



**ADDIS ABABA INSTITUTE OF TECHNOLOGY**

**SCHOOL OF CIVIL AND ENVIRONMENTAL**

**ENGINEERING**

**CONSTRUCTION TECHNOLOGY AND MANAGMENT**

**Study on Potential Cost Reduction Mechanisms in 20/80 Condominium  
Building Projects in Addis Ababa**

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**DECLARATION**

This thesis is my original work, and has not been presented for a degree in any other university and all sources of material used for the thesis have been duly acknowledged.

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## Abbreviations

CM: Construction management

DBB: Design bid build

DB: Design build

EVM: Earned value management

HCB: Hollow concrete block

HMSO: Shared materials services organization

LCH: Low cost housing

### **Abstract**

In construction industry the main objective of project control is to ensure that projects are completed on time, within budget and quality. In Ethiopia, building construction industry there are many problems associated with quality, time and cost of project. Cost is the main concern for contracting parties and end user. Ethiopian condominium housing program is designed with the objective of reducing the overall cost of buildings. However, there are arguments on condominium housing projects being implemented whether it addresses the desired cost reduction or not. On the other hand, reduction of cost of construction is very important for all contracting parties and end user.

The main objective of this study is to investigate potential cost reduction mechanisms on 20/80 condominium building construction sites. The study was conducted by selecting two 20/80 condominium building project sites and it presents the current practices of contractors, consultants and client, who are working in 20/80 condominium building projects, related with cost of project and some issues related to potential cost reduction mechanisms. The practice of 54 general and building contractors, 8 consultants and 8 client representatives were investigated via site observation and interviews. Furthermore, the existing practices related to potential cost reduction mechanisms and cost influencing factors were assessed as part of fulfilling the objectives of this thesis.

The result of study showed that delay of construction activities, market conditions, method of procurement, site overheads, productivity of labor, resource and service availability, labor cost, project program, the nature of the site and cost of design are the major ten factors that affect cost of project. In addition, the study indicated that more than 50% of the contractors were not checking their performance regularly and frequently. The case study results on the construction sites also indicated that most of the contractors have poor materials handling and management problems, do not apply metal shoring and scaffolding and ready-mix concrete. Furthermore, most of the contractors use poor quality formworks and the partially prefabricated building components were of poor quality and are exposed to wastage.

On the contrary the study indicated that, checking performance daily and regularly, good materials handling and management practice, using prefabricated building components and using metal shoring and scaffoldings instead of eucalyptus wood shoring and scaffoldings can reduce construction time and unnecessary expenses. In addition, using ready mix

concrete reduces construction time and wastage of concrete making materials and improves quality of concrete, which as a result reduces construction project cost. Furthermore, constructing by using good quality formworks will make the concrete to have good surface finish which as result reduces cement plastering and cost of project.

**Key words:** *Cost, Cost Influencing Factors, and Potential Cost Reduction Mechanisms*

## **Chapter One: Introduction**

### **1.1 General**

Within the last decade Addis Ababa city administration has been working on condominium building projects. The project office started its activities in 2004 by constructing 750 model housing around Gerji. Then city administration expanded this program in different part of Addis Ababa and also demands for condominium housing rapidly increased in the city. By understanding the situation Addis Ababa city administration reregistered 994,788 people to condominium housing scheme by all levels of the city dwellers in 2013. The housing programs are 10/90, 20/80 and 40/60. This means to address the residents that are able to pay 10%, 20% and 40% dawn payment schemes from the lower to the middle income respectively. Until now 177,037 houses were transferred to the residents among them 152,089 houses are 20/80, 23,976 houses are 10/90 and 972 houses are 40/60. But 960,090 people are waiting in all programs for housing and many condominium buildings are under construction in different part of the city (Addis Ababa housing development office report,)

The construction sites selected for this study are 20/80 condominium housing construction sites which are introduced by the government to address the residents that are able to pay 20 percent before acquiring their house and the remaining 80% after obtaining the house with in fixed time. Addis Ababa Housing Development Office report showed that costs of 20/80 condominium housing fairly increase from beginning to 4<sup>th</sup> round. But, after 5<sup>th</sup> -11<sup>th</sup> rounds cost of condominium housing has rapidly increased. That mean cost of condominium housing was increased more than triple from beginning. Therefore, the study is necessary on potential cost reduction mechanisms in order to tackle this problem.

### **1.2 Background**

Many construction project managers and contractors find difficulties like poor planning of project, poor quality of materials, labor shortages, increased cost of materials, delays in deliveries, wastage of material, over budgeting, unexpected weather changes, lapse in management control, loss of material and poor communication. This result lead to cost and time over runs, conflicts in project (Chris Hendrickson, 1998)

Addis Ababa housing project development office's profile (2004) stated that countries all over the world including Ethiopia have promised to implement in terms of improving the living environment and life of citizens. Housing has been universally accepted as the second, most important essential human need after food. It plays significant role in human life and the living environment of the world. And also, it has an influence on health, education, economy, environment, and political and social life of any society.

According to low cost housing, technical manual (2004) in Addis Ababa, there is a considerable housing and related land management problems. The main cause of these problems are high cost of construction, scarcity of construction materials, lack of knowledge in construction techniques, growth of population, shortage of fund for large-scale housing program. Utilizing low cost housing technology is expected to reduce cost, increase productivity and improve quality. As technology improves, building cost will be reduced and the quality and durability of the houses constructed may be achieved. Besides that, it will respond to the demands of the lower and middle class by building affordable houses

Projects constructed by conventional method are very slow considering the speed of our growing requirement for houses. To solve this problem effectively and to build large number of houses to wipe out the shortage of housing, it is necessary to increase the speed of housing construction. Therefore, detailed study is vital to identify potential cost reduction mechanisms in 20/80 condominium building projects in Addis Ababa with respect to the technology applied and the construction management practices.

### **1.3 Statement of the problem**

Condominium housing program is being widely implemented in different parts of the city and many contractors are involved in the construction of projects and huge amount of money is budgeted by the federal government every year for this project. This housing program is designed with the objective to reduce the per square meter cost of buildings. However, there are arguments on condominium housing projects being implemented whether it addresses the desired cost reduction or not. On The other hand, per square meter cost of the condominium building has been rapidly increasing from time to time and the total cost of the condominium house is not affordable for low income group (Tsion Getachew, 2016). In this aspect, it's important to study potential cost reduction

mechanisms with respect to the technology applied and the construction management practices.

## **1.4 Objectives of the study**

### **General Objective**

The general objective of this study is to investigate potential cost reduction mechanisms on 20/80 condominium construction sites.

### **Specific Objectives**

Specifically, this study will address the following points

- To identify critical factors that influence cost of condominium housing projects in Addis Ababa
- To investigate potential cost reduction mechanisms that are important to reduce cost of 20/80 condominium building projects.
- Forward recommendations, which help to reduce overall cost of housing in 20/80 condominium building projects.

## **1.5 Research Questions**

- What potential cost reduction mechanisms are being used by contractors working in 20/80 condominium building projects as cost efficient housing projects?
- What are the main factors that affect cost of condominium building projects?

## **1.6 Scope and limitation of the Research**

This research focused only on cost reducing mechanisms from construction management and construction technology perspective. The research mainly focused on practices of condominium building projects related to performance management, materials management, prefabricated building, shoring and scaffoldings materials, ready- mix concrete, and good quality of formwork. It doesn't include all construction management and technology aspect.

## **Chapter Two: Literature Review**

### **2.1 Background of Study**

#### **2.1.1 Developing Housing Needs**

Housing is one of the basic needs for living. Appropriate housing is an important need for every human being. But, the type of housing largely depends on the economic development of the country. Housing now a day has become one of the complex problems of our times and unless urgent measures are taken both at the regional and national levels to mitigate the housing problem, it will have serious problems with adverse consequences on the process of economic and social development (Mathura. G.C, 1993)

#### **2.1.2 Housing in Addis Ababa**

According to Tsion Getachew (2016) the city of Addis Ababa continues to experience the development of unplanned settlement and horizontal expansion more rapidly than ever before. The biggest challenges of the city are deteriorated living environment, disordered land management, unplanned urban development, and absence of effective promotional and regulatory frameworks, inadequate basic infrastructure and unbalanced population growth. The housing situation in Addis Ababa becomes even worse when the quality and the conditions of the houses are considered. Many are crowded, substandard and make shifts with very poor or no sanitation facilities and with unhealthy environment altogether.

#### **2.1.3 Affordability of Housing**

Housing affordability can be taken as a ratio of the sum of the monthly housing expenses (e.g. rent, mortgage repayments) to the monthly income per household. This proportion indicates what proportion of a household's income is needed for housing. Cost of housing should not be more than 30 percent of income or if a maximum of 30% of the monthly income is spent for housing, then the housing could be considered as affordable (Tsion Getachew, 2016)

#### **2.1.4 Low-Cost Housing**

The total cost of housing taking into consideration the initial capital cost for the housing construction and also the recurring cost of maintenance and repair over a period of its economic service life, should be determined during planning and designing and the most

cost-effective housing should be adopted. So that cost-efficient housing program is the timely solution for the drastically growing housing demand of the society in the city (Mathura. G.C, 1993)

## **2.2 Construction Industry**

According to Chikatra (2001) construction works are time bound activities which involve heavy investments of capital and resources. The implementation of these works is undertaken by organizing them into one or more construction projects. Construction works refer to a high value, time bound construction mission with pre-determined performance objective. In general construction project objectives are stated in terms of project completion time, budgeted cost and stipulated quality specifications. Construction projects management is a process which encompasses various sub processes and functions that are necessary for ensuring that these objectives are accomplished.

### **2.2.1 Concept of Construction Cost**

In general, construction cost is a production cost which is composed of two cost categories: direct costs and indirect costs. Direct costs are those costs that can be correlated to specific activity or a work-item, and all other costs that are incurred to accomplish an activity but cannot be related directly are indirect costs. Direct costs which include the direct cost of materials, labor as well as equipment and indirect costs which include but not limited to head office and site overhead costs (Tadesse Yemane, 2006)

#### **A. Direct Costs**

According to Abeselom Abraham (2008) direct costs in construction are all costs that can be specifically booked with an activity in a project. This cost consists of the cost of materials, labor, equipment and subcontractors needed to carry out a specific, well-defined item of work. It is obtained by establishing the measured quantities in the item of work, defining the resources that will be used to produce the work and the duration of time over which will be required, and then applying cost rates to the quantities and durations.

#### **I. Material and Labor Costs**

Direct material cost refers to the cost of materials, consumables and components used for executing an activity including the allowances for scrap and wastages. In general, cost of materials is composed of several cost items on the other hand direct labor is the work that

transforms materials from one state to another value-added condition. Carpenters, masons, steel setters, heavy equipment operators, plumbers and electricians are typical titles for direct labor (Tadesse Yemane, 2006)

## **II. Equipment, Plant and Sub-Contractor Costs**

According to Tadesse Yemane (2006) these costs refer to the costs of machineries and plants used in executing a specific activity, the cost of equipment involves ownership, operation, maintenance, moving, set up and tear down. Where specific activities are sublet to subcontractors the sub contract price will be considered as the direct cost of the activity

### **B. Indirect Costs**

Indirect costs include all costs which are attributable to a given project but cannot be identified with the performance of a specific activity or a work-package, in other words all costs other than direct costs are covered under indirect cost (Abeselom Abraham, 2008)

## **2.3 Cost Influencing Factors in Building Project**

Cost is a critical factor in building construction projects and cost of construction work is influenced by a wide range of factors. Many researchers mentioned different cost influencing factors on building projects, among them are, choices of construction materials, method of procurement, function of a building, cost of design, nature of the site, resource and service availability, market conditions, labor cost, labor productivity, site overhead and project program.

### **2.3.1 Choice of Construction Materials**

The selection of construction materials and the proposed construction details will have an important bearing on the cost of project. The choice depends on what the client is willing to pay and the choice of the material is influenced by factors other than aesthetic qualities. For example, fast construction projects may use a precast concrete in preference to a cast in place concrete or in order to reduce overall program durations. The shorter program achieved by using precast concrete may offset this initial cost advantage. Technical decisions are made for each building element and these have a direct bearing on the eventual cost (Tony Cunningham, 2013).

### **2.3.2 The Method of Procurement**

procurement is a process used to select the lowest responsive and qualified bidders for procuring services, works or goods from potential competitors based on reasonable and relevant criteria in addition, procurement processes involves the preparation of procurement documents, the invitation and submission of tender proposals, and opening and evaluation of tenders (Chris Hendrickson, 2003). It includes establishing responsibility for design is to be placed, how the work is to be coordinated, and on what price basis the contract is to be awarded. The procurement strategy also directly affects the level of risk borne by the contractor and leads to choices regarding the conditions under which the work will be executed and physical infrastructures are cost extensive and appropriate savings obtained through competition are the main factor behind the procurement process

#### **A. Competitive Tendering**

According to Absalom Abraham (2008) the price which the contractor quotes for the job is heavily influenced by both the amount and intensity of the competition expected. In an open tendering arrangement, the level of the competition is at its most intense and contractors must submit highly competitive bids to have any chance of winning the contract. With selective tendering a limited number of competent contractors are invited to tender for the job.

#### **B. Negotiated Contracts**

In this type of procurement instead of inviting competitive bidders, private owners often choose to award construction contracts to one or more selected contractors. The major reason for using negotiated contracts is the flexibility of this type of pricing arrangement, particularly for projects of large size and great complexity or for projects which substantially duplicate previous facilities sponsored by the owner (Absalom Abraham, 2008).

In the case of a negotiated tender there is no clear competition and the parties seek to agree a fair price for the work, hidden competition exists, however, as the employer can break off negotiations. The tendering arrangement is, therefore, one of the most cost significant decisions a client will make in the course of a building contract.

According to Thomas E. Uher and Philip Davenport (2002) stated that the success of contract administration depends on an effective communication between all the parties involved. This involves establishing relationships between the parties, defining responsibilities and determining the most appropriate administrative procedures. The contractual parties must

ensure that the lines of communication are established and kept open throughout the contract period. The fundamental aspect is to create a workable relationship between the contractual parties. This involves the determination of rules and procedures to be followed in the administration of the contract.

### **C. Design Bid Build (DBB)**

This system provides more price certainty to the client at the very early stage of the project. It also gives the client safer and more competitive price because the design plus the complete working drawings have been fully developed and detailed out prior to tendering. It eliminates any design or construction ambiguity which often causes the contractors to unnecessarily inflate the price. In the case where bill of quantities is used, the bidding tend to be more fair as such the project cost is also lower and due to its linear or sequential approach, the traditional procurement system has been identified as the slowest project delivery approach and works were often disrupted when there are too many variations due to unforeseeable problems and it tend to cause the cost to inflate (Masterman, J W E, 1996)

### **D. Design Build (DB) / Turnkey**

According to Thomas E. Ucher and Philip Davenport (2002) design and build project procurement system are called build-it-fast project delivery system where the design and construction are integrated. The design free pre-tender process allow for earlier construction date. It also allows the process of detail design and construction to run almost in parallel and concurrently to each other, thus reducing the overall project development period considerably. As a single entity responsible for both the design and construction, the contractor is able to control not only the construction time but also the time reserved for the design of the project, thus reducing the overall contract duration

Masterman (1996) stated the significant cost saving in this type of procurement system is made through the reduction of the overall development period. The cost of contractor's uncertainty can be set-off by the reduction in loan interest and early financial return or benefits and cost saving may also be made when the contractor applies his construction knowledge and experience to simplify design and work. At the same further cost saving can be made when the client offers the contractor some form of incentive if he is able to save a significant amount of cost.

## **E. Construction Management Consultancy**

This type of delivery methods characterized by a more active role for the principal as a member of the project team, the principal selects a design consultant to design a project, and a construction manager to manage construction. A construction manager can be a contractor, design consultant or any other consultant. The key requirement in appointing a construction manager is the knowledge and experience (Thomas E. Ucher and Philip Davenport, 2002)

Thomas E. Ucher and Philip Davenport (2002) also stated that, the system allows for early start of construction compared to the traditional approach. The preparation of simple or basic tender document and the shift of the process of schematic and detail design to construction phase, allow for an early start of construction. Under this system, the detail design is carried out either by the consultant or package contractors during the construction stage. All these factors brought about a considerable reduction of the overall project time compared to the traditional contracting systems

According to Masterman (1996) the cost of the project procured using this system tends to be lower than those using other procurement approach. This is because the cost of the project is actually the sum of prices quoted by the package contractors. With the management contractor being the consultant, no extra cost is being added up for main contractor's profit margin. The only additional cost is the consultant fee that the client has to pay to the management contractor or to the construction management consultant.

### **2.3.3 The Function of a Building**

According to J, Smith, and D, Jagge, (2007) the purpose of a building will have a major bearing on its cost. Housing has a very different cost range to apartments and commercial development. For example in mixed use building, there are apartments, commercial shops and offices. When compare to a cost of building, the per square meter cost of commercial building higher than apartments building and offices building with in the same floor and per square meter cost of hospital building different with the per square meter cost school this cost difference because of different function of a buildings. The cost of each building must be related to its individual design, which may be benchmarked against similar national and international projects.

### **2.3.4 The Cost of Design**

The geometry of a building has a major impact on costs. Overall shape of building or internal configuration is concerned with the size, shape and complexity of the building. In general, it can be said that larger buildings with simple, rectangular, regular floor plans and elevations will be less expensive per sq. m of floor area than smaller, complex shaped, curved or angular buildings and simple setting out and buildable solutions encourage greater plant use and generate higher productivity and less waste complex layouts and details are slower to assemble and may involve a number of trades with a consequent greater risk of mistakes and defects. The degree of repetition will also affect the overall cost of the work (Tony Cunningham, 2013)

### **2.3.5 The Nature of the Site**

The location of the project will influence its cost. High value sites attract high value developments and it is inappropriate to locate low value projects on valuable sites. Local development plans will constrain what can be built on such sites in any case. In general, urban locations are more expensive than their rural equivalents due to higher local wages, costs associated with access constraints, limited space for staff accommodation facilities and material storage, and the additional security measures required and the natural site features, ground conditions and obstructions, existing and adjoining building, and underground and over-ground services all impact on how the building is designed and subsequently constructed. The nature of each site must be individually checked to establish potential problems (J, Smith, and D, Jagger, 2007)

Smith, J and Jagger, D (2007) also stated that, heavily sloped sites require extensive stepping or cut and fill operations and such sites may be dangerous and adversely affect the working conditions and productivity of operatives and plant output. Sites with poor load bearing capacity will require more expensive foundations while exposed or waterlogged sites will also reduce overall productivity. The cost of dealing with unforeseen ground conditions, archaeological finds and encountering uncharted buried services may be substantial and will be borne by either the client or contractor, depending on the form of contract employed.

### **2.3.6 Resource and Services Availability**

Local contractors are usually at an advantage when competing for work. Contractors who have the capacity to construct work from within their own organization should, in theory at

least, be more competitive than those who sub-contract large proportions of the work. Current site management practices however tend to favor the widespread use of subcontractors (Seeley, 1996)

According to Seeley (1996) stated that the ability to attract labor and to source materials in the locality is an important factor in ensuring that unnecessary travelling and transport costs are not incurred in carrying out the work and the availability, location and capacity of existing utilities must be considered in the design. Connecting to these may involve significant costs particularly where they are inconveniently located or distant from the site what demands the proposed project would put on own plant, scaffolding and equipment. Contractors will have to consider whether management, labor and plant resource requirements can be met from within the contractor's own organization or whether it will be necessary to recruit specifically for the project.

### **2.3.7 Market Conditions**

Value for money is perceived within a time and location context. Construction activity is highly sensitive to changes in economic outlook and activity in the local and national economy. Construction activity is cyclical and flourishes in times of general economic growth and suffers during economic downturns. Contractors generally win contracts in competition and profit margins reflect the amount of work available at the time. When demand for construction work is high, contractors typically experience supply and capacity constraints, labor shortages, which result in rising tender levels. Conversely, when work is scarce margins are cut in an attempt to secure work, and may be insufficient to adequately cover risks eventuating during a project. In these instances contractors may be trading at a loss, which, ultimately cannot be sustained (Ashworth .A, 2004)

### **2.3.8 Labor Costs**

Identifies a number of factors which affect labor costs but which can also boost productivity: better training, realistic performance-based incentives and effective organization and supervision. The contractor's commitment to workers in terms of providing training and offering better rates of pay and conditions to core staff is normally a worthwhile investment, which is repaid in quality work and a reduced need for supervision. Temporary labor which may be obtained at lower cost normally incurs higher supervision and can damage to a firm's reputation and incur considerable remedial costs if the quality of work is poor (Seeley, 1996)

### **2.3.9 Productivity**

According to Tony Cunningham (2013) site productivity is influenced by a range of human and site related factors which combine to affect output. Human factors include the skill of the operative, familiarity with the operation, equipment used and motivation. Human needs such as job security and satisfaction and health also influence productivity and external conditions such as climate, the degree of supervision, the complexity of design, site layout and organization, and overall mechanization will also affect the productivity achieved on site. For example, difficult working conditions such as working at high level or working on scaffolding generates less output than working at ground level.

### **2.3.10 Site Overheads**

According to Ashworth. A, (2004) site overheads are often referred to as preliminaries and these reflect the cost the contractor incurs in setting up and running the site. Preliminaries represent a significant portion of a typical building contract. As building operations become more complex and the contracting role increasingly involves off site construction and the coordination of subcontractors, the pricing of the preliminaries takes on added importance to the main contractor by choosing efficient methods of carrying out the work the contractor can reduce program times, producing significant savings in management and accommodation costs, thereby gaining a competitive advantage over rival companies.

### **2.3.11 Project Program**

The client's requirements will dictate the amount of time available to construct the project and from the contractor's perspective there is an optimum time for completing a project. Contracts periods shorter than the optimum will result in the contractor incurring additional cost in terms of non-productive overtime, more intensive management input and coordination of subcontractors. These include, for example, increased health and safety management issues arising out of more intensive site activities. On the other hand, extended contract programs involve the contractor in unnecessary site preliminaries and overhead and financial costs (Seeley, 1996)

## **2.4 Cost Reduction Mechanisms**

In many construction projects project managers and contractors find difficulties like poor planning of project, poor material, labor shortages, increased cost of material, delays in deliveries, wastage of material, over budgeting, unexpected weather changes, lapse in

management and control, loss of material and poor communication. This result into cost and time over runs, conflicts in project. So there is need to identify cost reduction or cost controlling techniques for carrying construction project effectively. Reduction of cost of construction is goal for construction industry .One way of reducing construction cost is to develop innovative technology as well as methodologies to increase productivity. Due to cost reduction techniques cost of project is managed so that contractor does not suffer losses of while carrying different activities of project (Rajashri, Shahu, 2015)

### **2.4.1 Cost Reduction Mechanisms in Construction Management Aspect**

Construction management skill helps to retain the cost saving mechanisms considered during the design phase and also to attain additional cost saving techniques. However, if the project is not well managed it may cost additional amount and may become more expensive than the conventional construction method (Chris Hendrickson, 1998). There are many management mechanisms that help to reduce construction cost such us

#### **I. Developing a Cost-Control System**

Cost management is very much more than simply maintaining records of expenditure and issuing cost reports. This means understanding how and why costs occur and promptly taking the necessary response in light of all the relevant information. Keeping a project within budget depends on the application of an efficient and effective system of cost control. From the information generated it should be possible not only to identify past trends but also forecast the likely consequence of future decisions. Cost management is the process, which is necessary to ensure that the planned development of a design and procurement of a project is such that the price for its construction provides value for money and is within the limits anticipated by the client. Construction is a major capital expenditure, which clients do not commence until they are certain that there is a benefit (R, Flanagan,. and B, Tate, 1997)

According to R, Flanagan, and B, Tate, (1997) this benefit may be for society in the case of public projects, with justification based on a cost benefit analysis, or purely based on financial considerations in the case of private projects. Most clients are working within tight pre-defined budgets, which are often part of a larger overall scheme. If the budget is exceeded or the quality not met the scheme could fail. Pre-contract estimating sets the original budget forecasting the likely expenditure to the client. This budget should be used positively to ensure that the design stays within the scope of the original scheme.

## **II. Cost Estimating on Building Projects**

Estimates of the cost and time are prepared and revised at many stages throughout the project cycle. The technique is now well established in the building sector According to R, Flanagan, and B, Tate, (1997) all cost predictions should not be considered 100% accurate. The degree of realism and confidence achieved will depend on the level of definition of the work and the extent of the risk and uncertainty. Consequently, as the design develops, the accuracy of the estimate should improve. Building cost estimation is the basis for design cost control using the cost-planning technique into functional elements in order to provide a means of comparison between projects planned with data from existing projects. A building element is defined as part of a building performing a function regardless of its specification. Elemental analysis allows the comparison of the costs of the same element to be compared between two or more buildings.

## **III. Earned Value Management**

Earned value management (EVM) integrates project scope, time and cost through periodic measurements of actual cost and work completion. It views project progress in terms of cost as a function of time against a firm baseline set up at the start of the project. When the project is originally planned, it is divided into work breakdown structure and further sub-divided into work packages. These work packages are assessed for cost estimates and scheduled in a time sequence. Earned value management is a project management technique that measures forward progress objectively. It has the unique ability to combine measurements of technical performance that means accomplishment of planned work and schedule performance. It measures schedule behind/ahead of schedule and cost performance under/over budget within a single integrated methodology. Earned value management provides an early warning of performance problems while there is time for corrective action (D, Christensen, & S, Heise, 1993)

According to D, Christensen,. & S, Heise, (1993) these work packages are assessed for cost estimates and scheduled in a time sequence. Taken together, work breakdown structure, master schedule and cost budgets form the baseline, represented as a graph of planned costs over time. It simply tells how the costs will flow over time as planned. During the project execution, actual costs and the quantum of work completed are periodically noted. The work completion is pro-rated to equivalent monetary value based on the budgetary costs for the

work packages completed, by measuring at periodic intervals, EVM focuses on the flow rates of actual cost and completion against the planned cost and completion. It makes possible to compute cost and time variances, as well as extrapolate how much cost and time would be required for project completion.

#### **IV. Material Management**

Materials management is an important element in project planning and controlling and to make construction projects cost efficient. Materials represent a major expense in construction, so minimizing procurement or purchase costs of materials can reduce total project cost. By resource leveling, smoothing usage can be brought to optimum refined level so that much storage cost can be eliminated. Economic order quantity is very important to optimize total project cost (Naief Turki Ibn Homaid, 2002)

Turki Ibn Homaid (2002) also stated that, Poor materials management can also result in large and unavoidable costs during construction. On the other hand if materials are purchased early, capital may be tied up and interest charges incurred on the excess inventory of materials. Even worse, materials may deteriorate during storage or be stolen unless special care is taken. Some time, delays and extra expenses may be incurred if materials required for particular activities are not available. Accordingly, insuring a timely flow of material is an important concern of project managers.

An effective materials management system is required in order to avoid problems, such as delays in a construction projects. Many factors accelerate the delay of project duration, however poor materials management can have a major effect on site activities and common issues relating to materials management are storage problems, incorrect materials delivery, subsequent design changes, materials damage, incorrect materials take-off, and vendor evaluation. Hence, a good materials management environment enables proper materials handling on construction projects activities (Pataskar, A. R, 2013)

## **V. Cost Reduction Techniques in Construction Site**

### **Monitoring**

Monitoring is the continuous assessment of project implementation in relation to agreed schedules and the use of the procured goods, works and services by the project beneficiaries. It is an integral part of good management by the project implementing agency. Its main objectives are to provide continuous feedback on implementation and to identify actual or potential successes and problems as early as possible to facilitate timely adjustments to the project in general. A reliable flow of information during implementation enables the task team to keep track of progress and undertake mid-course corrections where needed (Chris Hendrickson, 1998)

Monitoring is concerned with making sure that all of our planning; organization and leading have gone as we anticipated. It is a very critical managerial function because the consequences of not meeting the standards of performance can be very negative for organization for example poor monitoring in construction may result in delay which finally leads to cost overrun.

Cunningham Tony (2015) stated that, quantity surveyor typically prepares a cash flow forecast based on the contractor's program in order to advise client during the construction period. The cash flow profile typically takes the form of an 'S' curve which becomes a useful aid in identifying cost variances. An updated cash-flow profile enables the actual level of expenditure to be compared with the planned expenditure. Variances between the two profiles can be readily identified and these indicate whether or not the project is running according to plan. Variance analysis often indicates that project is either taking longer or costing more to complete. The cause for the variance should be investigated in order to identify the source of the problem and to take appropriate action to correct it.

Contractor uses schedule to monitor the progress of the work which is related to cost and inspection of work is done and comparison with budget is made. Meetings held to review the progress of work provides motivation to all workers and stake holders to improve their performance. Documentation of all activities or record keeping is important to enable detection of deviation from the set standards (Chris Hendrickson, 1998)

According to Chris Hendrickson (1998), Clients, consultants and the contractors use monitoring tools of budget, schedule and feedback to keep watch on cost performance.

Quantification of work and comparing cost with bill quantities helps to evaluate the work and to check the progress of work.

### **Meetings**

Site meetings keep people up to the mark and impart a sense of urgency which is difficult in day-today correspondence. Regular site meetings are held during the construction period. Site meetings provide a forum for round table discussions regarding developments on site and provide opportunity to update the cost situation and provide the design team with the necessary information to make effective decisions. The meeting typically involves the quantity surveyor presenting a review of the financial progress and status of the project, which is recorded in the minutes. Meetings also present an opportunity for quantity surveyor to gather further information from the design and construction teams (Hongtao, S, 2014)

### **Cost Reports**

The client and the design team should be advised on a regular basis of the current financial situation on the project. A special report may also be warranted if a major cost issue arises. The reports are circulated to the client, contract administrator and often to the other design team members. Where a cost report indicates significant cost increases, the quantity surveyor should propose possible solutions to mitigate or eliminate the particular overrun. The process of reporting regularly to the client is, in itself, a driver for effective cost control and the maintenance of financial discipline on a project. The process requires the quantity surveyor to find out what the current financial position is from the various design team members and to question the reasons for any variances from the cost plan. Reporting, therefore, brings matters to a head and forces the design team to address the various cost issues at hand (Cunningham Tony, 2015)

## **2.4.2 Construction Technology**

Construction technology refers to the construction methodology, construction materials and equipment required during construction process. That is the making, usage, and knowledge of tools, machines, techniques, crafts, systems or methods of organization in order to solve a problem or perform a specific function. However, in relation to the low-cost housing both the design concept and prefabrication technology refers to material selection, which is appropriate to the intended purpose of the building, construction methodology. That is how to construct the designed building and assemble the prefabrication-building units by specifying it with respect to the material selected, and the type of equipment required for execution of the designed building starting from site clearance to completion. In general, the implication

of the construction technology to the low- cost housing project is very wide and important (Mathura G.C, 1993)

### **2.4.2.1 The Design as a Component of Construction Technology**

According to Mathura G.C, (1993), Cost reduction aspects by use of construction technology start at the design and planning phase as material, and to some extent construction techniques are determined during design phase. Here below the design phase is elaborated with the intention of outlining the design aspects required in achieving low cost construction using the construction technology. As a discipline the five basic components of design are functional requirement, economy, aesthetics, ecological requirement and construction methodology and importance of these requirements differs according to purpose of the project, financial capability, climatic condition, culture and religion of a community. On the other hand, more emphasis is given on functional requirement and economy for public work projects. This means the design and construction of low-cost housing should be appropriate in the economic and social conditions prevailing in country.

#### **2.4.2.1.1 Planning**

The cost of land and its development to provide essential housing services and other infrastructure facilities has grown irrespective to the income of low and middle-income groups and now accounts for substantial cost of housing construction. It has become necessary, therefore, to device ways and means of effecting saving in the use of land and cost of its development by resorting to economic physical planning for housing development. Multi-storied housing development is being increasingly adapted to effect saving in cost of land as well as cost of infrastructure services. There is substantial increase in net residential densities and consequent saving in plot areas in multi-storied housing, however, intensive use of land and densification has a side effect because it increases densities of utilities like sewer lines and electric cables. The problem with densification is not only in densification of utilities but also in the social effect of having to live in very dense surroundings where most spaces need to be shared (Mathura G.C, 1993)

#### **2.4.2.1.2 Design Concepts**

Due attention should be given to the spatial design in any housing projects. The size and shape of the building have bearing on cost of construction. Irregular shapes require more design as well as construction efforts in resource and time hence will result in greater cost of

construction. In general, whatever new construction technology is adapted it should not require highly skilled personnel and should be simple to understand and construct. However, care should be taken with structural parts not to compromise structural requirements in order to make the technology simple (Mathura G.C, 1993)

#### **2.4.2.2 Prefabrication-Building**

Prefabricated buildings are structures built by manufacturers and then installed in the selected location. The extent of the manufacturer's prefabrication can vary from structure to structure, but generally the majority of the building is constructed offsite and Prefabrication-building units is based on the concept that production is more controlled and predictable in a factory than on a construction site. The construction industry is attempting to increase the prefabrication of building components. Prefabricated components require tighter tolerance control in the field, as well as some detailing constraints on the prefabricated units in relation to their use in various applications. By necessity, prefabricated units have a lot in common so that a large number can be fabricated more efficiently, reduced cost of formwork, scaffolding and construction time, reducing wastage of materials as result of this, which reduce over whole cost of construction. (W, Kymmell, 2007).

According to W, Kymmell, (2007) advantages of Prefabrication building components are

- Prefabricated components speed up construction time, resulting in lower labor costs
- Prefabrication allows for year-round construction.
- There are less wasted materials than in site-built construction and is less theft of material / equipment
- Worker safety and comfort level are higher than in site-built construction.
- Materials are protected from exposure to the elements during construction.

In most cases, Prefabrication drastically reduces construction time and cost, and allows construction to take place regardless of environmental conditions. Prefabricated buildings can be designed for virtually any use, but are ideally suited to operations requiring temporary structures, short construction time, and relatively inexpensive construction costs. According to W, Kymmell, (2007) prefabrication has the following impact on, schedule, budget and quality

### **A. Impact of Prefabrication on Project Schedule**

Prefabrication can yield time savings through the ability to conduct work simultaneously onsite and offsite, as well as helping with better coordination among different trades. In addition, less onsite staging, such as scaffolding, is frequently involved. Regionally, the ability to avoid weather impacts can reduce construction time. Additional time may be spent in the design phase on complex projects to coordinate the use of prefabrication and modularization. However, the time saved onsite typically reduces the overall project schedule. Since construction onsite is both labor-intensive and expensive, this time savings can yield significant cost savings as well.

### **B. Impact of Prefabrication on Project Budget**

While prefabricated materials can cost less, in general the cost savings are due to secondary issues, such as reduced reliance on expensive onsite labor, the ability to avoid overtime pay and other unexpected labor costs, and the ability to reduce onsite resources required. Even when prefabrication appears to be slightly more expensive at the outset, the avoidance of unexpected costs during the process is valuable, especially for owners with inflexible budgets like those in the public sectors.

### **C. Impact of Prefabrication on Improving Project Quality**

Quality of the materials is one of the major benefits of prefabrication. Factory conditions offer the ability to do extensive quality control checks on each piece produced. Prefabricated concrete, for example, can avoid the imperfections frequently found in concrete poured onsite. The lack of exposure to the elements also increases the quality, as does the ability to fabricate in factory conditions rather than on ladders or from scaffolding.

#### **2.4.2.3 Preventing Wastage of Materials**

Construction material wastes refer to materials from construction sites that are unusable for the purpose of construction and have to be discarded for whatever reason. Construction material waste is defined as any material apart from earth materials, which needs to be transported elsewhere from the construction site or used on the site itself other than the intended specific purpose of the project due to damage, excess or non-use or which cannot be used due to non-compliance with the specifications, or which is a by-product of the construction process (Eskedar Girma, 2016)

Design and the specifications can contribute significantly to the amount of waste generated during the construction of a project particularly when uneconomical design solutions are selected or when unsuitable materials are specified. The best practice is to design this waste out as part of the design process. However, once the design is in place, the waste arising from the design can be estimated, controlled and reduced at tender stage, particularly for area-based packages such as flooring, walling and ceilings or when offsite manufacture is used. By focusing upon the way waste is generated, the participants to the construction process will be able to understand what their wastage is and subsequently, be able to take action to reduce it (Asmara Seyoum, 2015).

According to Asmara Seyoum (2015) reducing the wastage of materials should result in either a total saving to the project or an increase in profit for contractor. The former would be realized through a drop in tender prices and a resultant commercial, competitive advantage being achieved. The latter by maintaining tender prices with reduced materials costs. Either way, the contractors stands to benefit from using their materials more efficiently. In addition, if contractor can demonstrate a willingness to support and engage in waste reduction measures and demonstrate that these have an effect on his waste and have the opportunity to be pro-active and in doing so, reap the benefits from growing pressure for reduced material waste.

Generally, wastages of building materials can be divided into two types. One is direct waste and the other is indirect waste. Direct waste is the loss of those materials, which were damaged and could not be repaired and subsequently used, or which were lost during the building process; indirect waste distinguished from direct waste because it normally represented only a monetary loss and the materials were not lost physically (Eskedar Girma, 2016)

According to Eskedar Girma (2016) such losses arise principally from substitution of materials, from use of materials in excess of quantities allowable under the contract, and from errors. The failure to recognize and record waste from these causes makes accounting for materials meaningless. Therefore, a simple measure of waste on site would be the difference between that used as specified and the quantity of material delivered to site as a percentage of such deliveries for economic reasons people in the construction industry need to have an insight into the financial consequences of construction waste. Substantial savings could be obtained by reducing the amount of construction waste. The financial benefit gained by waste

minimization appreciated over a short term or long-term period. Waste minimization is a collective responsibility of all parties of the construction process from the client down to the contractor. Many researchers identified construction materials wastage minimization techniques among them most commonly used techniques are

#### **A. Standardization of Design**

Standardization means design items with generally accepted and uniform procedures, dimensions or materials. Standardization has the potential to dramatically reduce the current production of construction waste. This is by designing the building size and space to eliminate unnecessary elements, and to reduce off-cuts resulting from the construction process. Standardization of design in building construction ensures compatibility between market supply and specification (Andrew and Richard, 2004)

#### **B. Design for prefabricated Construction**

Offsite construction occurs in a manufacturing plant specifically designed for this type of processing off-site processes have been proved to decrease waste by optimizing cutting patterns and schedules. Its application also has the potential to significantly change operations on site, reducing the amount of trades and site activities and changing the construction process into one of a rapid assembly of parts that can provide many environmental, commercial and social benefits (Andrew and Richard, 2004)

#### **C. Proper Detailing During Design**

According to Andrew and Richard (2004) proper detailing during design is one of the most crucial skills needed in the building design process. This is because the nature and quality of detailing in the design document contribute to how the building is built, what it will look like, what it will cost, and how long it may take to build. Thus, design document should be specified in precise and brief ways so that the contractor can avoid excessive material ordering and estimate properly the possible amount of waste to be generated

#### **D. Proper Storage and Handling of Materials**

Once what materials need for the project established, there should be work on how those materials will be received and stored on the site. The site manager should plan in advance suitable storage space to protect materials degradation or damage from weathering or

moisture. The use of proper equipment for material handling and advance planning for minimizing multiple handling will result in direct cost reduction and time saving. Careful handling of materials reduces risk of wastage of materials on site. This will begin with the provision of suitable vehicles or delivery plants for transporting material from the storage area in the workplace so as to make the damage to the minimum. In addition, avoid double handling that the points of unloading should be the final position of stacking area (Andrew and Richard, 2004)

#### **2.4.2.4 Shoring and Scaffolding Materials**

Shoring and scaffolding materials are a temporary structure erected to support access or working platforms, which are usually used in construction work for workers have a safe, stable work platform when work cannot be done at ground level or on a finished floor. Shoring and scaffolding materials are required for all types of structures constructed above ground level. They have a variety of applications in the construction industry and are used in new construction, alteration, routine maintenance, renovation, painting, repairing, and removal activities (Keith Potts, 2008)

According to Keith Potts (2008) shoring and scaffolding materials are used for as access and support shoring and scaffolds. Access scaffolds are used to support light to moderate loads from labors to small construction materials and equipment for safe working space. The applicability of shoring and scaffolding materials vary from place to place but the common accepted and used types of shoring and scaffolding materials are from steel tube, aluminum, bamboo, Eucalyptus wood and composite materials. The most common accepted and used types of shoring and scaffolding materials are Metal, Eucalyptus wood and Bamboo.

##### **A. Metal Shoring and Scaffolding**

Metal shoring and scaffolding refers to constructed with metal components as structural skeleton, which is commonly used as working platforms at the building envelope and as false work to support formwork for in-situ concrete construction. A metal shoring and scaffolding system should be designed to withstand the self-weight of the whole shoring and scaffold system, construction and working loads and wind loads.



Figure 2.1 Metal shoring and scaffolding practices in Addis Ababa

### **B. Eucalyptus wood Shoring and Scaffolding**

Keith Pott (2008) stated that eucalyptus wood shoring and scaffolding can be constructed in different shapes and sizes, to support formwork for in-situ concrete construction and they should be designed to withstand the self-weight of the whole shoring and scaffold system, construction and working loads.



Figure 2.2 eucalyptus wood shoring and scaffolding practice in Addis Ababa.

### **C. Bamboo Shoring and Scaffolding**

According to Eyerusalem kelemewerk (2017) bamboo shoring and scaffolds can be constructed in different shapes to follow any irregular architectural features of a building within a comparatively short period of time. In general, bamboo shoring and scaffolds are mainly used to provide access of workers to different exposed locations to facilitate various construction and maintenance process. Besides widely erected on construction sites, bamboo shoring and scaffolds are also used in signage erection, decoration and civil work. But this bamboo material has slippery property therefore, from point view of safety it is unsafe to use. Rather it is recommended to use it as composite with metal shoring and scaffolding.

#### **2.4.2.4.1 Effect of Shoring and Scaffolding Materials on Cost of Project**

Among many factors types of shoring and scaffolding systems are key factors in determining the success of a building construction project in terms of cost, valuation of the whole life performance and cost of an asset over its lifetime takes into consideration of initial capital costs, future costs, including operational costs, maintenance costs and replacement/disposal costs at the end of its life (Eyerusalem Kelemewerk, 2017)

Cost of shoring and scaffolding system includes the initial cost of the shoring and scaffolding material, cost of accessories, labor cost, storage cost, wastage and disposal cost. The initial cost of metal shoring and scaffolding might be expensive but it's can be reused for more than ten years. On the other hand, eucalyptus shoring and scaffolding initial cost is cheaper but it cannot be used for more than one project, so, their cost analysis should also take into consideration of the impact of the material durability on the total construction period (Keith Potts, 2008)

#### **2.4.2.4.2 Effect of Shoring and Scaffolding Materials on Speed of Construction Project**

Shoring and scaffolding systems includes shipping or delivery time, preparation time, construction and dismantling. This is ideal to find a construction method to complete a specific construction activity with in short period of time with minimum cost and resource while maintaining the safety of work place, every activity in construction project contributes to the success of the project, particularly if the activity is a critical activity, it will directly affect the budget and completion time of the project. Metal shoring and scaffoldings are speed up construction activities, as result of this, it reduced contracting period (Eyerusalem kelemewerk, 2017)

#### **2.4.2.4.3 Effect of Shoring and Scaffolding Materials on Safety Management Practice in Construction Project**

One of the main reasons to use shoring and scaffolding are the amount of safety that it can provide. Shoring and scaffolding have supportive four anchor points, if not more, on the ground. This means that it provides a firm platform for workers to stand, sit and work from. Additionally, shoring and scaffolding can be made of a variety of strong, lightweight materials such as aluminum, which enables to stay even steadier. It is easier for workers to maintain their balance on a flat platform than on a ladder step, additionally; scaffolding often has a hand rail on the top platform, which helps prevent workers from falling off and injuring themselves while on the job (Keith Potts, 2008)

According to Keith Potts (2008) the abilities of the shoring and scaffold systems are dependent on the performance of each shoring and scaffolding units on handling of the loads and weather impacts of the structure. So that, designing of shoring and scaffolding units is dependent on the physical and mechanical properties of the shoring and scaffolding material. Different shoring and scaffolding materials have different physical and mechanical properties. Commonly natural materials show different behaviors, so that, it is very important to insure safety of shoring and scaffolding materials. A good safety record will also lower insurance rates and this saves accidents and fatalities costs in the project.

Many owners and contractors still believe that safety concerns will lead to greater cost and reduced productivity. The reality is that safety evaluation and control save money. The delays and total expenses following an accident are usually much higher than the original cost of establishing and maintaining safety standards (Eyerusalem kelemewerk, 2017)

According to Eyerusalem kelemewerk (2017) in general selecting poor quality of shoring and scaffolding systems with aiming to minimize the cost of project will directly affect the speed, quality and safety of construction. Similarly aiming purely at speed often contradicts the achievement of other quality targets and budgeted cost of the projects. The design and use of the right type shoring and scaffolding system, as well as stipulation of an effective resource planning strategy to control and maximize the use of the, right type shoring and scaffolding system are crucial to the overall success of a project.

### **2.4.2.5 Ready-Mix Concrete**

Ready-mixed concrete is a factory produced construction material, locally supplied and transported as a flow able material ready for placing and compacting into any desired shape and size on construction sites. Ready mixed concrete is proportioned and mixed outside the project site and delivered to the construction area in a freshly mixed and flow able state (Andrew Dunste, 2014)

It is Particularly useful on congested sites or in road construction where little space for mixing plant and for extensive aggregate stockpiles is available, that is advantageous because it is made under better conditions of control and close control of all operations of production of fresh concrete is possible. Proper care during transportation of the concrete is also ensured by the use of agitator trucks. Ready-mix concrete used in case of a large quantity of concrete is to be produced, which is essential to use materials-efficient range of designated concretes and gives the contractor his assurance of minimum strength and other specified requirements (Steven H. Beatrix Kerkhoff, William C, 2002)

#### **2.4.2.5.1 Manufacture of Ready-Mix Concrete**

According to Andrew Dunste (2014) the main focus of manufacturing process and supply of raw materials into the manufacturing process, is to use resource efficiently. That is associated with the use of the physical resources, energy, materials, water, reducing the amount of waste generated as a result of the manufacturing process and collecting data on the volumes of different concrete types supplied into the market.

##### **A. Central-mixed**

The mixing is done at a central plant and the mixed concrete is then transported, usually in an agitator truck which revolves slowly so as to prevent segregation and unnecessary stiffening of the mix

##### **B. Transit-mixed**

The materials are batched at a central plant but are mixed in a mixer truck either in transit to the site or immediately prior to the concrete being discharged. it permits a longer haul and is less vulnerable in case of delay. The main problem in the production of ready mixed concrete is maintaining the workability of the mix right up to the time of placing. Concrete stiffens

with time and the stiffening may also be aggravated by prolonged mixing and by a high temperature so proper care is mandatory. Andrew Dunste (2014) mentioned that, ready mixed concrete has the following specification,

**I. Specifying Concrete Quality**, an important aspect of ensuring resource efficiency is that the concrete supplied is as specified. For this reason, there should be a requirement for the concrete supplier to have product conformity certification

**II. Optimum Strength and Materials Efficiency**, the performance of concrete is a function of both the strength and durability of the concrete. Optimization of strength, durability and materials resources must take into account factors including criteria for the performance of concrete over its intended design life. The relationship and structural interaction with adjacent construction elements are also important to achieve an efficient structure

**III. Responsible Sourcing**, ready-mixed concrete producers must adopt responsible sourcing but this is not widely recognized by customers. Advantage of ready-mix concrete used in case of a large quantity of concrete is to be produced, which can be produced at a faster rate at a lesser cost and better quality.

## 2.5 Summary of Literature Review

In construction industry the main objective of project control is to ensure that project are completed on time, within budget and quality. Cost is main concern for contracting parties and end users. Construction cost is a production cost which is composed of two cost categories, direct costs and indirect costs. Direct costs are those costs that can be correlated to specific activity or a work-item and all other costs that are incurred to accomplish an activity but cannot be related directly are indirect costs. Cost of construction work is influenced by a wide range of factors among them choices of construction materials, methods of procurement, function of building, nature of the site, resource and service availability, market condition, site overhead, labor cost, labor productivity, cost of design and project program.

Reduction of cost of construction is very important for all contracting parties and end users. Cost can be reducing by using construction technology and construction management principals. Construction management aspects are interrelated and a good management skill helps not only to retain the cost saving mechanisms considered during the design phase but also to attain additional cost saving techniques. There are many management mechanisms

that help in reducing construction cost. Such as cost estimating on building projects, developing a cost-control system, using earned value management, applying material management and using cost reduction mechanisms at site. On the contrary, Project is not well managed it may cost additional amount and may become more expensive than the conventional construction method.

Construction technology refers to the construction methodology, construction materials and equipment required during construction process. Hence applying effective technologies are very crucial in reducing cost of projects such as using prefabrication-building, preventing wastage of materials, using cost advantageous shoring and scaffolding materials and using ready-mix concrete. Utilizing low cost housing technology and following construction management principles is expected to reducing cost, increasing productivity and improving quality. As technology improves building cost will be reduced and duration of project will shorter.

## **2.6 Gap Identification**

Existing literature on cost reduction mechanisms are extremely scarce in Ethiopia. In addition cost reduction mechanisms do not seem to be a well-researched area in Ethiopia because there is an attitude of reducing cost of project is difficult thing. The existing literatures are categorized under indirect works of cost of project. The other reason for sparse literature in this area is analysis of such scenarios would involve in-depth analysis and a considerable amount of time spent with the chance of success quite less compared to some other area of study. Therefore, this research is necessary in order to identify potential cost reduction mechanisms and to fill the knowledge gaps

## **Chapter Three: Research Methodology**

### **3.1 Introduction**

This chapter gives justification in the choice of methods used to achieve the objectives of the study which are specified at the beginning. Further, it gives information on the research study design, data sources and research instrument, population, sample size and statistical tools used for data analysis.

### **3.2 Study Design**

Qualitative observational study was conducted on two currently undergoing 20/80 condominium construction projects in Addis Ababa to evaluate the current practices on the potential cost reduction mechanisms. The research design was based on case study research methodology using both primary and secondary data. On the basis of the data and information sources the research instruments were interviews, observation and desk study and available documentary sources relevant to the research were reviewed. The review includes books and periodicals and academic journals and research papers.

After depth review of literature and on-site observations, semi-structure questionnaire was designed and interviewed to contractors, consultants and clients to get their opinion based on their experience. Upon obtaining the desired data, checking and sorting of data has been done and the data were analyzed for extracting the information obtained through the overall research work. This was followed by thorough discussions in order to draw a conclusion and forward recommendations based on the findings of the study.

### **3.3 Data Sources and Research Instrument**

Data sources included primary and secondary data's. As a primary source a case study was conducted on selected 20/80 condominium building projects sites, to assess the current practice of potential cost reduction mechanisms. Primary data was obtained from interviews and, observation and Secondary data was obtained by studying and investigating documents obtained from organizations involved in the condominium building projects. Interview used as research techniques/instruments to gather data from the respondents in the research sample.

Open-ended semi-Structured questions were prepared for interviewing purpose. The interview questions were prepared as applicable as possible to the respondents. The first part sought information about the respondents' profile and the second part assess cost influencing factors on condominium building projects, In the third part participants were asked about cost reduction mechanisms from construction management aspect. In the fourth and last part, participants were asked about cost reduction mechanisms from construction technology aspect. The respondents were requested to rank, cost influencing factors in order of impact on the cost of project. The rating values of 5, 4, 3, 2, and 1 were assigned to the options, very high, high, moderate, low, and very low respectively in obtaining the respondents' perception.

Additionally, the respondents were asked open ended equations which is related to construction management and construction technology. Observations made on site have helped to see the actual condition on the site and to countercheck the reliability of the interview response. Secondary data were analyzed according to mentioned cases

### 3.4 Research Population and Sampling

The populations of study were 20/80 condominium building construction sites. According to Addis Ababa Housing Development Project Office, there are 18 project sites under construction on 20/80 scheme. Most of these construction projects were started after 2015, but only four projects are nearly completed. The total population of the research was high; undergoing study on all of the populations was difficult because of time and resource constraint. Project 18 and 17 purposively selected for the case study. Table 3.1 describes that in both projects 243 blocks are under construction, and 107 contractors and 2 consulting offices and client representatives are participated.

Table 3.1 Project 17 and 18 details

Project	No of Blocks	Types of Buildings and No		No of Houses	No of Contractors	No of Consulting Offices	Progress of the project (%)
		G+7	G+4				
<b>Project 17</b>	124	80	44	6927	56	1	45.32
<b>Project 18</b>	119	69	50	6568	51	1	58.32



## Chapter Four: Study Result and Discussion

### 4.1 Introduction

The aim of this chapter is to display the results of study. The qualitative research findings are outlined in tables and text forms. Each result was discussed according to case. A semi-structure interview questionnaire was administered for contractors, consultants and client representatives on case study projects, Table 4.1 illustrates that, total numbers of interviewed people for this study were 58 contractors, 8 consultants and 8 client representatives but out of the respondent four were rejected for the analysis due to knowledge gape for interview contents.

Table 4.1 Respondent rate of interview

Stakeholders	Interviewed Distributed		Analyzed Interview	
	No	%	No	%
Client Representatives	8	100	8	100
Consultants	8	100	8	100
Contractors	58	100	54	93.1

The numbers of respondent were determined on the basis of the available contractors, consultants and client representatives on the sites and the time available for conducting interview for the research work.

### 4.2 Description of Respondents

#### 4.2.1 Classification of Organization

The data in Table 4.2 displays the classification of interviewed contractors. Grade 2 contractors constitute 5 (9.26%); those in Grade 3 were 8 (14.81%), those in Grade 4 were 15 (27.78%), those in Grade 5 were 18 (33.25%) and 8 (14.81%) were in Grade 6, There are two consulting offices in case study project sites and their grade are Grade 1 and Grade 3

Table 4.2 Company classification of contractors

<b>Contractors</b>	<b>No</b>	<b>Percentage%</b>	<b>Cumulative Percentage %</b>
<b>BC-2</b>	5	9.26	9.26
<b>BC-3</b>	8	14.81	14.81
<b>BC4</b>	9	16.67	27.78
<b>GC-4</b>	6	11.11	
<b>BC-5</b>	13	24.1	33.25
<b>GC-5</b>	5	9.25	
<b>BC-6</b>	8	14.81	14.81
<b>Total</b>	<b>54</b>	<b>100</b>	<b>100</b>

#### 4.2.2 Distribution of Respondents' Position on the Site

The distribution of respondents' position for contractors, consultants, and client representatives are shown in Table 4.3. From these 19 (27.14%) of respondent's occupation for the constructing companies are project manager, 41(61.43%) are site engineer and 8 (11.43 %) are resident engineer. Thus, all respondents are the responsible body about the construction practice in their project than any other person. Therefore, they are expected to give reliable information.

Table 4.3 Respondents' position on case study projects sites

<b>Respondent</b>	<b>Project Manager</b>	<b>Site Engineer</b>	<b>Resident Engineer</b>	<b>Total</b>
No	19	43	8	70
%	27.14	61.43	11.43	100

#### 4.2.3 Respondent's Experience in construction industry

Table 4.4 below shows the respondent's years of experience, the highest years of experience in the construction industry is between 4 and 8 years

Table 4.4 Respondents' experience in construction industry

Experience in years		Respondents	
Experience in construction industry		No	%
	1-4	12	17.14
	4-8	32	45.71
	8-12	22	31.42
	>12	4	5.72
<b>Total</b>	<b>70</b>	<b>100</b>	

### 4.3 An Overview of the Research Data Analysis Process

This section is contained for the purpose of creating continuity between the research objectives and data analysis and discussion. The major objectives of the research were

- To identify critical factors that influence cost of condominium housing projects in Addis Ababa
- To investigate potential cost reduction mechanisms that are important to reduce cost of 20/80 condominium building projects

Analysis of the data collected through the research interview questioners and actual site observation and desk study were to addressing these research objectives. For the purpose of relating the research objectives with the analysis and also for the ease of presentation, the results and discussions are presented on three major sections

Section 4.4 discusses about cost influencing factors in selected condominium building project in order to addresses the first objective

Section 4.5 addresses the second objective cost reduction mechanisms by using though construction management principles.

Section 4.6 addresses the second objective cost reduction mechanisms though construction technology aspect

### 4.4 Factors which affects the cost of projects

In this study contractors, consultants and client were asked to rate the magnitudes of impact of eleven factors on the cost of project on, 5-point scale. Table 4.5 presents contractors opinion. The top three cost influencing factors in view of contractors in selected projects are delay in construction activities, methods of procurement and market condition. Table 4.6 illustrates cost influencing factors in view consultants and client. The top three cost

influencing factors in view of consultants and client in selected projects are market condition, delay in construction activities and site overheads.

Table 4.5 Mean and ranking of cost influencing factors in views of contractors.

Rank	Cost influencing factors	Contractors	
		Mean	Rank
1	Delay of construction activities	4.34	Very high
2	Method of procurement	4.3	Very high
3	Market conditions	3.74	High
4	Labor cost	3.72	High
5	Resource and service availability	3.6	High
6	Productivity of labor	3.55	High
7	Site overheads	3.54	High
8	Project program	3.53	High
9	The nature of the site	3.42	High
10	The cost of design	2.9	High
11	Payment arrangement	2.8	Moderate

Table 4.6 Mean and ranking of cost influencing factors in views of client and consultants

Rank	Cost Affecting Factors	Mean	Frequency Category
1	Market conditions	4.92	Very high
2	Delay of construction activities	4.42	Very High
3	Site overheads	4.06	Very High
4	Method of procurement	3.94	High
5	The cost of design	3.94	High
6	Productivity of labor	3.91	High
7	Resource and service availability	3.8	High
8	Project program	3.47	High
9	Labor cost	3.44	High
10	The nature of the site	3.44	High
11	Payment arrangement	2.6	Moderate

#### 4.4.1 Delay of construction activities

In view of contractors delay on construction activities was ranked first with mean score 4.34 on the other hand for consultants and client it was ranked second with mean score 4.42. Opinion of respondents indicated that, delay of construction activities was affect cost of project very highly. If construction projects were delayed, the cost of project negatively affected. Because cost and time has direct relationship, from observation of case studies on project sites, estimated constriction period of project 17 and project 18 were eighteen months. This means both project started at Feb 2015 and ending period of these project were supposed to be on Aug 2016. If these projects constructed according to schedule, construction period of both projects completed before year. But the progresses of project17 and project 18 are 45.32% and 58.32% respectively. This shows that cats study projects will be delayed more and cost of project will be increased. Table 4.7 illustrates that delay of these projects lead to an increased cost of the following work items.

Table 4.7 Unit cost of work activities between start of project and now

Item no	Description	Unit	Prevised unit price	Revised unit price	Percentage of increased (%)
1	Trench excavation	m <sup>3</sup>	39.53	59.29	51.5
2	Fill around masonry	m <sup>3</sup>	37.03	45.81	23.7
3	25cm thick hard core	m <sup>2</sup>	70.78	154.33	108
4	Lean concrete	m <sup>2</sup>	13.99	16.17	15.6
5	Formwork	m <sup>2</sup>	97.59	114.06	47.6
6	Dia,6,8,10, 12, 14 rebar	kg	2.31	4.41	90.9
7	C-25 concrete	m <sup>3</sup>	515.5	666.36	29.3
8	50cmthick masonry below NGL	m <sup>3</sup>	483.08	1023.75	111.9
9	50cmthick masonry above NGL	m <sup>3</sup>	498.06	1033.9	107.6

In contractual relationship client is responsible to deliver most of construction materials and provide payment on time but contractors stated that client delays in materials supply. Lead to delay on project duration and also delay in payment which as a result causes many contractors to stop construction activities. Most of contractors mentioned damages caused by delay involve additional costs incurred such as indirect costs that occurred during the extended performance period, materials escalation costs, include costs of idle laborers and

equipment, the other component of delay damages is the unabsorbed overhead associated with the delayed period.

In addition to consultants, owner has involved in the projects sites for supervision of projects. According to client representative's case study projects delayed because of many factors such as shortage of fund, incapability of contractors and poor supervision of consultants. Client suffered the following damages materials escalation costs, additional supervision expenses, overhead expenses incurred during the delay period and On the other hand because of delayed of case study projects consultants incurred additional salary for their staff and overhead expenses. So delay damage affected all parties and as result can cause to increased cost of project.

#### **4.4.2 Market Conditions**

In view of consultants and client market condition was ranked first with mean score 4.92 on the other hand for contractors it was ranked third with mean score 3.74. According to respondents market condition was affect cost of project very highly. Value for money is supposed within a time and location context. Construction activity is highly sensitive to changes in economic position and activity in the local and national economy. Market conditions had high impact on the cost of project. That means when materials cost increased, cost of project will also increase. From the observation of the condominium projects, most of construction materials delivered by client are directly from manufacturing companies which, are not exposed for local market price fluctuation. However, materials delivered by contractors like sand, masonry stone and selected materials for fill excavated works are exposed for local market price fluctuation, on the other hand location of the selected condominium sites are fare from center of Addis Ababa, which as a result has additional transportation cost and it has great impact on cost of project. According to the respondents materials and labor costs are being increased from time to time and that were affecting the cost of project. By considering the condition of the market Addis Ababa Housing Project Development Office has been increased the fixed unit price for selected items of works starting from the year of 2016 to compensate contractors. This situation indicated that, market conditions have great impact on cost of project

### **4.4.3 Method of procurement**

According to contractors opinion procurement method was the second ranking factors in the order of impact of project cost with mean score 4.3 and for consultants and client it was fourth ranking factors with mean score 3.94. This indicated procurement has great impact on cost of project. Addis Ababa Housing Development Project Office uses negotiating type of contract. Contractors signed contract for construction work and to deliver some construction materials. On the other hand most of construction materials are being delivered by the client, according to respondents this contractual arrangement was cases to delay projects because contractors waiting for materials, which delivered by the client, as result contraction work was not working according to scheduled. Therefore, cost of project is affected by procurement and contract delivery methods, if qualified contractors and faster delivery methods are selected then the construction project duration will be improved and as a result cost of project will decrease. On contrary if we select unqualified contractors and time-consuming delivery methods, construction period will increase and also cost of project will increased too.

### **4.4.4 Site overheads**

In view of consultants and client site overhead was ranked third with mean score 4.06 on the other hand for contractors it was ranked seventh with mean score 3.54. Site overheads are often referred to as preliminaries and these reflect the cost incurs in setting up and running the site. Preliminaries represent a certain portion of a typical building contract, in case study projects contractors, consultants, and client have site offices and they have incurred site management costs. During delay of projects they have spent site management costs without working as a result, it has affect cost of project.

## **4.5 Cost Reduction Mechanisms from Construction Management Aspect**

### **4.5.1 Performance measurement practices**

Respondents were interviewed to get their perception on cost and time estimating practice and also their opinion weather their project will completed on budgeted cost and planned schedule, but 100% of respondents mentioned that, when the project will complete the actual project cost and project duration will be much higher than the estimated cost and duration. They gave different reasons for this: delay of delivering materials supply and payment by

client, poor contract administration of consultants, contractor's incapability and price escalation of materials and labor

The interview result, in Table 4.8 indicates that 35.2% of the respondents check their performance monthly, 22.22% of the respondents check their performance quarterly, 12.96% of the respondents check their performance weekly, 14.8% of the respondents check their performance randomly, 9.26% of the respondents check their performance annually and 5.56% of respondents check within every six months. The result revealed that more than 50% of the contractors were not checking their performance regularly and frequently. This result indicated that most of contractors working in 20/80 condominium projects have performance management problems.

Table 4.8 Intervals for checking performance

Performance checked in every	Respondent distribution	
	Frequency	Percentage %
Week	7	12.96
Month	19	35.2
Quarterly	12	22.22
Twice a year	3	5.56
Randomly	8	14.8
Yearly	5	9.26
Total	54	100

Checking performance is important to control cost, schedule of project and to measure progress objectively. It measures schedule behind/ahead of schedule and cost performance under/over budget. Checking performance daily and regularly provides an early warning of performance problems and leads to improve performance, as the result, it has contribution to reduce cost of project.

#### 4.4.1 Materials Management Practice

According to interviewees, good material management practice is very important to reduce cost of project, because the main aim of material management is to reduce wastages of materials. If materials wastages are reduced, materials cost and overall project cost will as well be reduced. But from the observation of the selected projects sites, there is a poor

materials management practices, and also there is storage space problem, which attribute to high proportion of wastage.

In case of condominium building projects most of construction materials are being delivered by client and some materials are being delivered by the contractors. Because of this contractors that much worried about majority of construction materials wastage and there is negligence about it. On the other hand contractors have certain standard for waste percentages to be applied in making estimation for bill of quantities; however there is probability that contractors will work with different subcontractors in different works, and sub contractors' labor will have a desire to finish the work as soon as possible. Thus, waste levels will probably be different than the estimated. Figure 4.1 indicates that, wastage and material handling practice in selected condominium sits

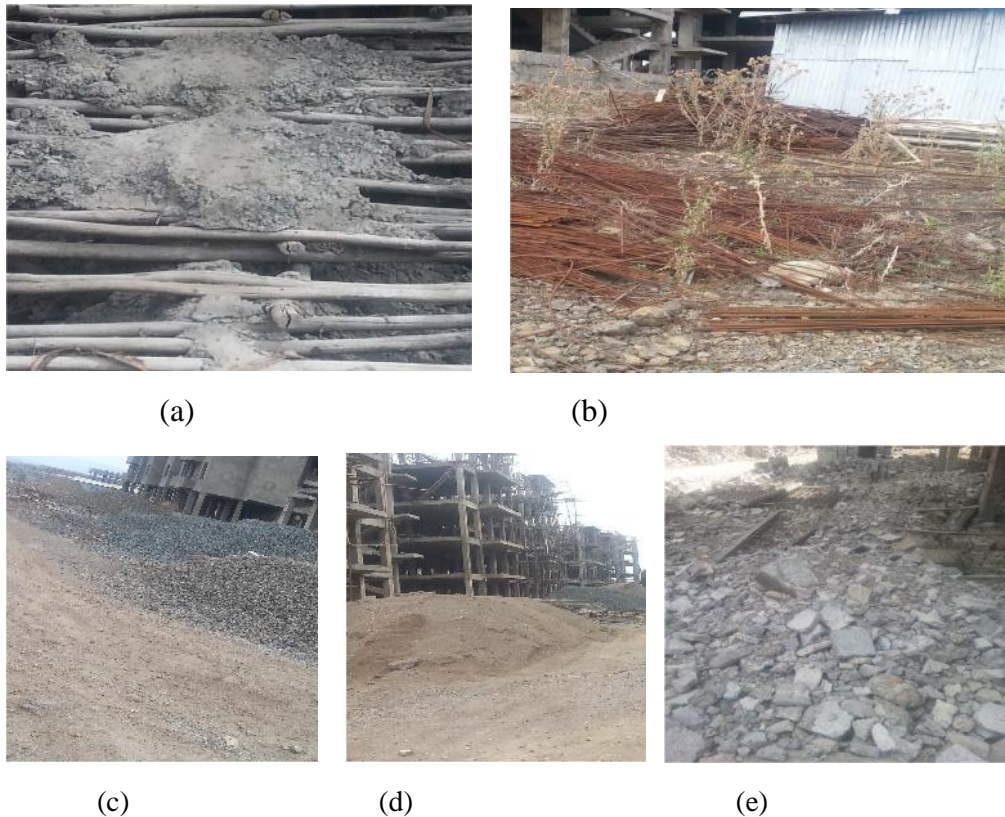


Figure 4.1 a, b, c, d, e wastage and material handling practice in selected condominium sites

#### **4.6 Cost Reduction Mechanisms from Construction Technology Aspect**

Cost can be reduced by using construction technology principles related to selected potential cost reducing mechanisms, these are prefabrication building components, scaffolding materials, ready-mix concrete, and using good quality of formwork.

### 4.5.1 Prefabrication Technology

In this study respondents were asked to rate the advantages of prefabricated building components from 1 to 5 scales where 1 represents very low advantage and 5 represent very high advantage Table 4.9 presents the rank of prefabricated building components along with their advantages. The result revealed that the top three advantages of prefabricated building components, speed up construction time, reduce cost of formwork, shoring and scaffolding, wastage of materials, and labor cost were “Highly” and on the other hand worker safety and conformity level was “low” advantageous on case study projects.

Table 4.9 Rank, advantages of prefabricated building components

Rank	Advantages of prefabrication building components	Mean
1	Speed up construction time	4.12
2	Reduce cost of formwork, shoring and scaffolding	3.81
3	Reduce wastage of materials	3.53
4	Lowering labor cost	3.51
5	Higher worker safety and conformity level	2.46

From observation of condominium housing projects case studies, the current practice of using prefabricated building components are limited in number. The above listed advantages of prefabrication building components were achieved except higher worker safety and conformity level. But these advantages are hidden by cast in situ construction, because prefabrication being practiced partially (partially prefabrication system). These prefabricated components are pre-cast beam, ribbed slab and Agro-stone wall. Prefabricated components are being used with cast in place beams, columns and other activities of work. These prefabrication components gave many advantages to the projects.

The pre-cast beams are partially casted in order to reduce cost of loading, unloading and transportation. Moreover, being partially prefabricated helps to easily assembly the system so that it can be placed manually; hence it avoids the need of equipment. These partially casted beams are placed on cast in place beams, which is monolithic to the columns. After the partially pre-cast beams are placed at center-to-center distance of 62.5cm the ribbed slab will be placed on it. Figure 4.2 Indicates partially prefabricated system, laid precast beams and ribbed slab, which is constructing with monolithically to on site construction.



(a) (b)  
Fig 4.2 a, b, Laid Precast Beams and ribbed slab

Prefabrication being practiced in condominium building projects is partially prefabrication system. Precast beams and ribbed slabs manufactured off site then constructing with cast in place construction. As observed in the case study projects, no formwork is required to support the ribbed slab, when compared to solid slab, this method saved cost of formwork as result of this, it reduce significant amount of the project cost. In addition to this, electrical cables and sanitary units can be executed in parallel, and the slab re-bars can be laid on both directions. Then after, the 6cm concrete floor slab is casted monolithically with the cast in place beams and pre-cast beam. In addition, constructing it by using ribbed slab significantly reduced cost of support scaffolding and speed up construction time. Figure 4.3 shows support posts for precast beams and ribbed slab.



Figure 4.3 Support posts for precast beams and ribbed slab

The ribbed slab system in condominium housing projects has advantages related to cost. It reduced a considerable amount of concrete because as mentioned earlier, only 6cm thick slab floor is casted and a few formworks to support the cast in place beams are needed. This technology allows parallel work progress, if they are properly used it can save considerable time and cost. On the other hand, they are using Agro stone panel for partition wall construction which, is manufactured by combining agricultural/industrial wastes and/or lightweight natural minerals as fillers. Using Agro stone panel for partition wall can cover wide range of area in shorter period of time compared to HCB wall and it has advantage related to cost. As discussed above condominium housing construction practice in related to using prefabrication component have many advantages.

On the contrary, most of the respondents stated that, prefabricated components have limitations related to quality, safety and conformity level. As observed from actual site, prefabricated components like ribbed slabs and precast beams are exposed to quality problems. According to interviews result, prefabricated components are manufactured by micro enterprises. Addis Ababa Housing Development Project Office are giving training to the micro enterprises before and during manufacturing process, but as observed on the actual construction sites, there are a lot of quality problems, wastages of ribbed slabs. Furthermore, prefabrication components like ribbed slabs and precast beams and Agro stone are transported by daily labors to the high-rise buildings in unsafe manner.

Prefabricated components practiced by Addis Ababa Housing Development Project Office are limited in number and the relevance of these components are hidden by cast in place construction on the site.

The respondents stated that the prefabricated building components reduce cost of the project. The cost reduction is from secondary issue like due to reduction on construction time, wastages of materials and cost of formwork and from observation of the case study projects sites, prefabricated building components gave many advantages, which are significant to reduce the cost of the projects.

#### **4.5.2 Shoring and Scaffolding Materials**

Shoring and scaffolding materials to be potential cost reduction mechanism, it should be constructed and dismantled in fast, repetitively use for more projects, should have contribution for quality of project and safety management practice. On this regard on the

condominium building projects case studies, shoring and scaffolding materials used in almost all the projects are eucalyptus wood.

From the observed construction sites, the erection of eucalyptus wood shoring and scaffolding system requires to be measured, cut and fixed on site which makes it more time consuming. Eucalypts wood as shoring and scaffolding material on the selected projects have contribution to longer project duration.

On the other hand, metal shoring and scaffoldings which, are practiced in some of projects in Addis Ababa are prefabricated and assembled easily. Metal shoring and scaffoldings materials are constructed faster than timber shoring and scaffolding materials, as result of this, it has big contribution for decreasing construction duration and also unnecessary expenses during construction and dismantling.

Interviews were conducted on the selected projects to asses weather the respondents were aware of the advantages of metal shoring material over eucalyptus wood in terms of speed of construction and their costs. 100% of respondents stated that metal shoring and scaffolding speed up construction time. Figure 4.4 illustrates Practice of shoring and scaffolding systems on the case study condominium building projects



Figure 4.4 Practice (a) scaffolding and (b) shoring systems on the case study condominium building projects.

The initial cost of metal shoring and scaffolding are expensive than eucalyptus shoring and scaffolding, but it can be reused for long period of time. On the other hand, initial cost of eucalyptus wood shoring and scaffolding are cheaper but it cannot be used for more than one project, so their cost analysis should also take into consideration of impact of the material durability on the total construction period.

Interviewed respondents also were questioned that which one of shoring and scaffolding material is very important to reduced overall cost of project. 88% of respondents stated that metal shoring and scaffoldings are very important to reduce the cost of project and in addition it speeds up construction time; reduce unnecessary expenses and gives serves for long period of time. Contractors working in condominium building projects have understanding about cost advantages of metal shoring and scaffolding, but they are incapable to purchase metal shoring and scaffolding, that why they are using eucalypts wood shoring and scaffolding.

From observation of the case studies on construction projects sites, eucalyptus woods were being reused from 4 to 8 times for shoring and scaffolding construction. On the other hand, it was difficult to identify how many times metal shoring and scaffoldings can be reused and there were not previous data available. In fact, initial cost of metal scaffolding is expensive but according to gathered data on other Addis Ababa building projects site, metal shoring and scaffoldings can give service for longer period of time than eucalyptus scaffolding. A study conducted by Eyerusalem Kelemewerk (2017), indicated that, using H-frames metal scaffolding instead of using eucalyptus wood have comparative advantage in cost and speed. This result is similar with the respondent's opinion and observation of actual sites. Figure 4.5 shows metal shoring material practices in Addis Ababa privet building projects.



Figure 4.5 Metal shoring material practices in Addis Ababa privet building project

From the constructed observations, eucalyptus wood shoring and scaffolding systems were not safe for high rise buildings and not environmentally friendly. Constructing and dismantling of eucalyptus wood shoring and scaffolding materials are time consuming, have an impact on the project duration and it cannot be reused several times. Shoring and scaffolding systems are key factors in determining the success of a building construction project in terms of cost, speed, quality and safety of work

#### 4.5.2.1 Comparison of Eucalypts wood and Metal Shoring and Scaffoldings Materials with Respect to Speed and Cost of Project

The speed and cost of eucalyptus wood and metal shoring and scaffolding were also assessed on selected projects. Unit cost analyses were done considering their speed of construction and reusability of each material. In addition Table 4.10 illustrates the initial cost and reusability of each material.

Table 4.10 Initial cost and reusability of different shoring materials

Types of material	unit	prices	Reusability
Eucalyptus wood dia. 10 cm-12cm	pcs	80	>4
Eucalyptus wood dia. 8cm – 10 cm	pcs	50	>4
H-frame 0.80m x 1.87m x3.2m Height	Full set	6545	>20
H- frame (daily rental)	m <sup>2</sup>	6.5	-
RHS 60cmx60cmx1.5cmx6m	pcs	560	>20
Nail	kg	60	1.5
Black wire 2.5	kg	60	-

The minimum reusability of each material was used to make the direct unit cost analysis. Eucalyptus wood was considered to be used 4 times. For metal shoring two approaches were considered owning the material or renting the material. For owning the material, the reusability has taken 20 times whereas for rental material duration to construct and dismantle the shoring materials which were 10 days and 21days were considered respectively. Spacing between eucalyptus wood posts is 60cm and wastage assumed 10% and Spacing of H – frame is 0.8 m and 1.87m in longitudinal and transversal direction. Table 4.11 shows the direct unit cost analysis in all three cases based on the above data,

Table 4.11 Direct unit rate analysis of eucalyptus wood and metal shoring system

Work item: Eucalyptus wood shoring system for ribbed slab

Output per day (D) : 18 m<sup>2</sup>/day

Total quantity of work item: 1 m<sup>2</sup>

Direct unit cost : **93.23 Birr/m<sup>2</sup>**

Material Cost (A)					Daily Labor Cost (B)					Daily Equipment Cost (C)			
Type of Material	Unit	Qty *	Rate	Cost per Unit	Labor by Trade	No.	UF	** daily indexed cost	Daily cost	Type of Equipment	No.	Daily rental cost	Daily cost
Eucalyptus wood dia 10 - 12cm	pcs	2.5	20	50.33	Carpenter	1	1	250	250	Tools	4	1	4
Eucalyptus wood dia 8-10 cm	pcs	1.213	12.5	15.17	Ass. Carp	1	1	100	100				
Nail 12	kg	0.05	40	1.98	Forman	1	0.25	300	75.0				
Nail 9	kg	0.05	40	1.92									
<b>Total (A)</b>				<b>69.4</b>	<b>Total (B)</b>				<b>425.0</b>	<b>Total (C)</b>			<b>4.00</b>

A= Materials Unit Cost =69.4 Birr/m<sup>2</sup>

B= Manpower Unit Cost= 23.6 Birr/m<sup>2</sup>

C= Equipment Unit Cost =0.22 Birr/m<sup>2</sup>

= Total material unit cost (A)

=Daily Labor cost(B)  
Daily productivity (D)

= Daily Equipment cost(C)  
Daily productivity (D)

**Direct Cost of Work Item = 93.23 Birr/m<sup>2</sup>**  
E+F+G =

Work item: metal shoring system (owned) for ribbed slab

Output per day (D) : 30m<sup>2</sup>/day

Total quantity of work item: 1 m<sup>2</sup>

Direct unit cost : **80.82 Birr/m<sup>2</sup>**

Material Cost (A)					Daily Labor Cost (B)					Daily Equipment Cost (C)			
Type of Material	Unit	Qty *	Rate	Cost per Unit	Labor by Trade	No.	UF	** daily indexed cost	Daily cost	Type of Equipment	No.	Daily rental	Daily cost
H-frame 0.80m x 1.87m x3.2 m Height full set	full set	0.17	327.3	54.69	Carpenter	1	1	250	250	Tools	4	1	4
RHS 60cm X60cm X 1.5mmx 6m	pcs	0.21	28	5.83	Ass. Carp	1	1	100	100				
black wire 2.5	kg	0.1	60	6	Forman	1	0.25	300	75				
<b>Total (A)</b>				<b>66.5</b>	<b>Total (B)</b>				<b>425</b>	<b>Total (C)</b>			<b>4.00</b>

A= Materials Unit Cost =66.52 Birr/m<sup>2</sup>

B= Manpower Unit Cost= 14.17 Birr/m<sup>2</sup>

C= Equipment Unit Cost =0.13 Birr/m<sup>2</sup>

= Total material unit cost(A)

=Daily Labor cost(B)  
Daily productivity (D)

= Daily Equipment cost(C)  
Daily productivity (D)

**Direct Cost of Work Item = 80.82 Birr/m<sup>2</sup>**  
E+F+G =

**Work item: Rented metal shoring system for Ribbed slab**

Output per day (D) : **30 m<sup>2</sup>/Dy**

Total quantity of work item: **1 m<sup>2</sup>**

Direct unit cost : **227.63 Birr/m<sup>2</sup>**

Material Cost (A)					Daily Labor Cost (B)					Daily Equipment Cost (C)					
Type of Material	Unit	Qty *	Rate	Cost per Unit	Labor by Trade	No.	UF	daily indexed cost	Daily cost	Type of Equipment	No.	Daily rental per pcs	Daily Cost		
H-frame( rented)	m <sup>2</sup>	1	201.5	201.5	Carpenter	1	1	250	250	Tools	4	1	4	4	
RHS 60cm X60cm X 1.5mmx 6m	pcs	0.21	28	5.83	Ass. Carp	1	1	100	100						
black wire 2.5	Kg	0.1	60	6.00	Forman	1	0.25	300	75						
<b>Total (A)</b>				<b>213.3</b>	<b>Total (B)</b>				<b>425</b>	<b>Total (C)</b>				<b>4.0</b>	<b>4.0</b>

**E= Materials Unit Cost= 213.3 Birr/m<sup>2</sup>**

**F= Manpower Unit Cost =14.2 Birr/m<sup>2</sup>**

**G= Equipment Unit Cost=0.13 Birr/m<sup>2</sup>**

= Total material unit cost(A)

=Daily Labor cost(B)

Daily productivity (D)

Direct Cost of Work = **227.63.Birr/m<sup>2</sup>**

Item = E+F+G =

= Daily Equipment cost(C)

Daily productivity (D)

Remark: Duration to construct slab formwork pre one crew is 10 days and duration to dismantle slab is 21 days

From the Above unit rate analyses considering the life use and productivity of each shoring materials eucalypts wood are more expensive than H- frame metal shoring in the case of the H- frame is owned, but eucalypts wood are cheaper in the case of H- frame is rented. Table.4.12.shows cost comparisons of direct and indirect costs of eucalyptus wood and metal H- frame shoring materials.

Table 4.12 Comparisons of Cost and speed of eucalyptus wood and metal H- frame shoring systems

Type of shoring system	productivity per day	Direct unit cost per m <sup>2</sup>	Unit cost including 15% overhead cost
Eucalyptus wood	18m <sup>2</sup>	93.23 Birr	107.21Birr
H- frame owning	29.6m <sup>2</sup>	80.82 Birr	92.94 Birr
H- frame rental	29.6m <sup>2</sup>	227.63 Birr	267.77 Birr

Table 4.13 Illustrates cost differences of eucalyptus wood and metal shoring system

Table 4.13 Cost differences of eucalyptus wood and metal shoring system

Types of shoring material	Unit Cost Differences (Cost of eucalyptus wood- H frame)	
	Direct cost	cost including 15% of overhead costs
H - frame Owned	12.40 birr/m <sup>2</sup>	14.29 birr/m <sup>2</sup>
H - frame Rented	134.4 birr/m <sup>2</sup>	160.57 birr/m <sup>2</sup>

Since the rented cost is dependent on duration to construct and dismantle the shoring system, adding the number of crew or using adhesives which help the concrete to get its compressive strength early so that the shoring will be constructed and dismantle in short period of time, will decrease the direct unit cost further less than 227.63 birr/m<sup>2</sup>. Table 4.14 illustrates direct unit cost analysis of rented metal shoring by using adhesive and adding number of crew. So that, the rental duration will decrease from 31 days to 14 days. The direct unit cost of rented metal shoring decreases form 227.63 birr /m<sup>2</sup> to 122.89 birr/m<sup>2</sup>. But it is higher by 29.66 birr/m<sup>2</sup> compare to eucalyptus wood shoring. Using rented metal shoring more expensive than eucalyptus wood shoring system.

Table 4.1 4Direct cost analysis of rented metal shoring using adhesive and additional number of crews

**Work Item: Rented metal shoring system and using adhesives for Ribbed slab**

Total quantity of work item: 1 m<sup>2</sup>

Output per day (D) : 60 m<sup>2</sup>/day

Direct unit cost **122.89 Birr/m<sup>2</sup>**

Material Cost (A)				Daily Labor Cost (B)					Daily Equipment Cost (C)				
Type of Material	Unit	Qty *	Rate	Cost per Unit	Labor by Trade	No.	UF	** daily indexed cost	Daily cost	Type of Equipment	No.	Daily rental	Daily Cost
H-frame (rented)	m <sup>2</sup>	1	91	91	Carpenter	2	1	250	500	Tools	4	1	4
RHS 60cm X60cm X 1.5mmx 6m	pcs	0.21	28	5.86	Ass. Carp	2	1	100	200				
black wire 2.5	kg	0.1	60	6.00	Forman	1	0.5	300	150				
Adhesive	lit	0.16	36	5.76									
<b>Total (A)</b>		<b>108.62</b>		<b>Total (B)</b>					<b>850</b>	<b>Total (C)</b>			<b>4.00</b>

**A= Materials Unit Cost**  
=108.62 Birr/m<sup>2</sup>

= Total material unit cost(A)

**B= Manpower Unit Cost= 14.2 Birr/m<sup>2</sup>**

= $\frac{\text{Daily Labor cost(B)}}{\text{Daily productivity (D)}}$

**C= Equipment Unit Cost =0.07 Birr/m<sup>2</sup>**

= $\frac{\text{Daily Equipment cost(C)}}{\text{Daily productivity (D)}}$

**Direct Cost of**

**Work Item = 122.89Birr/m<sup>2</sup>**

**E+F+G =**

Remark: Duration to construct slab formwork pre two crew is 7 days, duration to dismantle slab is 7 days and life use of RHS 20 times

### 4.5.3 Ready-Mix Concrete

Ready-mix concrete is proportioned and mixed outside the project site and delivered to the construction area in a freshly mixed and flow able state. In this study respondent were asked to mention significant of ready-mix concrete, if delivered to condominium housing projects. 92% of respondent stated that ready-mixed concrete for condominium housing project is useful because, it speed up construction time, reduce project duration, reduce materials wastage, reduce labor cost and improve quality of concrete and reduce mobility of materials and the rest 8% of the respondents didn't agree. Because they assumed that using ready- mix concrete is more expensive than site mixed concrete. From observation of the case studies, most of the condominium project sites are congested, and there is demand of large quantity of concrete.

#### 4.5.3.1 Market Practice of ready-mix concrete

In Addis Ababa ready-mixed concrete is being used in some building and road projects. From observation it has played very important role to speed up construction project duration and to delivered better quality of concrete. In addition, supply of quality ready mixed concrete has many advantages; it increases the quality of construction, reduces construction time and avoids poor handling of construction materials on site. Cost of ready-mixed concrete in Addis Ababa is relatively fair, according to the suppliers' information, the costs of C-25 read-mixed concrete is (2400-2450 Birr) including transportation, VAT and pump. Figure 4.6 depicts ready-mixed concrete practices in Addis Ababa



Figure 4.6 Ready-mixed concrete practices in Addis Ababa

Table 4.15 depicts market cost of ready-mixed concrete practices in Addis Ababa. These costs of ready-mixed have taken from five ready-mix concrete manufacturer companies. The ranges of this cost are between (2400-2450 Birr) and cost break down is done based on highest cost.

Table 4.15 Current market costs of 1m<sup>3</sup> C-25 ready-mix concrete using OPC

Concrete type	Materials	Unite cost	Total (Birr)
<b>1 m<sup>3</sup> C-25 concrete</b>	Cement = 3.6qutl	250	900
	Sand = 0.43m <sup>3</sup>	437.5	188.12
	Aggregate=0.80m <sup>3</sup>	380	304
	Water = 140 L	0.2	28
	Admixture =1.6 L	36	57.6
	All other costs and profit	20.34%	300.63
	Transportation		150
	Pump		300
	VAT	15%	221.65
<b>Total</b>			<b>2450</b>

From the observation of case studies, on the condominium housing projects there are no contractors who use ready-mix concrete. Contractors working in condominium building projects entered contract for labor and some materials, in case of concrete making materials contractors delivered only sand. They don't have capability to established ready- mix concrete production company and right to deliver ready-mix concrete or other materials and their thinking is not about individual project, it is for massive housing construction condominium projects constructed by government. Because establishing ready- mix concrete production company is easy for government. There is demand of large quantity of concrete in these condominium sites, instead of delivery aggregate and cement, ready-mix concrete is advantages for this kind of projects. On the other hand many contractors blame the client for delay of delivery concrete making materials. Their practices are time consuming and exposed to unnecessary expenses.

As mentioned above instead of delivering aggregate and cement if the client considers delivering ready-mixed concrete to these condominium projects, it will possible to deliver in lesser cost than current market price of ready-mix concrete. To illustrate the above statement direct cost of C-25 concrete materials are analyzed on Table 4.16 based on current delivering price of cement, coarse aggregate and water by the client and the market price of sand and admixture

Table 4.16 Unit cost of concrete making materials

<b>Material</b>	<b>Cost</b>
<b>Cement OPC</b>	225.21 Birr/qlt
<b>Aggregate</b>	288.00 Birr/m <sup>3</sup>
<b>Sand</b>	468.75 Birr/m <sup>3</sup>
<b>Water</b>	0.2 Birr/L
<b>Admixture</b>	36.00 Birr/L

Table 4.17 depicts cost of 1 m<sup>3</sup> of C-25 ready-mix concrete using 32.5 OPC types of cement. The ready- mix concrete assumed according to mix ratio 1:2:3 (1= Cement, 2= Fine aggregate, 3 = Coarse aggregate)

Table 4.17 Estimated Cost of 1 m<sup>3</sup> of C-25 ready- mix concrete using 32.5 OPC types of cement

Concrete type	Materials	Unite cost	Total (Birr)
<b>1 m3 C-25 concrete</b>	Cement = 3.6qutl	225.21	810.76
	Sand = 0.43m <sup>3</sup>	468.75	201.56
	Aggregate=0.80m <sup>3</sup>	288	230.4
	Water = 140 L	0.2	28
	Admixture =1.6 L	36	57.6
	All other costs and profit	20%	267.46
	Transportation		150
	Pump		300
	VAT	15%	200.59
<b>Total</b>			<b>2255.37</b>

All other costs and profit seems very small because this mix design assumption is very conservative which is based on using cement content of 360 kg/m<sup>3</sup> (7.2bags) for C-25 concrete, but C-25 concrete can be produced by using less than 360 kg/ m<sup>3</sup> cement content and wastages of materials is also significantly reduced as a result, cost of ready-mixed concrete can be reduced to certain level. On the other hand all other costs and profit is higher than calculated one. Estimated cost of ready-mix concrete base on Addis Ababa Housing Development Project Office delivery price of materials is 194.63 Birr/m<sup>3</sup> (7.94%) lower than market prices of ready-mix concrete. Table 4.18 indicates that, Addis Ababa Housing Development Project Office incurred 2013.95 Birr/m<sup>3</sup> for site mixed C-25 concrete

Table 4.18 Current costs of 1m<sup>3</sup> C-25 site mixed concrete using OPC type of cement

Materials	Cost of OPC (Birr)
Cement	810.76
Aggregate	230.4
Sand, water, overhead and profit	710.10
Sub-total	1751.26
VAT	262.69
<b>Total</b>	<b>2013.95</b>

When comparing estimated cost of ready- mix concrete with site mixed C-25 concrete based on Addis Ababa Housing Development Projects Office materials cost, it is higher by 241.42 Birr/m<sup>3</sup> (10.72%), but in the case of ready-mix concrete there are other advantages like

reducing cement content, quality improvement, reducing wastage of materials, reducing labor cost. As a result, cost of ready-mixed concrete can be reducing to certain level more than estimated cost.

#### 4.5.4 Quality of Concrete Surface Finish

In selected 20/80 condominium building project sites many concrete-related problems were observed such as discoloration, pores surface finish, and stains, are attributes of using poor quality formwork. Also, some deformed concrete surfaces were observed due to deformed formwork which is caused by repetitive use and inadequate support of formwork system. Figure 4.7 depicts poor quality of concrete surface on selected condominium buildings caused by poor quality formwork.

In this study respondents were asked whether using good quality formworks could have an effect on the quality of concrete surface finish or not. 82.85% of respondents strongly agreed that if formwork surface have good quality cement plastering and chiseling works are unnecessary and 10% respondents slightly agreed on the other hand 7.15% respondents didn't agree totally. Majority of the respondents stated that using good quality of formworks, minimizes the material required for the correcting defective works and reduce labor cost as result, the cost of project will be decreased.



Figure 4.7 Poor quality of concrete surface on selected condominium buildings because of poor quality of formwork.

The above picture shows poor quality of concrete surface finished on selected 20/80 condominium building project sites, due to poor quality of formworks used, the concrete surface has poor quality. In order to make concrete surface smooth plastering work is necessary for poor quality of concrete surface. Most of respondents agreed that concrete constructed by using good quality of formwork can have good surface finish and doesn't require cement plastering. Figure 4.8 shows a building with good quality surface finish.



Figure 4.8 Good quality of concrete suffice finished and located around Hayat

The above picture was taken to show the possibility of constructing good surface finish concrete by using good quality of formwork, in addition if the surface of concrete has good surface finish, it can be used without cement plastering and chiseling by applying only gypsum plastering and painting, as a result the cost of cement plastering and chiseling can be decreased, consequently the cost of building can significantly be reduced. When chiseling the building, beams, slabs columns stair cases landings and shear wall, contractors spend significant amount of cost. Furthermore, chiseling work promotes cracks on structures of the building and it has an effect on the durability of concrete. Figure 4.9 shows chiseling work on selected condominium building project.



Figure 4.9 Chiseling surface of concrete structure on selected condominium building project.

#### **4.5.4.1 Comparison of cost of formwork**

Cost of plywood formwork and metal formwork were assessed on selected projects. Unit cost analyses were done considering their speed and reusability of each material. In addition Table 4.19 illustrates initial cost and reusability of each material

Table 4.19 Initial cost and reusability of each material

Types of material	unit	prices	Reusability
Eucalyptus wood dia. 10 cm-12cm	pcs	80	>4
Eucalyptus wood dia. 8cm – 10 cm	pcs	50	>4
Plywood 1.2m x 2.4m	m <sup>2</sup>	850	>4
Sheet metal 0.4m*3m	m <sup>2</sup>	1200	>20
Batten	pcs	120	>4
Nail	kg	60	1.5
Black wire 2.5	kg	60	-

Unit cost analyses for metal and plywood formwork were done considering productivity and reusability of each material. Reusability of plywood formwork assumed four times and metal panel 20 times. On the other hand productivity for both materials is assumed equal for the construction of beam, column, shear wall, lift, stair case and landing. When comparing the direct cost difference of plywood and metal formwork, cost of plywood formwork higher by 25.52 birr/m<sup>2</sup> or (13.2%) to metal formwork. Contractors can construct good quality of concrete by using one of these formworks in order to reducing cement plastering and chiseling. If contractors will plan to use plywood formwork in order to reduce cement plastering and chiseling, they will save 71.04 birr/m<sup>2</sup> or (73.57%) cost of plastering. Table 4.20 illustrates direct unit rate analysis of plywood formwork and metal formwork.

Table 4.20 Direct unit rate analysis of plywood formwork and metal formwork

Work item: Plywood Formwork  
Total quantity of work item: 1 M<sup>2</sup>

Output per day (D) : 12.64 m<sup>2</sup>/day  
Direct unit cost : 193.94 Birr/m<sup>2</sup>

Material Cost (A)					Daily Labor Cost (B)					Daily Equipment Cost (C)				
Type of Material	Unit	Qty *	Rate	Cost per Unit	Labor by Trade	No.	UF	** daily indexed cost	Daily cost	Type of Equipment	No.	Daily rental cost	Daily cost	
Plywood	m <sup>2</sup>	1.05	73.78	77.47	Carpenter	1	1	250	250	Tools	4	1	4	
Batten	Pcs	1.00	30.00	30	Ass. Carp	1	1	100	100					
(Eucalypts Ø10-12cm)	Pcs	2.516	20	50.32	Forman	1	0.25	300	75.0					
Nail	Kg	0.05	40	1.92										
<b>Total (A)</b>				<b>159.7</b>	<b>Total (B)</b>				<b>425.0</b>	<b>Total (C)</b>				<b>4.00</b>

**A= Materials Unit Cost =159.7 Birr/m<sup>2</sup>**

**B= Manpower Unit Cost= 33.62 Birr/m<sup>2</sup>**

**C= Equipment Unit Cost =0.625 Birr/m<sup>2</sup>**

= Total material unit cost(A)

= $\frac{\text{Daily Labor cost(B)}}{\text{Daily productivity (D)}}$

= $\frac{\text{Daily Equipment cost(C)}}{\text{Daily productivity (D)}}$

**Direct Cost of Work Item = 193.94 Birr/m<sup>2</sup>**  
**E+F+G =**

Work item: Metal Formwork  
 Total quantity of work item: 1 M<sup>2</sup>

Output per day (D) : 12.64 m<sup>2</sup>/day  
 Direct unit cost : **168.42 Birr/m<sup>2</sup>**

Material Cost (A)					Daily Labor Cost (B)					Daily Equipment Cost (C)			
Type of Material	Unit	Qty *	Rate	Cost per Unit	Labor by Trade	No.	UF	** daily indexed cost	Daily cost	Type of Equipment	No.	Daily rental cost	Daily cost
Sheet metal 0.4*3m	m <sup>2</sup>	1.00	50	50	Carpenter	1	1	250	250	Tools	4	1	4
Eucalyptus wood Ø10-12cm)	pcs	2.516	20	50.32	Forman	1	0.25	300	75.0				
Eucalyptus wood Ø 6cm)	pcs	3.00	7.5	22.5									
Nail	Kg	0.05	40	1.92									
Mold oil	Lt	0.1	98	9.8									
Black wire 2.5	Kg	0.1	60	6									
<b>Total (A)</b>				<b>134.5</b>	<b>Total (B)</b>				<b>425</b>	<b>Total (C)</b>			<b>4.00</b>

**A= Materials Unit Cost =134.5 Birr/m<sup>2</sup>**     
 **B= Manpower Unit Cost= 33.6 Birr/m<sup>2</sup>**     
 **C= Equipment Unit Cost =0.32 Birr/m<sup>2</sup>**  
 = Total material unit cost(A)                     
 =  $\frac{\text{Daily Labor cost(B)}}{\text{Daily productivity (D)}}$                      
 =  $\frac{\text{Daily Equipment cost(C)}}{\text{Daily productivity (D)}}$

**Direct Cost of Work Item = 168.42 Birr/m<sup>2</sup>**  
**E+F+G =**

If the surface of concrete is good, the cost associated surface finish will be less. On the other hand, if a concrete surface has poor quality caused by poor quality of formworks, the cost of grinding and plastering will be higher, instead if they use good quality formwork such as plywood, they can reduce cement plastering and chiseling works. As observed, on condominium building projects case studies they are using ribbed slab system, so cement plastering work is necessary for ribbed slab and HCB wall, on the other hand if they use good quality formwork for columns, beams, stair case, and landing and lift and shear wall, they can reduce cost of cement plastering and chiseling work. Table 4.21 indicates that Addis Ababa housing development project office incurred 96.56 Birr/m<sup>2</sup> for 20mm thick cement plastering and chiseling work

Table 4.21 Unit cost of cement plastering in case study projects

Type	Unit	Qty Per Unit Work	Rate (Birr)	Cost Per Unit (Birr)
Cement	qtl	0.103	169.19	17.43
Sand, water, labor, Overhead, and profit				79.13
<b>Total</b>				<b>96.56</b>

To illustrate above statements Table 4.22 indicates that cement plastering work for some items of work, which, has been taken from the case study projects payment certificate and it included unit price and actual quantity of works. If they use good quality of concrete and formwork, they can reduce cement plastering work and can save 120,466.06 pre-a block. As mentioned in methodology part of this study, in the case study projects there are 149, G+7 buildings, multiplying by the numbers of blocks it can be saved 17,949,442.94 Birr on selected projects for G+7 buildings only.

Table 4.22 Cost of plastering for the G+7 building

Cost of plastering for G+7 Building				
Item of work	Unit	Unit price	Quantity	Amount(Birr)
Stair case and landing	m <sup>2</sup>	71.04	324.85	23,077.34
Lift and shear wall	m <sup>2</sup>	71.04	298.59	21,211.83
Elevation columns	m <sup>2</sup>	71.04	377.63	26,826.83
Intermediate and top tie beams	m <sup>2</sup>	71.04	694.68	49,350.06
<b>Total</b>				<b>120,466.06</b>

In similar way Table 4.23 indicates that cost of cement plastering for G+4 buildings, if they reduce cement plastering for listed works, they can save 46,802.57 Birr per a block and there are 94, G+4 buildings, multiplying by the number of buildings, it can be possible to save 4,399,441.58 Birr. This case study indicated that, if they use good quality of concrete and formwork for columns, beams, stair case, and landing, lift and shear wall, they can reduce cost of cement plastering and chiseling.

Table 4.23 Cost of plastering for G+4 building

<b>Cost of plastering for G+4 building</b>				
<b>Item of work</b>	<b>Unit</b>	<b>Unit price</b>	<b>Quantity</b>	<b>Amount(Birr)</b>
Stair case and landing	m <sup>2</sup>	71.04	148.84	10,573.59
Elevation columns	m <sup>2</sup>	71.04	249.65	17,735.14
Intermediate and top tie beams	m <sup>2</sup>	71.04	260.33	18,493.84
<b>Total</b>				<b>46,802.57</b>

## Chapter Five: Conclusions and Recommendations

### 5.1 Conclusions

The objectives of this study were to identify critical factors that influence cost and to investigate potential cost reduction mechanisms that are important to reduce cost of 20/80 condominium building projects. From the study conducted the following conclusions are drawn.

1. The study result indicated that delay of construction activities, market conditions, method of procurement, site overheads, Productivity of labor are the top five factors which affected cost of projects in case study condominium building projects.
2. Checking performance regularly has contribution to controlling cost of project. But in case study indicated that more than 50% of the contractors were not check their performance regularly and frequently.
3. Reducing wastages of materials are very important to reduce cost of project. In case study projects Poor quality of construction materials, inappropriate storage and handling of materials are key factor for physical waste generation in selected condominium building projects
4. Prefabrication building components speed up construction time and reduce cost of formwork, scaffolding, wastage of materials and labor cost, as a result, which reduce overall cost of project.
5. The initial material cost of eucalyptus wood is cheaper than metal shoring and scaffolding. However, unit rate analyses considering the life use and productivity of each shoring materials, eucalypts wood are more expensive than H- frame metal shoring in case of owning H- frame metal shoring. Eucalyptus wood shoring costs more than H- frames with direct cost difference of 12.4 Birr/m<sup>2</sup> (13.3%). However, in case study projects most of the contractors do not afford to own H- frame metal shoring
6. Estimated cost of ready-mix C-25 concrete base on Addis Ababa Housing Development Project Office delivery price of materials is 7.94% lower than market prices of ready-mix C-25 concrete and it is higher by 10.72% than site mixed C-25 concrete, but using ready- mix concrete speed up construction time, reduce materials wastage, reduce cement content and labor cost, improve quality of concrete and reduce mobility of materials, as a result of this it reduced cost of project.

7. Using good quality of formwork can reduce the requirement for plastering and modification work such as chiseling. If plastering work is avoided or minimized, significant amount of cost of project will be reduced.

## **5.2 Recommendations**

Based on the findings of this study, the following recommendations are forwarded in order to reduce cost of 20/80 condominium construction projects.

1. Contractors, who are working in condominium building projects, should give attention to cost influencing factors and check their performance regularly and frequently in order to control cost of projects.
2. Contractors working in case study condominium housing projects should appropriately store and handling construction materials on the site. In order to reduce wastage of materials
3. Contractors should use metal shoring and scaffolding material and good quality of formwork and government should support contractors in importing metal scaffolding and good quality of formwork free of duty and provide loans to contractors with collaboration of banks this will be improved capacity of contractors
4. Addis Ababa Housing Development Project Office should establish ready- mix concrete plant and delivered ready- mix concrete for condominium building projects in order to reduce wastages of materials, cement content, labor cost, mobility of materials and to speed up construction time and improve quality of concrete as a result to reduce overall cost of project.

### **Recommendations for Further Works**

This research has identified some of cost reducing mechanisms from perspective of construction management and construction technology. Therefore the following issues are identified and suggested for future studies.

- ✓ Development of a cost reducing mechanisms from architectural and structural design perspective. That could help to develop cost efficient design.
- ✓ Design of ready-mixed concrete, related to the current practice of the condominium building construction in Addis Ababa

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## **Appendix-A Interview Questionnaires**

Interview Questionnaires

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Addis Ababa University

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Institute of Technology School of Civil and Environmental Engineering

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Study on potential Cost Reduction Mechanisms in 20/80 Condominium Building Projects in Addis Ababa

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Semi-Structured Questions for Interview

### **Introduction**

This questionnaire is prepared to obtain information from key informants with semi-structured questionnaires. The information is required for the academic research entitled Study on potential Cost Reducing Mechanisms in 20/80 Condominium Building Projects in Addis Ababa, which is being conducted as partial fulfillment of MSc in Addis Ababa University Institute of Technology School of Civil and Environmental Engineering, Construction Technology and Management major

- To identify critical factors that influence cost of condominium housing projects in Addis Ababa
- To investigate potential cost reduction mechanisms that are important to reducing cost of 20/80 condominium building projects.
- Forward recommendations, which help to reduce overall cost of housing in the 20/80 condominium projects.

Your response, in this regard, is highly valuable and contributory to the outcome of the research. All feedback will be kept strictly confidential and will be utilized for this academic research only. I am sincerely thankful for your deep cooperation in advance.



### **PART III Cost from construction management aspect**

5. What is total estimated cost of your project? \_\_\_\_\_ in your opinion actual cost of this project will increase or decrease compare to estimated project cost? Why?

6. What is total estimated project duration of your project? \_\_\_\_\_ in your opinion actual completion time of this project will increase or decrease compare to estimated project duration? Why?

7. How frequently do you check performance of your project? If you have more than one answer, you can tick more than one.

Monthly      Quarterly      Twice a year      yearly      Randomly      After completion  
of the project

8. What is significance of checking performance of a project?

9. Could you tell me any possibility to reduce cost and duration of this project?

10. Which delivery systems do you think more important to reducing overall cost of project? Please rate the delivery systems with the level of significant to reduce cost? (1=very low, 2=low, 3=moderate, 4=high, 5= very high)

No	Delivery systems	1	2	3	4	5
1	Design bid build, (DBB)					
2	Design builds, (DB)					
3	Construction management consultancy (CM)					

11. Do you think good materials management practice is importance to reducing cost of project?

Why \_\_\_\_\_

12. Condominium housing projects being practiced in our country is a partial prefabrication system. Please level of advantages coming from using prefabrication and assembly system? (1=very low, 2=low, 3=moderate, 4=high, 5= very high)

Advantages	1	2	3	4	5
Speed up construction time,					
Higher Worker safety and comfort level					
Reduced cost of formwork and scaffolding					
Reducing wastage of materials					
Reduce overall cost of construction					
Lower labor costs					

14. In order to maximize advantages coming from using prefabricated building components, in your opinion, what shall we do as country?

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15 Do you think that using prefabricated building components reduces overall cost of project? How?

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16. Which scaffolding material used or scheduling to use to provide temporary access on raised area and for support construction work in this building project? Eucalyptus wood  
metal other \_\_\_\_\_

17 Using which scaffolding material are very important to speed up construction activities?  
Eucalyptus wood metal

18. Which scaffolding materials are very important to reducing overall cost of project?  
Eucalyptus wood metal

How? \_\_\_\_\_

19. Ready-mix concrete is a factory produced and used in case of a large quantity of concrete is to be produced, which can be produced at a faster rate at a lesser cost and better quality,

A. If ready- mix concrete deliver by suppliers to the condominium housing projects, what will be significant on performance of project?

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B. Do you think that using ready-mix concrete reduces overall cost of project? How?

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20. The formwork face in contact with the wet concrete determines the texture, shape, smoothness or roughness of the concrete surface. If we use good quality of formwork likes plywood and panels, concrete surface finish will have good quality.

A, Do you agree? If concrete surface finish will have good quality, we can reduce cement plastering and chiseling works      strongly agree      agree      slightly agree      not agree

B If you agree, Has it significant on cost of project?

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