ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES

ALTERNATIVE CONCRETE-STEEL BUILDING CONSTRUCTION FOR SOCIAL HOUSING PROJECTS

A Thesis Submitted to the Graduate School of Addis Ababa University in partial Fulfillment of the Requirements for the Degree of Master of Science in Civil Engineering

Addis Ababa
November 2008

ALTERNATIVE CONCRETE-STEEL BUILDING CONSTRUCTION FOR SOCIAL HOUSING PROJECTS

ADDIS ABABA UNIVERSITY SCHOOL OF GRADUATE STUDIES
TECHNOLOGY FACULTY CIVIL ENGINEERING DEPARTMENT

By
Tsehaye Eshetu

Advisor
Dr. Shifferaw Taye

Addis Ababa
November 2008

ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES

ALTERNATIVE CONCRETE-STEEL BUILDING CONSTRUCTION FOR SOCIAL HOUSING PROJECTS

By
Tsehaye Eshetu

APPROVED BY BOARD OF EXAMINERS

Dr. SHIFFERAW TAYE ______________________

Advisor

Dr. Ing. BEDILU HABTE ______________________

External Examiner

Dr. Ing. ADIL ZEKARIA ______________________

Internal Examiner

Ato FEKADU MELESE Fekadu melese

Chairman

ACKNOWLEDGMENT

I am gratefully to acknowledge my supervisor Dr. Shifferaw Taye for his continuous assistance through the entire work as well as his advice on technical and non-technical matters is greatly appreciated. Moreover, I would like to acknowledge the financial support of the Office of Research and Graduate studies, Addis Ababa University.

I would also like to thank:

- The Almighty **GOD,** I would like to praise for His blessings and blissfulness, He gave me to pass all these moments and finalize the paper.

- My lecturers, Dr.Ing Adil Zekria, Dr.Ing Girma Zereyohannes and Dr.Ing Asnake Adamu, Dr. Ing. Bedilu Habte for their help, advices and recommendations in my two year studies. Without their continued support and interest in lectures, this thesis would not have been the same as presented here.

- To my beloved and faithful Hiwot M. (ML) who have been there to support me in every aspect no matter how occupied she is. She has all the love and life and also has faith in me to complete the thesis.

- To all family members: Ato Eshetu, W/t kebebush, Akele, Dr. Bayush, Fikremariam and Meskerem whom had always been there to support me no matter how far or occupied they are. They had all the love and faith in me to complete my work.

- The last not but the least to all who give me their support and encouragement to complete the thesis, especially Temesgen W., Abraham Y. and Abel S.

LIST OF SYMBOLS

A	Cross section area
b	Width of the cross-section
V	The design ultimate shear force at the section considered
γ_f	Partial safety factor for load.
γ_m	Partial safety factor for material strength.
γ_c	Partial safety factor for concrete. Its value is 1.5.
γ_s	Partial safety factor for reinforcing steel. Its value is 1.05.
γ_{M0}	Partial safety factor at gross area
γ_{M1}	Partial safety factor resistance of the net section at bolt holes.
G	Permanent action
G_k	Characteristics load
I	Importance Factor
Q	Variable action
Q_d	Design value of a variable action
S_d	Ordinate of the design spectrum
T	Vibration period of a linear single degree of freedom system
t	Thickness
W	Weight
H	Building height
g	Gravitational acceleration
γ	Behaviour factor
β_o	Spectral acceleration amplification factor for 5% viscous damping
a_o	Bed rock acceleration ratio
d	Effective depth
D	Total depth
P_d	Design load

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDIX

ABSTRACT

In this thesis an alternative steel-concrete social-housing is studied with the comparison of the existing cost-efficient construction projects. To accomplish the work the presenter has been point out the problems manifested in the country especially the capital city, Addis Ababa besides the historical development, role and policies of social-housing is presented.

In addition the design of G+4, Type B social-housing building is considered in the course of this the design guide line from the design of roof to the footing design is carried out. To complete the design the 3D Model of the frame is analyzed using ETABS 9 software; all loads induced on the frame are considered. Besides the design of the building some construction defects of the normal concrete construction is stated.

Since the main aim of this thesis is focused on the alternative steel-concrete social-housing building, the design guide line is specified. The steel process from the design to erection is accomplished by considering bill of materials, erection and detail drawing. And special consideration in structural design and construction is prepared.

Finally, the comparison and structural evaluation of the two systems is carried out based on economy, and management and efficiency. From the comparison, some conclusion and recommendation are forwarded.

TABLE OF CONTENTS

CHAPTER ONE

INTRODUCTION

1.1 GENERAL

Generally, cost-efficiency is one of the most crucial points of social-housing. It can mainly be achieved by standardization of building elements and reducing the number of different items needed. Pre-fabrication and the use of machines and special tools to produce these standardized elements maximize productivity, resulting in lower costs per unit. Social-housing in Ethiopia has very petite familiarity and compare to its demand the development of the project is a smaller amount. In addition to the high demand the social-housing has encountered problems out of these are the shortage of construction materials (sand, gravel, cement, reinforcement bars) and construction material producers [15].

One of the solutions is usage of steel-concrete social-housing buildings. The application of steel-concrete structures in Ethiopia has been limited to small extent since its commencement in the country. In this study an alternative method of steel-concrete social housing buildings analysis and design is studied to come up with recommendations and conclusions for its wider application. In our country the last few decades’ steel has very common application in the roof trusses and ware houses. But Steel has finding diverse application in the building industry. It has many advantages for different stakeholders in building industry though its drawback is also presented as follows:

1.1.1 Benefits to Builders

Steel has many benefits to the builders like easy for material selection since it has no need to cull or sort - no warps, splits or knots. It enables the builder straight walls - all studs are straight and true and square corners. Windows and doors open and close, as they should. Small punch list because of the stability of steel, interior and exterior walls will not crack or split. In addition to these environmental selling and "Green" positioning and consumer perceives steel as better quality

1.1.2 Benefits to The Customer

For the customer it has reimbursement like high strength results in safer structures.

Not vulnerable to termites or chemical pesticides and not vulnerable to any type of fungi, mold or any organism. Less probability of foundation problems - less weight results in less movement. Less damage in earthquakes, hurricanes, hail storms, snow loads - lighter structure with stronger connections results in less seismic force.

1.1.3 Environmental Benefits:

Steel's unique magnetic properties make it easily identifiable as a recyclable material. If a magnet sticks, the consumers can be sure it is steel and should be recycled.

Steel recycling programs reduce the solid waste stream resulting in saves landfill space and conservation of natural resources.

Every ton of recycled steel saves 2,500 pounds of iron ore, 1.400 pounds of coal and 120 pounds of limestone.

In 1998, 88% of the steel taken from commercial construction demolition sites was recycled.

1.1.4 Drawbacks of Steel Structures

The principal drawback of steel members is their susceptibility to corrosion, which necessitates their painting or the use of other methods for their protection. The second drawback of steel is its low fire resistance. At high temperatures steel loses most of its strength, leading to excessive deformation or failure.

1.2 SCOPE AND STUDY OF THE THESIS

Therefore, the goals of the current research are:

- Assessment on the current practice of concrete social housing buildings in the Addis Ababa, Ethiopia.
- To Analyze and design concrete social-housing buildings accomplished nowadays.
- To Analyze and design steel-concrete social-housing buildings using some typical buildings.
- To make cost comparison of social-housing analyzed and designed by the concrete system and steel- concrete system.

- The main objective of the present study is to investigate and to set alternative usage of steel-concrete social-housing buildings in addition to the common practice carried out nowadays. This is achieved by making analysis and design of typical buildings using both concrete and steel-concrete system. And cost comparison of concrete building, analyzed and designed by the steel-concrete system is carried out. For this purpose of the comparison the systems of a four-story condominium building is analyzed and designed using both systems.
- In addition, conclusions and recommendations are drawn which may be useful for further developments and the application of these system of construction.
- To come up with recommendations and conclusion for the future wider application of steel in the country.
- To set an alternative option for the development of social-housing buildings in Addis Ababa.

1.3 APPROACHES AND METHODS USED FOR THE STUDY

The following methods are employed to achieve the objectives of the research:

- Field Work
  - Assessment of the different plants and /or sites and the practice in Addis Ababa where social-housing buildings are carried-out
- Desktop works:

Literature survey on analysis and design of social-housing building using concrete and steel-concrete systems which include:

- Loading computations
- Analysis
- Design and detailing for various design action including connections effect.
- Connection practice of steel frame with the pre-fabricated slab.
- Detailed analysis and design to be followed with the design guide.

1.4 SOCIAL-HOUSING

1.4.1 The Historical Development of Social-Housing

The housing needs of the socially vulnerable and disadvantaged form the basis of the work of the committee on housing and land management. Poverty and the social exclusion of vulnerable population groups are increasing social and political challenges throughout the most regions in the world. In recent years, the gap between income and housing prices has continued to widen across the region, making housing less affordable. At the same time, many countries have seen both a decline in the role of the state in the housing sector and a growing reliance on market forces to satisfy housing demand.

Consequently, the housing needs of the poor and vulnerable are often inadequately addressed. The availability of affordable housing, however, is crucial for individuals' well-being and for ensuring a socially cohesive society. It is also an important factor in economic productivity: affordable housing is a prerequisite for labour mobility and an essential part of the creation of an environmental policy conducive to the development of enterprise and job creation.

Given the increasing challenges faced by the socially vulnerable in the housing sector and the importance of affordable housing for socially cohesive societies, countries of the regions are beginning to realize the need for a renewed and stronger role of the state in the provision of social housing. However, in order for the provision of social housing to be efficient and effective, countries have called for a better sharing of experience on social housing policies and practices as well as improved guidance to policymakers through well-documented information on these policies and practices.

The development of the housing situation in individual countries is influenced both by their governments' housing policy and by a number of external factors, such as the socio-economic and demographic situation and political, administrative and legal factors [6]. These external variables, together with the housing policy, shape the role, aims and characteristics of social housing.

1.4.2 The Role of Social Housing in Housing Policies

1.4.2.1 Housing policy goals

The basic goal of housing policy is to provide the whole population with adequately equipped dwellings of suitable size in a well-functioning environment of decent quality at reasonable cost. To make this overall goal more tangible, and also to include recent new dimensions in housing policies, it is worthwhile to list key questions:

- Access to housing: How is it possible to ensure that the underprivileged section of the population has access to a dwelling?
- Affordability: What instruments can be used to ensure that low-income households can live in dwellings of a reasonable size, so that housing expenditure does not form an unreasonably large proportion of their disposable income?
- Qualitative targets: What instruments can be used to ensure that the quality of current housing and of any new construction will correspond to changing needs now and in the future? This concerns the quality of both buildings and the housing environment.
- Special needs: In addition to economic factors, it is important to pay attention to the special needs of different segments of the population. These needs include the need for housing care: sheltered and supported housing for disabled, elderly and homeless people.
- In addition to these basic goals there are many other important issues to consider, such as:
    - Combating social exclusion and supporting the social mix: How to avoid social segregation in residential areas.
    - Security of tenure: Sufficient protection against eviction (kicking out).
    - Tenant participation: Ways and means of participating in decision-making relating to the building and the immediate neighborhood. This relates especially to the apartment building stock in general, and to the rental housing stock in particular.
    - Energy savings in dwellings: This should be incorporated into the qualitative goals for dwellings.

Here it is important to make three points**:**

A. One cannot achieve everything immediately or simultaneously. This makes it necessary to prioritize goals.
B. The higher the income, the more easily housing policy goals can be realized. This means that housing policy instruments should include special support for improving housing conditions for low- and medium-income groups. This provides the justification for assessing the efficiency of housing policy according to how well it supports improved housing for those living under the most difficult conditions: “social effectiveness”.
C. No single housing policy instrument will solve all the problems. Instead there is a range of potentially useful instruments, and combinations of them, which are suitable for use in different situations. The efficiency of these instruments and combinations of them can be assessed by looking at the extent to which goals are achieved. One can focus particularly on how the goals can be implemented at the lowest possible public cost (“economic efficiency”).

1.4.2.2 Comparison of social housing with other housing policy instruments

When considering the need for additional social rental housing, one should first examine how well the existing housing stock and the present tenure models, such as owner-occupied housing, cooperatives and ordinary private rental dwellings, can satisfy the housing needs and requirements of the population.

First of all, the need for new social rental housing declines as market rents and housing prices fall and as people with middle and low incomes become more satisfied with ordinary owner-occupied, cooperative and rental dwellings. This is the situation in many areas outside growth centers all over Europe.

The situation is much more complex in areas where housing is expensive and in very short supply. A widely held view is that there should be dwellings with different types of tenure so that different types of demand can be met. A certain number of rental dwellings are necessary both for social reasons and for employment policy reasons, to facilitate labour mobility. The number of rental dwellings can be increased by building more private or social rental dwellings or by acquiring them from the existing housing stock.

Social housing may be needed if the rent levels of ordinary privately owned rental dwellings are so high that people on low incomes cannot afford them. Here, an alternative means is housing allowances, which make it possible to lower the effective rent to a level residents can afford, even in private rental dwellings. A relatively high level of housing allowances would, however, lead to higher demand for housing and would also result in higher rents, particularly if the supply of housing were, for various reasons, unable to respond to rapidly rising demand.

Another problem with housing allowances is that, particularly in countries with a large grey economy where the authorities do not know enough about actual income levels, it may be difficult to build a sufficiently effective and fair housing allowance system. Likewise, housing allowances are not particularly effective when the main objective is to increase housing production and renovation.

1.4.3 Social Housing in Addis Ababa, Ethiopia

The shortage of housing is among the most visible problems of poverty in Addis Ababa. 3 millions out of the total population of 4 millions are living in overcrowded houses or dilapidated structures, under unhygienic condition, lacking basic urban services like safe drinking water and sewage, and in sprawling informal settlements with a growing number of shacks. 85% of the housing structures in Addis Ababa are dilapidated and would have to be demolished or rehabilitated in costly manner. They are in their majority without the minimum basic infrastructure such as flushing toilets and connection to the sewer system.

An estimated 80% of the 150,000 kebele houses' have serious problems of maintenance and are in very bad shape. Up to 50% of the population is without fixed employment.

The accumulated housing backlog is estimated to be 300,000 units. Moreover, 60,000 units are needed to accommodate the population increase of 7-8% p.a.- mainly a result of migration from the rural areas.

In order to solve the housing deficit, the Addis Ababa city Government has launched an ambitious "Addis Ababa Grand Housing Program" with the objective to construct up to 50,000 housing units per year.

The aim of this program is to provide low and middle urban income dwellers with decent shelter. At the same time the housing programs are aims at promoting micro and small enterprises, implementing training-on-the-job, mobilizing the saving potential and diversification of the construction sector. The overall impact is a boost to the economy as the construction sector is the motor for economic development.

The Addis Ababa City Government additionally plans to upgrade and renew the inner City of Addis Ababa transforming Addis Ababa into the “Capital of Africa”. Not only the Capital city but the construction of social-housing in the country’s different regions is increased with high endeavor [14, 15]. To fulfill the demand of the housing needs of the population searching an optional means of construction like steel is sensible, since the construction industry is increasing with the alarming rate so to address the shortage of construction materials manifested in these days.

CHAPTER TWO

DESIGN OF SOCIAL-HOUSE BUILDINGS USING CONCRETE–REVIEW OF EXISTING PRACTICE

2.1. GENERAL

In the design of concrete structures, the required areas of steel for flexure and shear shall be calculated based upon the structural members' moments, and shears, load combination factors, and other criteria described as follows.

The concrete design procedure involves the following steps:

- Design of roofs
- Design of Pre-cast beam-slab system
- Design of staircases
- Modeling of the frame structure
- Design of the frame structure
- Cost Estimation of the building

2.2 DESIGN GUIDE LINE:

2.2.1 Project Specification

- 290.90 m^2 G+4 social housing building
- 30.3m length and 9.6m width
- Each story height is 2.80m
- Each of the six spans is 5m long.

2.2.2 Design Load Combinations

The design load combinations define the various factored combinations of the load cases for which the structure is to be checked. The design load combinations are obtained by multiplying the characteristic loads by appropriate partial factors of safety, γ_f [2]. The structure is subjected to dead load (DL), transferred loads from the different parts of the structure like pre-cast beams, loads from stair cases (TDL) and depends on the function of the building live load (LL). However, in addition to the dead load and live load, depending on the location of the structure the governing load might be wind (WL) or earthquake (EL) loads, but for this particular social housing the earthquake (EQ) load, and the EQ load has two components earthquake in x-direction and in the y-direction are considered in the combination as per EBCS 2, 1995. Table 2.1 indicates the available combination in the design of the frame structure.

Table 2.1 Load Combinations for Concrete-Frame Structure

Combo	Type	Case	Factor	Case Type
COMB1	ADD	DL	1.30	Static
		PL	1.30	Static
		TDL	1.30	Static
		LL	1.60	Static
COMB2	ADD	COMB1	0.75	Combo
		EQX	1.00	Static
COMB3	ADD	COMB1	0.75	Combo
		EQX	-1.00	Static
COMB4	ADD	COMB1	0.75	Combo
		EQNX	-1.00	Static
COMB5	ADD	COMB1	0.75	Combo
		EQNX	1.00	Static
COMB6	ADD	COMB1	0.75	Combo
		EQY	1.00	Static
COMB7	ADD	COMB1	0.75	Combo
		EQY	-1.00	Static
COMB8	ADD	COMB1	0.75	Combo
		EQNY	-1.00	Static
COMB9	ADD	COMB1	0.75	Combo
		EQNY	1.00	Static
COMB10	ADD	DL	1.00	Static
		TDL	1.00	Static
		LL	1.00	Static
		PL	1.00	Static

2.2.3 Design Strength

The design strength for concrete and steel are obtained by dividing the characteristic strength of the material by a partial factor of safety, γm. The values of γm used in the program are listed below.

γm=

1.05 For reinforcement, (EBCS 1995)

1.50 For concrete in flexure and axial load, and

1.25 For shear strength without shear reinforcement.

2.2.4 Modeling

The loading on the frame model are:

- The load from the roof
  - From the design of the roof the load transferred to the top tie beam is 25kN/m and assigned as the transferred dead load i.e. TDL.
- The load from the stair case obtained from the design shown in Appendix A
  - Dead load from the staircase =7.32kN/m
  - Live Load from the staircase=2.63kN/m
- The load from the pre-cast beam slab system
  - Design Procedure for the pre-cast beam element:
    - i. The general procedure is to determine the loads on the slab system both at the initial and final conditions of the pre-cast beam. The loading in the case of initial and final conditions of the pre-cast beam shall be separately analyzed for different loading considerations and an initial trial section shall also be assumed.
    - ii. Loading for the initial condition:

The loading considered in this condition of the pre-cast beam are as follows:

a. Dead Load:

- Weight of Pre-cast beam Concrete.
- Weight of Hollow Ribbed Slab Block.

b. Live Load:

The live load at the time of handling and placing are considered here.

- Weight of wet concrete at the time of casting is also considered as dynamic load on the pre-cast beam.

Loading for the final condition:

The loading considered in this condition of the pre-cast beam are as follows:

a. Dead Load:

- Weight of Pre-cast beam Concrete
- Weight of Hollow Ribbed Slab Block
- Weight of Cast in-situ concrete
- Weight of Partition
- Weight of Cement screed and weight of Cement plasters

b. Live Load:

This depends on the purpose of the structure

On the basis of the above loading for the different conditions of pre-cast beam determine the moment and shear at the critical sections both at the initial and final conditions of the pre-cast beam.

Using the critical moment and shear forces the pre-defined section and the assumed reinforcements shall be checked for buckling resistance and for the requirement of temporary support for the case of the initial condition state of the pre-cast beam.

Temporary supports are provided when the pre-cast beam in its initial condition cannot support all the loads at the initial condition state. When the length of pre-cast beam is getting longer (more than 3.5m), the tendency for provision of temporary support is increased.

- ☞ Check for buckling resistance of top reinforcement:
- ☞ Calculate the critical moment in the pre-cast beam at the initial condition state and using it, determine the compression force coming to the top bar.
- ☞ Calculate the compression resistance of the top bar by taking in to consideration the unsupported length of the bar. If the compression force coming to the top bar is greater than the compression resistance one of the following actions can be taken depending on the designer:
    - Increase the diameter of the top bar
    - Reduce the c/c spacing of the diagonal stirrup to reduce the unsupported length of the top bar
    - Provide intermediate support to the pre-cast beam at the time of construction.

- Check for buckling resistance of diagonal shear reinforcement:
  - Calculate the critical shear in the pre-cast beam at the initial condition state and using it, determine the compression force coming to the diagonal shear reinforcement.
  - Calculate the compression resistance of the diagonal shear reinforcement by taking in to consideration the unsupported length of the bar. If the compression force coming to the shear reinforcement is greater than the compression resistance one of the following actions can be taken depending on the designer:
    - Increase the diameter of the bar
    - Provide intermediate support to the pre-cast beam at the time of construction.
- The moment and shear forces are then calculated based on the loading of the final condition to calculate the bottom reinforcement and also to check the top reinforcement determined in the initial condition if it is sufficient for the compression reinforcement.

- Finally the slab section in the final condition shall be checked for shear resistance and if it has no sufficient resistance the section shall be increased. The final slab orientation is shown in Fig. 2.1.

Note that all the above calculations and checking shall be as per the EBCS code.

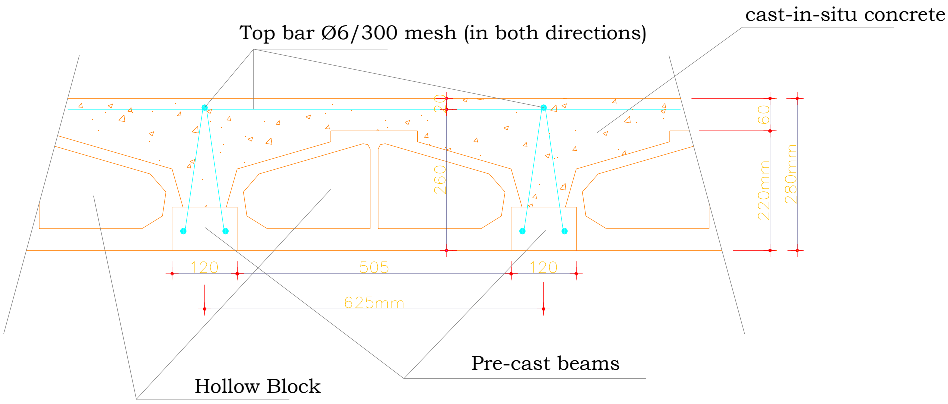


Fig. 2.1 Final Pre-cast Beam Slab System

After the above procedure is carried out the transferred concentrated load from the pre-cast beam slab system is found as:

i. Dead load-c/c spacing=0.625m

☞ Wt of topping=25kN/mG30.06mG0.625m=0.9375kN/m

☞ Wt of Finishing $= 23 \times 0.02 \times 0.625 = 0.28125 kN/m$

☞ Wt of screed $= 23 \times 0.03 \times 0.625 = 0.4375 k\,N/m$

☞ Wt of partition $= 0.33 \times (15 \times 2.76 \times 0.24) \times 0.625 = 2.0469 k\,N/m$

☞ Wt of HCB $= 20 \times 0.24 \times 0.525 = 2.25 kN/m$

☞ Wt of Rib $= 25 \times 0.22 \times 0.10 = 0.55 k\,N/m$

☞ Wt of plaster $= 23 \times 0.02 \times 0.625 = 0.28125 k\,N/m$

$$\text{Gk} = 6.7844 kN/m$$

$\therefore$ Unfactored Concentrated dead load $= 5m/2 \times 6.7844 k\,N/m = 16.96 kN$

ii. Live load

☞ $\text{Gk} = 3.00 k\,N/m^2 \times 0.625 m = 1.875 k\,N/m$

$\therefore$ Unfactored Concentrated live load $= 5m/2 \times (1.875 k\,N/m) = 4.69 kN$

The unfactored concentrated dead and live loads from the pre-cast beam slab system are transferred at the interval of 0.625m on the beam elements which are perpendicular to the pre-cast beam elements.

A trail section of the frame elements are defined, and by checking the capacity of the section to that of the internal forces, the final designed sections are

- Beams: Top Tie Beam (TTB) = (30*20cm), Typical Floor Beam (TFB)= (40*20cm) and Grade Beam (GB) = (50*30cm)
- Columns: Column 1 (C1)= (50*30cm), Column 2 (C2)= (40*20cm), Column 3 (C3)=C3 (30*20cm).

The value of S_d for the earthquake load combination is calculated by considering the geometry of the building and the final value is tabulated in Appendix D.

By considering all the loads and combinations 3D model of the frame structure is shown in Fig. 2.2.

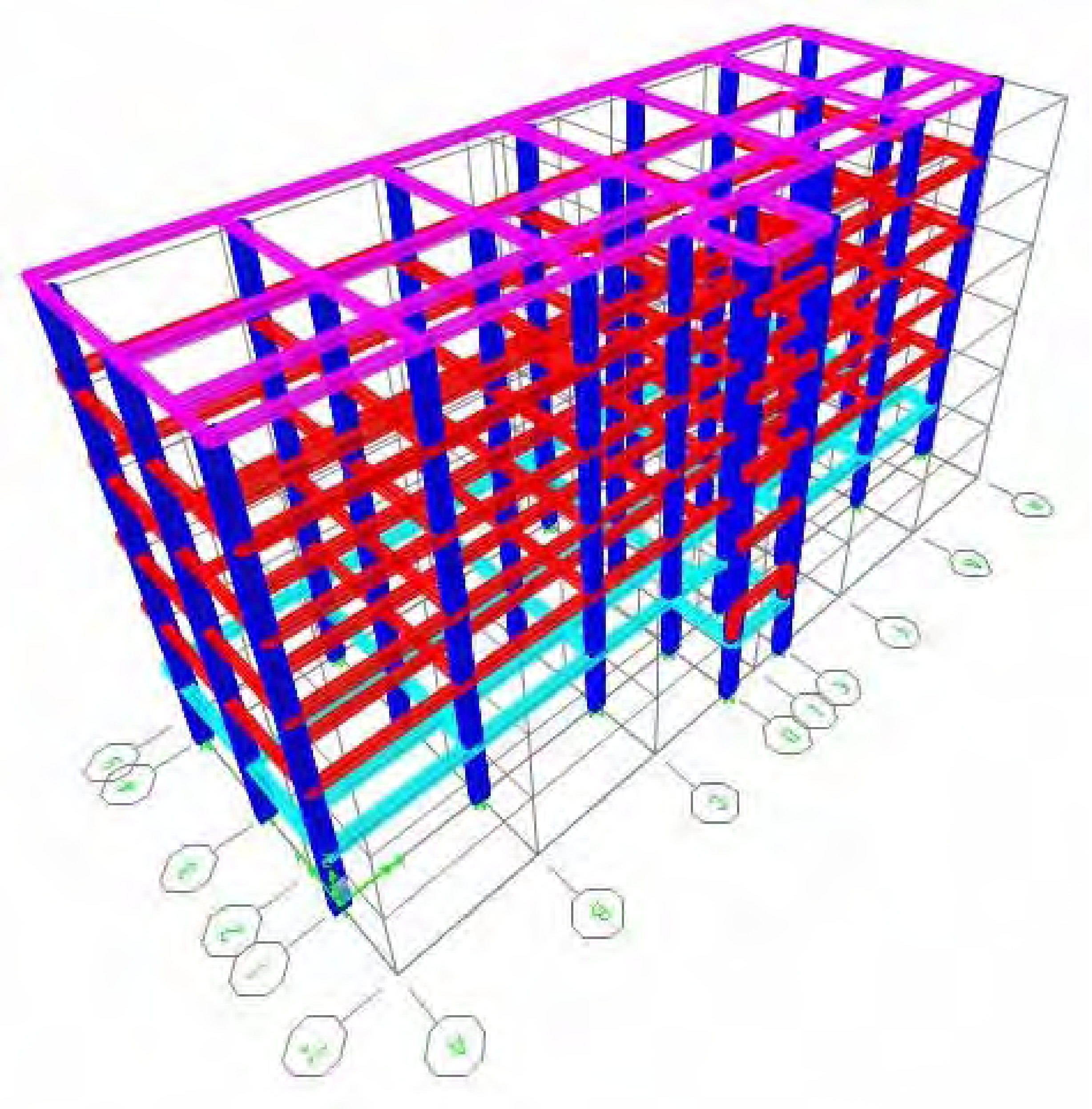


Fig.2.2 The 3D Model of Concrete-Frame Structure

From the analysis result all structural design is carried out and the cost of the building is calculated.

The total cost is attached at Appendix B but the summary of total prices is shown in Table. 2.2

Table 2.2 Summary of Prices for concrete-framed structure

	SUMMARY OF PRICES	
Item No.	**Description**	**Amount (Birr)**
	A. SUBSTRUCTURE	
1	**Excavation and Earth work**	**109,628.70**
2	**Concrete work**	**343,517.45**
3	**Masonry work**	**20,487.00**
	Subtotal (A)	**473,6**
	B.SUPERSTRUCTURE	
1	**Concert Work**	**546,539.41**
2	**Block work**	**345,613.40**
3	**Roofing**	**57,926.00**
4	**Metal Work**	**140,959.40**
5	**Joinery**	**110,980.80**
6	**Structural Steel Work**	**193,164.14**
7	**Pre-cast work**	**156,672.00**
8	**Lintel work**	**18,693.90**
9	**Finishing**	**519,741.75**
10	**Glazing**	**11,583.00**
11	**Painting**	**147,916.35**
12	**Sanitary installation**	**203,339.53**
13	**Electrical installation**	**262,797.50**
14	**Lift Work**	
	Subtotal (B)	**2,715,927.18**
	Total (A+B)	**3,189,560.33**
	15%VAT	**478,434.05**
	Total	**3,667,994.38**
	10%CONTINGENCY	**366,799.44**
	Grand total	**4,034,793.82**

2.3 CAUSES OF FAILURE ENCOUNTERED IN THE CONSTRUCTION

Now a days in the construction of social-housing buildings there are many problems has been manifested through day to day experience of construction practice. In this topic some part of failures of concert structures are discussed in the following ways especially for the frame structural members.

2.3.1 Rusting of Reinforcement Bars

In our country the social-housing building projects are carried out in massive amount and usually the raw materials are supplied is not as per the site work schedule so the reinforcement placed for long time before usage due to the time elapsed in the project site; it leads the reinforcement to be rusted as in Fig. 2.3 (a) shown below. In addition to this since reinforcement bars are susceptible to moisture so proper handling on the site is mandatory. As shown in Fig. 2.3 (b)

Due to rusting of the reinforcement many problems are taken place such as:

- ✓ Reduction of the strength of the reinforcement, in the long run it contributes to the failures of beams and columns.
- ✓ Depending on the severity of the rust, it requires replacement that means it incurs additional cost.


a b

Fig. 2.3 Rusting of Reinforcement Bars

2.3.2 Poor Workmanship

For any type of construction industry to have a safe, economical and sustainable result besides material, machinery quality, the quality of the workmanship has a vital impact on the construction quality. Due to poor workmanship practices uneven concrete filling is encountered especially at the connections since the concrete is poured from a height of 3.2m as shown in the Fig. 2.4.

Fig. 2.4 Defects Due to Poor Workmanship

CHAPTER THREE

DESIGN OF SOCIAL HOUSE BUILDINGS USING STEEL

3.1 INTRODUCTION

Steel is a common building material used throughout the construction industry. Its primary purpose is to form a skeleton for the building or structure-essentially the part of the structure that holds everything up and together. Steel has many advantages when compared to other structural building materials such as concrete, timber, plastics and the newer composite materials. Steel is one of the friendliest environmental building materials-Steel is 100% recyclable. Steel, unlike wood, does not warp or twist and substantially expand and contract with the weather. Unlike concrete, steel does not need time to cure and is immediately at full strength. Steel is versatile, has more strength with less weight, has an attractive appearance, can be erected in most weather conditions, is of uniform quality, has proven durability and has low life cycle costs. These advantages make steel the building material of choice.

Steel as a building material has been studied and tested for many years. It might be said that we understand the behavior of steel better than any other building material. Steel is predictable material and during the 1990’s the industry had implemented new procedures for designing steel structures. Structural design has evolved, mostly due to the necessity caused by earthquakes.

The evolution of steel design brought us from the theory that the stiffer the structure the better. Today, flexibility and ductility is key. Until the 1970’s, structures were designed using proven formulas, but the calculations were done by hand. Today, using software on your PC, you can literally design a structure in a day, something that could have taken a structural engineer months to do using paper and pencil. The new tools available today solve some old problems and create some new ones. One of the key ingredients of the evolution of steel structure design is CAD (Computer Aided Design). The days in drafting are almost gone digitizing the structure in the computer saves time, ensures quality and usually results in a lower cost [17].

3.2 GENERAL

In the design of steel structures, the required cross-sections of steel members for flexure and shear shall be calculated based upon the structural members' moments, and shears, load combination factors, and other criteria described herein.

The steel design procedure involves the following steps:

- Design of roofs
- Design of Pre-cast beam-slab system
- Design of staircases
- Modeling of the frame structure
- Design of the frame structure
    - Design Main Members
    - Design of Secondary Members
    - Design of Connections.
- Cost Estimation of the building

3.3 DESIGN GUIDE LINE:

3.3.1 Design Load Combinations

The design load combinations define the various factored combinations of the load cases for which the structure is to be checked. The design load combinations are obtained by multiplying the characteristic loads by appropriate partial factors of safety, γf (EBCS 3, 1995). The structure is subjected to dead load (DL) and depends on the function of the building live load (LL). However, in addition to the dead load and live load, depending on the location of the structure the governing load might be wind (WL) or earthquake (EL) loads, but for this particular social housing the earthquake (EQ) load is considered in the combination. The total combination is shown in Table 3.1.

The following Table 3.1 indicates the available combination in the design of the steel-framed structure.

Table 3.1 Load Combinations for Steel-Framed structure

Combo	Type	Case	Factor	Case Type
COMB1	ADD	DL	1.00	Static
		PL	1.00	Static
		TDL	1.00	Static
		LL	1.00	Static
COMB2	ADD	COMB1	0.75	Combo
		EQX	1.00	Static
COMB3	ADD	COMB1	0.75	Combo
		EQX	-1.00	Static
COMB4	ADD	COMB1	0.75	Combo
		EQNX	-1.00	Static
COMB5	ADD	COMB1	0.75	Combo
		EQNX	1.00	Static
COMB6	ADD	COMB1	0.75	Combo
		EQY	1.00	Static
COMB7	ADD	COMB1	0.75	Combo
		EQY	-1.00	Static
COMB8	ADD	COMB1	0.75	Combo
		EQNY	-1.00	Static
COMB9	ADD	COMB1	0.75	Combo
		EQNY	1.00	Static
COMB10	ADD	DL	1.00	Static
		TDL	1.00	Static
		LL	1.00	Static
		PL	1.00	Static

3.3.2 Design Strength

The design strength for steel is obtained by dividing the characteristic strength of the material by a partial factor of safety, γ_m. The values of γ_m used in the program are listed below.

- γ_{M0}=1.1 partial safety factor
- γ_{M1}=1.25 resistance of the net section at bolt holes.
  (EBCS3 1995)

3.3.3 Modeling

The loading on the frame model are:

- ☞ The load from the roof
- ☞ From the design of the roof the load transferred to the top tie beam is 25kN/m

  and assigned as the transferred dead load i.e. TDL.
- ☞ The load from the stair case obtained from the design shown in appendix 2
- ☞ Dead load from the staircase =9.51kN/m
- ☞ Live Load from the staircase=4.20kN/m
- ☞ The load from the pre-cast beam slab system
  - o Dead load-c/c spacing=0.625m

$\therefore$ Unfactored Concentrated dead load $= 5m/2 \times 6.7844\,kN/m = 16.96kN$

$\therefore$ Unfactored Concentrated live load

$$= 5m/2 \times (1.875k\ N/m) = 4.69kN$$

The unfactored concentrated dead and live loads from the pre-cast beam slab system are transferred at the interval of 0.625m on the beam elements which are perpendicular to the pre-cast beam elements.

A trail section of the frame elements are defined, in this thesis the final safe and economical sections are top-tie beam and typical floor beams (B1) =W200×200×46.1 and column (C1)= W250×200×49.1.

The value of S_d for the earthquake load combination is calculated by considering the geometry of the building, as shown in Appendix D.

S_d=0.03

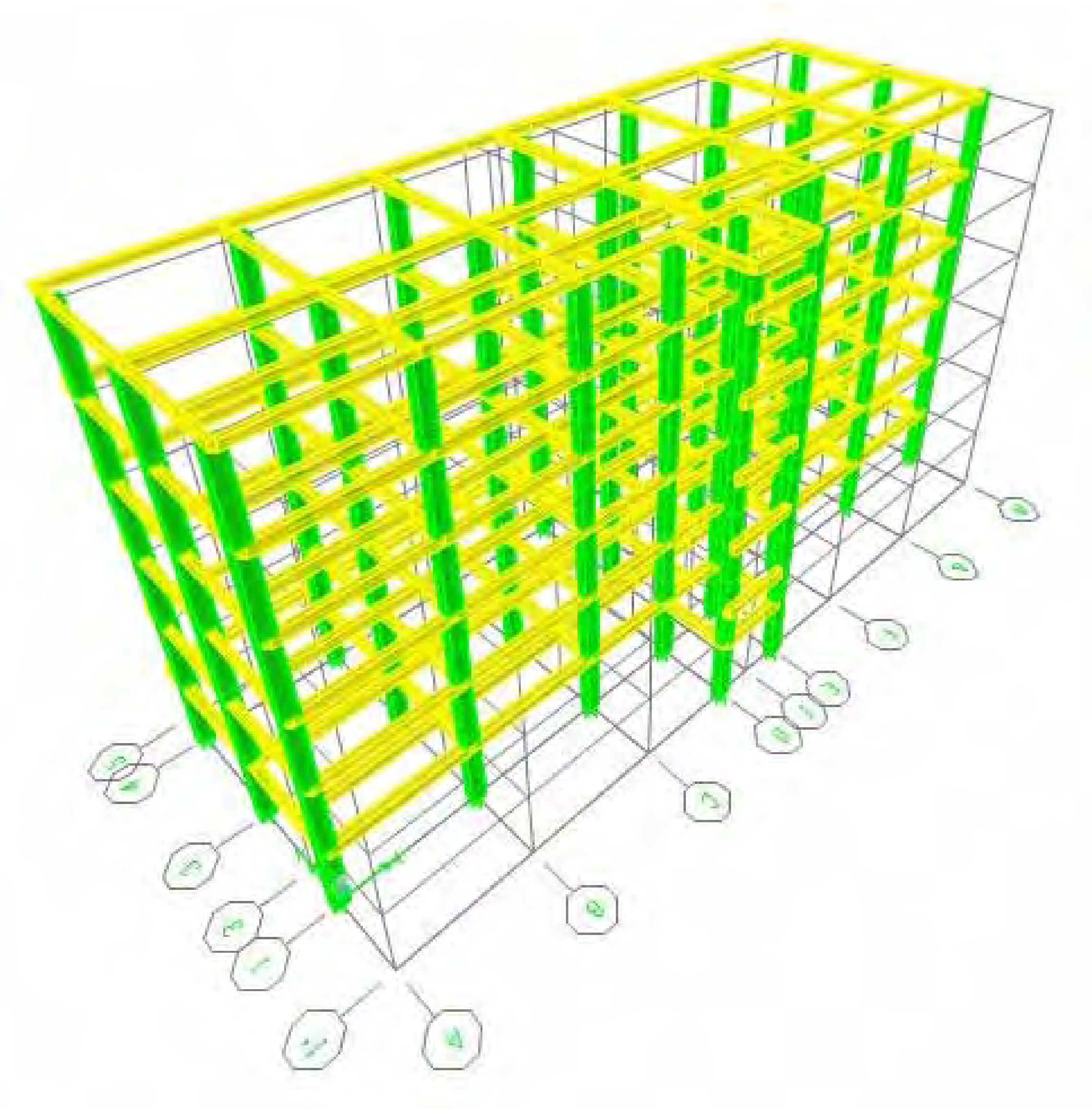


Fig.3.1 The 3D Steel-Framed Model of Structure

By considering all the loads and combinations 3D model of the frame structure is shown in Fig. 3.1 below.

From the analysis result all structural design is carried out and the cost of the building is calculated. The total cost is attached at Appendix C but the summary of total prices is shown in Table 3.2.

Table 3.2 Summary of Prices for steel-concrete-framed structure

	SUMMARY OF PRICES	
Item No.	**Description**	**Amount (Birr)**
	A. SUBSTRUCTURE	
1	**Excavation and Earth work**	**95,878.70**
2	**Concrete work**	**306,784.90**
3	**Masonry work**	**20,487.00**
4	**Steel Works**	**20,400.00**
	Subtotal (A)	**443,550.60**
	B.SUPERSTRUCTURE	
1	**STRUCTURAL STEEL WORKS**	**1,862,563.88**
2	**Block work**	**345,613.40**
3	**Roofing**	**57,926.00**
4	**Metal Work**	**182,955.80**
5	**Joinery**	**373,537.40**
6	**Structural Steel Work**	**193,164.14**
7	**Pre-cast work**	**156,672.00**
8	**Lintel work**	**18,693.90**
9	**Finishing**	**519,741.75**
10	**Glazing**	**11,583.00**
11	**Painting**	**147,916.35**
12	**Sanitary installation**	**203,339.53**
13	**Electrical installation**	**262,797.50**
14	**Lift Work**	**-**
	Subtotal (B)	**4,336,504.65**
	Total (A+B)	**4,780,055.25**
	15%VAT	**717,008.29**
	Total	**5,497,063.54**
	10%CONTINGENCY	**549,706.35**
	Grand total	**6,046,769.89**

3.4 THE STEEL PROCESS-FROM DESIGN THROUGH ERECTION

While the size and complexity of the project may drive and in some way change the process, the path of steel structural design and construction is predictable and proven. The production of conceptual, schematic and design development drawing are essential predecessor activities to finalizing the design of the structural framework. In theory, it is the structural engineer’s job to make the vision of the architect comes true. While most architects can appreciate the complexity of the structural design of their vision, only the structural engineer can gauge what needs to be done to satisfy the architect’s requirements. After the architecture of the building is determined, the design of the framework-beams, columns, bracing etc.-proceeds with engineering calculations.

3.4.1 Engineering

Structural engineering is the application of science and math to design a structure. With reference to the various building codes, the recommendations and codes of the Ethiopian Building Code of Standards-3 (EBCS-3), and the empirical data derived from all the testing done on steel structures, the structural engineer understands and can adequately predict the behavior of steel.

3.4.2 Main Member Design

The actual structural engineering calculations for the main (primary) members’ takes place after a number of critical factors are determined. To start, the engineer uses the architectural drawings to determine the column locations from which the concrete foundation will be designed. The Steel columns will connect to the concrete and connected to column base plates with nuts and washers. The location of the columns determines the configuration of the framework of members.

In this study the members are designed for the following mode of failures as per EBCS-3, 1995:

- ☐ Axial tension and bending
- ☐ Axial compression and bending about one axis
- ☐ Axial compression and bending about the strong axis
- ☐ Axial compression and biaxial bending-torsionally stiff sections
- ☐ Axial compression and biaxial bending thin-walled open sections

- ❑ Axial compression, biaxial bending, and torsion

3.4.3 Secondary Member Design

After the main members have been located, sized and their reactions and loads are known, supporting secondary members must be designed for the structure. Secondary members include braces, stiffeners and other structural elements that typically support main members causing the main members to be smaller in size. Other secondary members that need to be designed include stairs, catwalks, grating, ladders and other miscellaneous appurtenances.

The dead weight of the secondary members may be significant enough to consider in the design of the main structural members.

3.4.4 Connection Design

Every structure is an assemblage of individual parts or members which must be fastened together, usually at the ends of its members. The two main fastening means are bolting and welding (with a few and isolated case also riveting and pins). Connections are structural elements used for joining different members of a framework. Connections can be classified according to:

- The type of connecting medium used: bolted connections, welded connections, bolted-welded connections riveted connections.
- The type of internal forces the connections are expected to transmit: shear (Type PR, semi-rigid, simple) connections, moment (Type FR, rigid) connections.
- The type of structural elements that made up the connections: single-plate angle connections, double web angle connections, top and seated angle connections, seated beam connections, etc.
- The type of members the connections are joining: beam-to-beam connections (beam splices), column-to-column connections (column splices), beam-to-column connections. Hanger connections.

3.4.4.1 Bolt Connection Design

A bolted joint is subjected to various types of stress. These stresses and the verification of the joint for capacity are presented subsequently.

Bearing Resistance

The bearing resistance of each ply in a connection may be determined by summing the resistance, F_{bp},R_d, obtained at all bolt locations.

$$F_{bb.Rd} = \frac{d\,t\,f_{bp,d}}{\gamma_{Mb}} \le \frac{1}{2} e_1^{\,t} \frac{f_{bp.d}}{\gamma Mb}$$

Where:
D = the nominal diameter of bolt
T = the thickness of the connected ply, or if the bolts countersunk, the thickness if the ply minus half of the depth of countersinking.

$f_{bp.d}$ = the design bearing strength of the connected parts = 0.8 (f_{u1} + f_{yx})
in which f_u = the specified minimum ultimate tensile strength of the connected part f_y = the specified minimum yield strength of the connected part
e_1 = the dege distance

Tension Capacity

The tensile capacity of the connected part subject to collinear forces should be based on the lesser of:

- The ultimate resistance of the net section which may be taken as:

$$N_{u.Rd} = \frac{0.9k_r\ A_n\ f_u}{\lambda_{M2}}, \gamma_{mL} = 1.25$$

Where:
K_r = 1.09r + 3rd/c
r = the force transmitted by the bolt or bolts at the section considered, divided by the tension force in the member at that section
d = nominal bolt diameter
c = spacing of bolts perpendicular to line of stress. In the case of a single bolt,
s = width of shear of plate

- The plastic resistance of the gross section:

$$N_{p1.RT} = \frac{A\,f_y}{\gamma_{M0}}$$

If ductile behavior is required then the plastic resistance must be less than the net section ultimate resistance.

Shear Rupture Strength

The design value of the effective resistance $V_{eff.Rd}$ for rupture along a block shear failure path shall be determined from:

$$V_{eff,Rd} = \frac{0.6\,x\,f_y\,x\,A_{v.eff}}{\gamma_{M0}}$$

Where

γ_{M0} = 1.1. = partial safety factor

F_y = specified minimum yield stress of steel

$A_{v,eff}$ = effective shear area subject to block shear.

The effective shear area $A_{v.eff}$ for block shear, Fig. 3.2, is determined from:

$A_{v.eff} = t\,(L_v + L_1 + L_2 - nd_0)$

In which L_1 and L_2 are given by:

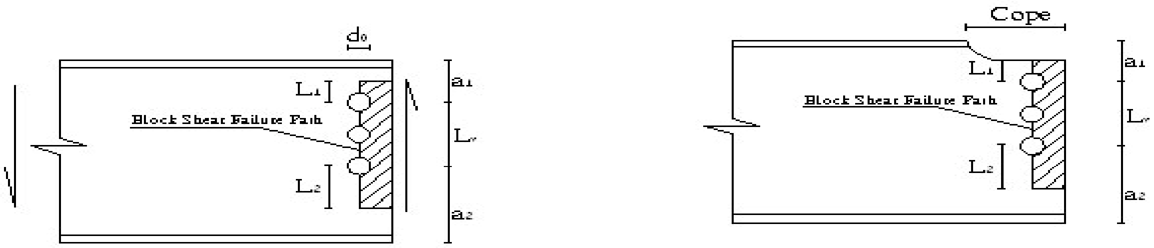
$L_1 = 5.0d_0 \le a_1$

$L_2 = 2.5d_0 \le a_2$

and n = the number of fastener holes in the block shear failure path

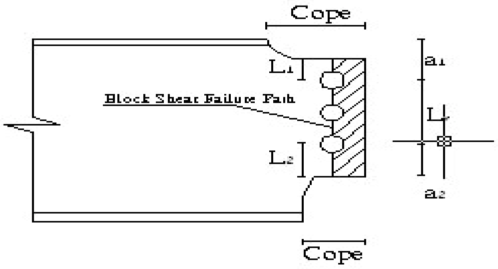
d_0 = hole diameter

t = thickness of the web or bracket.



a. Plain end

b. Coped end



c. Double coped end

Fig. 3.2 Net Shear Area-Block Shear

3.4.4.2 Shear Stud Design

The purpose of shear connectors is to ensure composite action between a concrete slab and a steel beam by preventing the slab from slipping relative to or lifting off the flange to which the connectors are welded. Headed-stud or channel shear connectors are generally used. The studs should extend at least four stud diameters above the flange. The welds between the connectors and the steel flange should be designed to resist the shear carried by the connectors. When the welds are not directly over the beam web, they tend to tear out of a thin flange before their full shear-resisting capacity is attained. Consequently, the AISC ASD and LRFD specifications require that the diameter of studs not set directly over the web be 2.5 times the flange thickness or less. The specifications also limit the spacing center-to-center of shear connectors to a maximum of eight times the total slab thickness. The minimum center-to-center spacing of stud connectors should be 6 diameters along the longitudinal axis of the supporting composite beam and 4 diameters transverse to the longitudinal axis of the supporting composite beam, except that within ribs of formed steel decks, oriented perpendicular to the steel beam, the minimum center-to-center spacing should be 4 diameters in any direction.

Shear connectors, except those installed in the ribs of formed steel deck, should have at least 2.54cm of concrete cover in all directions.

The AISC LRFD specification requires that the total horizontal shear V_h necessary to develop full composite action between the point of maximum positive moment and the point of zero moment be the smaller of V_h (kips) computed from Eqs. (1) and (2):

$$V_h = A_s f_y \qquad \text{……3.1}$$

$$V_h = 0.85 f'_c A_c \qquad \text{…......3.2}$$

Where A_s = area of the steel cross section, in^2

A_c= area of concrete slab, in^2

f_y = specified minimum yield stress of steel tension flange, ksi

f'_c =specified compressive strength of concrete, ksi

The AISC ASD specification requires V_h to be the smaller of V_h computed from Eqs. (3) and (4):

$$V_h = A_s f_y/2 \qquad \text{…..3.3}$$

$$V_h = 0.85 f'_c A_c/2 \qquad \text{…...3.4}$$

If longitudinal reinforcing steel with area A'_s within the effective width of the concrete slab is included in the properties of the concrete, $1⁄2 f_{yr}A'_s$ should be added to the right-hand side of Eq. (3).In negative-moment regions of continuous composite beams, longitudinal reinforcing steel may be placed within the effective width of the slab to aid the steel beam in carrying tension due to bending, when shear connectors are installed on the tension flange. For LRFD, the total horizontal shear force between the point of maximum negative moment and the point of zero moment should be taken as the smaller of $A_r f_{yr}$ and $\sum Q_n$;

where A_r = area of adequately developed longitudinal reinforcing steel within the effective width of the concrete slab, in^2

f_{yr} = minimum specified yield stress of the reinforcing steel, ksi

$\sum Q_n$ = sum of nominal strengths of shear connectors between the point of maximum negative moment and the point of zero moment, kips

For ASD, the total horizontal shear (kips) to be resisted by the connectors between an interior support and each adjacent inflection point should be taken as

$$V_h = A_r f_{yr}/2 \qquad \text{….3.5}$$

where A_r = total area of longitudinal reinforcing steel within the effective flange width at the interior support, in^2

f_{yr} = specified minimum yield stress of reinforcing steel, ksi

In LRFD, for full composite action, the number of shear connectors each side of a point of maximum moment required to resist a horizontal shear V_h (kips) resulting from factored loads is

$$N = V_h/Q_n \qquad \text{….3.6}$$

where Q_n is the nominal strength of one shear connector (Table 3.3).

In ASD, for full composite action, the number of shear connectors each side of a point of maximum moment required to resist a horizontal shear V_h (kips) resulting from service loads is

$$N = V_h/q \qquad \text{….3.7}$$

where q is the allowable shear load for one connector (Table 3.4). If N_1 connectors are provided, where $N_1<N$, they may be assumed capable of carrying a total horizontal shear (kips) of

$$V_h' = N_1 q \qquad \text{….3.8}$$

This shear is used for determining the effective section modulus.

Shear connectors generally can be spaced uniformly between points of maximum and zero moment. Some loading patterns, however, require closer spacing near inflection points or supports. The AISC specifications consequently require that when a concentrated load occurs in a region of positive bending moment, the number of connectors between that load and the nearest point of zero moment should be sufficient to develop the maximum moment at the concentrated load point. The LRFD specification gives no special equation for checking this. The ASD specification gives the following equation for number of shear connectors:

Table 3.3 Nominal Stud Shear Strength (kips) for 3⁄4-in Headed Studs (LRFD)

Specific concrete compressive Strength, ksi	Unit weight of concrete, lb/ft3	Nominal strength, Qn, kips
3.0	115	17.7
3.0	145	21.0
3.5	115	19.8
3.5	145	23.6
4.0	115	21.9
4.0	145	26.1

$$N_2 = N_1 \frac{M\beta / M_{\max} - 1}{\beta - 1} \qquad \text{….3.9}$$

Where: $M_{\max} =$ maximum positive bending moment

$M =$ Bending moment at a concentrated load ($M < M_{\max}$)

$\beta = S_{tr} / S_s \; or \; S_{eff} / S_s$, Whichever is applicable

$S_s =$ Section modulus of steel beam, referred to bottom flange

$S_{tr} =$ Section modulus of transformed composite section, referred to bottom flange, based on maximum permitted effective width of concrete flange

$S_{eff} = S_s + (S_{tr} - S_s)\sqrt{\frac{V_{h'}}{V_h}}$, effective section modulus

Table 3.4 Allowable Shear Loads (kips) for Shear Connectors (ASD)

Connector size	Specific concrete compressive strength, ksi		
	3.0	3.5	$f_c' \geq 4.0$
Hooked or headed studs:			
½-in dia.× 2 in or more	5.1	5.5	5.9
5/8-in dia. ×2½ in or more	8.0	8.6	9.2
¾ in dia. × 3 in or more	11.5	12.5	13.3
7/8-in dia. ×3½ in or more	15.6	16.8	18.0

3.4.5 Engineering Calculation

Somewhat analogous to as-built drawings, the EOR should prepare a record of final calculations used for determining the size and type of all members and their connection configuration. Later, this record can be used for many purposes, including to re-analyze the design after a failure or to check the structural integrity of the framework for new loads due to changes in the physical configuration of the structure such as a new floor or an addition.

Unfortunately, large and complex jobs rarely have the final structural calculations in order. Oftentimes, preliminary designs and the iterative design of structural elements are mixed up with final calculations. Lastly, it is important that the results of the final design calculations match what was fabricated and erected in the field.

3.4.6 Detailing

Detailing is the process of converting the structural design drawings to shop drawings. These shop drawings are used by the fabricator to identify the size, shape, and material grade of every single piece of structural steel in the framework. Detailing is step by step, arduous process, although technological advancements such as CAD and electronic mail have made the job of the steel detailer easier. Detailers have the responsibility to interpret the structural design drawings for the purpose of determining what steel needs to be purchased and how it will all fit together.

- ✓ Advanced bill of material
- ✓ Erection drawing
- ✓ Detail drawings
- ✓ Submittals and approvals

- ✓ Fabrication
- ✓ Erection

3.4.7 Special Consideration in Structural Steel Design and Construction

Problems in the steel industry share many of the same characteristic as sister industries: plumbing, electrical, concrete, instrumentation, life safety and more. But, steel has some unique characteristic of its own which gives rise to special considerations in its design and construction.

- **Weight**

Steel is heavy and people associate weight with money and that is true. But the real cost of the steel framework is in the design of the connections. Efficiently designed connections translate into cost savings during fabrication and erection.

- **Connections**

As discussed earlier, the connection designer needs full information on loads and design intent from the EOR in order to design efficient and construct able connections.

- **Quality**

If one thing can be said about the steel construction industry it is that we can detect the differences between good steel and bad, and good workmanship and bad.

- **Schedule**

From engineering through erection all the steps are purposeful and necessary. Shortcuts are not tolerated, and when taken predictably result in unintended consequences.

- **Changes**

As discussed earlier, changes generated for whatever reason are the structural steel industry’s nemesis. The AISC code of Standard Practice for Steel Buildings and Bridges deals effectively with this issue. From SECTION 4.1 of the commentary it states:

“On phased construction projects, to insure the orderly flow of material procurement, detailing, fabrication and erection activities, it is essential that designs are not continuously revised after progressive releases for construction are made. In essence, once a portion of a design is releases for construction, the essential elements of that design should be “frozen” to assure adherence to the construction schedule or all parties should reach an understanding on the effects of future changes [change orders and claims] as they affect scheduled deliveries and added costs, if any”.

- **Cost Estimates**

We know so much about the design and construction of steel structures that cost estimates are reliable and accurate. Detailers, fabricators and erectors prepare cost estimates that meticulously reflect the work required during engineering, detailing, fabrication and erection.

- **Other Disciplines**

The AISC code requires that all data needed for the fabrication and erection of steel be located on the structural drawings. However, often times it is not. The EOR often records details and dimensions on architectural, electrical and mechanical drawings. The fabricator has to literally search for the information and must review every iteration of every drawing of every discipline to assure itself that changes to steel have not been made.

- **Structural Drawing**

In any discipline there is a convention for preparing plans. The protocol for steel is well known, agreed to, and it works.

- **Failure**

Even though so much is known about steel and structures are designed with conservative safety factors, structural failures occur. Structural failures can be forensically studied to determine their cause. Failures may result from bad design, poor assumptions, unanticipated loadings or combinations, bad material, poor workmanship, or microscopic anomalies. Material science is such today that with more than reasonable certainty we are able to determine the cause of any particular failure. With this information, the AISC collects and analyzes this information and periodically updates the code.

- **Economies of Scale**

Steel detailers strive to draw similar detail pieces and assemblies on single shop drawings to save time and money. Consider a project that has thirty-nine built-up columns (four plates welded together to form a box), all having the same end conditions and differing only in their length. Typically, the detailer might elect to show one illustration of the column on one shop drawing and use a column schedule to depict the lengths of each column giving each a shipping piece number. Thirty-nine shop drawings are clearly not needed and detailers, when putting together their proposals, count on such economies of scale.

CHAPTER FOUR

COMPARISON AND STRUCTURAL EVALUATION OF THE TWO SYSTEMS

4.1 EVALUATION OF THE SYSTEMS BASED ON ECONOMY

4.1.1 Cost Comparison

As the main objective of this study is to investigate the relative advantages of the use of steel structural members with that of normal concrete construction, this section deals with cost comparison of the two systems

The cost comparison is divided in to two components, the first is construction cost component, and the second - construction time component.

4.1.1.1 Construction Cost Component

In this section, the cost of construction (Material Labor and equipment including profit and overhead costs), using the two systems, of the four-story building is calculated.

4.1.1.1.1 Quantities of materials

Information required are:

- ☐ Quantity of material required to produce a unit amount
- ☐ Basic price at the source of material
- ☐ Transport, loading and unloading to the site
- ☐ Waste/loss

4.1.1.1.2 Labor Costs

Required information for the calculation of labor cost

- ☐ Number and type of skilled and unskilled manpower for a particular type of work, (Crew)
- ☐ Performance of crew per hour for a unit amount of work
- ☐ Indexed hourly cost of the workman ship.
- ☐ Utilization factor (UF) of the workmanship: Share of a particular personal per hour for the
- ☐ specified work.

4.1.1.1.3 Equipment Costs

Required information for the calculation of Equipment cost

- ☐ Type of equipment for a particular item of work.

- ☐ Performance of equipment per hour for a unit amount of work (production rate)

Two methods of calculation are followed.

i) With charges accounted for depreciation, interest return and monthly repair costs

ii) With monthly rental charges. And it is considered in this study

For the concrete system

Table 4.1 Cost summary of the concrete building partially

A. SUB-STRUCTURE	
Excavation and Earth work	109,628.70
Concrete work	343,517.45
Masonry work	20,487.00
Subtotal (A)	473,633.15
B.SUPER-STRUCTURE	
Concrete work	546,539.41
Structural Steel Works	193,164.14
Subtotal (B)	739,703.55
Total (A+B)	1,213,336.71

For the Steel system

Table 4.2 Cost summary of the steel-concrete building partially

A. SUB-STRUCTURE	
Excavation and Earth work	95,878.70
Concrete work	306,784.90
Masonry work	20,487.00
Subtotal (A)	423,150.60
B.SUPER-STRUCTURE	
Main structural steel works	1862563.88
Concrete work	264,264.24
Bolts, washers, plates, studs	184,735.10
Subtotal (B)	2,311,563.22
Total (A+B)	2,734,713.82

As can be seen from the two systems there is the difference

=**2,734,713.82 - 1,213,336.71=1,521,377.11birr**

4.1.2 Construction time component

It is known that the major advantage of using steel structural members for construction is the speed of construction, i.e. the use of this system saves construction time. Since in the construction, time is money the use of steel structural system saves time and it gives opportunity to save money and to answer the vast demand of house shortage relative to that of concrete systems.

Concrete structural System
Note: FR C filling and Curing stands for Formwork, Reinforcement Concrete filling and Curing.

In most construction activities, a number of crews are involved in particular activity to speed up the rate of construction, provided that, the contractor is capable of providing the necessary equipment and there is enough working area. For the purpose of comparison, in this research two crew are assumed to participate in each activities respectively,

Table 4.3 Rate of formwork, reinforcement and concrete

Main activity	Activities	Quantity	Output/day
FR C filling and curing	Formwork	m^2	125m2/day
	Reinforcement	kg	192kg/day
	Concrete	m^3	28.8m3/day

Table 4.4 Construction schedule for concrete system

PART	Main Activities	Specific Activities	Quantity	Output/day	Duration(Days)
SUB-STRUCTURE	EXCAVATION and EARTWORK	Site clearing	425 m2	425 m2/day	1
		Trench Excavation	52 m3	26m3/day	2
		Pit Excavation	689 m3	100m3/day	7
		Backfill around masonry and footing columns	375 m3	125m3/day	3
		Preparation of stone core	230 m3	125m3/day	2
	CONCRETE	Formwork	499 m2	125m2/day	4
		Reinforcement	11790 kg	192kg/day	62
		Concrete fill and Curing	424 m3	85m3/day	5
	MASONERY WORK	50cm thick hard trachytic masonry foundation	35 m3	18m3/day	2
		10mm thick expansion joint to be filled with Styrofoam	255 m	100m/day	3
SUPER-STRUCTURE	GROUND FLOOR COLS	FR C filling and curing			24
	1st FLOOR BEAMS	FR C filling and curing			21
	1st FLOOR COLUMNS	FR C filling and curing			25
	2nd FLOOR BEAMS	FR C filling and curing			22
	2nd FLOOR COLUMNS	FR C filling and curing			26
	3rd FLOOR BEAMS	FR C filling and curing			23
	3rd FLOOR COLUMNS	FR C filling and curing			27
	4th FLOOR BEAMS	FR C filling and curing			24
	4th FLOOR COLUMNS	FR C filling and curing			28

Steel structural System

Table 4.5 Construction schedule for steel-concrete system

PART	Main Activities	Specific Activities	Quantity	Output/day	Duration(Days)
SUB-STRUCTURE	EXCAVATION and EARTWORK	Site clearing	425 m2	425 m2/day	1
		Trench Excavation	52 m3	26m3/day	2
		Pit Excavation	689 m3	100m3/day	7
		Backfill around masonry and footing columns	375 m3	125m3/day	3
		Preparation of stone core	230 m3	125m3/day	2
	CONCRETE	Formwork	499 m2	125m2/day	4
		Reinforcement	7450kg	192kg/day	39
		Concrete fill and Curing	424 m3	85m3/day	5
	MASONERY WORK	50cm thick hard trachytic masonry foundation	35 m3	18m3/day	2
		10mm thick expansion joint to be filled with Styrofoam	255 m	100m/day	3
SUPER-STRUCTURE	GROUND and 1st FLOOR COLUMNS	Erection with connections	24pcs	6pcs/day	4
	1st FLOOR BEAMS	Erection with connections	230m=40pcs	4pcs/day	10
	2nd FLOOR BEAMS	Erection with connections	40pcs	4pcs/day	10
	2nd and 3rd FLOOR COLUMNS	Erection with connections	24pcs	6pcs/day	4
	3rd FLOOR BEAMS	Erection with connections	40pcs	4pcs/day	10
	4th FLOOR BEAMS	Erection with connections	40pcs	4pcs/day	10
	4th FLOOR COLUMNS	Erection with connections	24pcs	6pcs/day	4

Notes:

The preparation of the columns and beams for assembling the frame i.e. the works like preparation of holes, plates and angles at the connection is carried out parallel to the concrete work. For instance the columns of the ground floor are prepared when the footings are accomplished.

Since the I-sections are obtained in the length of 6m, and each floor of the building are 2.8m high; the consecutive columns is prepared at once.

As it can be clearly seen from the construction tables for the two systems, the construction time saved by using the steel structural system is, 191days=6.37months.

The current rental cost of buildings, on average, is about 85 Birr/m2 - month. The owner of a building project will be benefited this sum, if the two systems are compared with time duration. Hence the saving gained from the speed of construction may be converted to financial value as:

Saving from construction time = 9.56m×30m)×(6.37months)×85birr/(m2-month)

=155,287.86 birr

The total cost difference between the two systems is the sum of the difference of the two systems with regard to total construction cost component and from construction time component.

Total difference =1,521,377.11-155,287.86

= **1,366,089.25 birr**

The total cost of the steel-framed structure is in excess of **1,366,089.25 birr** with respect to the concrete building.

4.2 EVALUATION BASED OF THE MANAGEMENT AND EFFICIENCY OF THE CONSTRUCTION

- At Initial Level
  - ✓ Production stage

In the production of steel structural members the environment is controlled and managed with the help of machineries, since the production of steel structural members inquire steel industries, so one can get exactly the required strength and dimensions of the members. Thus at the production stage steel structures are more manageable and efficient to that of concrete.

- ✓ Analysis and Design stage

In the analysis and design of steel frame structures, one can use the exact weight of the members in the analysis and in the design part the strength of the section is used more than of 85% unlike concrete. So steel structural members are more manageable and efficient in analysis and design phase.

- o At Construction Level

At construction phase since most part of the steel structural members are arrived at the site almost processed; so the quality of the construction is hardly influenced by the site condition, so one can get the same quality of work regardless of the location of the site.

In addition steel members are processed in machineries, so it is not possible to adjust the size or the dimensions of the members in addition it doesn't allow chiseling to get the required shape unlike the concrete. In addition to these, shorter erection period permits an earlier recovery of capital.

- o At Functional Stage
  - ❒ A very long service life, provided care is taken.
  - ❒ The possibility of disassembling or replacing some steel members of a structure, for strengthening purposes.

As shown in the Fig. 4.1 for the construction of concrete-framed structure i.e. beams and columns scaffoldings are required but in steel-framed structure no need to use scaffoldings. In addition if proper maintenance and follow up is made, steel structures are more efficient than that of concrete. And from the dense nature of steel, it is more durable than concrete.

Fig. 4.1 Scaffoldings

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1. CONCLUSIONS

In this study a steel framed social housing building is proposed as alternative option for the buildings carried out these days. The steel framed social housing has given a good result with regard to the construction time required for the completion of the construction. Though there is a disadvantage with regard to the construction cost component.

In design and cost estimation of the steel framed social housing, the most part the building cost is incurred on the main members and labour costs since the work of steel structures needs highly skilled and professional manpower. Since steel construction in our country is rare, so it requires great effort for all stakeholders to contribute their share for the development of steel industries and to have well trained and skilled manpower especially the government, steel industries, governmental and private higher institutions.

If the steel structural members demand in the Ethiopia is increased, so the newly steel industries get an opportunity to open and the existing steel industries expand their production with quality and quantity of production. In the long run it will enhance the capacity of the inborn industries in Ethiopia and reduces the hard currency spend for importing steel products.

In Ethiopia especially in the capital, Addis Ababa, the construction industry is increasing with alarming rate so the demand of construction materials is augmented from day to day, by virtue of this the cost of raw materials like cement, sand etc is increased. From the this study and prevailing conditions in the country it cab be concluded using the steel structure construction is logical that is to lessen the burden of the customary construction system and to see a better development in the construction industry.

Finally from using the steel-framed social housing buildings, it can be concluded that many small-scale enterprises develop from the new opportunity encounter; the users, different parties in the construction (from planning to the construction completion) and in cumulative effect the country get benefited.

5.2 RECOMMENDATION

In this study the steel-framed social housing G+4 building is studied, the full building cost comparison is not accomplished. It is clear further and extensive research work needs to be done in order to accurately incorporate another alternatives and the total cost comparison among different options.

The following are among the areas of the steel structure which need further research.

1. Alternative steel-framed structure for high-rise buildings like G+8, G+20
2. Alternative steel structure with different slab system like hollow core beam, steel slab system and the wall system.
3. This study is carried out based on social-housing projects, it can be further studied in another commercial buildings.
4. Further extensive work is recommended to investigate the opportunity and benefits for the steel industries and stakeholders in the country.

APPENDIX A Design of Stair and Load Transfer to The Frame

DESIGN OF STAIR & LOAD TRANSFER TO THE FRAME

Span of stair =	**2.8**	**m**	**Fck=**	**20**	**mpa**				
Riser height=	**0.15**	**m**	**Fyk=**	**400**	**mpa**				
Ba=	**30**		**γc=**	**25**	**KN/m^3**				
Le=	**2.8**	**m**							
Depth to avoid									
deflection=	**d>=(0.4+0.6*fyk/400)*Le/Ba**			**d>=**	**93.3333**	**mm**			
	D=	**d+15mm+10mm**		**D=**	**118.333**	**mm**	**Take D=**	**150**	**mm**
Loading							**Take d=**	**125**	
	Dead load=								
		Own weight of							
		slab=	**γc*D=**	**3.75**	**KN/m^2**				
		Own weight of							
		step=	**γc*R/2=**	**1.50**	**KN/m^2**				
		Own weight of							
		Finishing=							
		Marble=	**γm*Dm=**	**0.54**					
		Screed=	**γs*Ds=**	**0.60**					
		Plastering=	**γp*Dp=**	**0.40**					
			TDL=	**6.79**					
			FTDL=	**8.83**					
	Live load=	**3**	**KN/m^2**						
			FTLL=	**4.80**	**KN/m^2**				
	Design load=	**Pd=**	**FTDL+FTLL=**	**13.63**	**KN/m^2**				
Design									
	Moment M=	**Pd*Le^2/8=**	**13.35446**	**KN-M**					
		Km=	**M^0.5/d=**	**29.24**	**Ks=**	**3.02**			
		As=	**Ks*M/d=**	**322.64**	**mm^2**				
		spacing using							
		Dia 8	**154.9697**	**mm**					
		Dia 10	**243.3024**	**mm**					
	Therefore use dia 10 c/c 200								
Reaction from stair									
to beam									
	Rdl=	**FTDL*Le/2=**	**12.3578**	**KN/M**	**9.51**		**7.31**		
	Rll=	**FTLL*Le/2=**	**6.72**	**KN/M**	**4.20**		**2.63**		

APPENDIX B Cost-estimation of Building using Concrete

	COST-ESTIMATION OF BUILDING USING CONCRETE				
No.	**Description**	**Unit**	**Qty.**	**Rate**	**Amount**
	A. SUB-STRUCTURE				
	1.EXCAVATION & EARTH WORK				
1.1	Clear area from top organic soil and vegetation to an average depth of 20cm.	m^2	425	4.4	1,870.00
1.2	Excavate trenchcy for foundation to depth not exceeding 150cm. in ordinary soil to remove expansive soil to a depth of about 67 cm from natural ground level.	m^3	52	23.25	1,209.00
1.3	Pit excavation in ordinary soil to a septh 250cm for footing and footing column.	m^3	689	36.95	25,458.55
1.4	Back fill around masonary footing and footing column with selected materials brought form outside and well ram in layers.	m^3	375	110.00	41,250.00
1.5	Ditto, 1.4 But under hard-core and interal grade beams.		107	115.65	12,374.55
1.6	Cart away all surplus excavated materials and deposit to a distance not exceeding 2km from the site.		828	20.95	17,346.60
1.7	25cm thick basalic or equivalent stone core well rolled consolidated and blinded with crushed stone.	m^3	230	44.00	10,120.00
	Total carried to summary Eth. Birr				**109,628.70**

	2. CONCRETE WORK				
2.1	5cm thick lean concrete of class C-5, 150kg of cement/m3 under				
	a) Masonary foundation	m^2	33	32.30	1,065.90
	b) Footing	m^2	201	32.30	6,492.30
2.2	Reinforced concrete class C-25 360kg cement/m3 filled in to form work and vibrated around reinforcement (Reinforcement bar and form work measured separately):				
	a) In footings	m^3	108	1,034.05	111,677.40
	b) In foundation columns.	m^3	8	1,065.65	8,525.20
	c) In grade beams	m^3	21	1,034.05	21,715.05
	d) In 10cm thick ground floot slab.	m^2	287	101.95	29,259.65
2.3	Provide, cut and fix in position sawn zigba wood Formwork:				
	a)To footing.	m^2	272	75.05	20,413.60
	b) To footing column.	m^2	76	75.05	5,703.80
	c)To grade beams	m^2	151	75.05	11,332.55
2.4	Mild steel reinforcement according to structural drawings. Price includes cutting, bending, placing in position and tying wires.				
	a) Φ 8 mm deformed bars.	kgs.	1,363	10.80	14,720.40
	b) Φ 12 mm deformed bars.	kgs.	87	10.80	939.60
	c) Φ 14 mm deformed bars.	kgs.	6,212	10.80	67,089.60
	d) Φ 16 mm deformed bars.	kgs.	1,614	10.80	17,431.20
	e) Φ 20 mm deformed bars.	kgs.	2,514	10.80	27,151.20
	Total carried to summary Eth. Birr				**343,517.45**

	a)To footing.	m^2	272	75.05	20,413.60
	b) To footing column.	m^2	76	75.05	5,703.80
	c)To grade beams	m^2	151	75.05	11,332.55
2.4	Mild steel reinforcement according to structural drawings. Price includes cutting, bending, placing in position and tying wires.				
	a) Φ 8 mm deformed bars.	kgs.	1,363	10.80	14,720.40
	b) Φ 12 mm deformed bars.	kgs.	87	10.80	939.60
	c) Φ 14 mm deformed bars.	kgs.	6,212	10.80	67,089.60
	d) Φ 16 mm deformed bars.	kgs.	1,614	10.80	17,431.20
	e) Φ 20 mm deformed bars.	kgs.	2,514	10.80	27,151.20
	Total carried to summary Eth. Birr				**343,517.45**
	3.MASONRY WORK				
3.1	50cm thick hard trachytic or equivalent stone masonary foundation wall bedded in cement mortar 1:4.	m3	35	454.2	15897
3.2	10mm thick expantion joint to be filled with styrofoam between floor slap and grade beam.	M1	255	18	4590
	Total carried to summary Eth. Birr				**20,487.00**
	B. SUPER STRUCTURE				
	1.CONCRETE WORK				
1.1	Reinforced concrete class c-25, 360 kgs cement/m^3 filled in to forms work and vibrated around reinforcement bar.(Reinforcement bar and form work measured separately:)				
	a) In elevation columns.	m^3	30	1,071.38	32,141.40
	b) In floor beams	m^3	51	1,035.10	52,790.10
	c) In water tower slab.	m^3	3	1,031.50	3,094.50
	d) In stair case	m^3	12	1,072.38	12,868.56
	e) In water tawer beams.	m^3	1	1,035.10	1,035.10
	f) In top tie beams.	m^3	10	1,035.10	10,351.00
1.2	Ribbed slab for(1st-4th)floors made of 6mm thick concrete slab,80*120mm one way precast concrete beam(girder) with C/C spacing 625mm, 220*515mm avg. hallow concrete reimed block all according to the detail structural drawing.	m^3	67	1,027.20	68,822.40
1.3	Provide, cut and fix in position sawn Zigba wood steel form work which every apropriate.				
	a)To elevation columns.	m^2	405	75.05	30,395.25
	b) To floor beams	m^2	718	75.05	53,885.90
	c)To water tawer slab	m^2	21	75.05	1,576.05

	2. BLOCK WORK				
2.1	20cm thick HCB wall bedded with cement mortar 1:3 type B.	m^2	1,283	142.60	182,955.80
2.2	10cm thick HCB wall bedded with cement mortar 1:3 type B.	m^2	586	96.60	56,607.60
2.3	Slab HCB	m^2	1,050	101.00	106,050.00
	Total carried to summary Eth. Birr				**345,613.40**
	3. ROOFING				
3.1	Supply and fix FGA-500, 0.3 mm thick roof cover including all the necessary fixing accesseries	m^2	327	124.20	40,613.40
3.2	Supply and fix ridge cover G-28 development length 33cm	M1	31	39.70	1,230.70
3.3	Supply and fix gutter G-28 development length 66cm including all the nacessary	M1	62	59.75	3,704.50
3.4	Supply and fix PVC (diam. 110mm) down pipe with anchorage distance of 80cm	M1	196	63.15	12,377.40
	Total carried to summary Eth. Birr				**57,926.00**
	4.METAL WORK				
	Supply and fix metal window and door(glazed measured separately) made 38*38 LTZ black steel from. Price including best qualitiy iron cylinder door lock and one coat of antirust with two coat synthetic enamel paint all according to the detail drawing				
4.1	Doors				
	Size:-a) 90*230cm front	Pcs	30	1,128.36	33,850.80
	b)70*230cm tailes	Pcs	30	877.61	26,328.30
	c)70*210cm kare	Pcs	30	801.30	24,039.00
4.2	Windows				
	Size:-a) 100*140cm	Pcs	110	478.54	52,639.40
	b)50*80cm	Pcs	30	136.73	4,101.90
	Total carried to summary Eth. Birr				**140,959.40**
	5. JOINERY				
5.1	Supply and fix flush wooden doors.				
	Size:-a)80*210cm	Pcs	60	1,384.28	83,056.80
5.2	8mm thick cheap wood ceiling mailed to 4*5cm Zigba buttons placed in C/C 60cm both ways price includes Zigba button and corner list	m^2	260	107.40	27,924.00
	Total carried to summary Eth. Birr				**110,980.80**

	6. SRUCTURAL STEEL WORK				
	Supplies fabricate and mount steel truss and pure line according to the structural drawing price shall be including one coats of antirust painting and all other necessary accessaries.				
6.1	TRUSS				
	C)RHS upper and lower chord (50*50*3)mm	kg	677	26.78	18,130.06
	d) RHS vertical and diagonal members (40*40*3)mm	kg	367	26.78	9,828.26
6.2	RHS pure line (2*25*2.5mm)	kg	5,642	26.78	151,092.76
6.3	RHS hand rail and balustrade(50*50*2mm)	kg	527	26.78	14,113.06
	Total carried to summary Eth. Birr				**193,164.14**
	7. PRECAST WORKING				
7.1	Pre-cast element of 4960*120*8mm mode of 0.048$m^{3/}$beam	Pcs	256	408	104448
7.2	Pre-cast element of 5000*120*80mm mode of 0.048m^2/beam	Pcs	128	408.00	52,224.00
	Total carried to summary Eth. Birr				**156,672.00**
	8.LINTEL WORK				
8.1	Reinforced concrete quality C-20,300kg cement/m^3	m^3	4	928	3,712.00
8.2	Mild steel reinforcement bar price includes cutting, binding, placing in position tying wire				
	h)Φ 6mm plain bar	kg	134	10.80	1,447.20
	i)Φ 10mm reinformed bar	kg	600	10.80	6,480.00
8.3	Proved cut and fix in position sawn Zigba wood form work	m^2	94	75.05	7,054.70
	Total carried to summary Eth. Birr				18,693.90

	9. FINISHING				
9.1	Apply three coats of plaster finish upto fine coat to all interal wall surface, exposed concrete beams & columns with cement mortar(1:3)	m^2	4,228	42.50	179,690.00
9.2	Apply tyrolin tundering to external plastered vertical surfaces including beams and columns.	m^2	870	41.00	35,670.00
9.3	Sermic wall tile for toilets (1:2m high) of size 15*15	m^2	234	115.00	26,910.00
9.4	4.8cm thick cement sand screed (1:3)	m^2	845	64.00	54,080.00
9.5	3cm thick cement sand screed (1:3)	m^2	454	49.30	22,382.20
9.6	Terrzzo tiles for toilet and verandah and kitchens (20*20*2)	m^2	454	140.00	63,560.00
9.7	Plastering ceiling part of the slab edged and also for the stair cases(three coats upto fine finish)	m^2	1,338	39.10	52,315.80
9.8	PVC tile floor finish for bed room and living dinning room (Size:-30*30cm)	m^2	845	100.75	85,133.75
	Total carried to summary Eth. Birr				**519,741.75**
	10. GLAZING				
10.1	4mm thick ordernary glizing quality clear sheet glass glized to metal windows with putty	m^2	120	89.10	10,692.00
10.2	Ditto, item 10.1 but to metal doors	m^2	10	89.10	891.00
	Total carried to summary Eth. Birr				11,583.00
	11. PAINTING				
11.1	Apply three coats of aproved type plastic paint to all internal wall surface exposed concrete beam and column .	m^2	4,228	18	76,104.00
11.2	Ditto to 11.1 but external rendered vertical surface	m^2	870	18	15,660.00
11.3	Ditto to 11.1 but chip wood and concrete ceiling	m^2	1,598	18	28,764.00
11.4	Synthetic paint for skirting 15cm high	m^2	1,509	18.15	27,388.35
	Total carried to summary Eth. Birr				**147,916.35**

APPENDIX C Cost-estimation of Building using Steel-Concrete

	COST-ESTIMATION OF BUILDING USING STEEL-CONCRETE				
No.	**Description**	**Unit**	**Qty.**	**Rate**	**Amount**
	A. SUB-STRUCTURE				
	1.EXCAVATION & EARTH WORK				
1.1	Clear area from top organic soil and vegetation to an average depth of 20cm.	m^2	425	4.4	1,870.00
1.2	Excavate trenchcy for foundation to depth not exceeding 150cm. in ordinary soil to remove expansive soil to a depth of about 67 cm from natural ground level.	m^3	52	23.25	1,209.00
1.3	Pit excavation in ordinary soil to a septh 250cm for footing and footing column.	m^3	689	36.95	25,458.55
1.4	Back fill around masonary footing and with selected materials brought form outside and well ram in layers.	m^3	250	110.00	27,500.00
1.5	Ditto, 1.4 But under hard-core and interal grade beams.		107	115.65	12,374.55
1.6	Cart away all surplus excavated materials and deposit to a distance not exceeding 2km from the site.		828	20.95	17,346.60
1.7	25cm thick basalic or equivalent stone core well rolled consolidated and blinded with crushed stone.	m^3	230	44.00	10,120.00
	Total carried to summary Eth. Birr				**95,878.70**

	2. CONCRETE WORK				
2.1	5cm thick lean concrete of class C-5, 150kg of cement/m3 under				
	a) Masonary foundation	m^2	33	32.30	1,065.90
	b) Footing	m^2		32.30	
2.2	Reinforced concrete class C-25 360kg cement/m3 filled in to form work and vibrated around reinforcement (Reinforcement bar and form work measured separately):				
	a) In footings	m^3	108	1,034.05	111,677.40
	b) In foundation columns.	m^3		1,065.65	
	c) In grade beams	m^3		1,034.05	
	d) In 10cm thick ground floot slab.	m^2	287	101.95	29,259.65
2.3	Provide, cut and fix in position sawn zigba wood Formwork:				
	a)To footing.	m^2	272	75.05	20,413.60
	b) To footing column.	m^2	76	75.05	5,703.80
	c)To grade beams	m^2	151	75.05	11,332.55
2.4	Mild steel reinforcement according to structural drawings. Price includes cutting, bending, placing in position and tying wires.				
	a) Φ 8 mm deformed bars.	kgs.	1,363	10.80	14,720.40
	b) Φ 12 mm deformed bars.	kgs.	87	10.80	939.60
	c) Φ 14 mm deformed bars.	kgs.	6,212	10.80	67,089.60
	d) Φ 16 mm deformed bars.	kgs.	1,614	10.80	17,431.20
	e) Φ 20 mm deformed bars.	kgs.	2,514	10.80	27,151.20
	Total carried to summary Eth. Birr				**306,784.90**

	3.MASONRY WORK				
3.1	50cm thick hard trachytic or equivalent stone masonary foundation wall bedded in cement mortar 1:4.	m3	35	454.2	15897
3.2	10mm thick expantion joint to be filled with styrofoam between floor slap and grade beam.	M1	255	18	4590
	Total carried to summary Eth. Birr				**20,487.00**
	4.STEEL WORKS				
4.1	2No 600*800*15mm thick plates price includes cutting, drilling	Pcs	24	400	9600
4.2	J-bolts lemgth 1.80m price includes bending and nuts, washers	Pcs	96	112.5	10,800.00
	Total carried to summary Eth. Birr				**20,400.00**
	B. SUPER STRUCTURE				
	1.STRUCTURAL STEEL WORKS				
1.1	The main structural frame elements W-section 6m length. Price includes cutting, drilling for bolts, machineries for erection				
	a) In elevation columns W200*47.	Pcs	56	11,235.00	629,160.00
	b) In floor beams W200*36	Pcs	90	10,568.45	951,160.50
	b) In top-tie beams W150*25	Pcs	12	8,125.69	97,508.28
1.2	Bolts, washers, splie plates, studs price includes welding for studs				
	a) Bolts and washers	Pcs	2,353	68.90	162,121.70
	b) splice plates 10mm thickness	m^2	168	78.80	13,238.40
	c) studs Φ 8mm	m	150	62.50	9,375.00
	Total carried to summary Eth. Birr				**1,862,563.88**

	2.CONCRETE WORK				
2.1	Reinforced concrete class c-25, 360 kgs cement/m^3 filled in to forms work and vibrated around reinforcement bar.(Reinforcement bar and form work measured separately:)				
	a) In elevation columns.	m^3	2	1,071.38	2,142.76
	b) In floor beams	m^3	2	1,035.10	2,070.20
	c) In water tower slab.	m^3	3	1,031.50	3,094.50
	d) In stair case	m^3	1	1,072.38	1,072.38
	e) In water tawer beams.	m^3	1	1,035.10	1,035.10
	f) In top tie beams.	m^3	1	1,035.10	1,035.10
2.2	Ribbed slab for(1st-4th)floors made of 6mm thick concrete slab,80*120mm one way precast concrete beam(girder) with C/C spacing 625mm, 220*515mm avg. hallow concrete reimed block all according to the detail structural drawing.	m^3	67	1,027.20	68,822.40
2.3	Provide, cut and fix in position sawn Zigba wood steel form work which every apropriate.				
	a)To elevation columns.	m^2	1	75.05	75.05
	b) To floor beams	m^2	1	75.05	75.05
	c)To water tawer slab	m^2	21	75.05	1,576.05
	d) To stair case	m^2	58	75.05	4,352.90
	e)To water tower beams .	m^2	2	75.05	150.10
	f) To floor slabs	m^2	897	75.05	67,319.85
2.4	Mild steel reinforcement according to structural drawings. Price includes cutting, binding, placing in position and tying wire.				
	a) Φ 8 mm deformed bar.	kgs.	2,353	10.80	25,412.40
	b) Φ 10 mm deformed bar.	kgs.	1,985	10.80	21,438.00
	c) Φ 12 mm deformed bar.	kgs.	976	10.80	10,540.80
	d) Φ 14 mm deformed bar	kgs.	2,000	10.80	21,600.00
	e) Φ 16 mm deformed bar	kgs.	80	10.80	864.00
	f) Φ 20 mm deformed bar.	kgs.	1,000	10.80	10,800.00
	g) Φ6 mm plain bar.	kgs.	1,647	10.80	17,787.60
	Total carried to summary Eth. Birr				**261,264.24**
	3. BLOCK WORK				
3.1	20cm thick HCB wall bedded with cement mortar 1:3 type B.	m^2	1,283	142.60	182,955.80
3.2	10cm thick HCB wall bedded with cement mortar 1:3 type B.	m^2	586	96.60	56,607.60
2.3	Slab HCB	m^2	1,050	101.00	106,050.00
	Total carried to summary Eth. Birr				**345,613.40**

APPENDIX D Analysis for Lateral Load Based on ESCP-1

ANALYSIS FOR LATERAL LOAD BASED ON ESCP-1							
	Basment	Ground	First	Second	Third	Fourth	Roof
DEAD LOAD (KN)							
LIVE LOAD (KN)							
Total Height of the Building (m)	16.00						
Total Distance along X-direction, (m)	30.30						
Total Distance along Y-direction, (m)	9.60						
Total Dead Load, Gk (KN)	-						
Total Live Load, Qk (KN)	-						
Live Incident Factor, y	-						
Equivalent Load,Geq.	= Gk + y Qk	-					
Bed rock acceleration ratio, ao	0.05						
Importance Factor, I	1.00						
a	= ao* I	0.05					
Soil Classification, S	1.20						
T	=(0.075*H^(3/4))	0.60					
bo	= 1.2/(T^(2/3))	1.69					
Elastic Response Factor, b	bo*S	2.02					
Behaviour Factor depending on the type of structure, g	0.30						
Sd=	α* β*γ	0.03					
Fb (KN)=	Sd*Geq.	-					
Ft (KN)=	0.07*T*Fb	-					
	Fb-Ft=	-					

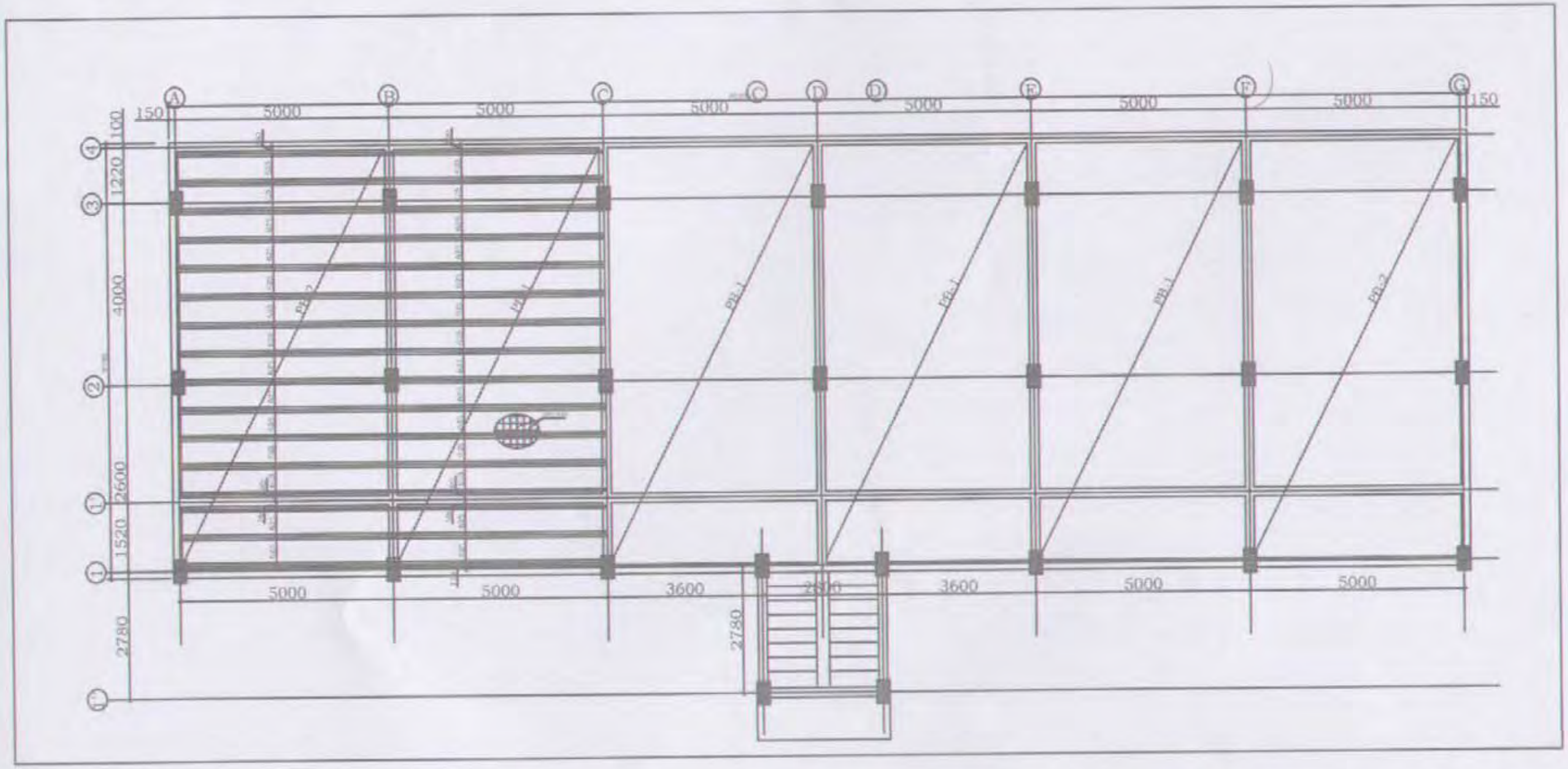


Fig. E-1 Concrete Typical (1 - 4 Floor) Slab Reinforcement Sc1:50

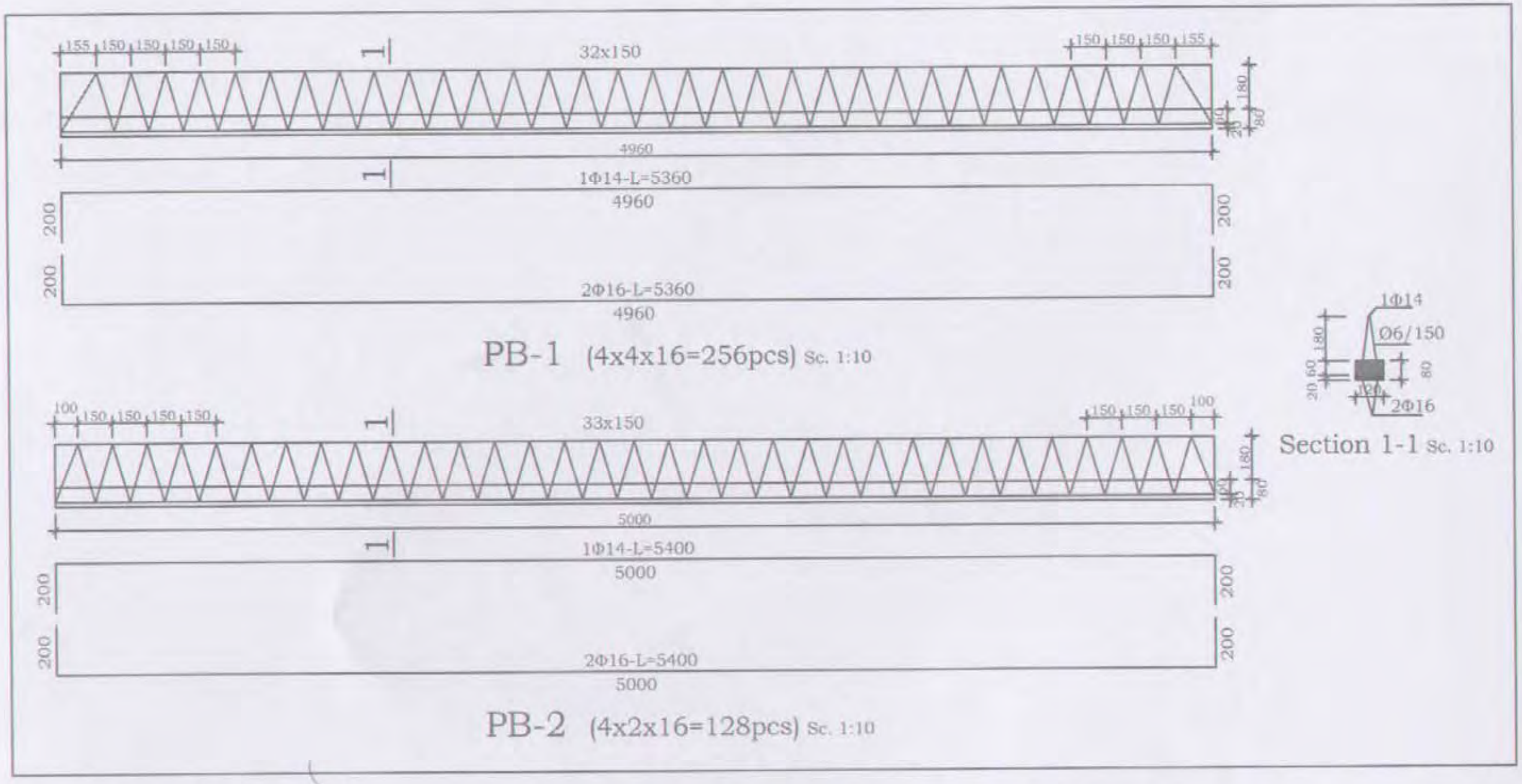


Fig. E-2 Precast Beam Detail Sc1:10

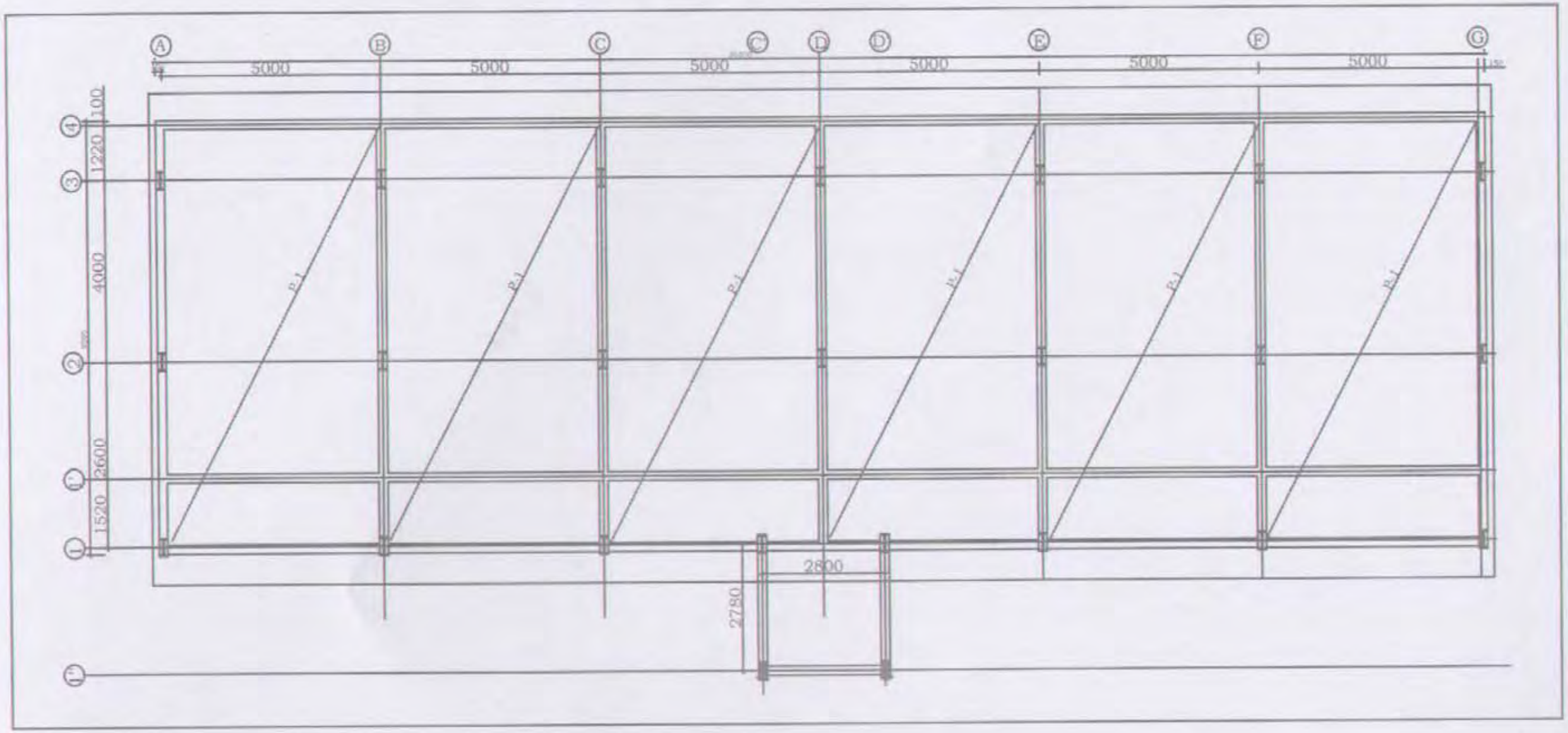


Fig. E-3 Typical Steel Slab Detail Sc1:50

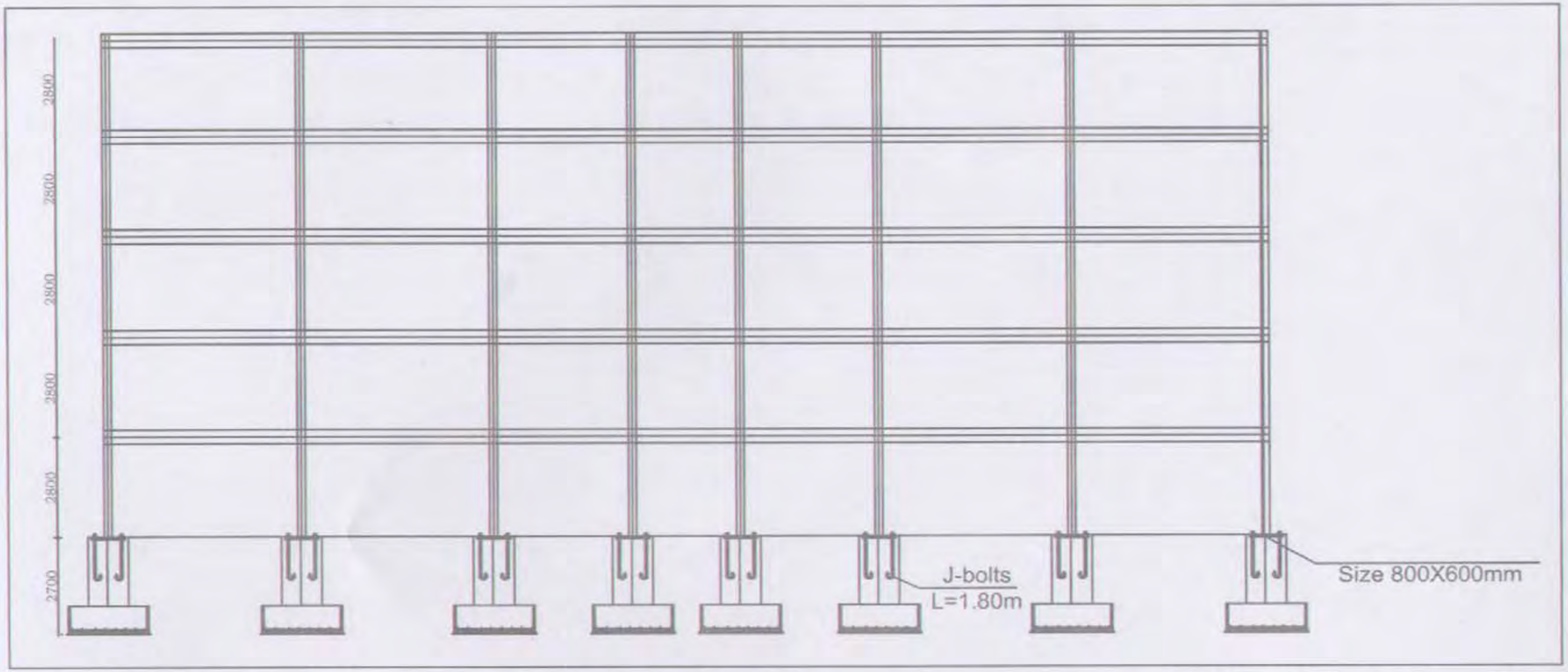


Fig. E-4 Frame on Axis 1-1 Sc1:50

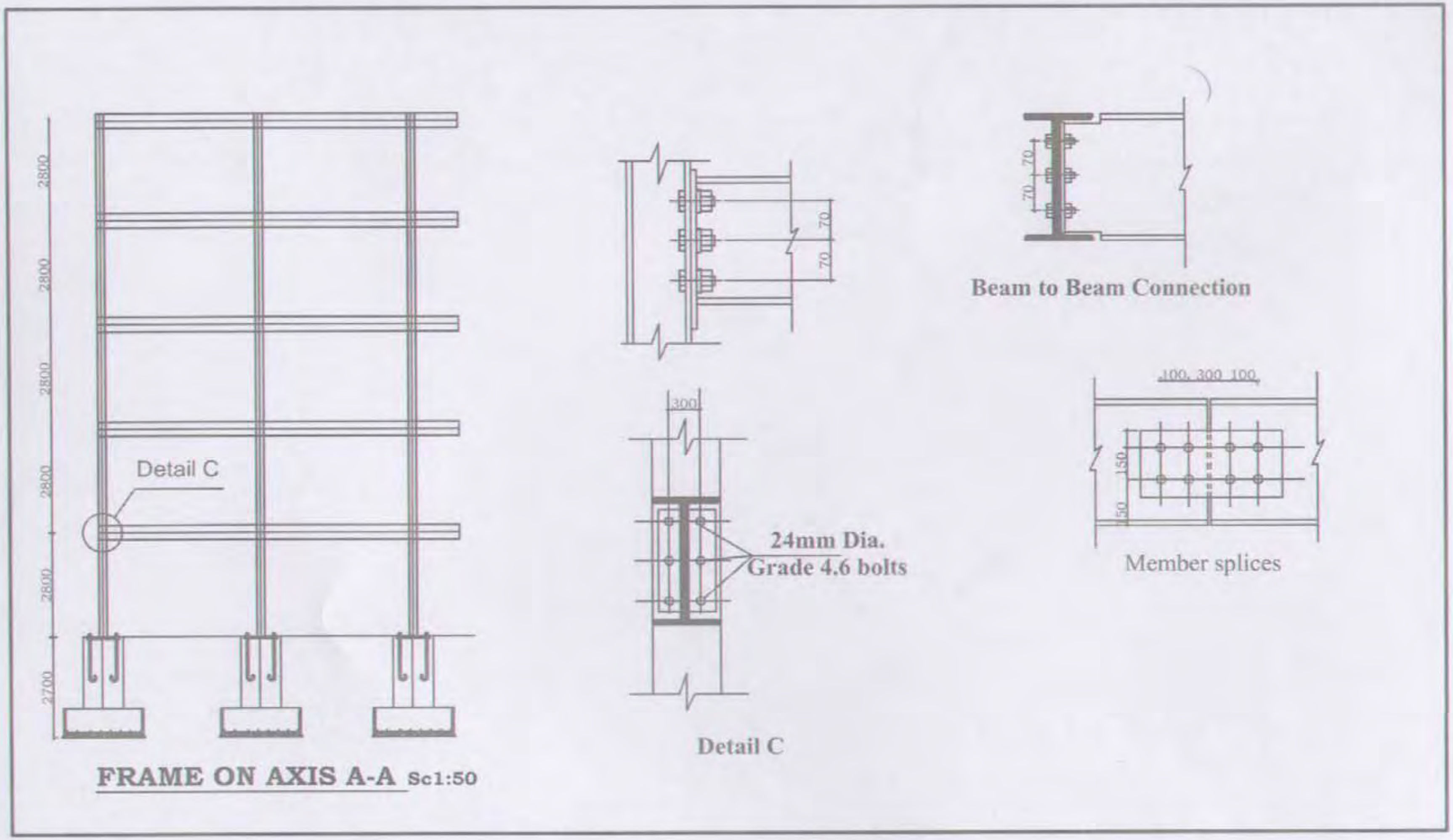
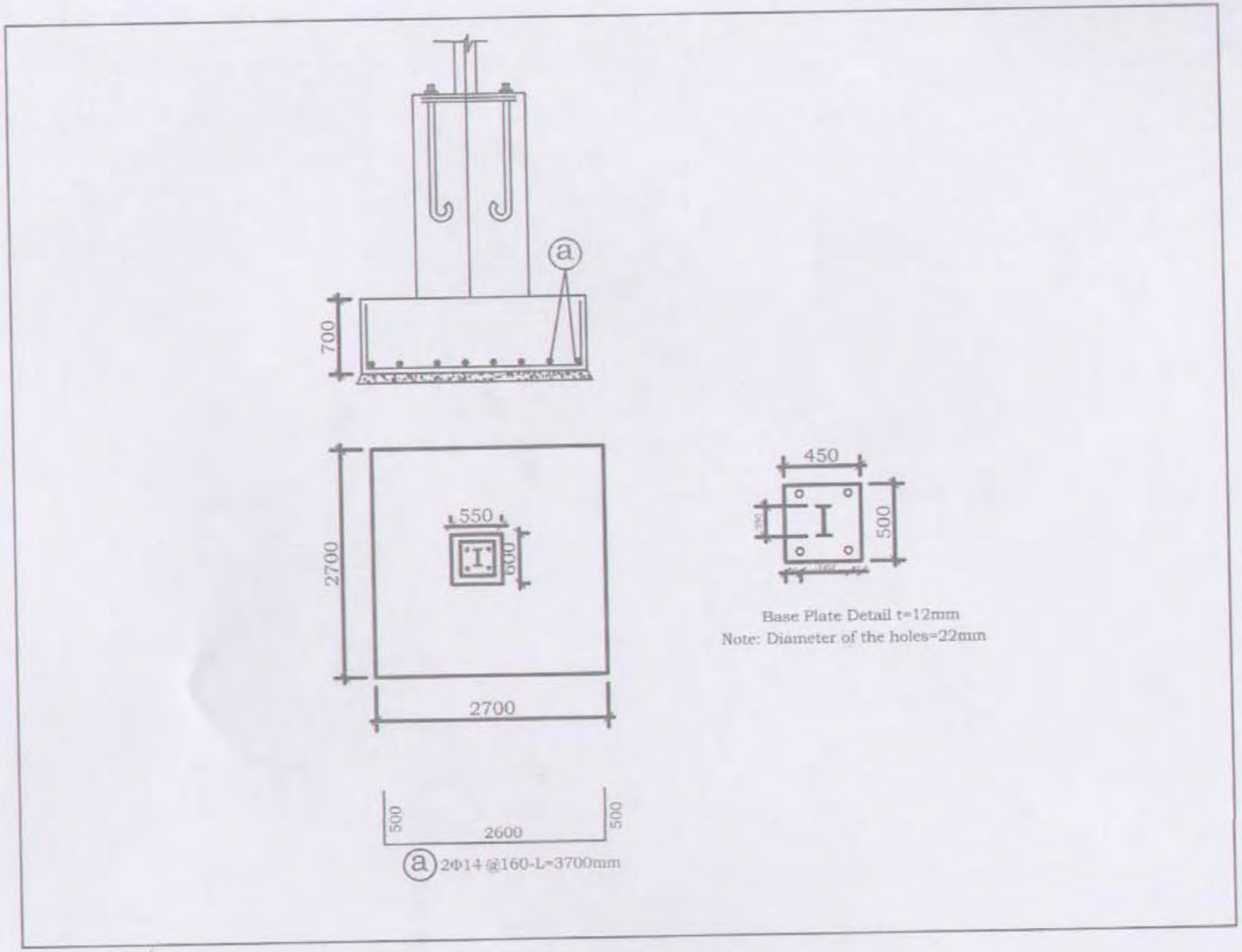


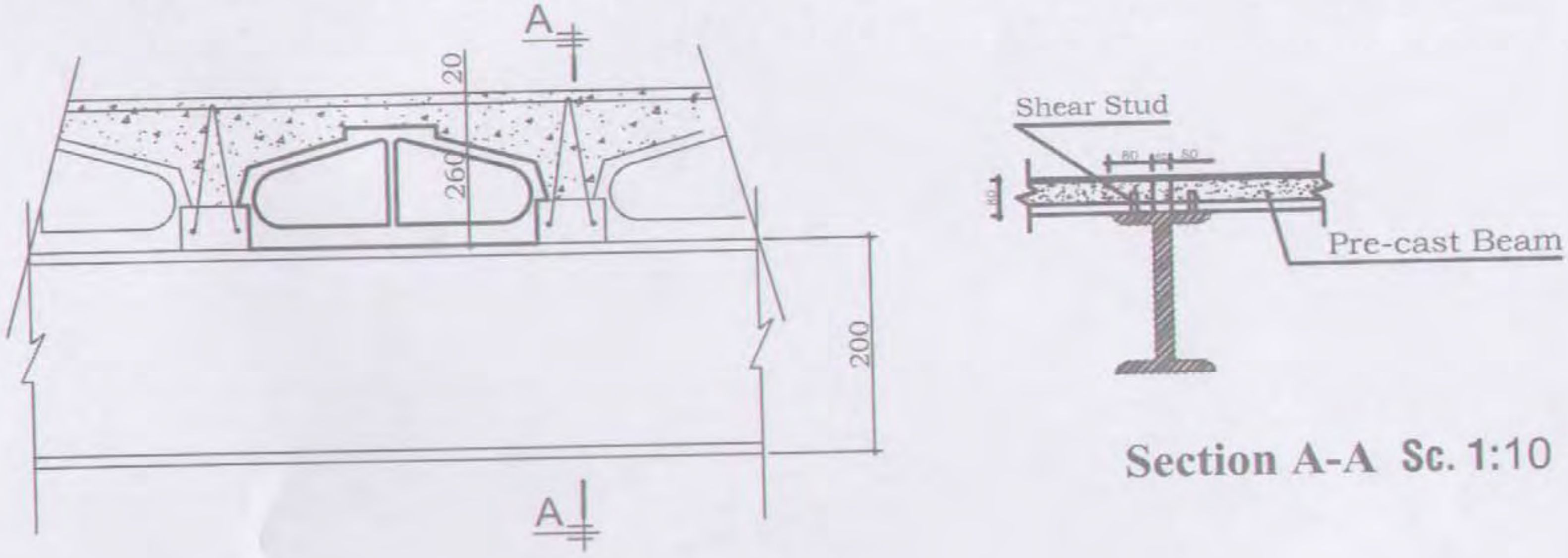
Fig. E-5 Frame & Detailing



Base Plate Detail t=12mm
Note: Diameter of the holes=22mm

ⓐ 2Φ14 @160-L=3700mm

Fig. E-6 a. Footing Detail Sc1:50



Slab to Beam Connection Sc. 1:05

Section A-A Sc. 1:10

Fig. E-7 **Slab to Beam Connection and detail**

REFERENCES

1. CEN. Euro code 3: Design of Steel Structures. Design of steel structures (prEN 1993), Draft Edition.2004
2. Design guide manual by Dr. Shifferaw Taye (D.Sc PPst Engineer, an Associate professor of Civil Engineering at A.A.U)
3. Design of steel structures,
4. Design of steel structures, Bowels, Mc-Gram Hill Book Company.
5. EBCS-2(1995): Structural use of Concrete, Ministry of Works and Urban Development, Addis Ababa, Ethiopia
6. EBCS-3(1995): Design of Steel Structures, Ministry of Works and Urban Development, Addis Ababa, Ethiopia
7. EBCS-7(1995): Foundation, Ministry of Works and Urban Development, Addis Ababa, Ethiopia
8. EBCS-8(1995): Earthquake, Ministry of Works and Urban Development, Addis Ababa, Ethiopia
9. ETABS Release 9.0 Documentation, Computer and Structures Inc.,1995
10. Foundation Analysis and Design, Bowles, Mc-Gram Hill Book company, 3rd edition; 1982G.C
11. Housing as a Social Right: Implications for Welfare State Theory, Boelhouwer and van der Heijden 1992.
12. Lecture Notes, by Dr. Ing. Asrat Worku (AAU), 2002G.C
13. Lecture Notes, Steel and Timber Structure, by Dr. Shifferaw Taye, 2002/2003G.C
14. Low-cost-housing-Ethiopia-technical-manual, Addis Ababa, 2003
15. Low-cost-housing-Ethiopia-technical-manual, Addis Ababa, 2003
16. Structural Mechanics, A.Darkev D.Sc(Eng.), Mir publishers Mascow; 1979G.C
17. Structural Steel Design and Construction by Gary S. Berman, PE; Grayhawk North America, LLC
18. W.F.Chen And S.Toma, Advanced Analysis of Steel Frames, CRC Press , Inc,1994

Candidates Declaration

I hereby declare that the work which is being presented in this thesis entitles"**Alternative Concrete-Steel Building Construction for Social Housing Projects"** is original work of my own, has not been presented for a degree in any other university and that all sources of material used for the thesis have been duly acknowledged.

TEN-HL.

Tsehaye Eshetu

Dec. 17/2008.

Date

This is to certify that the above declaration made by the candidate is correct to the best of my knowledge.

Dr. Shifferaw Taye (Advisor)

17 December 2008

Date