to a date/time after the data date.
- Compare the newly updated schedule model outputs with the stored baseline and, where necessary, employ actions to lock in gains and/or recover losses (manage schedule variances). Due to the normal small variances in project execution from plan, variance thresholds may be used to determine which activities and conditions require reporting and/or further action. A commonly used date variance is the finish variance between early finish and baseline finish, which is usually expressed in units such as working days.
- Update the schedule with any agreed changes resulting from the overall change control process to ensure the schedule model represents 100% of the current work scope of the project. The updating and adjustment processes may need a number of iterations to maintain a schedule model that remains realistic and achievable.
- Distribute reports in accordance with the project's communication plan once the updated schedule has been confirmed to be accurate.
- Update the baseline if authorized scope changes have been incorporated into the updated schedule model.
- Maintain records that explain all changes in activity durations or logic as the alterations are being made in the schedule. Activity log notes are often used for this purpose. These records will provide valuable data if it becomes necessary to reconstruct what happened and why. The scheduler must ensure a complete and thorough understanding of the various components in order to maximize the potential for their proper application and the development of a sound schedule (PMI, 2007).

2.2.3.2 Activity And Project Duration Estimate

When considerable uncertainty surrounds the duration of a given activity, sometimes

it can be helpful to subdivide that activity into smaller elements.

Six important rules apply to the estimation of activity durations:

1. Evaluate activities one at a time, independently of all others. For a given activity, assume that materials, labor, equipment, and other needs will be available when required. If there is a fundamental reason to believe that this will not be true, then the use of a preceding restraint may be in order.

2. For each activity, assume a normal level of manpower and/or equipment.

Exactly what “normal” is in this context is difficult to define. Most activities require only a single crew of workers or a standard spread of equipment. Based on experience, conventional crew sizes and equipment spreads have emerged as being efficient and economical. In short, a normal level is about optimum insofar as expedient completion and minimum costs are concerned. A normal level may be dictated by the availability of labor and equipment. If shortages are anticipated, this factor must be taken into account.

3. If time units of working days are being used, assume a normal workday. Do not consider overtime or multiple shifts unless this typical or a part of the standard workday. Around-the-clock operations are normal in most tunnel work, for example, and overtime is extensively used on highway jobs during the summer months to beat the approaching cold weather. Some labor contracts guarantee overtime work as a part of the usual workday or workweek. In these cases, the extra hours are normal and should be considered.

4. Concentrate on estimating the duration of the individual activity and ignore all other time considerations. In particular, the completion date of the project must be put entirely out of mind. Otherwise, there is apt to be an effort made, consciously or unconsciously, to fit the activities within the total time available. This is one of the serious drawbacks of the bar chart as a planning and scheduling device. Most contractors will admit that the average bar chart is made up primarily by adjusting the individual work items to fit within an overall time requirement. The only consideration pertinent to estimating an activity duration is how much time is required to accomplish that activity, and that activity alone.

5. Use consistent time units throughout. When using the working day as a time unit, it must be remembered that weekends and holidays are not included.

6. Assume normal weather conditions in estimating the duration needed to accomplish each activity. Some operations are sensitive to the effects of weather and may not be performed at all or will take longer to complete if necessary climatic conditions are absent. In general, such activities should be estimated assuming the existence

of conducive weather. Using historical weather data for the site location, operation specific calendars can be developed to account for the seasonal variations that weather will have on these activities.

The total run-time project estimation can be approached in several ways:

Bottom-up Estimation or Expert judgment – is the project work breakdown until the lowest level possible, at which the presented work time and resources can be determined very precisely. This method, however, is very labor intensive and uses expert knowledge, which make the method one of the most accurate.

Evaluation by analogous estimating – using data from earlier completed projects, in combination with Expert judgment can give perfect results. This method is used both for the whole project duration assessment as well as its fragment. Unfortunately, the difficulties in the application of such method are often a lack of historical data.

Parametric estimating – the method uses historical data as an input to different models and mathematical formulas. Based on the knowledge of resources availability, the amount of work to be performed and the values of factors influencing labor productivity (based on historical data), project as well as its individual activities duration can be than estimated

Reserve analysis – project manager and / or project team can be choose to incorporate additional time referred to as contingency reserves, time reserves or buffers, into the coverall project schedule in recognition of schedule risks.

Three – Point estimate for activity duration is an estimate that includes optimistic, most likely and pessimistic estimate. This Method is known as PERT analysis or PERT method. The method used these three different time estimations for each activity duration and calculated the probability of project completion by any given time.

Estimated activity duration resulting from the application of the above methods can cause a lot of problems and before all many errors due to the lack of complete historical data. Therefore, the application of three-point estimation derived from PERT method provides very effective results, and is most frequently used by project managers.

2.2.3.2.1 Duration Estimating Standards

Construction industries have their standard of duration estimation in making a construction schedule by considering the productivity of resources. Under here an example the Korea Land and Housing Corporation (LH) duration estimate of activities presented. According to the study of LH Research Institute (Korea Land and Housing Corporation, 2003), the estimating standard of the structural work is as follows:

Estimating Standard of LH

a) Structural work

▶ 15 floors below : 1st floor (29 days) + floor number X 12 days
(above 2nd floor)

▶ 16 floors above : construction duration of 15th floor below +
floor number x 13 days (above 16th floor)

(Add if steel roof will take 9 days, and if concrete roof will take 13 days)

b) Finishing work

▶ 15 floors below : 127 days

▶ 16 floors above : 127days + 1 day/floor (above 16th floor)

In the case of a common residential project, construction duration in superstructure structural work is about 10~13 days per floor, or approximately 12 days per floor (Seok and sang , 2012).

2.2.3.3 Crashing Of Project Duration

Reducing the project duration can be achieved by adding more resources to the performance of the activity in the form of overtime, resources or by assigning additional labor. This managerial decision of additional resources, overtime and labor will however increases the overall cost of the project thus trimming down the project duration of activities on critical path. This concept of project management which involves investment of extra budget in order to minimize the duration to meet the targeted date is known as crashing. The objective of expediting project by crashing total project duration is helpful so that delays can be recovered and liquidated damages can be avoided. The aim is always to strike balance between the cost and time and to obtain an optimum schedule which optimize time and cost.

Various Terms used in Time Cost Optimization

- 1) **Normal Cost:** It is the lowest cost of completing an activity in minimum time employing normal means that is not using overtime or special resources.
- 2) **Normal Time:** It is minimum time required to achieve the normal cost.
- 3) **Crash Cost:** It is a least cost of completing an activity by employing all possible means like overtime, additional machinery and proper materials.
- 4) **Crash Time:** It is an absolute minimum time associated with the crash cost.
- 5) **Critical Path:** It is the sequence of project network terminal elements with the longest overall duration, determining the shortest time to complete the project.

The following Steps are carried out while performing the time and cost optimization.

Step1. The Schedule required for completing the project is developed based on the normal duration and normal cost of activities involved.

Step2. Then it is required to find out the crash cost and crash duration for each activity. After this cost slope is obtained with the help of following formula:

$$\text{Cost Slope} = (\text{Crash cost} - \text{Normal cost}) / (\text{Normal time} - \text{Crash time})$$

Step3. To identify the critical activities on the critical path, then identifying the critical activity that can be crashed with the least crashing slope. If there is more than one critical path, a critical activity from each path should be selected and crashed as long as the two selected activities can still be crashed and the total crash cost of the selected activities is the minimum.

$$\text{Slope} = (C_c - N_c) / (N_T - C_T)$$

NC: Normal Cost of an activity

CC: Crash Cost of an activity

NT: Normal duration of an activity

CT: Crash duration of an activity

The relationship between activity's actual crash time to its cost is assumed to be linear. We define the overall cost per unit time reduction, to be change in cost divided by change in time:

Step4. Shortening the activity by the units required that is maximum crashing units is obtained by subtracting crashing time from normal time.

Step5. The new cost and duration of the project should be calculated at this step, and then steps through three to five should be repeated until the optimum solution is obtained (Bhusshan and Rahul, n.d).

2.2.3.4 High-Rise Building Scheduling

High-rise buildings have a large degree of repetition; their scheduling needs are different from either linear projects such as highways and pipelines, or nonlinear projects such as multiple similar houses. This is because high-rise buildings involve repetitive activities that advance within the building not in one direction but in two directions: A horizontal direction through the floor, and a vertical direction from one floor to the next. The sequencing of activities is, therefore, controlled by horizontal and vertical constraints.

Network-based methods for project scheduling, such as critical path method CPM, exhibit major drawbacks when applied to scheduling of repetitive projects, as widely reported in the literature. Network methods do not provide an efficient structure for the representation of repetitive tasks. All tasks are represented similarly, and there is no

consideration of the location of work in the schedule. Moreover, CPM methods are not suitable for representing and/or balancing the production rates of repetitive activities. As such, production rate imbalance can negatively impact project performance.

The major benefit of the LOB (line-of-balance) methodology is that it shows production rate and duration information in an easily interpreted graphical format.

Because repetitive scheduling techniques, such as LOB, assume purely sequential activities, various efforts have attempted to combine the benefits of the CPM and the LOB techniques. (Tarek et al., 2008).

The time and effort required to complete the repetitive tasks decrease as the number of repetitions increase. Most researchers recognize two or three distinct phases in learning. The first takes place through an operational learning phase; workers develop familiarity with the task. The second entails learning the routine, which leads to better coordination learning the routine, which leads to more efficiency, and minor site and environmental improvements. A third phase can either happen simultaneously or succeed the first two phases if management and craftsmen make a continuous effort to improve by applying a combination of techniques. Due to the repetitive nature of high-rise construction, the effect of the learning curve cannot be neglected and therefore must be incorporated into estimating activity durations, using suitable models and factors.

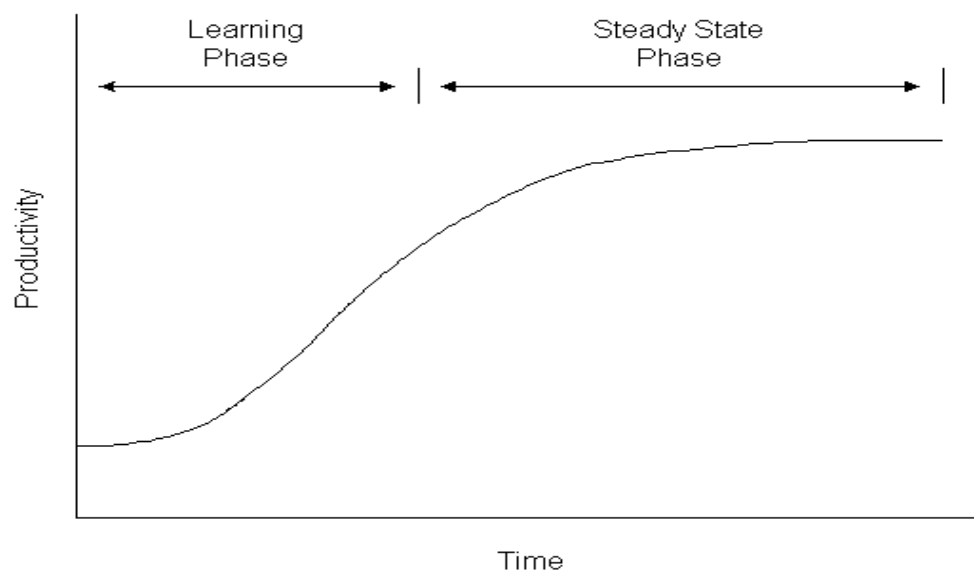


Figure 3 Illustration of Productivity Changes Due to Learning (Ch.chowdeswari et al., 2017)

Two large general contracting firms specialized in high-rise construction in the Toronto area were contacted and information was collected about their scheduling practice through interviews with project managers. This was combined with three months of regular site

visits to a high-rise construction site to investigate how the job was progressing. Each of the two investigated companies provided a copy of a master schedule of one past project. The approach used by the two general contractors to schedule their high-rise projects is similar. They use an Excel spreadsheet as a media to represent the building shape using cells example in Fig. 4 . The vertical cells represent the number of floors and the horizontal cells represent the activities. Each activity is assigned six cells, three for the planned start, finish, and duration, in addition to three for actual start, finish, and duration. This enables the project managers to update the schedule based on feedback from the site (Tarek et al., 2008).

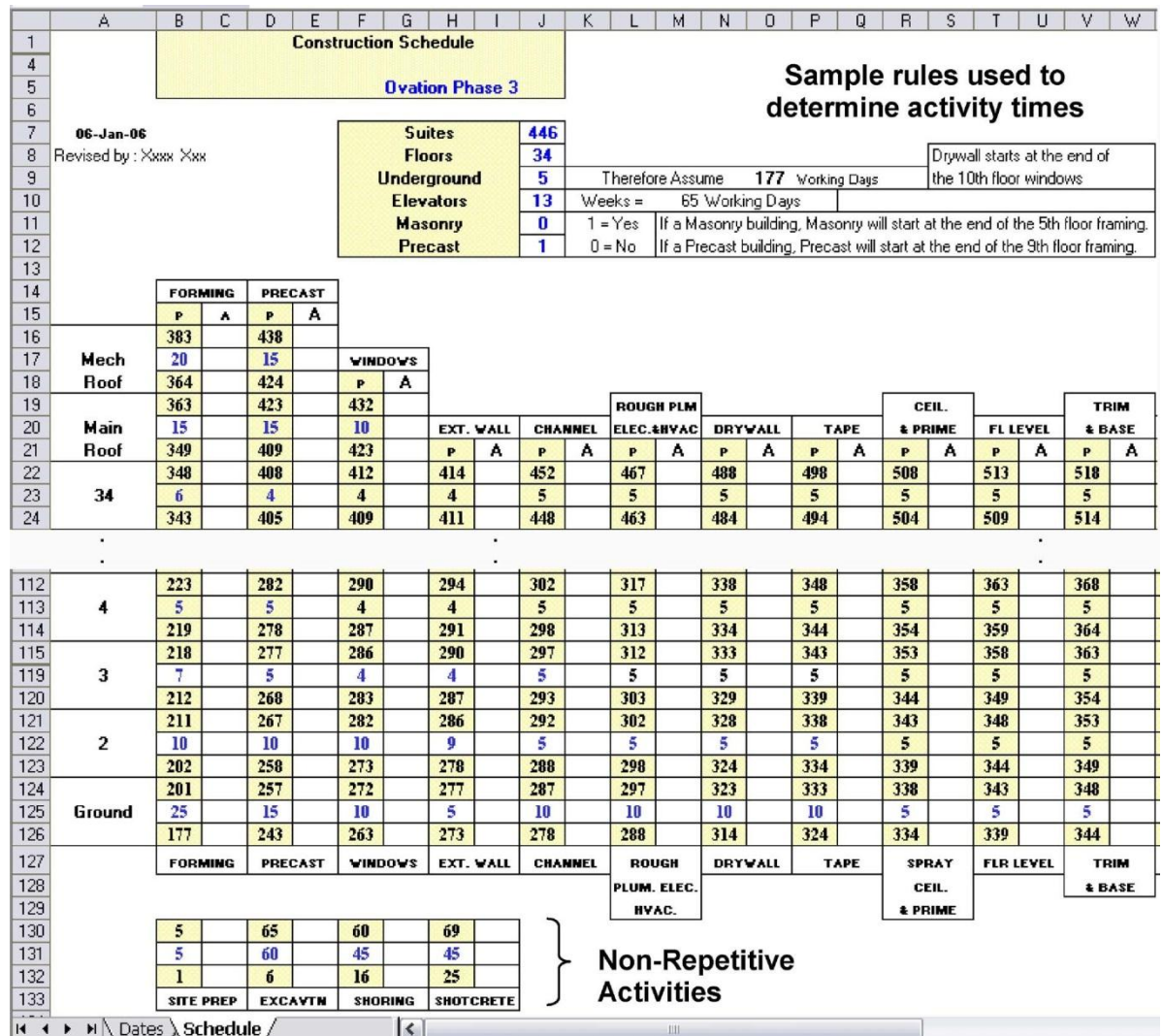


Figure 4. Sample portion of a manual high-rise schedule

2.3 Reducing Construction Duration Of High Rise Building

2.3.1 Project Planning And Management

The major activities in the construction of tall buildings generally are classified into the following packages (Maria, 2000)

- 1. Site set-up :-** Activities necessary to establish temporary facilities at the work place and prepare the site for subsequent activities, including site layout.
- 2. Piling :-** Activities necessary to complete the groundwork up to but excluding the ground floor slab, as well as foundations, under slab drainage, basement, etc.
- 3. Pile caps/raft :-** Activities necessary to construct either the pile caps in the case of a piled foundation, or the raft foundation, including the ground slab floor.
- 4. Superstructure:-** Activities necessary to erect the load-bearing frame starting from the ground floor column/wall elements, up to and including the main roof and upper roof. as well as precast recode installation.
- 5. Electrical and mechanical (E&M) services:-** Activities necessary to install the E&M works including electrical, fire services, elevators, water pump and water supply system, wastewater system, town gas, telephone system, storm water drainage, lighting protection, etc.
- 6. Finishes:-** Activities necessary to complete the building including any brick work for internal partitions, plastering and tiling, carpentry and joinery, ironmongery, steel and metal works, glazing, painting, window installation, wall finishes, etc.
- 7. External works:-** Other works adjacent to the building including underground cable ducts and drainage, covered walkways, planters, access roads, paving, play areas, pavilion, etc.

The duration of construction is the time span from the beginning of the foundations to the completion and handover of the building to the client. The total schedule can be determined based upon the duration of the above phases that usually are work packages and separate contracts. Durations for site set-up and external works are not critical in determining the overall construction time (Maria, 2000).

2.3.2 Construction Processes And Materials

2.3.2.1 Jump Form System To Construct Concrete Core Walls

The use of a climbing formwork systems [sometimes referred to as self-climbing or self-lifting) to construct the core walls of high rise buildings has been successful in different countries in reducing construction times, primarily because the process become repetitive though the whole height of the building. Steel formwork panels are hung from this frame, some supported on rollers. After the concrete walls are

poured, the framework is released and rolled back from the concrete face. Jacks then lift or climb the whole frame up one level. All the formwork panels are attached to the frame. This process takes approximately one and a half hours (Maria, 2000).

2.3.2.2 Prefabrication Of Elements

Prefabrication of elements is another method that has been successfully used to save time in the construction of tall buildings. The repetitiveness of many elements makes this process suitable and very effective. Walls, staircases, external facades, and door sets are common examples of prefabricated elements. Components are manufactured units, made to predetermined sizes, to be used in buildings.

The advantages of prefabrication are:

- a) Mass production of units
- b) Reduction of cost and construction time on site
- c) Effective use of formwork
- d) Improved quality of units
- e) Special shapes and surfaces finishes
- f) Casting under cover
 - Protection from hot or drying winds
- g) Demountable structures
 - Bolted connections can be easily dismantled and re-erected in other places
- h) Construction over and under water
- i) Casting of units before the site becomes available
- j) Built-in services and insulation
 - Services and insulation can be built into precast units accurately in the factory
- k) Accelerated curing techniques
- D) Solution to the problem of lack of local resources and labor

The limitations of prefabrication are:

- a) A small number of units required may prove to be uneconomical
- b) Special connections, such as special bearings to transmit the vertical and horizontal loads, can add cost to the system
- c) Waterproofing at joints
- d) Transportation difficulties
- e) Need for cranes



Figure 5. Prefabricated concrete manhole for CBE head quarter project

2.3.2.3 Composite Materials

Two factors in the design of high-rise buildings set them apart from other structures. They are required to resist large lateral loads, and the repetitive nature of the construction requires that the design is refined to enhance the speed of construction and usable areas. Composite construction in high-rise buildings refers to the mixed use of concrete and structural steel in major load supporting elements. Composite construction endeavors to use the best properties of concrete and structural steel in the most appropriate way:

Concrete:- it is cheap, local production, unskilled labor, plasticity of shape, good compressive strength, built-in fire protection, corrosion protection, short lead time, reuse of molds, alternative hoisting methods.

Structural steel: - prefabrication, off site labor, high strength/weight ratio, high stiffness, high tolerances, smaller member sizes, speed of construction, reduced hoisting, reduced site labor, flexibility of alterations. The dominant elements where composite construction has been adopted in high-rise buildings are floor systems, columns, and transfer structures. In general terms, composite construction must be compared with other forms of construction to be rated.

2.3.2.4 External Cladding

A building envelope serves the functions of weather and pollution exclusion, thermal and sound insulation. It also provides adequate strength, stability, durability, fire resistance, aesthetics appeal, etc. With the advancement of prefabrication, non-

load bearing claddings in panel forms have become common especially for tall commercial buildings, where accelerated schedule and architecture of facades have become driving decision factors. The common type of prefabricated cladding is curtain wall cladding. Curtain walls are non-load bearing external walls of buildings composed of repetitive factory assembled elements. Its dead weight and wind loading are transferred to the structural frame through anchorage points (Maria, 2000)

2.3.3 Construction Equipment

2.3.3.1 Special Equipment

Facilitating horizontal and vertical movement is one of the main tasks in tall buildings construction that must be accomplished in order to develop a schedule that is effective and tight. This means: getting more effective work times; providing materials as soon as they are needed; and reducing time by avoiding repetition of tasks that require closer supervision. Special equipment that has been developed to meet these objectives is described below.

Hoists:- these are intended for vertical movement only and thus are only able to move in one direction. The maximum reachable height is virtually unrestricted in theory, but depends on the particular hoist design.

Gondola/Swinging Stage: - provides vertical movement for workers working in painting, spraying, caulking, sash-sealing, cleaning, etc.; in general for all the external finishes of a building. The gondola is powered by motors, which are either situated at the top of the building or on the gondola itself.

Work platforms :- used for glazing or masonry, they can be matched to any type of building. The machines that operate them are located around the perimeter of buildings.

Elevators: - moved on tracks are more stable and have higher capacities as compared with a gondola.

Cranes: - they are generally capable for moving objects in all directions. Various attachments are available for a crane to perform different functions. Common types of cranes used on building sites are the truck mounted crane, the mobile crane, the tower crane and the climbing crane.

Management methods, construction processes and materials, and construction equipment have been successfully used in reducing time in the overall schedule of tall buildings. Significant factors that have emerged with regard to applying management methods to reduce construction schedules of tall buildings are: (a) project scope

factors (actual cost, presence/absence of precast facades, height and number of stories); and [b] non-scope factors such as speed of decision making involving all project teams, information flow between consultant and contractor and informal communications between architect/engineer and contractor. While certain common strategies can be adopted to reduce construction durations in general, specific measures should be formulated to focus on the specific sector and specific project according to their special and unique characteristics.

Jump form systems to construct concrete core walls, prefabrication of elements, composite materials and external cladding have been extensively used in the past decade to improve productivity, taking advantage of repetitiveness in processes, quality control, optimization in the use of materials, and technological development of new materials.

The implementation of these technologies requires the use of specialized equipment. Innovative equipment solutions facilitate vertical and horizontal transportation in the structures while being erected (Maria, 2000).

2.4 Planning and Scheduling of Commercial Bank of Ethiopia New Head Quarter Building Construction

2.4.1 The Project Background

The Commercial Bank of Ethiopia (CBE) is the leading bank in Ethiopia, established in 1942. Commercial Bank of Ethiopia New Head Quarter Building assembly consists of a high-rise office tower and two low-rise building is under construction. The objective of the new head office building is to house all head office functions under one roof. It is envisaged such a move will enable CBE to achieve its goal of providing first class service to its customers creating conducive work environment and up to date technical facilities. The project site is located within the Central Business District of Addis Ababa, next to Ethiopia Hotel (N09°01' & E38°45'). The site is bound by established roads on all the four sides. The building height requirement for the area is 34 – 55 floors. The total floor area is estimated to be 165,476.4 m². The office tower has floors of 4B+G+48 which includes the main departments of the Bank. The low-rise buildings (4B+G+6 and 4B+G+8) are mainly conference centers, commercial center and parking garage. The contract type is Design and Build Project and awarded to China State Construction Engineering Corporation, CSCEC with a project cost of USD 298,511,920.00. The currency Proportion of the contract is USD: 65%; ETB: 35%. The project

Commencement date was July 27, 2015 and planned completion date is January 21, 2020.

The consultant for the project is Addis Ababa University-Addis Ababa Institute of Technology (AAU-AAiT) was doing the Design Review and Supervision of CBE New Headquarter Design-Build Project since February, 2016 and it was appointed as “Employer’s Representative”. The contract type Design Review, Contract Administration and Site Supervision Service and the contract amount for the duration of the project is ETB 136,986,839.00 and USD 1,168,213.00 (AAiT, 2017)

2.4.2 Employer’s Requirement Expressed In The Contract Document

During construction, the Contractor shall meet with Employer’s representative on a weekly basis and provide a one-week look ahead for activities to be performed during the coming week. The Contractor shall, on monthly basis, provide written reports that describe the items of concern and the work performed in comparison with the plan on each task for that particular month.

The contractor shall prepare design of the building and submit to the design review consultant for approval. Major design disciplines are identified, but not limited to the followings:

Architecture

Façade design

Structural and Seismic Engineering

Wind Engineering

Infrastructure Roads

MEP (Mechanical Electrical and Plumbing) Design

Kitchen Design

Vertical Transportation

Sustainable Building Design

Signage and Way finding

Acoustic Design

Landscape Design

Interior Design

Security Design

Fire Protection

Artificial Lighting Design (Interior and Exterior)

The monthly and quarterly progress reports which shall be checked, commented and verified by the Consultant before submittal to the Employer will include the following issues:

1. Progress in work
2. Current status narrative report
3. Upcoming and planned construction activities
4. Status assessment of Construction Schedule
5. Manpower on site and Home Office
6. Major equipment on site and in factory
7. Material & equipment delivered to site for permanent works
8. Special events having impacts on schedule and costs and precautions to be taken
9. Status of Claims, if any
10. Weather report
11. Site and factory digital photographs
12. Miscellaneous

2.4.2 Planning Of the Project

2.4.2.1 Overall Construction Process

1) Supporting and earth work engineering

The foundation pit support adopts the program of maintenance pile + steel structure ring beam + anchor rope. The soil that exists b/n piles will make it stand stable by applying jet concrete reinforcement with an average 20 m excavation depth. Earth is excavated according to the hierarchical elevation of steel structure ring beam and anchor.

2) Foundation and foundation Engineering

The project has 34 manpower dug piles located in the tower area, of which perimeter frame column uses single column and single pile, and group piles are adopted in the core tube area. Excavation for pile was done by manpower because the largest size of available machine for pile excavation is 1.2m but the main building pile diameter is 1.8m and the head is 2.5m. For the basement floor construction each floor of basement divided into A,B,C and each area consisting of three working sections ; according to the contractor information the work area division is based on the volume of concrete.

3) Main structural project

The construction above ground level organized according to three different division, i.e.

office building, Conference center and business center. Office building again divides into two construction sections, in the way assembly line construction that is 1) external frame work system, 2) core barrel and they are constructed simultaneously.

4) Mechanical and Electrical Installation

Installation preset and pre-embedded are conducted along with the construction schedule. After the underground structure has been checked and accepted electro-mechanical equipment installation shall be started.

5) Walls and Decoration

For Business center and conference center after completion and checking concrete structure external curtain wall and interior decoration started. For office building curtain wall and interior decoration started after 18th floor concrete casting completed. The formwork system is self-lifting due to this it does not affect the activities executed under it. The curtain wall installation is not done according to the schedule; the contractor said that it is because the curtain wall system was changed from Frame to Unit.

2.4.2.2 Vertical Transport Planning

1) Tower Crane

To start excavation first install one crane (#1) when earth work is excavated to the foundation slab elevation by leaving reserve ramp and then install two tower cranes (#2 and #3) inside climbing tower crane. On completion of the installation of tower cranes remove the ramp and then steel ring beam and cable anchor construction activities started. After commercial and conference center structure are completed crane # 1 shall be demolished

b.2) Construction elevators

For the purpose of vertical transportation of secondary structure (HCB...) and decoration of business center and conference center double cage elevator for each installed. When core tube construction of tower on the 10th floor begin the two double cage high speed elevator will be installed. Four construction elevators in total will be assigned on this project.



Figure 6 Tower crane and elevators

b.3) Pumping concrete

The concrete type used is pumpable concrete. The concrete pump used on site has a theoretical output of $112/73 \text{ m}^3/\text{hr}$ and the height that can pump not indicated on the pump body; according to the contractor staff information it can pump up to 300 m high.

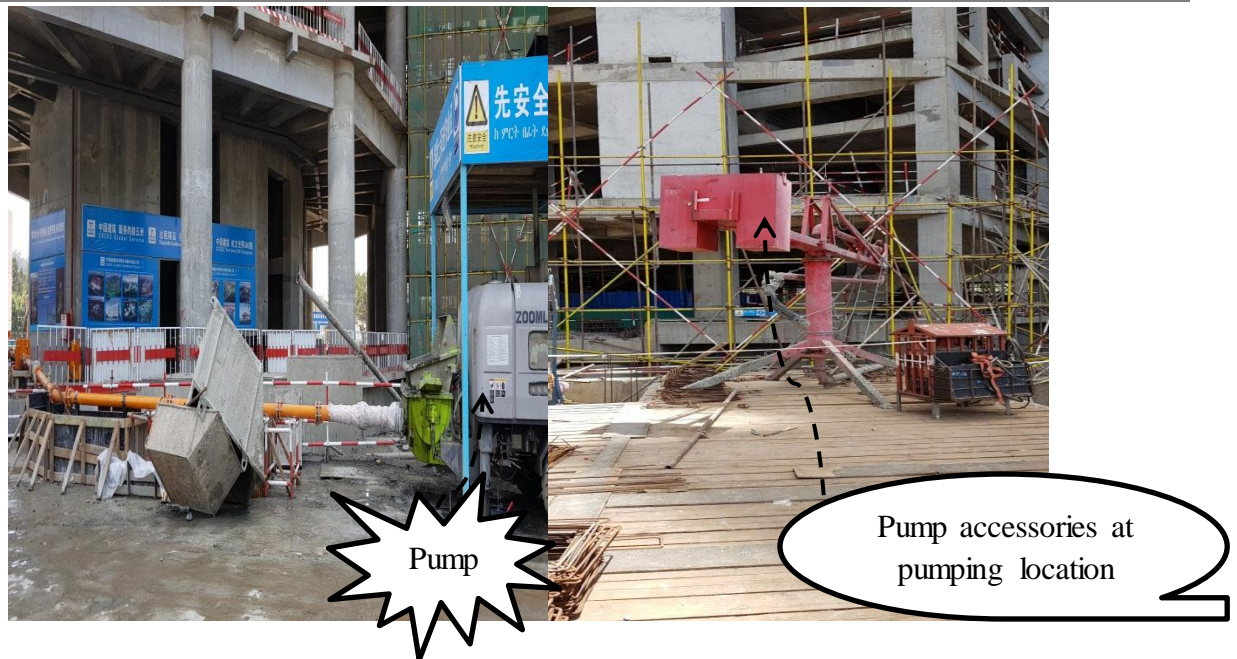


Figure 7. Concrete pump and its accessories

2.4.2.3 Steel structure Construction

The estimated total steel consumption for this project is 1000 tons of steel structure. For the tower we use Composite construction endeavors to use the best properties of concrete and structural steel in the most appropriate way. Tower composite structure installation as follows Hosting steel column → Welding connection interface → formwork (template support) → Reinforcement → Concrete pouring. Because the column is composite (Steel concrete) the diameter of column at the ground level reduced from 2.4 m diameter to 1.8 m diameter. Instead of overlap mechanical Connectors used for longitudinal bars and the tensile strength of the connector is not less than the actual tensile strength of the connected steel bar and it has strength of 1.1 times reinforcement bar, and it has high ductility and repeated tension and pressure performance.

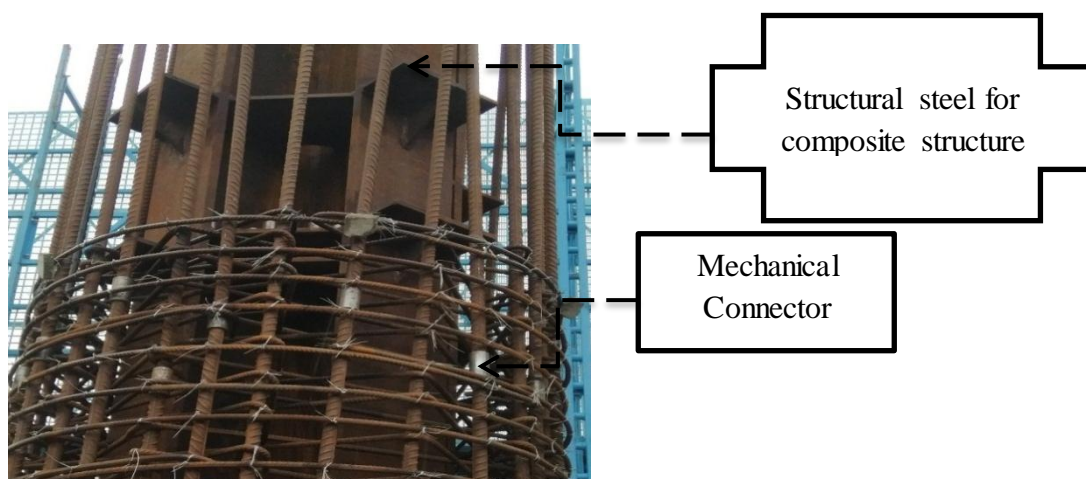


Figure 8. Composite column structure

2.4.2.4 Tower Construction

e.1) Integral lifting frame

By maintaining outside the tower body adopts hydraulic integrated lifting frames.

e.2) Template and supporting frames

Tower core and outer frame columns with shaped steel formwork; others are used in carpentry, support frame using steel pipe scaffolding.

2.4.2.5 Curtain Wall Construction

One ring beam orbit should be arranged respectively on the structure outside of the 24th and 48th floor of the tower install electric gourds and operation hoist baskets.

2.4.3 Organization Structure of the Project and Related Issues

The organization structure of the project which is given by the contractor is shown below.

In local contractors assignment of business manager isn't common.

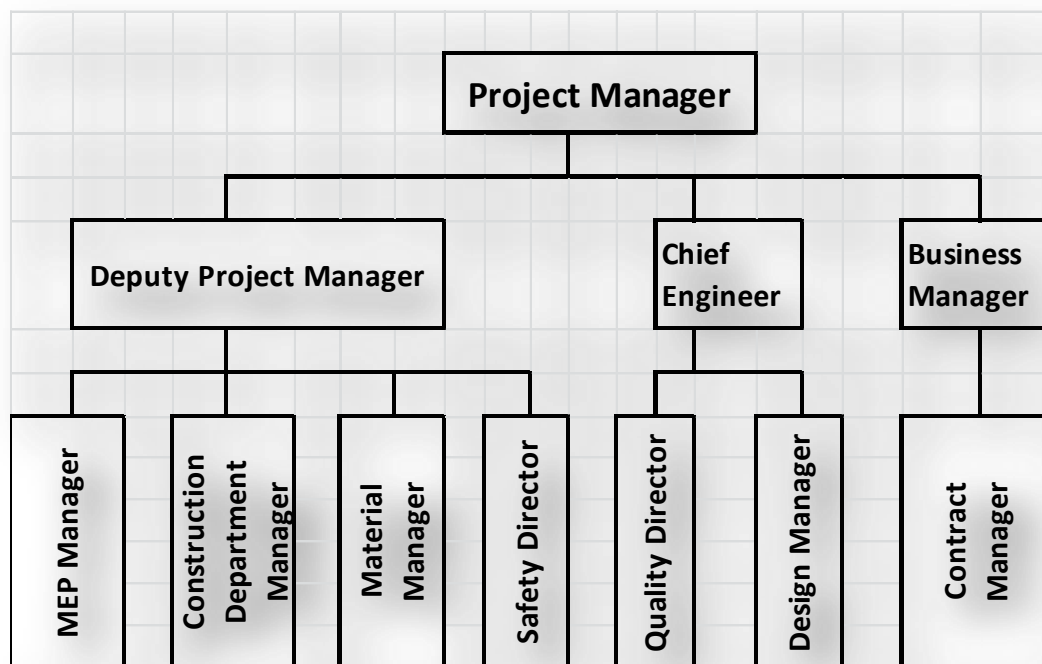


Figure 9 Organization structure of the project.

For the follow up of the project progress the contractor said that every day the project construction department have meeting with the labor team to see their performance with in the day and arrange the next day's work. Summarize experience in weekly project production meeting, analyze and compare with the construction schedule. For the material wastage control; the materials department has the special personnel responsible for the material usage follow up and accordingly there will be reward and punishment. According to the contractor information external factors which affect their planning and scheduling of the project are as follows

1. The approval time of drawing is not controllable.
2. Insufficient supply of local materials and limited source choice, resulting in unstable concrete delivery at the initial stage.
3. The owner's payment is not timely.
4. There are many local festivals, and local workers have poor discipline and cannot continue on their job.

2.4.4 Scheduling Of The Project

2.4.4.1 General

For the project there is construction schedule only which is done by Microsoft project; that means it doesn't include material, labour, financial and equipment schedule. In the master construction schedule for especial items like elevator installation, conference center system construction work schedule includes like material bidding preparation, material purchasing and shipment in addition to the main work activities. Crane installation and removal also included in the master construction schedule. The activities like bidding preparation, material purchasing, crane installation...included in the master schedule which isn't experienced in local contractor is a good lesson from this project because it is basic and mostly affects the progress of the project. The schedule prepared in the project is not detail. The activities listed in the description seem milestone activities. When we see the activity dividing principle of an activity is as follows: (Seok and sang , 2012)

- ▶ If work item is different, the activity is separated.
- ▶ If work item is same and production unit are different, the activity is separated.
- ▶ though work item and production unit are same, the activity is not continuous, the activity is separated.

In the master construction schedule "tower building structure construction of level A" is taken as an activity. But when we see floor 'A' structure work according to the above principle activities should be listed as below,

- Stair case formwork
- Slab and beam formwork
- Column and shear wall formwork
- Stair case rebar work
- Slab and beam rebar work
- Column and shear wall rebar work
- Concrete casting for slab and beam
- Concrete casting for column and shear wall

- Floor electrical/mechanical work
- Wall electrical/mechanical work

When the schedule is not detailed most probably the resources will not be balanced, there will be a large difference between the peak and the minimum number of manpower (if they terminate according to the volume of work). If the contractor doesn't terminate workers by considering the volume of work, there may be delay or efficiency of manpower will be low.

2.4.4.2 The Schedule Of Typical Floor Structural Work.

For the project it is difficult to produce a schedule and to evaluate the overall progress of the project; rather it is better we see the typical floor structural work. Concrete curing, form remaining period, and worker planning are major influences on construction duration (Seok and sang , 2012).

A) WBS of structural work

Structural work consists of formwork, rebar work, concrete work, mechanical work, and electronic/communication work.

The dividing principle of an activity is as follows:

- ▶ If work item is different, the activity is separated.
- ▶ If work item is same and production unit are different, the activity is separated.
- ▶ though work item and production unit are same, the activity is not continuous, the activity is separated.

B) Activity duration

After all the activities and the relation of each activity are defined, activity duration is estimated. Activity duration should be minimized and be considered according to productivity. The conditions of activity duration are as follows:

All activity is only limited to physical and environmental conditions.

- ▶ The minimum duration is one day.
- ▶ There is no limitation of delivering workforce, while production unit, which is involved

CHAPTER THREE: RESEARCH METHOD

Based on the goal of the research; it is applied type of research. The approach of research will be both qualitative and quantitative. To do this research the methodology that was applied as follows,

3.1 Literature Review

In the literature review part the importance of planning and scheduling for the efficient completion of the project and theoretical duration estimation procedures is presented. In this paper in addition to the theoretical duration estimation; the experience and standards of duration estimate of high-rise building structure works also presented to use for comparison purpose of the project that is studying. From the literature review we can understand that for high-rise building the activity duration vary with respect to height. Due to this it is difficult to use the same crew output performance without considering height for a single activity. In this study it is explained also duration reduction of high-rise building by using different work methods, special materials and equipment and then compared with the work methodology on the study performed project. As we saw in the literature review high-rise building construction is highly especial equipment intensive and it needs good planning and scheduling to perform the project successfully.

3.2 Desk Study/Site Observation

a) From the site observation and desk study the work method, equipment and material available for the execution of the project compared in relation to the expectation according to the literature review. In addition to this their plan and schedule of the project compared with what actually exists in the site by taking their master schedule and pre-construction planning as a reference. From the site observation and the desk study it has been concluded that whether the project is executing according to their plan and schedule or not? Was their plan and schedule workable or not? In addition to these from site observation the project safety warning and follow up, material handling and site organization was examined. Finally from the desk study and site observation the study concluded about the project scheduling and planning performance.

b) Preparation of sample schedule and compare with the actual (updated) schedule. For this purpose it was necessary preparing sample schedule for the 28th floor structural activities and then primary data collected daily for 28th and 32nd floor the executed structural activities. Finally the result has been compared with the baseline schedule prepared for the study purpose.

CHAPTER FOUR: ANALYSIS AND DISCUSSION

4.1 Overall

The project includes the office tower which has floors of 4B+G+48 which includes the main departments of the Bank. The low-rise buildings (4B+G+6 and 4B+G+8) are mainly conference centers, commercial center and parking garage. The contract type is Design and Build Project and awarded to China State Construction Engineering Corporation (CSCEC). The consultant for the project is Addis Ababa University-Addis Ababa Institute of Technology (AAU-AAiT) The project is in a good progress and constructed according to the approved drawing and the contractual agreement. Such a type of high-rise building is a new start in our country. The successful progress of the project is due to the good capacity of the contractor as well as the consultant. So such a type of consultancy of mega projects by higher institutions is a very good start and the practice is good for the country. Working with the higher institutions makes the client to get different capable staffs and as well for the university staffs it is good to get practical experience from such a type of project.

What is observed in the site most works which need skill executed by foreigners (chinese) even activities which can be executed by local workers is executed by the chinese as an example most masons that execute HCB masonry wall are foreigners. Such type of activities can be done by hiring local skilled workers or subcontracting to the local subcontractors.



Figure 10 CBE office tower building under construction

4.2 Equipment And Tools

The project is a high-rise building and it needs special equipment especially for vertical transportation. In the project elevators, tower cranes, 3-5T forklift, 25-50T truck crane, and others are in use. The CBE head quarter building construction project is highly equipment intensive which is powered by electric power. The project has standby generators (360KW, 120KW, 50KW) for construction purpose which works when electric supply

interruption happens (Finally in the project two 2000kW standby generators will be installed by the contractor). Because of most equipment and tools function with electric power even the vibrator, bar bending work, panel cutting for formwork... and others due to this uninterrupted supply of electric power is mandatory for the good progress of the project. If the power supply in the project uninterrupted, there will not be idle of manpower and equipment due to electric power supply shortage. Most of the under listed equipment and tools are working with the supply of electric power.

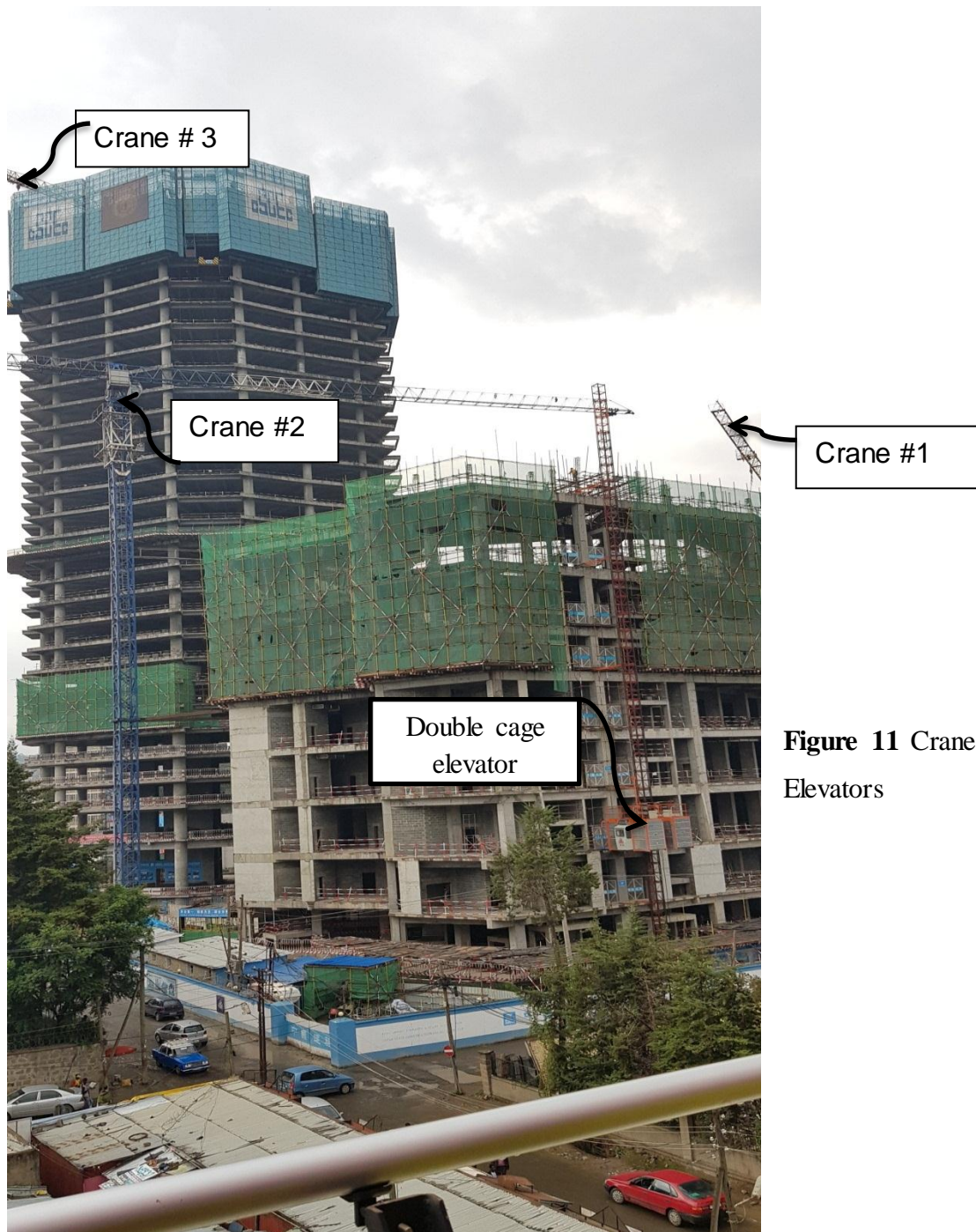


Figure 11 Cranes and Elevators



Reinforcement bar to be measured and cut

Figure 12 Reinforcement bar in roll measuring and cutting machine



Treaded bar and tread making machine

Figure 13 Reinforcement bar tread making machine



Figure 14 Concrete casting using vibrator which works with electric power



Figure 15 Plywood drilling machine for tying by treaded bar



Figure 16 Concrete drilling machine

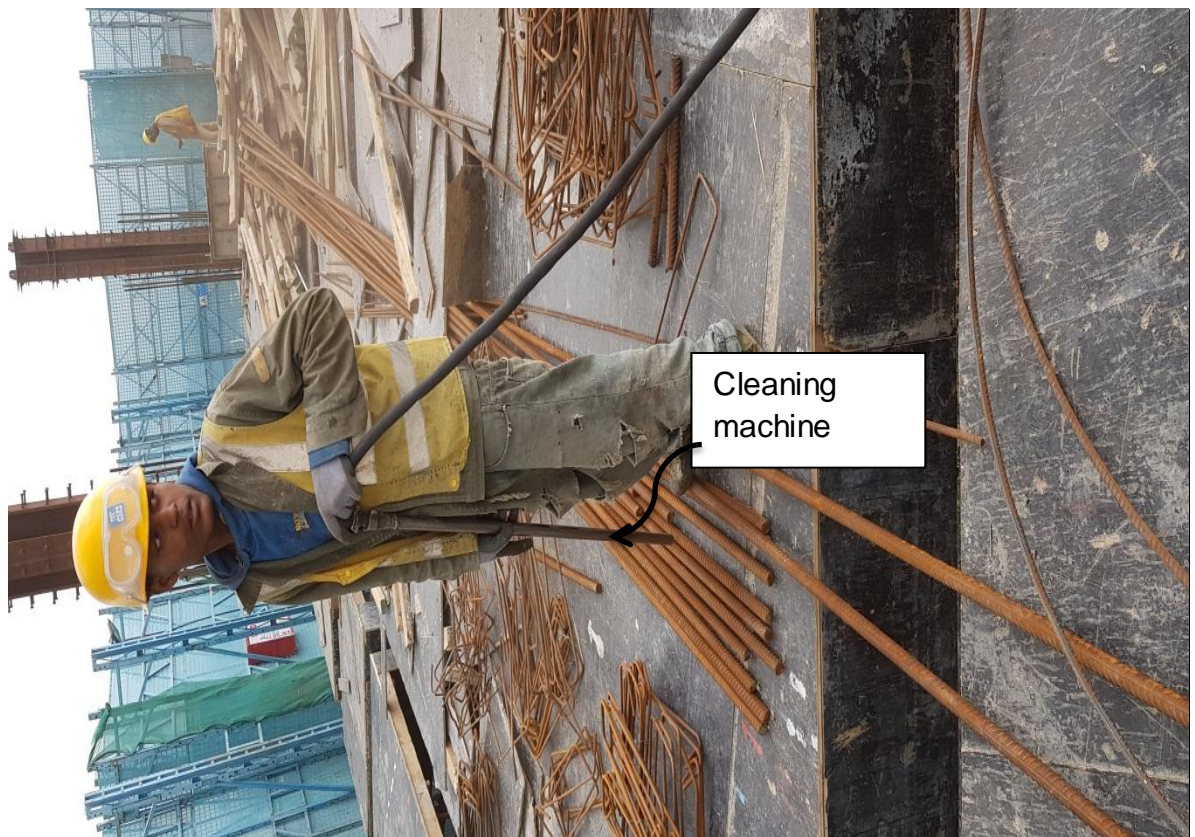


Figure 17 Dust/wood chips cleaning machine which works by compressor



Figure 18 Bolt fixing and loosening tools for formwork post erection



Figure 19 Plywood cutter for formwork placing

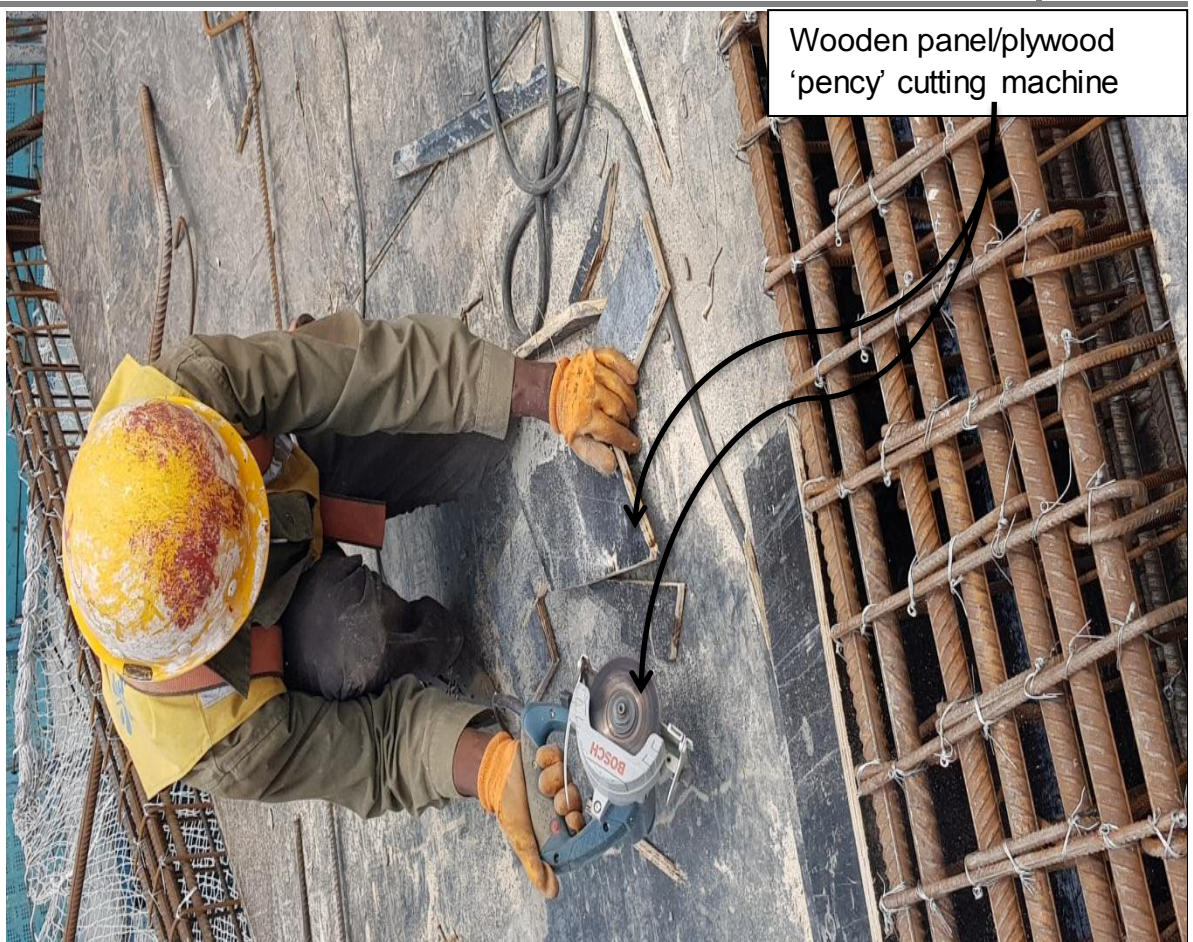


Figure 20 Plywood/timber cutter for 'pency' formwork placing



Figure 21 Concrete pump



Figure 22 Damper used to transport mortar and debris

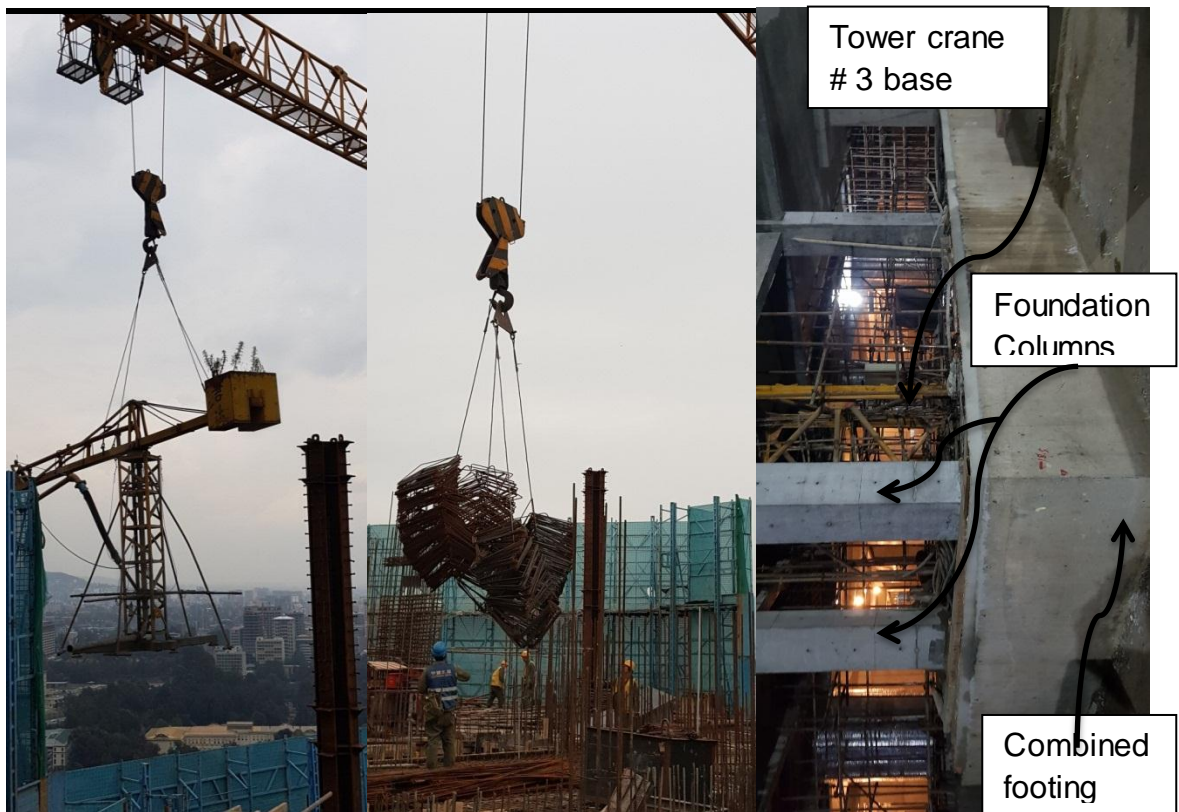


Figure 23 # 3 Tower Crane which cover all area of office tower

4.3. Safety In The Site

The safety condition in the site is good. As we saw from the literature review in the contractor organization structure there is safety manager. I saw most of the time safety

man standing and controlling the working conditions and also there is safety warning posted everywhere. Sample of the safety warnings posted in the site are as shown below.



Figure 24 Safety Warnings

4.4. Site Lay Out And Working Condition

In the site there is bar bending yard which covers most of the free area in the compound as well contractor’s office and staff residence also inside the compound of the site. But materials used for concrete production like aggregate, sand and cement is out of the site because the project use concrete from batching plant outside of the project site. Most of the time they cast concrete at the night time in order not to be affected by the day time traffic jam.

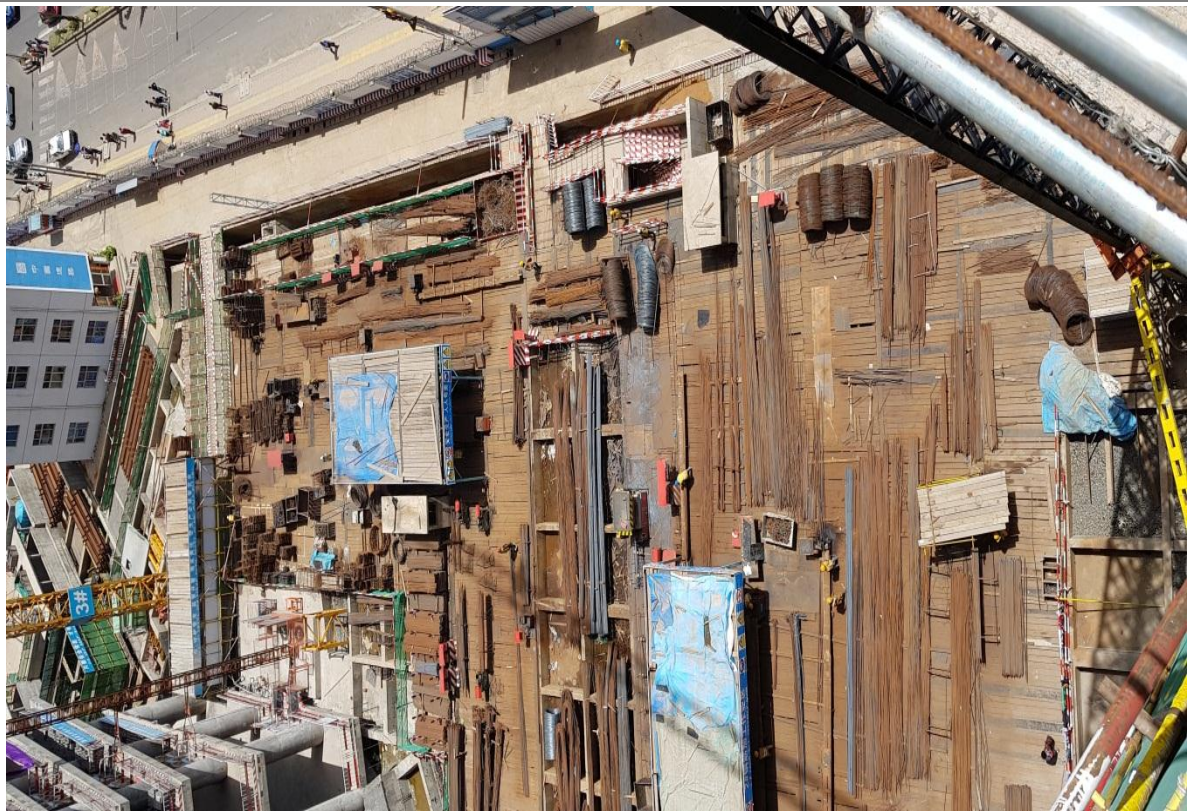


Figure 25 Reinforcement bar preparation (cutting & bending) area



Figure 26 Workers during reinforcement bar & pipe for electric installation fixing on the 29th floor



Figure 27 Carpenter and bar bender working on the 30th floor of the tower
 Starting from this floor the Column isn't composite column simply reinforced concrete column.



Figure 28 Contractor project office and resident building location inside the site

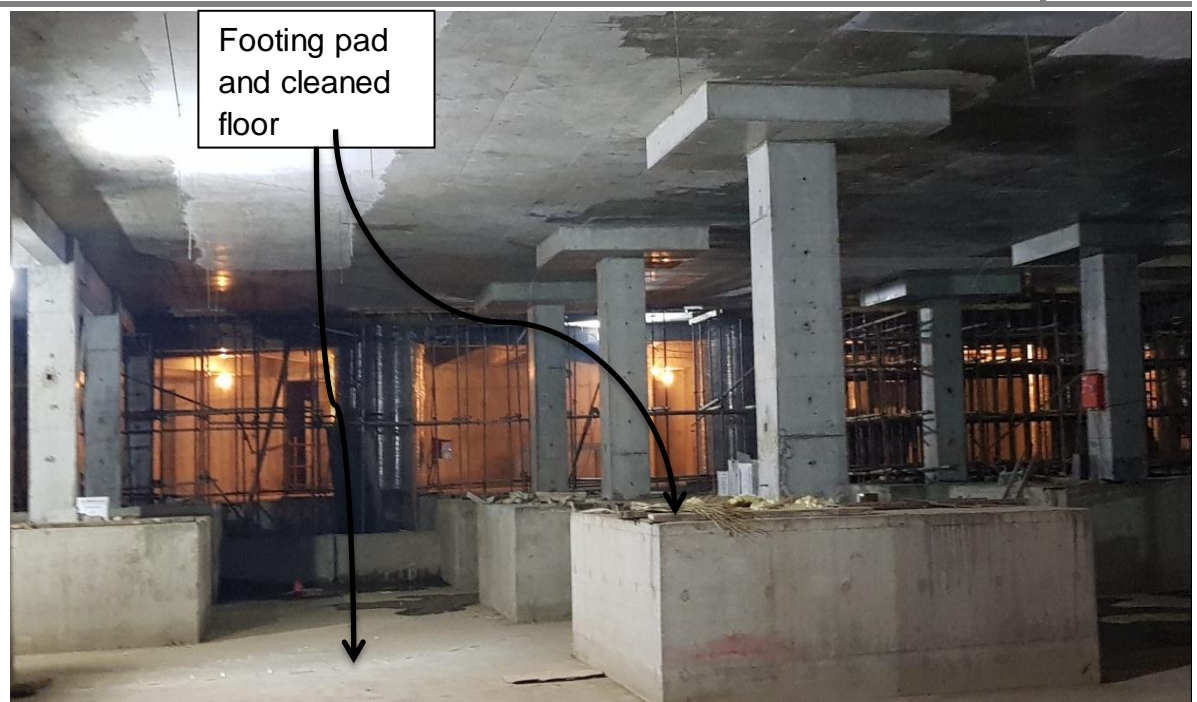


Figure 29 Basement cleaning and make ready for fill



Figure 30 Different class of concrete (for beam & column) separation using rough texture sheet metal

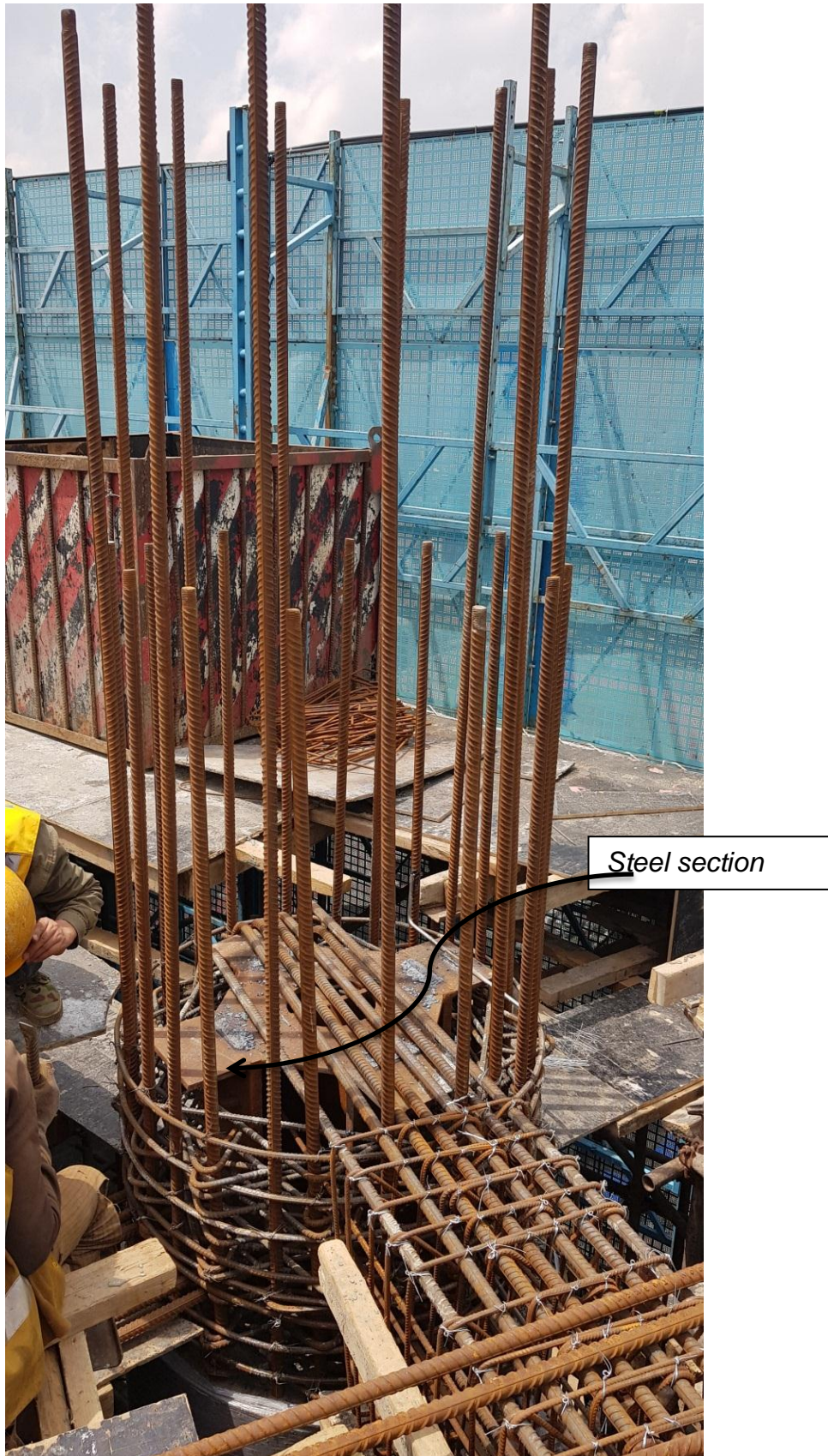


Figure 31 End of composite steel section (30th floor of the tower)

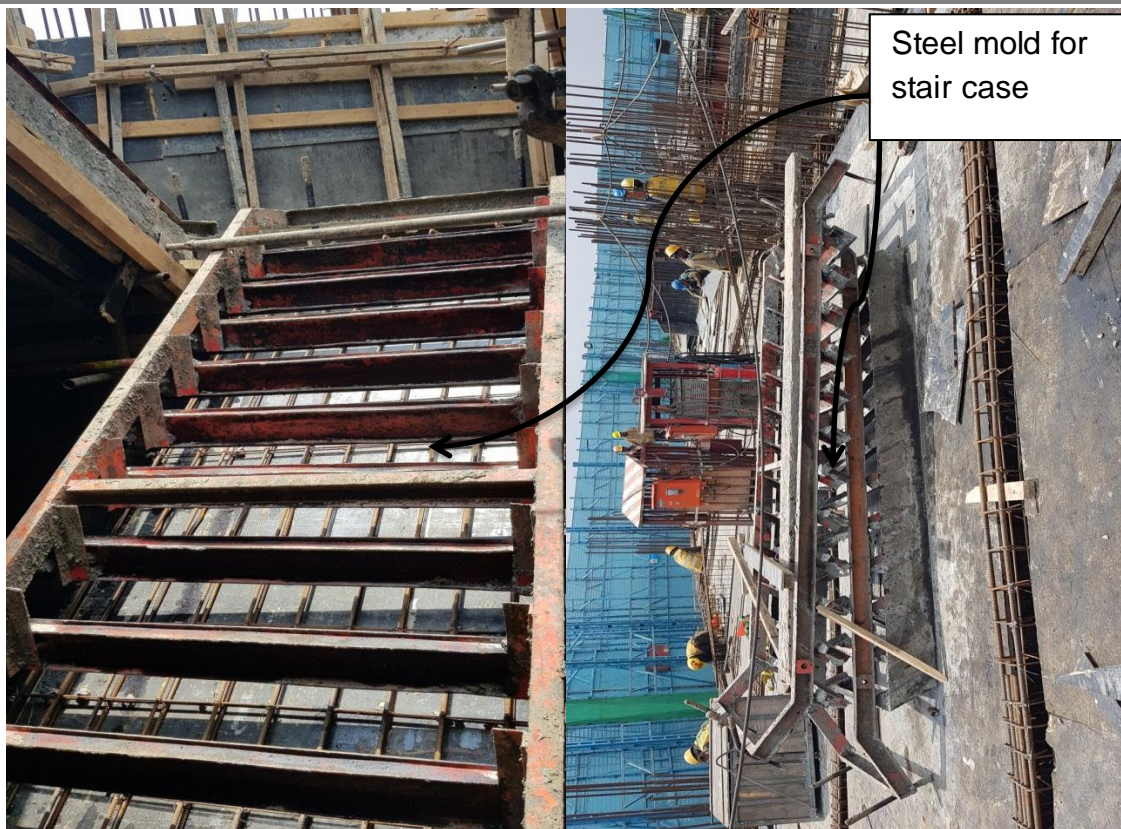


Figure 32 Stair case riser prefabricated formwork

4.5. Sample baseline schedule versus updated schedule

To prepare baseline schedule using Microsoft project for the structural work of 28th floor tower building which can be used as a typical schedule for the floors; I used WBS of activities according to the under listed principles.

- ▶ If work item is different, the activity is separated.
- ▶ If work item is same and production unit are different, the activity is separated.
- ▶ though work item and production unit are same, the activity is not continuous, the activity is separated.

So according to the above principle structural work activities are listed as follows,

- Stair case formwork
- Stair case rebar work
- Stair case concrete casting work
- Slab and beam formwork
- Slab and beam rebar work
- Slab and beam concrete casting
- Column and shear wall formwork
- Column and shear wall rebar work
- Column and shear wall Concrete casting

- Floor electrical/mechanical work
- Wall electrical/mechanical work

For the baseline schedule I used the above WBS of activities. When I was collecting the data for the purpose of updated schedule what I observed is the site practical working condition is different from my baseline schedule. In the site they aren't doing an activity continuously like for example floor concrete casting. They cast floor concrete at two times by creating construction joint along axis Te-5. They use this method I think to use their resources efficiently like to minimize idleness of workers. So for the purpose of updated schedule the WBS of activities are as follows,

⇒ **West side of the work from axis Te-2 to Te-5**

- Stair case formwork
- Stair case rebar work
- Stair case concrete casting work
- Slab and beam formwork
- Slab and beam rebar work
- Slab and beam concrete casting
- Column and shear wall formwork
- Column and shear wall rebar work
- Column and shear wall Concrete casting
- Floor electrical/mechanical work
- Wall electrical/mechanical work

⇒ **East side of the work from axis Te-5 to Te-8**

- Stair case formwork
- Stair case rebar work
- Stair case concrete casting work
- Slab and beam formwork
- Slab and beam rebar work
- Slab and beam concrete casting
- Column and shear wall formwork
- Column and shear wall rebar work
- Column and shear wall Concrete casting
- Floor electrical/mechanical work
- Wall electrical/mechanical work

When we compare their progress in relation to their master schedule there is delay in the project. For example construction of structure work of tower building from level 25-29

scheduled to complete on 30/11/2017 but floor 28 structure work completed on 28/05/2018. So to eliminate the backlog the project requires crush programme by revising the schedule. I schedule the floor structure work to complete within 10 days. When I compare the baseline schedule with the actual executed duration; floor 28th completed within 12.5 days and floor 32nd is completed within 10.25 days. This progress indicates us even in the next floor structure work activities may complete within less than 10 days.

Baseline and updated schedule by using Microsoft project for the structural work of 28th and 32nd floor tower building are attached under the appendix A and B. In addition to this the master construction schedule is attached under appendix C.

4.6. Project Progress Relative to the Master Schedule

Generally the project has delay relative to the master schedule. To see this delay let's see the status of some critically delayed activities in the head quarter tower building construction.

Table 3 Plan versus executed for some activities

Item No.	Description of activity	Planned completion date according to the master schedule	Status of activity as of may 17, 2018	Remark
1	Structure work of from floor 25-29	30/11/2017	Floor 28 th finished on 28/05/2018	From this we can see there is delay in the project. So it is better to apply crush programme by the rescheduling the activities.
2	Masonry (HCB) construction from floor 25-29	28/02/2018	Not yet started	
3	Preliminary decoration (plastering) from floor 3-6	10/10/2017	Not yet started	
4	Installation of curtain wall from Ground to 11 th floor	25/01/2018	Not yet started	
5	Refined decoration like painting, flooring, From Ground to 2 nd floor	26/03/2018	Not yet started	

In the master construction schedule supportive activity like material bidding preparation and purchase presented and appropriate time allocated for it. As an example HVAC (Heat, Air Ventilation, and Cooling) work of tower building from ground to 24th floor a total allocated time of 757 days from this 452 days that is $(452/757)*100= 59.7\%$ of the total work duration assigned for material bidding preparation, material purchasing and shipment. From this we can see their schedule gives special attention for supportive activities.

According to the master construction schedule preliminary decoration (plastering) activity start date on 12/09/2017 and refined decoration start date on 26/03/2018. From this schedule refined decoration to be started approximately after 6 months from the start date of preliminary decoration. According to the current status of the project if the preliminary decoration starts on September, 2018 then the refine decoration will be started on March, 2019. On the master schedule the planned total duration required for the refined decoration is 597 days. In order to get the completion date of refined decoration we can add the required time on the start date of this activity, accordingly the completion date of refined decoration will be on November, 2020. By referring the master schedule the completion date of the project is 4 months after the completion of refined decoration. From this we can extrapolate the completion date of the project will be March, 2021 that will be after 1 (one) year from the planned completion date.

When we consider curtain wall construction for tower building as a critical activity then according to the master construction schedule start date on 28/09/2017 and planned completion date on 02/04/2019; so the total duration of the activity is approximately 18 months. Curtain wall completion time is 9 months before the completion of the project that means there is 27 months require from the start of curtain wall installation to the project completion date. By assume the curtain wall of tower building start on October, 2018; so the project completion date will be after 27 months of the curtain wall start date that will be February, 2021.

By considering the above activities case as a sample we can extrapolate the project may delay by 1(one) year if crush programme not applied early on the project for the critical activities.

CHAPTER FIVE:

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

As we see from the literature review pre-construction planning and scheduling of CBE head quarter building construction project has done very well which includes the activity planning and scheduling, equipment planning and location where to be installed, work methodology and others. The planning and scheduling that has done before the start of the project is applicable. Due to this the activities sequence and work methodology, equipment type like crane, elevator and their number ,location to be fixed and the timing it should be fixed and demolished is according to the pre-construction planning. In high rise building construction the major problem is vertical transportation of resources. For this project the planner has given special attention for vertical transportation by assigning;

- Three cranes - one tower crane for office tower building, one tower crane for commercial center and one tower crane to conference center.
- Four double cage elevators- two double cage elevators for office tower building, one double cage elevator for conference center and one double cage elevator for commercial center.
- Concrete pump which has high pumping capacity in relation to height and volume.

Because of the good plan and application of the plan the vertical transportation system is good in the site. The resources like manpower transport by the elevator; the panels, reinforcement bar, spacer, small machines and other materials transport by tower crane; Concrete transported from the ground to the floor to be casted by concrete pump. By taking into consideration the situations in the project we can conclude as follows;

- Prepare good plan and schedule and then working according to it during the construction period is very important for the successful progress of the project.
- Vertical transportation system is very important for high rise building construction. In this project good planning of vertical transportation system which minimize the manpower output decrease due to increase in height.
- The project is equipment intensive which includes small machinery like plywood cutter to heavy machinery and almost all are electric power driven.
- Even if in our country the experience of high rise building construction is less due to this it is difficult to estimate the duration of activities like structure work from experience. But as we discussed in the literature review part Korea Land and Housing Corporation, 2003 the structural work completion of each floor requires from 12 to 13

days even it is difficult to use this standard as it is, it can be used as a rough comparison purpose. This project structural work completion period as we saw from the sample schedule; it is within and even below the above standard.

- The batching plant used for concrete production isn't inside the project site. So using ready mix concrete solves the stocking (sand, aggregate) area problem in the site. Due to this ready mix concrete for such a type project which has an area limitation exists using concrete batching plant outside the project is a good practice.
- Most of the time concrete casting is done in the night time. It is good for the movement of truck mixes because of the city traffic jam does not exist at the night time.
- As observed during the site observation; the safety condition in the site is good because there is warning posts, temporary light is available, and helmet wearing is must except safety shoe. Site utilization is good like material stocking (all materials like panel, reinforcement bar,.. have no direct contact with the soil)
- The resident of Chinese staffs inside the site; this may facilitate the project execution.
- The master construction schedule WBS of activities doesn't done in detail as well there is no resource schedules like manpower, equipment, material and financial. The work break structure used for scheduling seems milestone tasks.
- In this project construction schedule even though the construction schedule activities aren't listed in detail that is the weakness of the schedule but the good quality of the schedule ; it includes supportive activities like installation and removal of tower cranes, for especial equipment material bidding preparation, material purchase and shipment. Including supportive activities in the schedule is important to avoid delay due to late material and equipment delivery.
- Mechanical connectors for longitudinal bars are good for rebar wastage reduction and for narrow structure section it avoids rebar congestion.
- On the working area there are fire extinguishers available and it is a good practice especially during welding it is very important.

5.2 Recommendation

The project pre-construction planning and scheduling is very good but at this stage there is delay. If this backlog not solved soon; it results overall delay of the project. Finally the following recommendations are forwarded that can contribute a lot for the successful execution of the project.

- As discussed before the project doesn't have detail schedule (construction, manpower, equipment and material). But for such complex project detail schedule is very important for the efficient completion of the project.

- Electric power is very important for high rise building construction. We should have three phase power and standby generators whose capacities depend on the power to be required. In this project the power supply system is good so sustain it in the future too.
- Even if the time required for completion of structural part of a floor that was used as sample schedule (28th and 32nd floor of structure work) is within the standard specified in the literature review but the project has delay. So this project needs schedule revision and crush programme to complete the project within the contract duration.
- For such a type of mega project which will be model (icon) to the city its early completion time is very important to the bank and the society. So to complete within the contract duration and to avoid congestion of manpower in the site; working by two shifts with the adjusting of the morning start time is very important that means early start of the first shift.
- Safety case follow up should continue as it is or better than this because the height of the building is increasing. If there is hollow concrete block work near to the edge of the building especial care should be taken to avoid accident.
- Planning and scheduling of high-rise building construction is very important and complex. So it is better the schedule prepared in detail and revised periodically by experienced professionals.
- During the construction of the upper part of the office tower building it is better to have urinating area for workers to avoid urinating on the working floors.
- The number of skilled local workers in the electromechanical work and female workers in the project is less. Especially the number of skilled/professional local workers in the electromechanical work better increased for the purpose of future maintenance, knowledge transfer and for the contractor it reduces salary cost in comparison with the foreigner.
- In the project during the study time there is no local subcontractors but for experience sharing and to shorten the project duration; it is good local contractors to participate in the project as a subcontractor like activities hollow concrete block work, plastering work, floor finishing work and others.
- The contractor response for the factors which affect their schedule; one of the factor is local workers are not continuing on their work due to this the project schedule affected. In order to encourage local workers site cafeteria out sourced or managed by the main contractor may increase interest of workers to stay in the project. Site cafeteria motivates workers because local workers can get food inside the project with a minimum price.

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APPENDIX A: Floor 28th Structure Work Baseline Construction
Schedule Of The Project (Sample Typical Schedule)

**APPENDIX B: Floor 28th and 32nd Structure Work Updated
Construction Schedule Of The Project (Sample Schedule)**

**APPENDIX C: Master Construction Schedule of The CBE
Headquarter Construction Project**