Addis Ababa University

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School of Civil and Environmental Engineering

STUDY ON THE ALTERNATIVE STRUCTURAL SUSTAINABLE HOUSE SYSTEM (CASE STUDY IN DEBRE BIRHAN CITY)

Teferi Tekliye

A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Science in Civil Engineering

(Structures)

Addis Ababa | June, 2020

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STUDY ON THE ALTERNATIVE STRUCTURAL SUSTAINABLE HOUSE SYSTEM (CASE STUDY IN DEBRE BIRHAN CITY)

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Addis Ababa | June 2020

The undersigned have examined the thesis entitled '**Study on the alternative structural sustainable house system(case study in Debre Birhan city)** presented by **Teferi Tekliye** a candidate for the degree of **Master of Science** and hereby certify that it is worthy of acceptance.

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Advisor	Signature	Date
Internal Examiner	Signature	Date
External Examiner	Signature	Date
Chairperson	Signature	Date

DECLARATION

I certify that research work titled "study on the alternative structural sustainable house system (case study in Debre Birhan city)" is the author's work. The work has not been presented elsewhere for assessment. Where material has been used from other sources it has been properly acknowledged.

Teferi Tekliye

ABSTRACT

As many developing countries, Ethiopia has a lot of challenge. Along with the Ethiopian growth in the house construction of buildings come the predictable adverse on environmental, economic, and social effects. These effects are ongoing all over the life cycle of the house structure. A problem fronting the Ethiopian society is thus to give a growing population opportunities to obtain sustainable and inexpensive housing. Now a day's house construction in Debre Birhan city has undesirable impacts on the economic cost environment and social. Currently, there are many house systems with different goals and valuation scopes in some details. One way to attain this is to use steel technology, which means that houses are constructed by steel frame and composite deck slab. This report is explored some misunderstanding in choosing the suitable system for the house construction in agreement its environmental, social, and economic contexts. Also the study was aimed to equate and deliver overview and components of the systems. The contrast results can be used as a guideline for additional expansion of sustainable house systems. It is initiate that most major sustainable house systems still concern only environmental issues while newly advanced methods have involved social and economic issues in their criteria.

To comprehensive the thesis, structural analysis and cost analysis of the three systems are carried out based on cost estimation and new proposed design of two stories and the 3D Model of the steel frame with composite slab is analyzed using ETABS 16 software. Environmental assessment is carryout of the three type house construction.

Keywords: Steel, Reinforced Concrete, Wood, Environmental Impact, Economic Impact, Social Impact, Filled Composite Deck slab, ETABS 16 Ultimate.

ACKNOWLEDGMENT

First thanks and praise is to the almighty GOD who has strengthened me through my journey. I would like to thank my thesis advisor **Dr. Sifferaw Taye** for his valuable suggestions and advice. His office was always open whenever I ran into a trouble spot or had a question about my research. He consistently allowed this thesis to be my own work, but steered me in the right the direction whenever he thought I needed it.

Finally, I must express my very profound gratitude to my family for providing me with unfailing support and continuous encouragement throughout my years of study and through the process of researching and writing this thesis. This accomplishment would not have been possible without them. Thank you.

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LIST OF SYMBOLS

ETABS = Extended Three-Dimensional Analysis of Building Systems

Ea = Design Value of Modulus of Elasticity of Structural Steel

Ecd = Design Value of Modulus of Elasticity of Concrete

Ecm = Secant Modulus of Elasticity of Concrete

EI = Flexural Rigidity (per unit width for slabs)

Es = Design Value of Modulus of Elasticity of Reinforcing Steel

Mb,Rd = The Design Buckling Resistance Moment of A Laterally Unrestrained Beam

Mpl, Rd = Plastic Moment Resistance of the Steel Section

Msd = Design Bending Moment

Ncr = Critical Buckling Load

P,Rd = Plastic Resistance to Compression

Wpan = Plastic Section Moduli for the Structural Steel

RII = Relative Important Index

LCA = Life Cycle Assessment

EOF = End –of-Life

GWP = Global Warming Potential

USDOE = United State Department of Energy Production

EEPA = Ethiopia Environmental Protection Authority

MOEP = Ministry Of Environment Protection

EELP = Ethiopia Environmental Law Proclamation

EEFI = Ethiopia Environment and Forest Institute

LEED = Leadership in Energy and Environmental Design

CHAPTER 1 INTRODUCTION

Rendering to the Human Development Report (2014) Ethiopia orders number 175 out of 186 nations. It's expected that 81% of the city society are living in a difficult area where proper public facilities like access to potable water, electric power supply and emergency access etc. are not properly available. This needs the government to encourage the construction of residential house in slum area in unalike cities of the country. Since construction house needed higher investment, it's difficult to curb the challenge with limited resources.

This showed that the low profile Ethiopia should be taken a lot of measures taken to improve the affordable house opportunity. Still many accomplishments have yet been taken to introduce relatively low cost and sustainable design so that to constructed as many houses as possible. (Benget Hjort and Kirstian Widen, 2015)

The data has been composed mainly through cost analysis, questionnaire, and observations. This paper reports on an analysis cost and environment impact four cases of attempts to introduce the steel technique in Debre Birhan.

1.1 Objective

1.1.1 General Objectives

The key objective of the research is basically to understand current house of construction based on sustainable building design evaluation and find the possible way to improve current wood and reinforced concrete house in city.

1.1.2 Specific Objectives

1. To introduce simple and light weight steel structure types so that to increase low cost house of work and speed of construction;
2. To investigate and assessment the impact of three different constructions house on Environment in the areas.
3. To compare of wood, concrete and steel house system to show which type of construction is the best sustainable construction house.

1.2 Statement of the Problem

Construction house have an effect on the environment and economical. Sadly, although free land and green areas are included in the residential building plan in Debra Birhan, when it comes to the implementation, those areas have been changed into rough surface and used for other purpose.

At present day the of environmental effect and costs of houses are increasing at alarming rate particularly that of the cost of concrete is currently very high as compared to its cost that was even a year ago. Since the house construction is wide-ranging so as to meet the ever increasing housing demands of the population of Debre Birhan, if meaningful measures aren't taken, its impact on the environment and economic would be negative unless we introduce the thought of ecological sustainability.

1.3 Research Questions

Moreover, the following research questions will be considered carefully and treated properly:

1. Which construction Material are environmental friendly for the area?
2. What do we need to do to make the house economical safe?
3. Which construction material effective for sustainable house?

1.4 Scope of the Study

Basically, this study is expected to identify the answer or result for some of the irregular issues that exist in construction industry such as issue that related the impact of wood and concrete housing. It mainly focuses on the extent to which environmental sustainability factors have been taken into consideration so that the construction footprint on the environment would be minimal. The research is limited to the study of the environmental and economic sustainability of house despite the multiple factors that could affect both.

1.5 Limitation of the Study

There are numerous boundaries to this study. Firstly, during the questionnaire, the respondent were careful when answering questions related to the government because it could be perceived as though they were judging the government and could put them in trouble. Another Ethiopia does not have a rating system that can be used to evaluate the extent to which a building is environmentally sustainable, thereby allowing a specific environmental sustainable figure to be given at the conclusion of the research. These limit us for using all my design method of data collection**.** Thirdly, constraint was financial, encountered because of the scattered nature of the sites from one another. Sites were on the periphery of the city.

1.6 Significance of the Study

Understand ways sustainability can be incorporated in the design and use of the house construction. The results of this study will enable stakeholders (Builder, Contractor, Engineer, and Arctecture) in the house construction to know how environmentally sustainable house construction are implemented.

1.7 Research Procedure

The steps undertaken in the present study to accomplish the above-mentioned objectives are as follows:

1. Thesis proposal developed based on the sustainable construction house in Debre Birhan and its surrounding
2. Literature and background study will be identified.
3. Field study would be conducted based on my schedule.
4. Desktop study would be conducted from different journal study.
5. Questionnaire will be prepared.

6. Questionnaire response is collected from respondents.
7. Propose new Architectural lay out, analysis and design G+1 using ETABS software the steel structural system and quantifying its component materials for frames of the building.
8. The collected data are analyzed and discussed
9. Thesis writing by taking in to account analyzed data from literature, questionnaire, software analysis and cost comparison three house system.
10. Conclusion and recommendation.

1.8 Thesis Organization

This thesis is divided into five chapters:

Chapter 1: Gives a general introduction with theoretical background, statement of the problem, research question, scope of the study, limitation of the study, significance of the study, objective, and methodology of the study and organization of the thesis.

Chapter 2: Briefly reviews on behaviour wood, reinforced concrete and steel house system based on suitability house design

Chapter 3: Discusses about the research methodology and the data collected method.

Chapter 4: Discusses about the cost estimation analysis and environmental wood, concrete and steel house system.

Chapter 5: The main conclusion and recommendations that can be drawn from the current Studies are summarized, and also suggestions for future studies are outline.

1.9 Organization of the Thesis in Figure

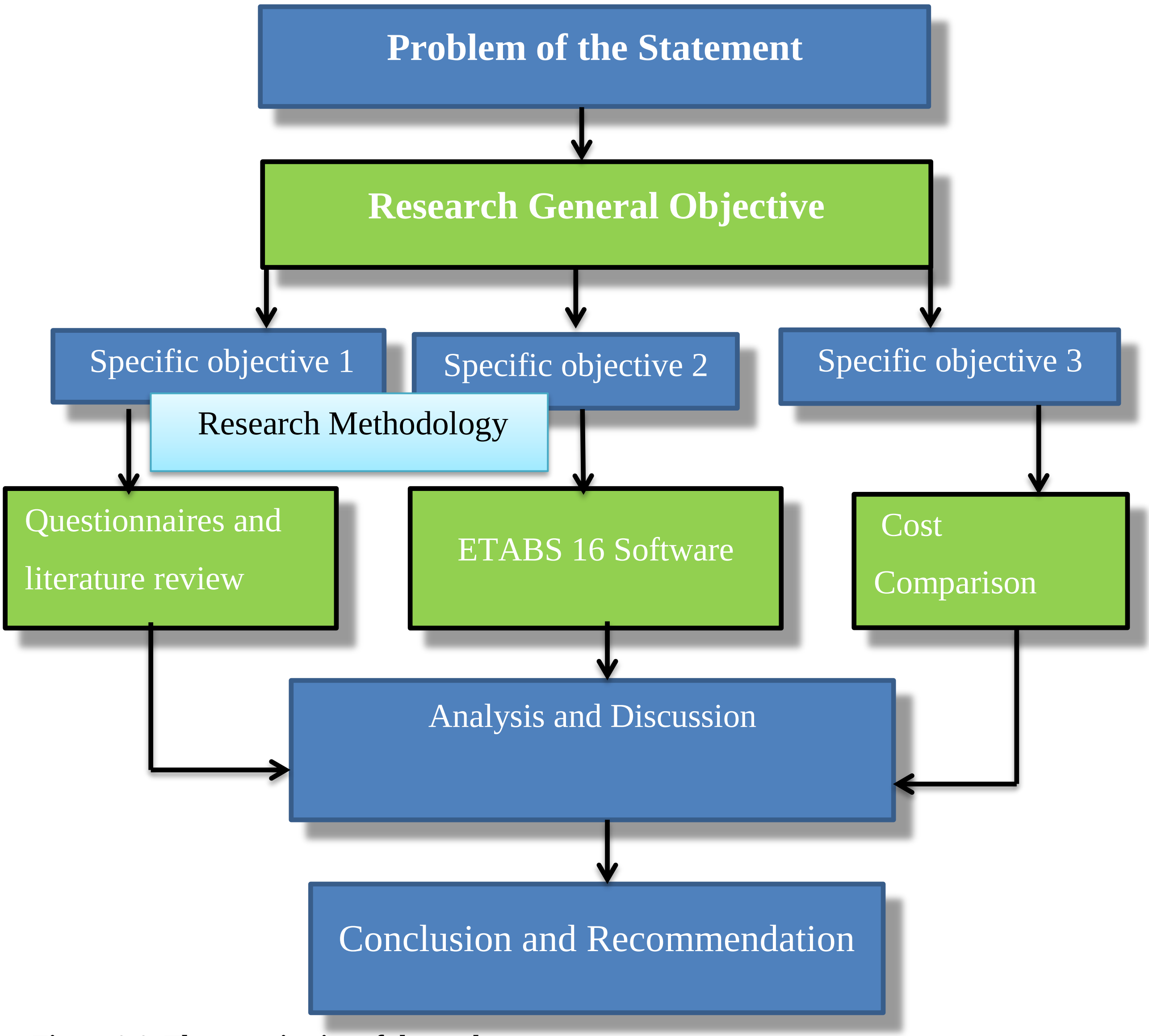

Figure 1-1: The organization of the study

CHAPTER 2 LITRATURE REVIEW

2.1 The Historical Development of Housing

Low economical and the environmental prohibiting of susceptible population groups are increasing social and political challenges across the most regions in the world. The house needs of the community susceptible and deprived system the source of the effort of the management housing and land. Growing the gap between housing constructions has continued to widen across the region, making house construction less. Nations have seen both a failure in the play of the public in the cover sector and a rising trust on market services to mollify housing need.

The advance of the construction house condition in separate nations was unfair both by their governments' housing plan and by many outside reasons, like the socio-economic political, administrative management , and legal issues.

However, in order for the providing of housing to be well-organized and operative, countries have named for a better allocation of knowledge on housing policies and performs as well as enhanced guidance to officials through well-documented evidence on these policies and practices. Given the increasing challenges faced by the socially exposed in the housing sector and the importance of reasonable housing for socially cohesive societies, countries of the regions are beginning to realize the need for a renewed and stronger role.

2.2 Housing in Debre Birhan, Ethiopia

Absence of housing is among the most encounter in Debre Birhan. 100,000 out of the total population of 150,000 are living in overcrowded houses or, not hygienic condition, lacking basic urban facility like safe drinking water and sewage, and in sprawling informal settlements with a growing number of shacks. 86% of the housing structures in Debre Birhan are dilapidated and would have to be destroyed or transformed in costly manner. (Adminstrative, 2009)

They are in their common without the minimum basic substructure such as reddening toilets and connection to the sewer system. An assessed 81% of the 9 kebele houses' have serious problems of maintenance and are in very bad shape.

At the same time the housing packages are aimed at endorsing micro and small enterprises, applying training-on-the-job, assembling the exchangeable potential and diversification of the construction sector. In order to solve the house problem Debra Birhan city administrative has hurled by giving house land that lived for 2 years in city. The aim of this program is to provide low and middle urban income people with decent shelter. (Adminstrative, 2009)

Figure 2-1: Wood cultural houses around city (Alamay,2012)

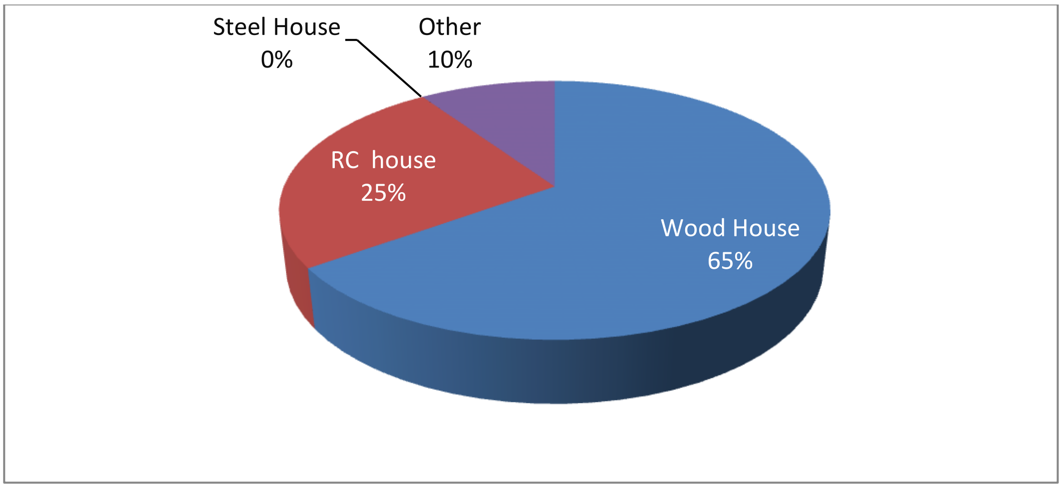

Figure 2-2: Show the type of exist house type construction in Debre Birhan (Debre Birhan city construction development, 2019)

2.3 House Construction Type Structure

The most common house constructions are;

- Wood house frame structure
- Concrete house frame structure
- Steel house frame structure

2.3.1 Wood House Frame Structure

The wood used in sustainable construction is specialized and initiate in responsible. In addition, building with wood requires less energy, has a lower environmental impact and smaller carbon footprint than conventional building methods: wood absorbs CO_2. These wooden homes are made from natural; they are recyclable and environmental and are also 'ecological. Wood House Frame Structure are a more ecological and economic alternative than homes made of old-style concrete. Wood is not only come from natural, but its use for the environment. (Sustainabilty, 2019)

Figure 2-3: Wood frame houses under the construction (source Jaksmata, 2008)

2.3.2 Reinforced House Frame Structure

Concrete is one of the common broadly used recent construction materials. Concrete is "artificial stone "obtained by intercourse sand, cement, and aggregates by water. Concrete can be shaped into any shape, which is characteristic benefit over other materials. Concrete tension become very common after the invention of Portland cement 19^{th} century; however its imperfect resistance tension prevented its wide use in building construction .To solve this problem, steel are surrounded in concrete to form a combined material called concrete reinforced .

The world use of concrete construction stalks from the wide obtainability of reinforced bar in addition the concrete components .Different steel, concrete manufacture does not need costly manufacturing. Concrete constrictions, dose however, require a certain level of technology, expertise, and workmanship, particularly in the filed during construction. In some cases, single –family house, or simple low- rise residential building are constructed without any engineering assistance.

Advance in the modern reinforced concrete design and construction practice were pioneered by European engineers in the late 19^{th} century .At the present time , Reinforced concrete is extensively used in a wide variety of engineers applications(e.g.; building, bridges ,dams).

Unfortunately, in many case there is not the necessary level of expertise in design and construction. Design application range from single –family building in countries like Algeria and Colombia to high-rises in Chile Canada, Turkey, and China.

The broadly reinforced concrete used construction, especially in evolving nations, is because its affordable compared to other materials such as steel. The cost of construction changes with the region and residential construction.

2.3.3 Steel House Frame Structure

With this respect my planned system is two stories hence I selected steel frame.

The structural system essential for is subjective by the building height. For house two story height, the steel frame may be planned to deliver stable, but for taller house concrete or steel is more effective structurally.

The most important steel framing house it is flexibility, it can turn without any cracking, which is high benefit, as a steel house building can bend when it is lacking to side by laterally. This huge strength is high benefit to structures. The other characteristic of steel is additional ductility. This earnings that when exposed to great force; it will not suddenly crack like glass, but gradually bend shape. This characteristics shows steel house buildings to turn shape, or bend, thus charitable warn to people to discharge. Fail in steel house structure is not immediate - a steel structure little collapses.. (DR.Ing.Girma, 2013)

However, they are now being man-made in systems which reflect the greater strength and reliability of steel. The variety of steel shape, strength, and sizes has prolonged outside that of normal lumber, and this versatility offers the advantage of saving in both material cost and time while delivering a consistently high quality product.

Although short column may be favored for architectural, the applied purpose connections to the floor should be measured.
This is in adding to its construction advantage and good reusable skills are manufacture steel house increasing for house construction.

This follows the long times use of steel framing in commercials construction where steels has proven quality and performance. It can be difficult and costly to provide connection into the minor axis of a very small column section. Residential steel framing member were originally designed as a substitute for reinforced concrete framing. Environmental and economic concerns have prompted the building industry to research alternative building materials and methods.




Figure 2-4: Typical sustainable steel frame house structures (Google web site)

2.4 Housing and Environment

Emissions would growth by 37% by 2030. House of constructions is the major underwrite the world wide greenhouse emissions making them the major contributor even more than manufacturing and transportation. (Yudleson, 2007)

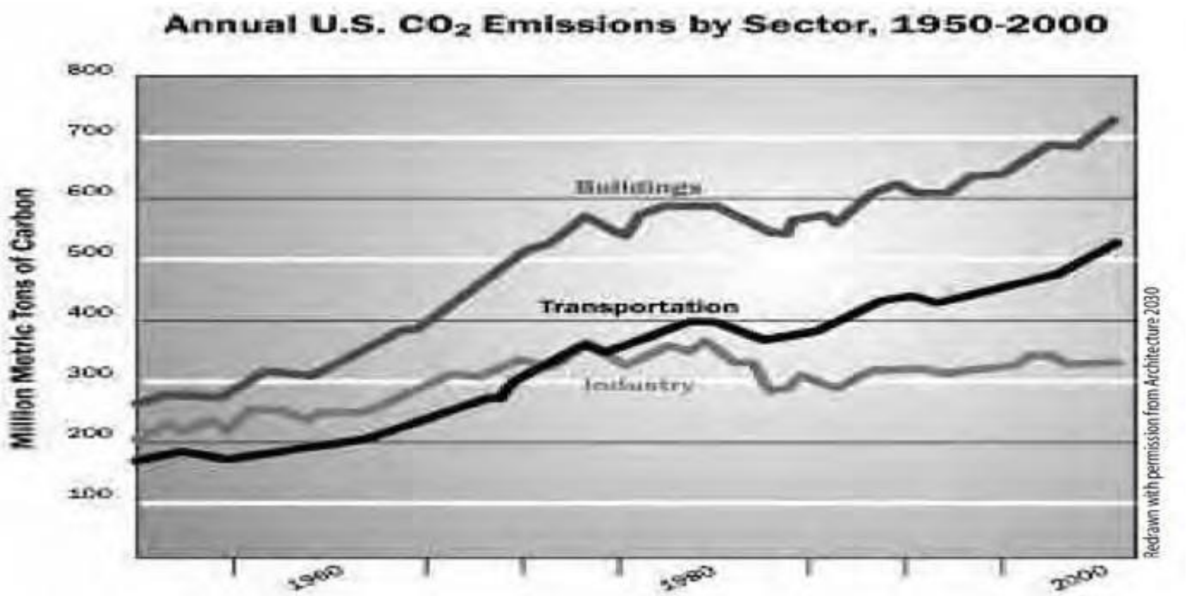

Figure 2-5: Greenhouse gas emission of buildings, transportation, and industry (Source: Yudelson Jerry, 2007)

Such settlements are characterized by poor water, air and soil quality and lack of access to sanitation, creating a troubled urban environment. The challenges of the environment posed by housing are more pronounced in the developing world. Rapid urbanization, and with it, the large slum areas, deteriorates the urban environment through unplanned and therefore, unsustainable settlement. (Emaculate Ingwani, Tendayi Gondo, Trynos Gumbo, Elias Mazhindu,, 2010).

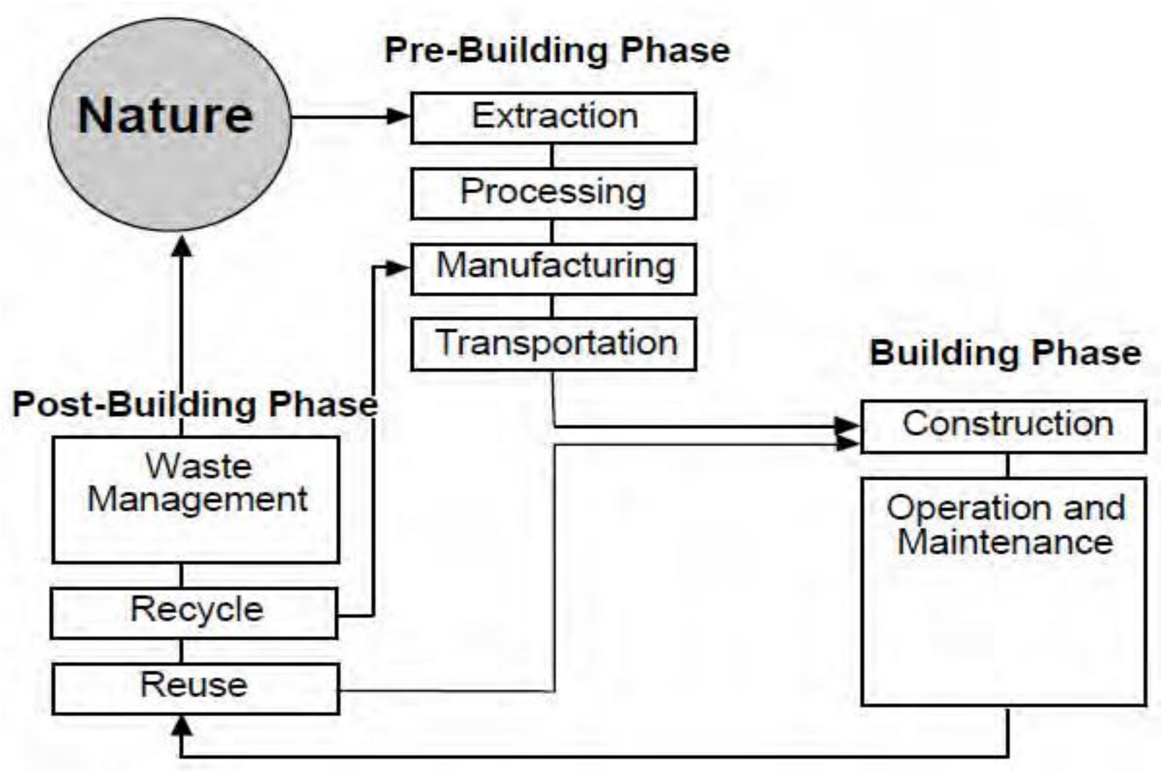

Figure 2-6: Life cycles of buildings (Source: Jin Kim Jong and Brenda Rigdon, (1998)

2.5 House and Cost

Pre-fabrication and the use of machines and special tools to produce these standardized elements maximize productivity, resulting in lower costs per unit housing in Ethiopia has very petite familiarity and compare to its demand the advance of the construction is a smaller amount. Now a day's cost-efficiency is one of the most crucial points of housing. It can mainly be achieved by regulation of building elements and reducing the number of different items needed. Moreover, the high demand the housing has encountered problems. Out of these are the shortage of construction materials (sand, gravel, cement, reinforcement bars) and construction material producers (Afairs, 2003)

2.6 Sustainable Construction

The Conseil International du Bâtiment (CIB) (1994), a global construction investigation networking group, defined sustainable construction as "creating and operating a healthy built environment based on resource efficiency and ecological design".

The phrases green, high performance and house construction are frequently used interchangeably; but, the term sustainable construction furthermost widely discourses the ecological, economic and social issues of a building with regard to its community.

Table 2-1: Principles of sustainable construction (Kibert, 2012)

Reduce resource consumption
Reuse resources
Use recyclable resources
Protect nature
Eliminate toxics
Apply life-cycle costing
Focus on quality of life

Furthermore, these principles of sustainable construction (see Table 2.1) consider through the whole life cycle of construction, from organization to demolition. (Kibert, 2012). For example, through sustainable construction, we will do our own part to enhance the utilization of regular assets by means of reusing and recycling of materials. Sustainable house construction discusses to the confirm of building plans, construction methods and materials that are more environmentally friendly, reduction construction cost and social benefits. (Fikire Mariam, 2019)

Therefore, it shows that building materials are playing significant role to achieve sustainability in building construction. Consequently, Sustainable construction provides an ethical and practical response to issues of environmental impact and resource consumption. (Kibert, 2012)

2.6.1 Sustainable Building Materials and Their Features

In other ways there is no clear agreement about the criteria for materials that would describe them as sustainable preferable, sustainable responsible or sustainability. The consideration of sustainability in building materials to achieve a sustainable building project has generally been the most difficult and challenging task facing the project team. (Kibert, 2012).

Generally, the significant way to identify sustainable building material is to evaluate them by their quality and characteristics in context of the principles and methodologies of sustainable construction. Sustainable building materials refer to basic materials that may be the components of products or used in a stand-alone manner in a building. Sustainable house materials have low environmental impacts compared to the alternatives. (Kibert, 2012)

We need to get rid of the pervasive misperceptions about sustainable building materials. The majority of building owners, designers, engineers, contractors, manufacturers, and building officials are not receptive to using sustainable materials to accomplish the task. Understanding this perspective is essential for effectively resolving such concerns. The unfortunate perception is that sustainable building materials look bad, cost a lot, and do not perform well. Therefore, in order to better understand what sustainable house materials are, we need to clarify what are their features. (Spiegel & Meadows, 2010).

Noted that sustainable materials in building construction section: are themselves recyclable, regard the renewability, toxic, and effort inside the form of natural cycle.
As mentioned, house material plays a key role in growing the sustainability of building construction sector therefore; there has been much research about this. For instance, Kestner, Goupil and Lorenz (2010) and also (Kim, J.J. and Rigdon, 1998)

Measurement of Sustainability Measuring what is sustainable in building material and construction can be a complicated task. There are many measurement methods.

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Table 2-2: Some of the famous methods of sustainability measurement in building construction (Pitt Matthew et,al 2009).

Measure	Description
Eco-quantum	Assesses the lifecycle of whole units of construction; for example, glazing systems/structural walls.
Life-cycle Assessment	Evaluates performance of the building through its life. It considers the individual elements, which when used together will affect the overall benefits.
Leadership of Energy and Environmental Design (LEED)	Created by the United States Green Building Council, the Leadership in Energy and Environmental Design (LEED) Rating System was introduced in 1999, and is the most popular green building rating system now in use in the United States. LEED covers the entire construction project process from the design phase to the operation phase. LEED is a point-based rating system. The points are achieved by satisfying credit requirements.
Building Research Establishment Environmental Assessment Method (BREEAM)	Developed for office buildings by the BRE and compares and scores different design strategies for possible pollution and local impact. Some consider the BREEAM assessment techniques to be heavily "feature" orientated – for example providing showers for cyclists although it does some CO2 and energy analysis.
Eco-labels	Used for specific product items, for example light bulbs, paints, etc. and are based on EU standards. These use lifecycle analysis on pre-production, production, distribution, utilization and disposal of the product.
Eco-points	A method of ranking and scoring of different environmental impacts. Different issues are weighted using the points so allowing comparisons to be drawn.
Embodies impact study	A way of measuring the impact of manufacturing construction materials, including quarrying and transport, the construction process, including transport to site and the demotion and disposal of materials at end of life of the building.

2.6.2 Sustainable Structural Building Design

Decreasing the use of resources and ensuring the health and well-being of occupants and the surrounding built environment both today and for generation. Sustainable house construction are structures that are built in an environmentally responsible manner by increasing use of materials,

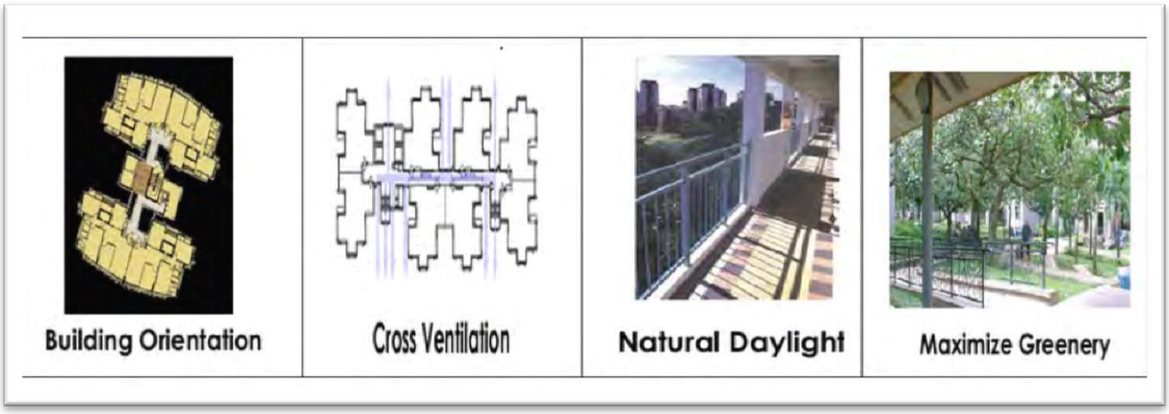

Figure 2-7: Utilizing natural solutions. (Source: Dr Johnny Wong Liang Heng, 2008)

Based on the LEED principle there are seven topics that should be include in the design and construction of new environmentally friendly house.

1. Sustainable sites:
2. Water efficiency:
4. Energy and atmosphere:
5. Materials and resources:
6. Indoor environmental quality:
7. Innovation in design:

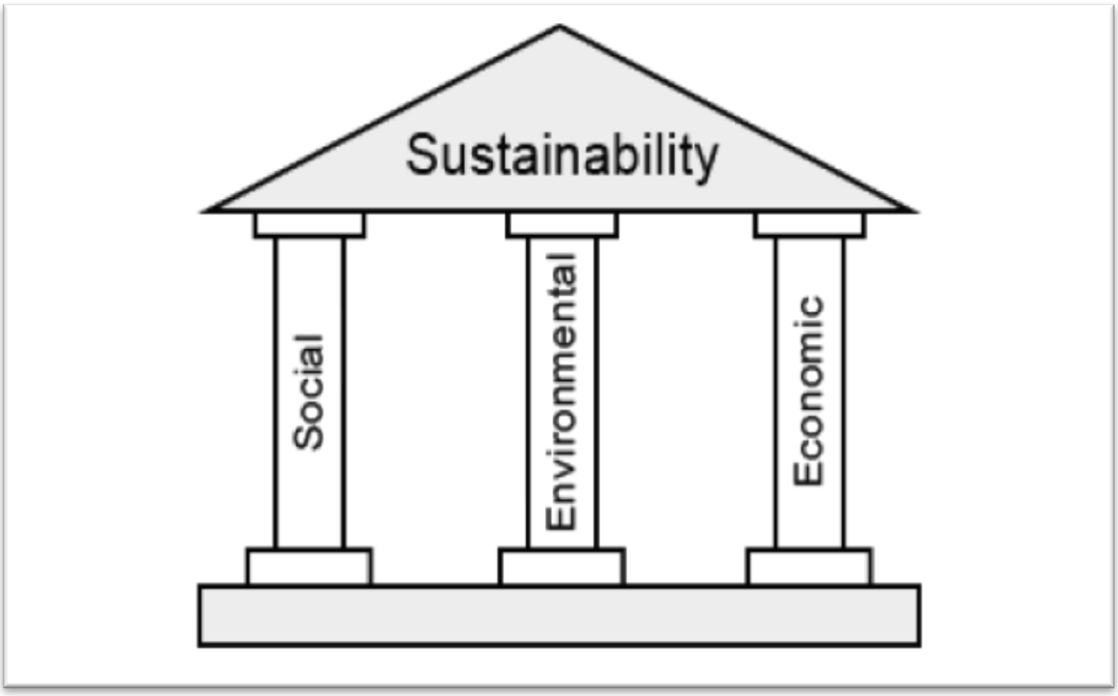

Figure 2-8: The three dimensions of sustainability (source Trabucco, 2008)

Environmental sustainable house design must include the following three elements.

a) Environmental priorities

b) Environmental Goals

c) Sustainability and Construction Materials

2.5.3.1 Green areas

a. Perpendicular greening

Perpendicular greening is the process of replacing a green area that has been lost when erecting buildings. The most common type of vertical greening is

- Climbing plants system
- Trellis system
- Modular system

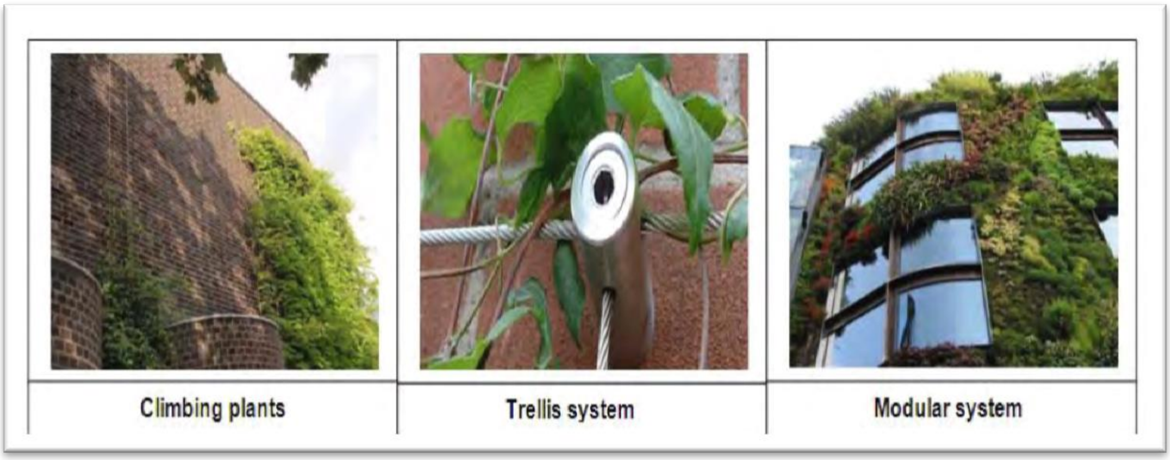

Figure 2-9: The adventitious, trellis and modular system of vertical greening in their respective order (Source: Cheetham et al, 2012)

b. Green roofs

The two types of vegetation roofs are extensive and intensive.

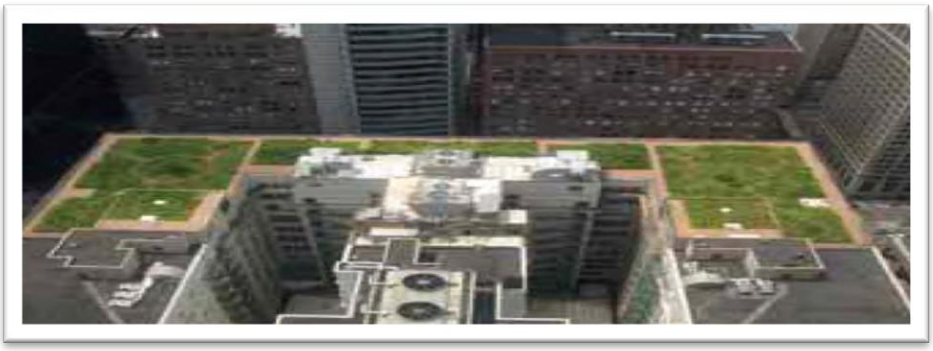

Figure 2-10: Green roofs, Chicago city hall (Killings worth, et al, 2012)

CHAPTER 3 RESEARCH METHODOLOGY

2.6 Research Design

The research design was based on the following method.

2.6.3 Computer Modeling (for Economical Study)

The design steel structure data collected from arctuctural drawing sample. ETABS is a powerful program that can greatly enhance an engineer's analysis and design capabilities for structures. Computer based structural analysis ETABS 2016 since the project objectives are aimed to improve current reinforced concrete and wood structural system by steel structure and also use deck slab for floor units.

2.6.4 Questionnaire and Literature Review (for Environmental Study)

Most important data was composed using questionnaire and by observing the sites and taking pictures, while secondary data, which comprises the literature review and field observation were collected by reviewing different research works and texts dealing with the environmental impact and socio-economical buildings concept.

The population for the study comprised of clients/developers, contractors, consultants, manufacturers, professional bodies, trade unions and Debre Birhan city development and construction who are involved in building construction. A total 45 of questionnaires were asked but 40 (85%) were returned which was used for the analysis. Two statistical methods were used to analyses the data provided by the questionnaire. The first to obtain percentage standards through frequencies of the replies received. Data for the study were collated through a survey questionnaire administered to participants on building disasters that occur frequently in city. Another was to compute a Relative Important (RII). For this purpose, a rating scale of 1 to 5 was adopted with 1 representing the lowest level of effect and 5 on behalf of the maximum level of effect was evaluated using the following expression.

Relative Importance Index (RII) = $\frac{\sum wixi}{5}$ $\sum_{i=1} Xi$ 1≤RII≤5

The defendants asked to showed how a grade of related impacts of house construction affects the environment and negatively. The places where Adisu Sefer, Mariam Sefer, Habitat Sefer and Diyaspora Sefer are selected because of the methodology for environmental considered and adapted for this research work focus on structured questionnaire survey was designed and employed to assess the knowledge and practice on the impact of environmental. It is also essential face to face discussion.

3.1.3 Texts on the Sustainable Buildings Concept (for Social Study)

Study of sustainable house construction examples of how it has been implemented were consulted to have ideas about how the concept could possibly be adapted to the house construction and will be used in the interpretation of the results.

3.2 Description of the Study Area

The relative location of the city is in central Ethiopia 2750 m above sea level and 130 km North of Addis Ababa and 690 km from Regional city, Bahir dar, within North Shewa Zone of Amhara regional state. In absolute terms it is located at 90 36’ E longitudes. Debre birhan is the place where founded by Zeryakob in 1446. The land include 86% percent plain 14% irregular and slightly rose in its central parts. Most land uses are commercial, residential, industrial, and administrative According to the city administrative town has a population of 90,037 within area of 3000.95 Hectares.. The climate of the town is temperature dega ; with total annual temperature of 10^0C which is suitable for juniper / tide plants.. (Adminstrative, 2009)

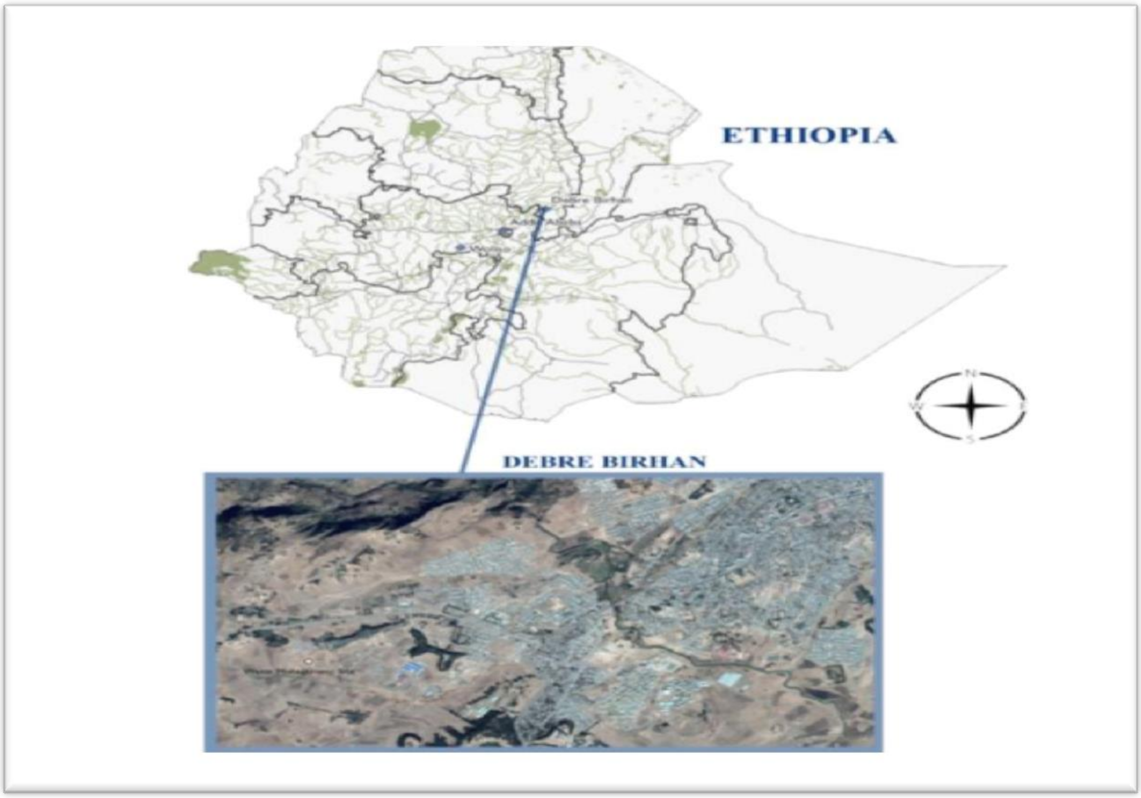

Figure 3-1: Location map of the study area

Adisu Sefer

Mariam Sefer (new site)

Habitat Sefer Diaspora Sefer (new site)

Figure 3-2: Location map specific study selected area

3.2.1 Adisu Sefer

The Adisu Sefer site was selected for several reasons.The most house structure built by wood material.Studying it would indicate what environmental sustainable house construction and concepts were not measured and applied in the construction of the site. And lastly, because the site had been in use for roughly 10 years since at the time of the study, the durability of the materials used in the construction would be able to be checked.

3.2.2 Mariam Sefer

The Mariam Sefer site was selected for the following reasons. Firstly, it was the latest of the sites when the research was made and therefore any environmental sustainable house construction concepts considered and implemented by the government since the swearing in the Adisu Sefer residential site could be observed. Secondly, the site had once been a horse-riding range, implying that green fields had once been there. With the construction of the residential buildings, their footprint would clearly be seen and any forms or methods of replacing the greenery that had once been there to offset the effect the buildings would have on the environment could also be investigated. Finally, the site shows some modifications to the site made by the dwellers after the lands were delivered to them.

3.2.3 Diaspora Sefer

And finally, because the site had been in use for unevenly 1 year since at the time of the study, the new of the materials used in the construction would be able to be checked.

The site was selected because of it was the most house structure built by concrete material and studying it would indicate what environmental sustainable building and concepts were not considered and implemented in the construction of the site.

3.2.4 Habitat Sefer

With the knowledge of what had once been there, it would be an ideal site to investigate what positive environmental s measures were being undertaken by the dwellers to compensate for the forest that had once stood there. This site was selected because of personal involvement in the construction of the site where the large clearing of a forest to create the space necessary to have the house was personally witnessed.

Figure 3-3: Wood house constructions Habitat Sefer in Debre Birhan city (photo by Author, 2012)

3.3 The Study of Population

Builder, government house builder, the Consultant, the Engineer and Architect. They are taken as a part of the target population due to the reason that they have better information concerning the issue under investigation. The population selected was based on the participants experience and education qualification in the construction industry especially in the house construction is composed of those people who are directly affected by the problem of the thesis this population included the Contractor, the private house .

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CHAPTER 4 ANALYSIS OF RESULTS AND DISCUSSIONS

4.1 Structural Evaluation of the Systems on Economy Sustainability

The cost comparison is include two parts,

- Construction cost,
- Construction time.

One objective of this thesis is also to explore the economy sustainable advantages of the use of steel structural members with that of normal wood and concrete construction house, this section mainly deals the cost comparison of framed structures of the proposed three systems.

4.1.1 Structural Wood House Systems

Properties of wood

- Cellular structure is very efficient
- Handles both compression and tension well
- Different strengths with and against the grain
- Inhomogeneous material with imperfections

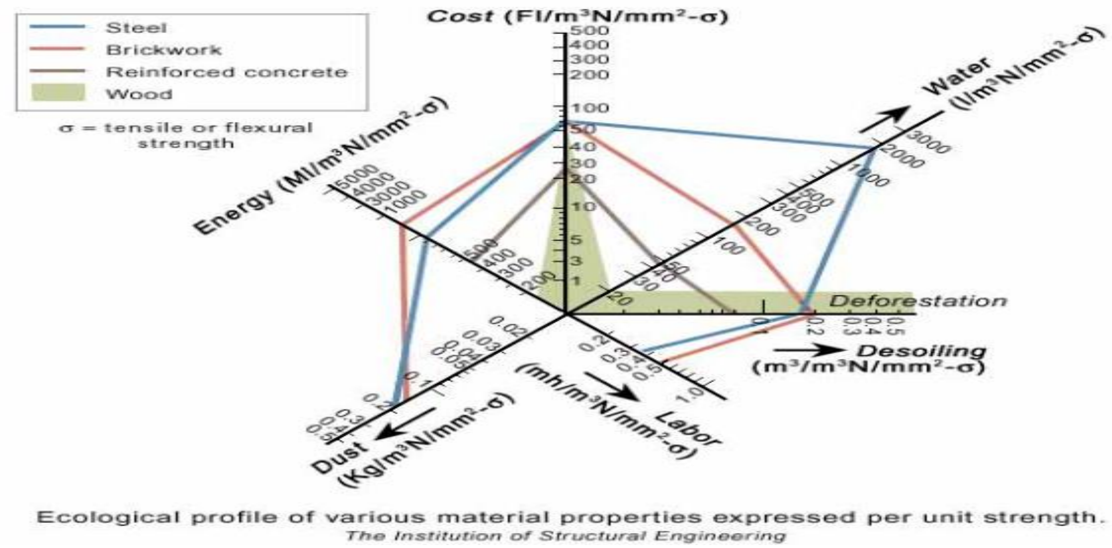

Figure 4-1: Ecological profile of various material properties expressed per unit strength (Institute of structural engineering, 2008)

Specification of wood building structure

- Area of the house building = 65.41 m^2
- 8.78 m length and 7.45 m widt
- height is 3.00 m

1. Design information

- Material data

  Class I works

  Soft wood

  Section property

Width b = 100.0 mm

Depth h = 200.0 mm

Column section: =100 mm*200 mm

Beam section: = 100 mm*200 mm

Beam span L = 4.00 m

Dead load = 2.00 kN

Live load = 3.50 kN

Md = = P L/ 8 =7.95 *4.00/ 8 = 3.98 kNm

Pd= 1.35 * DL + 1.50 * LL = 7.95 kN

a. Beam design

Check bending at ULS

moment resistance

kh= max(1.0 ; min($(200/h)^{0.2}$; 1.3)) = 1.00

M_r = k_{mod} *k_h $f_{m,k/}$ rM = 0.80 *1.00* 24.00 / 1.30 = 15 N/mm²

Wyy = b h^2/ 6 = 100*200^2 / 6 = 667,000.0 mm³

M_{ult} = Mrd Wyy = 15000* 0.000667 = 9.8 kNm

M_d/M_{ult}= 3.98/9.8= 0.4<1…..OK

Checking the lateral torsional buckling (ULS)

Depth hef = 100.0 mm

h/b = 2.0:1

Limiting height/breadth ratio = 5:1

Maximum = b * factor = 500>h

Distance x = 50.0 mm

Support l = 100.0 mm

Check Shear capacity the beam(ULS)

hef/ h = 100/ 200 =0.2

V= PL/2 =3.98/2= 1.99

$k_{V=}$ 0.462

Shear stress = 1.5v/bhef = 1.58*1.99/100*100== 0.31 N/mm²

Shear stress/shear resistance = 0.31/0.9 = 0.34 <1 ….OK

Check the bearing capacity (ULS)

$ac,_{90,d}$ = V /b l = 1.99/100.0 100.0 = = 0.20 N/mm²

$kc,_{90}$ = 2.31

Bearing capacity of the beam = $k_{c,90}$ *k_{sys} *k_{mod} $f_{c,90,k}$/ rm

= (2.0 *1.0 *0.90* 2.40)/ 1.20 = 4.30 N/mm²

$a_{90,d}$/ $f_{c,90,d\,=}$0.2/4.3 = 0.05<1 ……OK

Section property of the column

Column design

Width	b = 100.0 mm
Depth	d= 200.0 mm
Height of the column	h= 3m

Check the axial load capacity

Design compressive strength of wood: (fc,d = k $_{mod}$ f $_{c,k)}$ /partial factor

= 0.70*21.00/1.30 = 11.33 N/mm²

Depth h = min (hy ; hz)	= 100.00 mm
Buckling	
Slendernes ratio	= l/i = 3m/28.87 = 0.1
Radius of gyration i	= 28.87 mm
B_c	= 0.2
k	= 0.28
k_c	= 0.21

Axial load capacity

$N_{Ed,max}$ = k $_{c,fc,0,d}$ *h_y *h_z /10³ = 2.4 *200*100/10³ = 48 kN

$k_{c,fc,0,d}$ = k_c $f_{c,0,d}$ =0.21* 11.33 = 2.4 N/mm²

Axial capacity of the wood column

e_z = 0.05

e_y = 0m

From the analysis of column frame the compressive load N_{Ed} =30 kN

M_y = 30*0.05 = 0.15 kN.m

M_x = 30*0 =0 kN.m

Compressive capacity of wood column

fc,0,d = kmod * fc,0,k / gm = 0.80 *21.00 / 1.30 =12.92 N/mm²

Depth factor k_h = 1.00

Bending capacity of wood column

$f_{m,z,d}$ = k_{mod} *k_h * $f_{m,k}$ / g_M= 0.80 *1.08 *23.00 / 1.30 = 15.01 N/m

$f_{m,y,d}$ = k $_{mod}$ $k_{h\ f}$ / m,k/ gm = 0.80* 1.00*23* 1.30 / = 14.52 N/mm

Bending and compressive stresses

Elastic section modulus

Wyy = hz *hy^2/6 =100*200^2/6 = 667.00*10^3 mm

Compressive stress

ac,0,d = N_{Ed}/hy *hz = 30000/200*100 = 1.5 N/mm^2

Bending stress

$a_{m,y,d}$ = My/Wyy =15000000/667000 = 3.34 N/mm^2

Bending stress $a_{m,z,d}$ = M_z/Wyy = 0.00/333000 = 0.00 N/mm^2

Elastic section modulus

Wzz = hz^2 *hy/6 =100^2*200/6 =333.00*10^3 mm

Calculations for buckling about z-z axis

Slenderness ratio l = l/i = 3000/28.87=103.91

Radius of gyration i = 28.87 mm

lrel =1.76

bc = 0.20 k =2.19

kc =0.29 a,0,d/kc = fc,0,d+0.7*(am,y,d/fm,y,d)+(am,z,d/fm,z) =0.97<1

4.1.2 Structural Reinforced Concrete House Systems

A total of two story concrete building models are analyzed and designed. House building which selected for study described properly. Building structural members size, material properties, seismic loading parameters, capacity design principles and design detailing rules used for in design for selected building models according to ES EN are expressed..

a. Loads and load combinations

The load combinations are created as per ES EN -1998 -2015. The live load is taken from the structural function of the buildings and is chosen as 4kN/m2 assuming the floor is used for residential house. The dead loads considered in this project are the self-weight of the structure, floor finishing and part ion load of 2.7kN/m2.

Preliminary Architectural Design

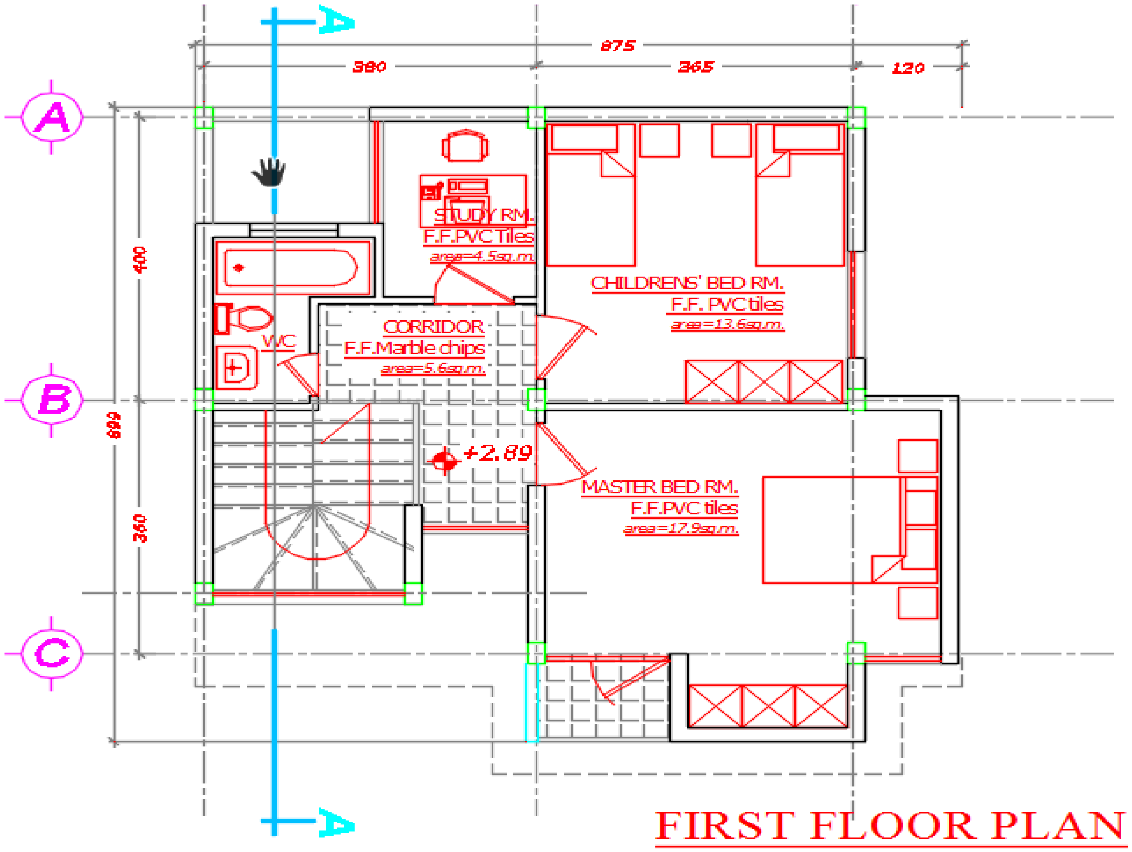

Figure 4-2: Sample typical first floor plan for existing concrete structure scale 1:50

b. Seismic Load

The seismic load parameter at each zones described in ES EN 1998:1-2015. Accordingly to this guideline the seismic hazard map is divided in to 5 zones, where the ratio of the design bedrock acceleration to the acceleration of gravity for the respective zone indicated below.

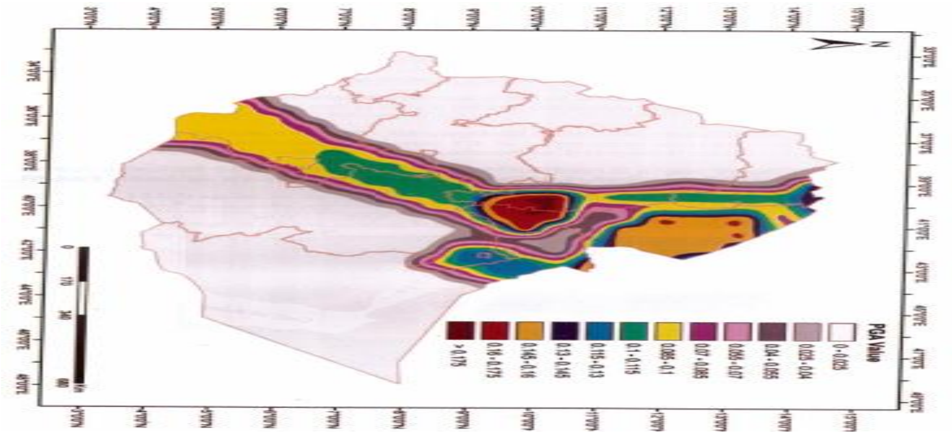

Figure 4.3: Ethiopia's Seismic hazard map in terms of peak ground acceleration (ES EN 1998:1-2015)

Table 4.1: Details of selected house building structure

Building parameters	**Details**
Location where building construction	Debre Berhan
Usage	Residential building
Area	65.41 m^2
height	3 m
Concrete	C-25/30Mpa for structural members
bar	S-300 for confinement rebar and for longitudinal
Seismic zone	IV
Slab thickness(Ribbed)	100 mm
Number of story	2
Density of concrete	25kN/m3
Damping of structure	5 percent

Poisson ratio	0.2
Structural system of building	Moment resisting reinforced concrete frame fixed at base
Geometry of building	Plan regular
Soil class	E

1. The loading on the frame model are: load from the stair assume
    - Permanent load from the staircase = 2 kN/m^2
    - Variable Load from the staircase = 4 kN/m^2
2. Load from roof
    - The design of the roof the load transferred to the top tie beam is 14.53 kN/m and assigned as the transferred dead load.
3. load from the design ribbed slab
    - Permanent load from slab = 2.2 kN/m^2
    - Variable Load from slab = 3.54 kN/m^2

The concrete design procedure involves the following steps

- Design of staircases
- Design of roofs
- Design of the frame structure
    - Design Beam
    - Design of Column
- Design of the concrete slab
- Modeling of the frame structure
- Cost Estimation of the building

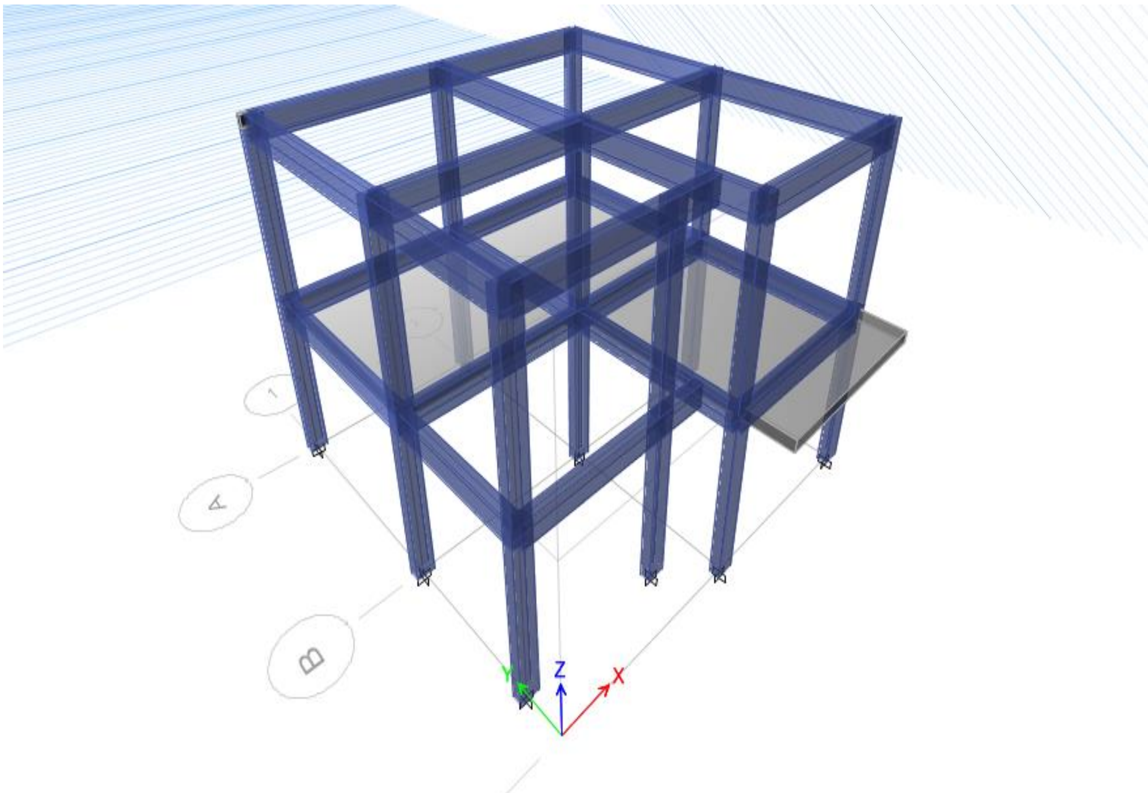

Figure 4-4: Structural modeling layouts for concrete frame (ETABS 2016 Ultimate 16.2.0)

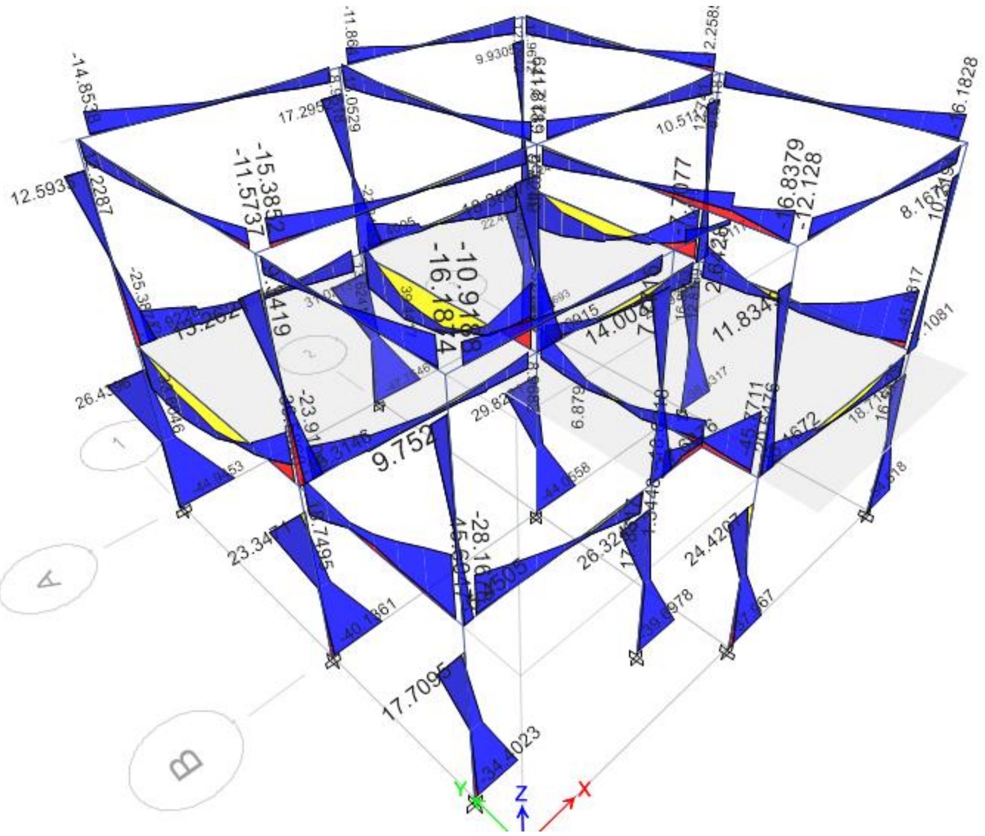

Figure 4.5: Analysis result Moment 3-3 diagram (kN-m)

a. Ribbed slab design

Material property

- Concrete strength fcu = 20Mpa
- Rebar strength fy = 300 Mpa

Geometry property

- Over all depth = 400 mm
- Slab thickness =100 mm
- Stem width at the top =125 mm
- Stem width at the bottom =125 mm
- Rib spacing(perpendicular to rib spacing) = 900 mm

Loading

- Dead load (self-weight, floor finishing) = 2.7 kN/m^2
- Live load = 4 kN/m^2

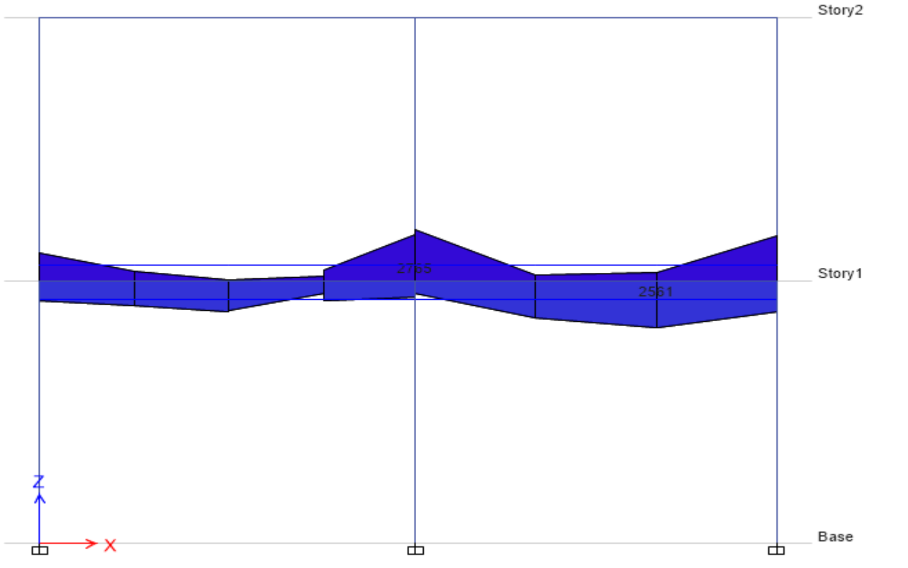

Figure 4.6: Top and bottom reinforcement area for slab [Flexural] (mm^2)

b. Beam design

As beams are most carry flexure, and transfer, they are planned for flexure and in addition it is necessary to check and design the beam sections for torsion and shear. Our code recommends that beams are not designed for axial forces. Beams are structural members which carry most flexure and transfer the loads from slab to columns..

Design information

- Material data

  Steel S-300

  Concrete C-25

  Class I works

- Section property

  200*400 mm

c. Column design

In the design of Rc columns involves determination of size of concrete portion and the amount of steel portion and its arrangement.

Column is a compression member supporting the roofing system (slabs, beams) and ultimately transferring the loads to the footing.

- Least lateral dimension
- Effective length Le (effective length of the isolated element)
- Slenderness ratio (ratio of Le and least lateral dimension)

It is a rare case that the column are exactly loaded axially

- Material data

  Concrete C-25

  Steel S-300

  Class I works

- Section property 200 mm*350 mm

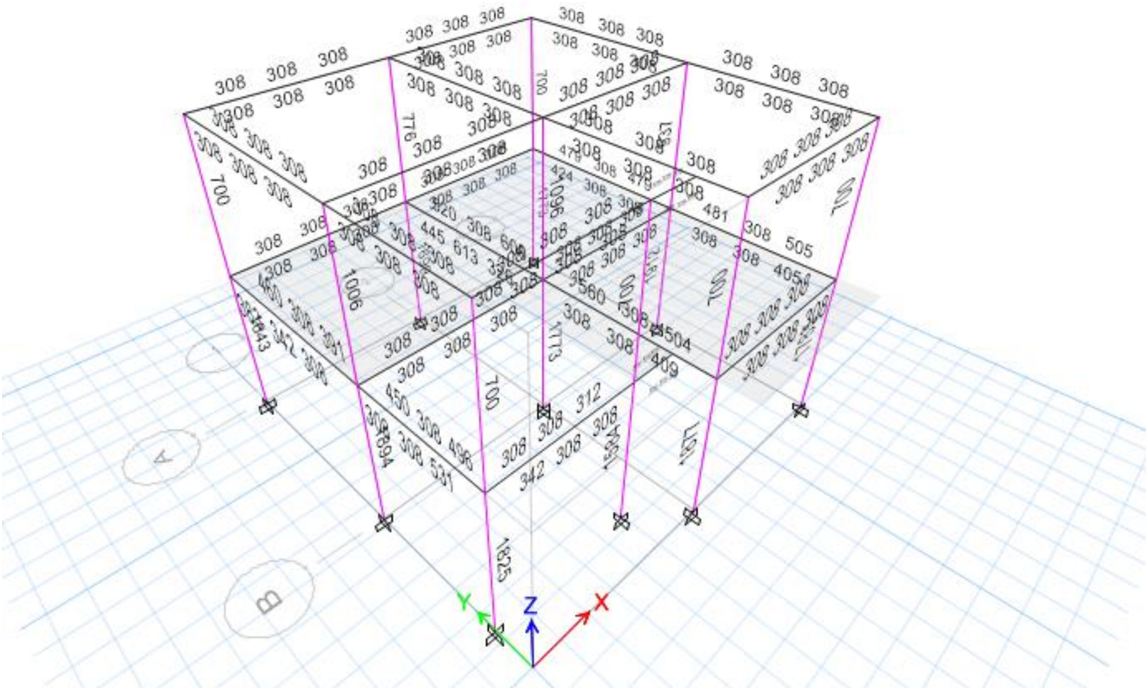

Figure 4.7: 3-D view longitudinal reinforcing frame section (Euro code 2-2004) (mm^2)

4.1.3 Structural Steel House Systems

In two-story steel residential buildings, the design of the primary structure is strongly influenced by many issues, as defined below: In this study, residential steel house building with two stories is proposed to protect both environmental and economic impact of the city.

- Type soil conditions, which dictate the foundation system and location of foundations.
- Design requirements, which may limit the building height and the maximum floor-to-floor zone
- Sustainable house construction.
- Adequate living area and.
- The type of partition system.
- Debauched of construction, which may influence the number of components that are used and the installation process.
- The more usable space.
- The services strategy and effective integration of building services.

With this respect steel frame structures are best suit, hence I have proposed steel frame structures with filled deck slabs.

Advantage of Steel Structure

2. **Flexibility Member:** They are more flexible, than concrete and wood structure
3. **Connection System:** As most systems are produced in factory system it has very low disruption to the locality pad foundation for good soil condition.
4. **Reduce Foundation Load:** Reduced self-weight, steel structures are comparatively light which reduces the weight by 60% of concrete frame structures. This makes the foundation system to be easy we can use simple.
5. **Speed Construction:** A wide range of ready-made structural sections are available, such as I, C, and angle sections. Steel structures have the following advantages .they are speed to build at site, as a lot of work can be pre-fabricated at the factory..
6. **High Stiffness:** steel is stiffer than the wood and concrete structure.

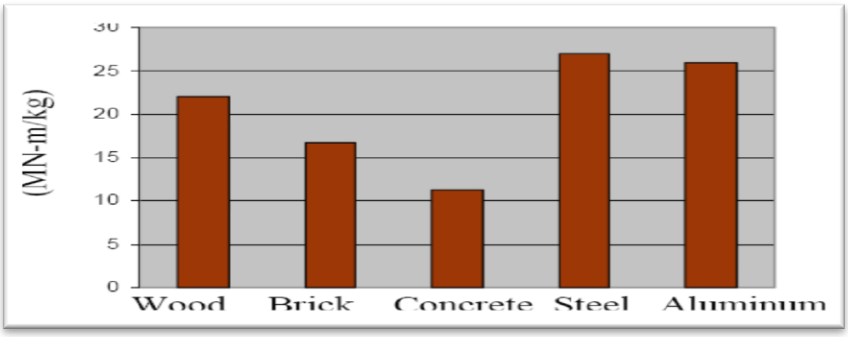

Figure 4-8: Comparison of stiffness (E) per weight

Draw backs

Steel Frame structures have the following draw backs:

- They are affected by corrosion in moist area

Measure- Our countries' environmental system is not aquatic.

- Needs Modern Technology

Measure taken- As the construction house difficult in Debra Birhan is critical, the government can   train professional personnel's and provide construction equipment's in bulk.

- When temperatures is low, steels are susceptible to fire,

Measure-can be reduced by coating insulated materials

- Comparatively expensive than wood and concrete house.

Measure- it is compensated by low cost foundation system speed construction

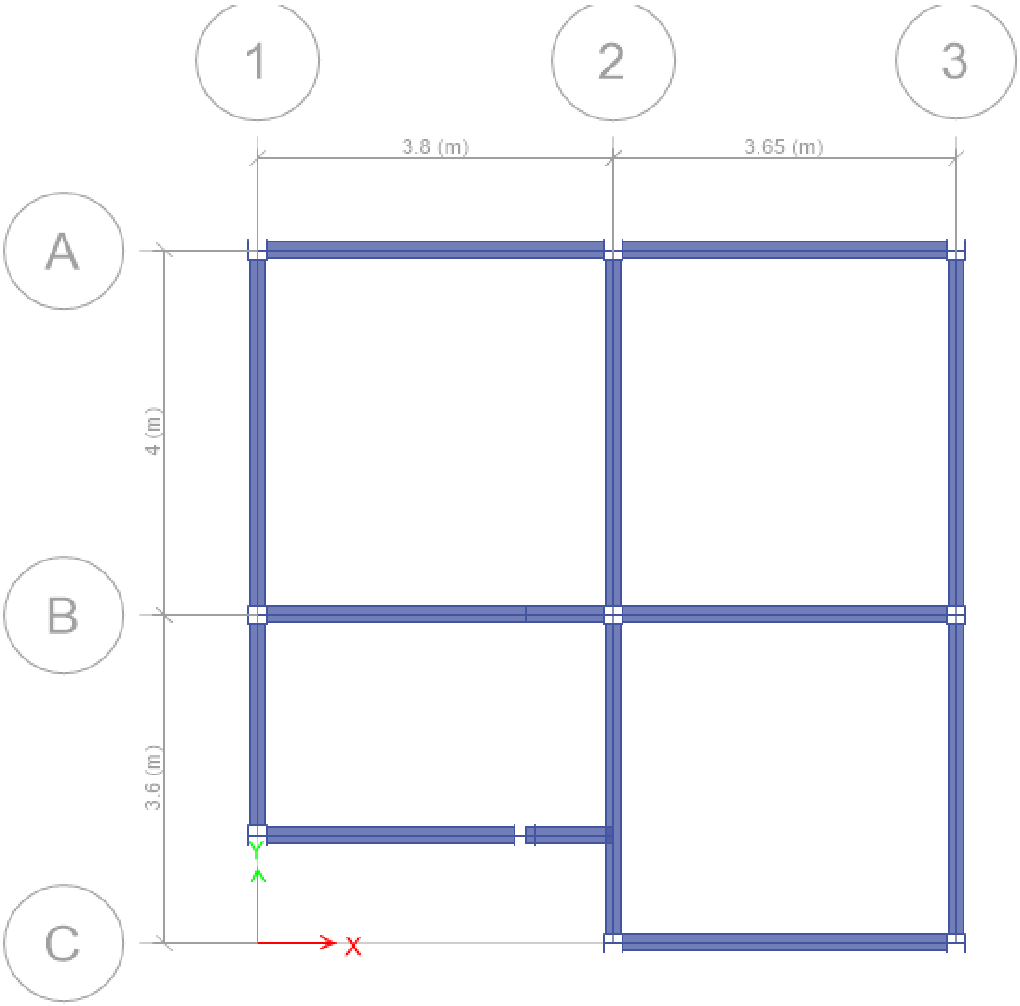

Figure 4-9: Typical first floor plan for new proposed steel structure (ETABS 2016 ultimate)

In the steel structures design, sufficient 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:

- Staircases Design
- Roof design
- composite filled deck slab design
- Steel member structure design
    - Main members structure
    - Secondary members structure

- Connections.
- Modeling of the steel structure
- Cost Estimation of the building

Load Factors and Load Combinations

1. UDSTL1=1.4DL
2. UDSTL2= 1.4DL+1.6LL
3. UDSTL3=1.2DL+0.5LL+1.3WL
4. UDSTL4=1.2DL+0.5LL-1.3WL
5. UDSTL5=0.9DL+1.3WL
6. UDSTL6=0.9DL-1.3WL

Where DL = dead load

LL = live load

WL = wind load

Modeling

House Specification

- 65.41 m^2 G+1 house building (I recommended for middle income society)
- 8.78 m length and 7.45 m width
- story height is 3.00 m

The loading on the frame model are:

1. load from the stair case assume
    - Permanent load transfer from the staircase = 2 kN/m^2
    - Variable Load transfer from the staircase = 4 kN/m^2
2. Load from roof structure
    - The design of the roof the load transferred to the top tie beam is 14.53 kN/m and assigned as the transferred dead load.
3. load from the design composite deck slab Spacing 0.95 m
    - Permanent load transfer from slab = 2.2 kN/m^2
    - Variable Load transfer from slab = 3.54 kN/m^2

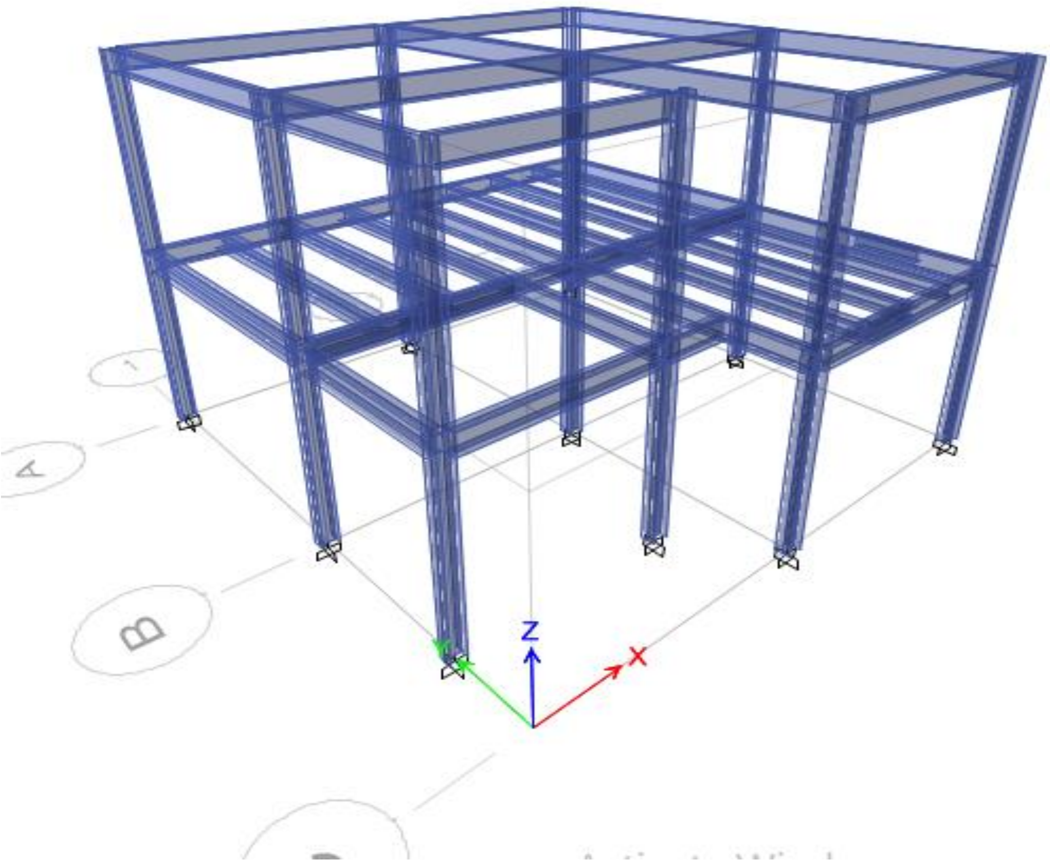

Figure 4-10: Structural modeling layouts for new proposed steel frame (ETABS 2016 Ultimate 16.2.0)

i. Connections in deck slab

The bond between the steel Profile and concrete is generally not adequate to create composite action in the slab and thus an efficient connection is achieved with one or several of the following. The profiled sheeting should be able to transfer longitudinal shear to concrete through the Interface to ensure composite action the composite slab. (Redie, 2003)

Hence slip forces are zero at mid span and maximum at support of simply supported beam subjected to a uniformly load. Hence shear is less in connectors at center than at corners.

In this system the slab and the beams connected by the help of deliberately designed shear connectors so that the slip between beam and floor can be avoided. Such shear connectors also help to minimize uplift forces acting at the composite interface and this will give pure composite action.

ii. Shear connectors

These shear connectors have two major benefits. One is they transmit longitudinal shear along the interface and the other is that they prevent separation of steel beam and concrete slab at the interface. Vertical force at the border between slab concrete and beam steel is around eight times the carried load by the beam. That's why the shear connectors are important elements.

There are three types of shear connectors.

- Rigid type
- Bond or anchorage type
- Flexible type

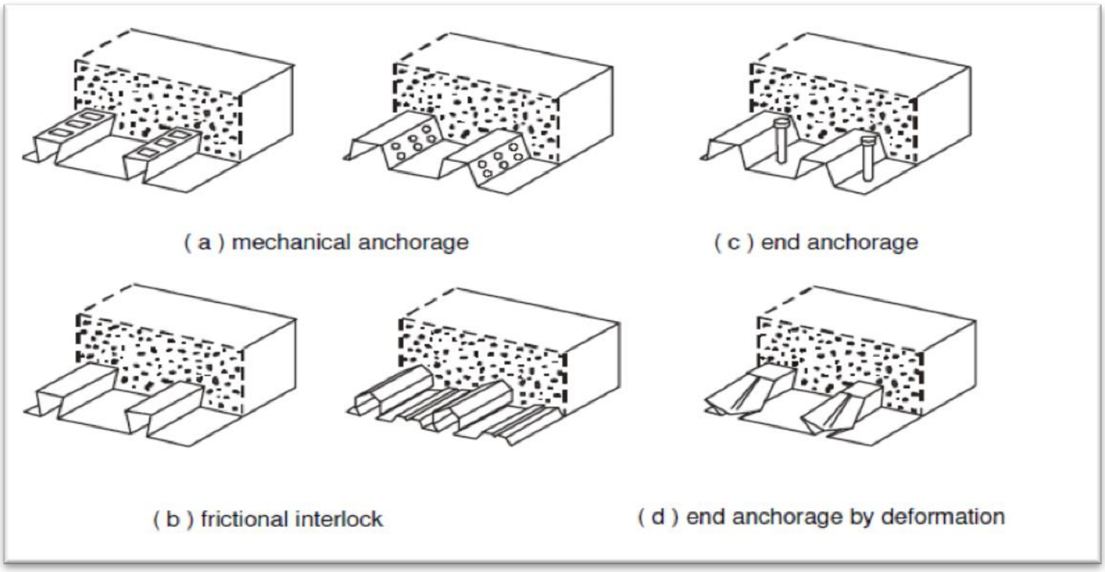

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Figure 4-11: Typical forms of interlock in composite slabs (Euro code, 1994)

iii. Foundation system

Variety of unlike foundation choice out around and selecting the most suitable one for my needs depends upon a few different variables:

- Parallel forces on the structure
- The layout of the terrain foundation will rest on
- Vertical load on structure

Since my structure is light and less complex then it is not necessary to build a full slab (mat foundation), instead several concrete pads when facing good soil conditions or piles if the soil condition is loose will provide enough support and anchor the building, (Bowles, 1982)

The structural design for the project was done with the main aim of providing safe and cost efficient housing. ETABS 2016 Ultimate 16.00 are used for analysis, modeling and Designing of structural member systems.

Structural steel house design

Specification

Type Residential Buildings

Design type Limit state design method

Material – Concrete – 25, class – I works

Steel Grade S 300

RHS for roof truss and purling

EGA- 300 for roof cover is used.

Partial safety factors – concrete = 1.5

Steel =1.15

weight of concrete = 24 m kN/m^3

Design Data and Materials

Concrete f ck =20 MPa

f ctk = 1.5MPa

Steel, fyk= 300MPa

fcd= 260.87MPa

Steel Grade, fy= 275 MPa Fu= 430 MPa (from the table 4.2)

Table 4-2: Nominal values of yield strength fy and ultimate tensile strength fu for structural hollow sections (Table 3.1 EBCS-EN10210-1)

Standard and steel grade	Nominal thickness of the element t[mm]			
	$t \leq$ 40mm		40 mm < $t \leq$ 80 mm	
	f_y [N/mm^2]	f_u [N/mm^2]	f_y [N/mm^2]	f_u [N/mm^2]
EN 10210-1				
S 235 H	235	360	215	360
S 275 H	275	430	255	410
S 355 H	355	510	335	490

iv. Roof design

Tasks to be taken into consider in the design of roofs include the repairs of appropriate internal environments by control of heat loss, prevention of condensation, control of transmission of external noise, prevention of fire spread from external sources, provision of day lighting where appropriate, and many other important considerations vital to the performance of the building as an entity.

Span of the roof truss = 7.45 m

Spacing of the truss = 3.00 m

Roof Cladding (EGA 300) - f_{yd}=275 mpa γ=17kN/m^3

Nodal spacing of trusses = 1.20 m

<u>Dead load</u>

Weight of Ceiling = 0.077 kN/m^2

Weight of services = 0.1 kN/m^2

Self-weight of EGA-300 0.4 mm roofing sheet = 0.011 kN/m^2

Self-weight of truss assume = 0.2 kN/m^2

Total dead load = 0.535 kN/m^2

Total permanent load transfer top tie beam = 0.535 kN/m^2*7.45 =3.99 kN/m

<u>Live load</u>

Category of of roof = category H- Roof not accessible except for

Normal maintenance and repair (Table 6.9EN 1991-1-1:2001)

Live load on roof Qk = 0.75 kN/m^2

There for total live load across span truss Qk =0.75 kN/m^2*7.45 =5.59 kN/m

Using the design combination UDSTL2 = 1.4DL+1.6LL

The total load transfer to top tie beam Pd = 1.4*3.99+1.6*5.59= 14.53 kN/m

v. Beam design

Because of such beam is very economical, while the parallel flanges facilitate the structural connections. The I section, which is selected from universal steel and section has ranging in depth from 70 to 600 mm, is now the most widely employed in buildings.

Figure 4-12 Universal steel beam and section (source: NJR steel, 2012)

Universal steel section beam section properties are taken from universal beam from section property tables the most economical section.

Total Depth h = 303.4 mm

Total Width b = 165.0 mm

Web thickness tw = 6.0 mm

Flange thickness tf, = 10.2 mm

Root radius rb = 8.9 mm

Second moment of area y axis Iy ,b1 = 8500 cm4 **(See Appendix C**)

vi. Column Design

This is the most frequently used shape for column sections. It is very suitable for connections to beams in both directions, as all parts of the section are accessible for forming bolted joints. Dimension and properties are taken from universal beam table.

Total Depth hc = 203.2 mm

Total Width bc = 203.2 mm

Flange thickness tf,c = 11.0 mm

Root radius rc = 10.2 mm

Web thickness tw,c = 7.2 mm

Second moment of area y-y axis Iy,c = 4570 cm^3

Area Ac=58.7 cm^2 **(See Appendix D)**

vii. Composite Slab

The effective area Ape of the steel sheeting is used in the calculation of the flexural resistance. The effective area is calculated ignoring the width of embossments and indentations in the sheeting.

Once the concrete has hardened, there is action between the steel sheeting and the concrete. Local buckling no longer limits the effective section of the sheeting as it is stabilized by the concrete.

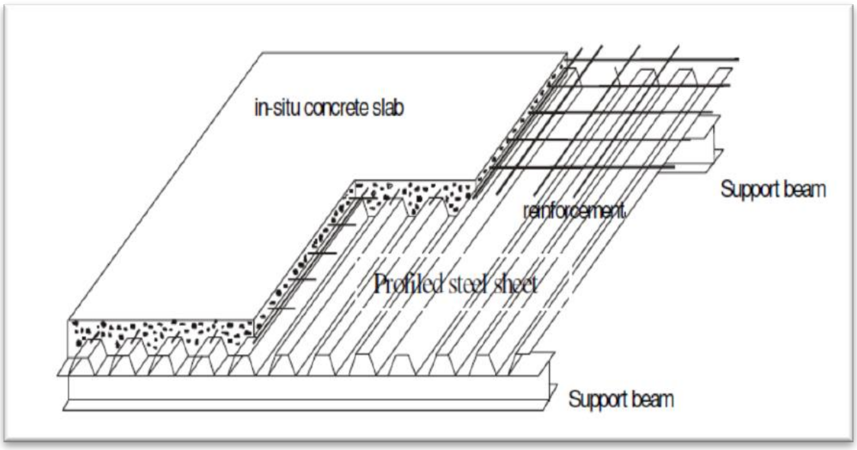


Figure 4-13: Component of deck slab (Stephen Hicks, 2008)

Figure 4-14: Composite steel decking constructions in London (decking supplies limited,2008)

a. Check of Slab with ULS

Flexure check

This check is made for the Composite slab is made at the section of maximum positive moment. The condition can be expressed as: MSd,≤MRdp Where

MRdp = the design the positive bending resistance of the section.

Msd = the design bending due to load

Vertical shear check

This condition may occur at end supports where the flexure is zero.

The condition is expressed as: VSd≤ Vv,Rd

This check is made for the composite slab and is rarely critical; however, it is critical in the case of deep slabs with loads of relatively large magnitude.

Where;

Vv Rd is the value of the vertical resistance of the section.

VSd is the value of the vertical load due to load.

Longitudinal shear check

It indicates that total disaster of the slab happens by failure of the vertical shear bond. The flexure at section I cannot then be reached. This check is often the decisive factor for composite slabs with sheeting profile without end anchorage. If the empirical "m-k" method is used, the condition can be determined: VSd≤ Vl,Rd

Where;

VSd is the vertical shear (equivalent span).

VlRd is the shear resistance.

b. Resistance with Full Shear checks

When the neutral axis is located in the slab, above the steel sheeting profile, as shown in Figure the compressive force in the concrete Ncf is equal to the tensile force in the profiled steel sheeting, Np. Thus: $Ncf=Np=A_{pef}\ fy_{p,d}$

Connection In the case of complete shear connection, the flexure per unit width MRd can be strong-minded by plastic theory. Where Ape is the effective area of the steel sheeting, per unit width of slab, neglecting embossments and indentations, as $fy_{p,d}$ is the design yield strength of the steel profile sheet.

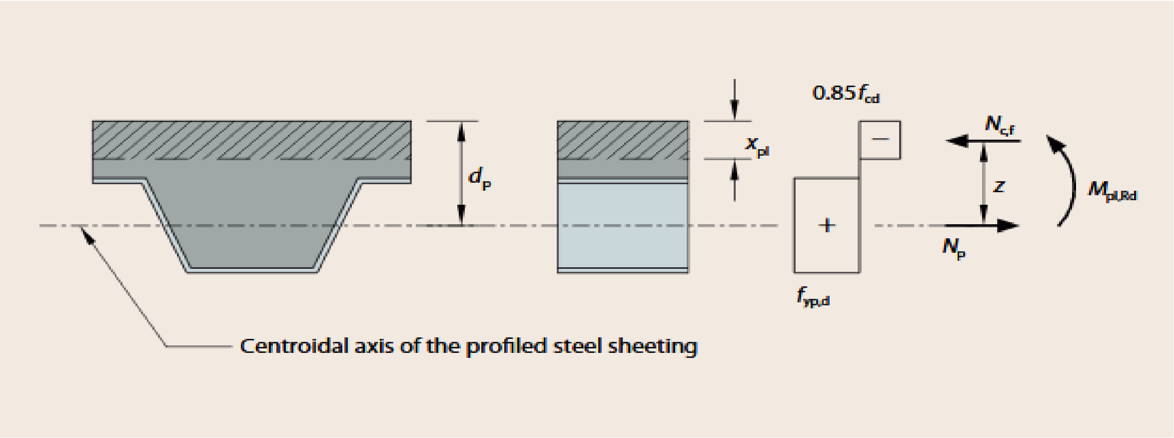


Figure 4-15: Cross Section of Profile Sheeting

The total depth of the mixing slab *h* should not be less than 80 mm. The width of concrete *h*c overhead the foremost flat surface of the top of the ribs of the sheeting shall be not less than 40 mm. A slab in which steel sheets are initially as dead shuttering and next combine structurally with the tough concrete and act as ductile reinforcement in the finished floor. *(EN 1994-4)*

c. Reinforcement of the slab

It is generally useful to provide reinforcement in the concrete slab for the following reasons

- Hogging moment area;
- To decrease cracking due to shrinkage
- Load distribution
- Local reinforcement
- Placed at the top of the profiled decking

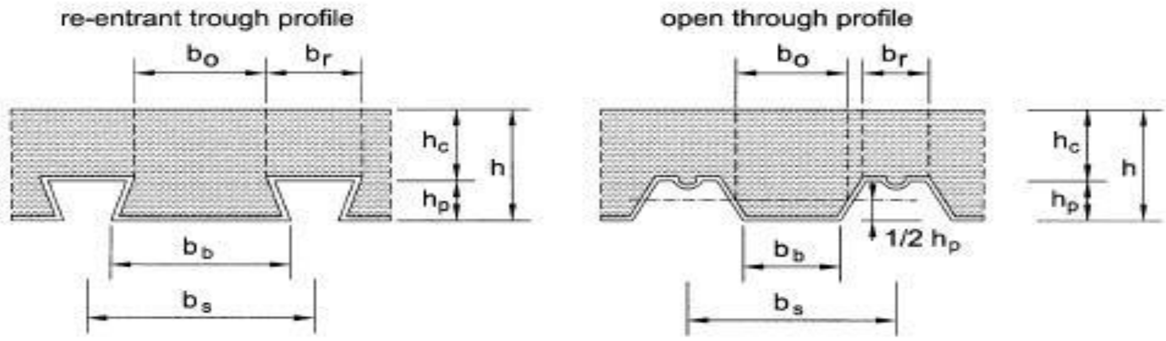


Figure 4-16: Sheet and slab dimensions (source EBCS EN 1994-1-1)

a. Design composite deck slab

Slab depth	hc	= 75 mm
Rib slab depth	h_P	= 75 mm
Rib width top	bo	= 175 mm the profiled decking
Rib width bottom	b_b	= 125 mm
Rib spacing	bs	= 150 mm
Deck shear thickness		= 1 mm
Deck unit weight		= 0.11 kN/m^2
Shear stud diameter		=19 mm
Shear stud height		= 125 mm
Shear stud tensile strength		= 400 MPa

Imposed load

The resistance of the metal decking during the construction level needs to be verified at the ultimate. Slab should be designed for both the construction level and the composite level.

Concrete weight

Self-weight of the concrete slab (volume from decking manufacturer's data)

0.096 × 21 × 10-6 = 1. 94kN/m2 (dry)

0.096 × 20 × 10-6 = 2.04 kN/m2 (wet)

Permanent load

Construction action

Steel Deck =0.11 kN/m^2

composite action

Steel deck	= 0.11 kN/m^2
Ceiling and services	= 0.15 kN/m^2
Slab	= 1.94 kN/m^2
Total	= 2.20 kN/m^2

Temporary load

In this case the span and so the construction loading across the whole span is 1.50 kN/m²

At the construction action the loading considered is a 0.74 kN/m² load across the entire slab, with an additional 0.74 kN/m² load across a span, which can be loaded anywhere on the slab span.

Construction action

(1) Outside the working space = 0.74 kN/m^2

(2) Inside the working space = 0.74 kN/m^2

Slab = 2.04 kN/m^2

Total = 3.54 kN/m^2

Composite action

load =2.81 kN/m^2

Ultimate Limit State Design approach

Partial factors for actions

Live load = 1.5

Dead load = 1.35

Reduction factor = 0.925

Combination of actions at

$= 1.35G_k + 1.5Q_K$

Construction action:

Distributed load (0.925×1.34×0.11)+(1.5×3.54) =5.45 kN/m2

Composite action

Distributed load (0.925×1.34×2.2)+(1.5×2.81) =6.97 kN/m2

Design moment and shear force

The design bending moment across width of the steel deck is:

The design shear force per metre width of the steel deck is:

$V_{Ed} = \frac{WL}{2} = \frac{5.45*3.8}{2} =$ 10.36 kN/m

$M_{Ed} = \frac{WL^2}{8} = \frac{5.45*3.8^2}{8} =$ 9.84 kN.m/m width

The design bending moment per meter width of the steel sheet deck is:

$M_{Ed} = \frac{WL^2}{8} = \frac{6.97*3.8^2}{8} =$ 12.58 kN.m/m width

The design shear force per metre width of the steel deck is: $V_{Ed} = \frac{WL}{2} = \frac{6.97*3.8}{2} = 13.24$ kN/m

Verification of the composite slab (ULS)

Maximum tensile resistance across of the profiled steel sheet is

$N_p = f_{yd*} A_{P=}$ 350*1424*$10^{3=}$498.KN/m

$N_{C} = F_{cd*} A_{C=}$13.11* 70* 1000 *$10^{-3=}$ 917 kN/m

As Np < N the neutral axis lies above the profiled sheeting. The depth of concrete in compression is:

$x_p = \frac{A_{pe} f_{ypd}}{b f_{cd}}$ where: b is the width of the floor slab being considered,

here;

b = 1000 mm $\quad x_{pl} = \frac{1424*350}{1000*11.33} = 43.99$ mm

Bending resistance – full shear connection

For full shear connection, the design moment resistance is:

Mpl,Rd = Apf yd (d p -x pl / 2)

dp =h - depth from soffit to centroidal axis of sheeting d p =130 – 43.99 =86.01 mm

The plastic bending resistance per metre width of the slab is:

$M_{PL,Rd} =$ 1424*350 *8* (86.01- 35.1 2)*10^{-6}= 34.14 kNm/m

$\frac{M_{Ed}}{M_{PL,RD}} = \frac{12.58}{34.14} = 0.37 \leq 1.0$

Therefore the bending moment resistance for full shear connection is ok.

Longitudinal shear resistance: m-k method m and k are design values obtained from the manufacturer.

m = 157.2 N/mm2 k = 0.1232 N/mm2

For a uniform load applied to the whole span length;

$L_{s} =$ L/3= 3800/4= 1260 mm

$V_{l,Rd} = [\frac{1000*86.01}{1.25} * (\frac{157.2.1424}{1000*1260} + 0.1232)]$ =20.70 kN/m

The design shear resistance must not be less than the maximum design vertical shear

$\frac{V_{Ed}}{V_{L,Rd}} = \frac{13.24}{20.7} = 0.63 \leq 1$

Design vertical shear resistance

The vertical shear resistance will normally be based on BS EN 1992- 1-1

Vv,Rd =$\mathbf{V}_{min}$bsd p

The recommended value of v_{min} is $v_{min} = 0.035k^{3/2}f_{ck}^{1/2}$ where $k = 1+ \sqrt{200/dp}$ =2.52 so, k=2 $V_{min} = 0.035*^{3/2}20^{1/2}= 0.44$ N/mm^2 $V_{v,rd} = 0.44*86.01= 37.84$ kN/m, > 13.24 kN/m **ok!!**

Therefore vertical shear resistance is adequate.

All design checks of the composite slab in the ULS are satisfied.

b. Steel Connection Design

The two main fastening means are bolting and welding (with a few and isolated case also riveting and pins).Every structure is connected of individual parts or members which must be fastened together, usually at the ends of its members. Etabs is design three steel type connection.

a. beam to beam

b. beam to column

c. column to base plate

a. Beam to Beam

The joint was bolted into the frame**.** The structural steel connection analysis and design are done using ETABS 2016.

b. Beam to Column

Angles with holes are welded to columns and eventually connected to beams by means of bolts. Beam –column joint the steel beam and embedded steel column could be connected by two patterns:

c. Column to Base Plate

The function of a column base plate is to distribute the column forces to the concrete foundation. In general a plain or slab base is used for pinned conditions or when there is very little tension between the plate and the concrete. Then base plate thickness, bolt and weld are determined.

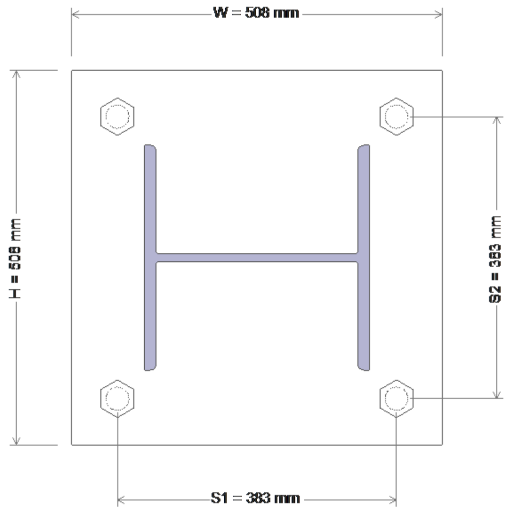


Figure 4-17: Column Base Plate Connections

4.1.4 Construction Cost Component

The cost of construction using the three house systems of the building is calculated

4.1.5 Cost Comparison of the Three House Systems

Table 4-3: Cost summary domestic one story wood house structure

EXECUTED WORK	TOTAL COST(ETB)
A. Sub-Structure	
Stonework work	110,235.00
Earth work and Excavation	70,887.70
Subtotal (A)	**181,122.70**
B. Super-Structure	
Wood work	13,075.00
Roofing	26,934.00

Roof Wood structure	28,580.00
Water proofing structure	11,250.00
Subtotal (B)	**79,839.00**
Total (A+B)	**260,961.00**

Table 4-4: Cost summary two stories existing concrete house

EXECUTED WORK	TOTAL COST(ETB)
A. Sub- House Structure	
Concrete work	116,434.35
Excavation and Earth work	70,887.70
Subtotal (A)	**187,322.05**
B. Super- House Structure	
Concrete work	74,446.84
Roofing	50,215.00
Roofing wood structure	40,424.00
Water proofing	11,250.00
Subtotal (B)	**176,335.84**
	363,657.89

Total (A+B)	

Table 4-5: Cost summary two story new proposed steel structure house

EXECUTED WORK	TOTAL COST(ETB)
A. Sub- House Structure	
Excavation and Earth work	48439.23
Concrete work	82,851.40
Subtotal (A)	**131,290.63**
B. Super- House Structure	
Steel work	280,247.41
Roofing	29,590.00
Roofing steel structure	53,535.00
Water proofing	11,250.00
Subtotal (B)	**374,622.41**
Total (A+B)	**505,913.04**

Note Table 4.4 indicated since the steel structure for the column price high it affects total cost of steel house construction. If we can replace the universal column and beam by local product the overall cost of the steel house will below.

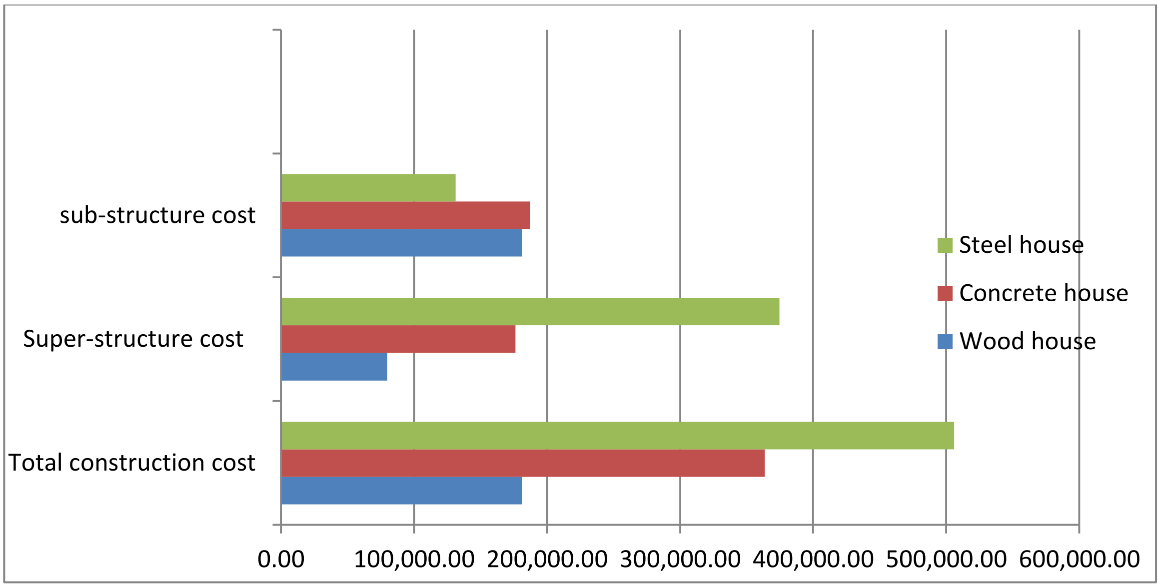


Figure 4-18: The total cost of three structural house systems

4.1.6 Construction time Component

Since construction time interruption is the key reasons of titles in the construction , the use of steel systems is supposed to answer this difficult, in addition to cost saving. The main benefit using steel structure house elements for construction is the speed of construction, i.e. the use of this system protects construction time.

Table 4-6: Construction installation schedule using wood house structure system

No	Activity	Quantity	Output per 2 crew	Duration (days)
1	Column	50 per pcs	25 pcs/day	2
2	Beam	40 per pcs	40 pcs/day	1
3	Form work Beam and Column	0.00	0.00	00.00
4	Slab work	0.00	0.00	0.00
4.1	Deck sheet profile	0.00	0.00	0.00

4.2	Reinforcement	0.00	0.00	0.00
4.3	concrete	0.00	0.00	0

Table 4-7: Construction installation schedule using concrete house structure system

No	Activity	Quantity	Output per 2 crew	Duration (days)
1	Column			
1.	Reinforcement	895.75 kg	179.15 kg/day	5.00
1.2	concrete	8.02 m^3	4$m^{3/}$day	2.00
2	Beam			
2.1	Reinforcement	1094.32 kg	179.15 kg/day	7.00
2.2	concrete	16.72 m^3	4m^3/day	4.00
3	Form work Beam and Column	98.38 m^2	18 m^2 /day	6.00
4	Slab work			
4.1	Deck sheet profile	0.00	0.00	0.00
4.2	Reinforcement	620 kg	179/day	4.00
4.3	concrete	4 m^2	2m^3/day	2.00
4.4	Form work	56 m^2	8m^2/day	7.00

Table 4-8: Construction installation schedule using steel house structure system

No	Activity	Quantity	Output per 2 crew	Duration

				(days)
1	Column	56.2 meter	25 m/day	2.00
	Beam	88.1 meter	40 m/day	1.00
3	Slab work	0.00	0.00	0.00
3.1	Deck sheet profile	523.27kg	600kg/day	1.00
3.2	Reinforcement	0.00	0.00	0.00
3.3	concrete	4 m^3	$2m^3$/day	2.00

As it can seen from the table of the three systems, the construction time saving by using wood house system is 34 days than concrete and 3 days than of the steel structure. Inappropriately due to the environmental and social effect and other many factors it doesn't recommend for construction house. In other hand the steel structure saving 31 days than concrete house structure. This means the steel house system of construction will take only 16.21% of the time by the concrete house system.

4.2 Environmental Assessment Three House Structure System

The first part presents survey distribution and response by stalk holder respondent, in Debre Birhan house construction. The finding and discussion below is devised in two parts corresponding to the research field observation. The second part of the result and discussion contain the finding the data.

4.2.1 Survey Response

A total of 40 respondents were asked among the respondent different background working on the house construction on the selected site.

Table 4-9: Respondent working sector

Working sector	Quantity	Each Sample (%)	Total Sample (%)
Private worker	15	37.5	-
Public worker	11	27.5	37.50
Plc worker	9	22.5	65.00
Other	5	12.5	87.50
Total	40	100.00	100.00

From Table 4.8 in shows it is that majority of respondents (37.5%) work with private organization, 27.5% work with public organizations, and 22.5% work with private limited company in the city 12.5 % work other sector.

Table 4-10: Type of house construction executed by the house builder for study

Type of House Construction	Quantity	Each Sample (%)	Total Sample (%)
House / wood structure one story	27	60.00	_
House /Reinforced concrete structure with two story	16	35.55	60.00
House /steel structure with two story	0	0.00	95.55
Others	2	4.44	95.56
Total	45	100.00	100.00

Most of the construction house carries out with both wood and reinforced concrete housing while no with steel house construction carry out separately as recorded in Table 4.10

Table 4-11: Highest certification of respondent at Adisu Sefer site

Certification	Quantity	Each Sample (%)	Total Sample (%)
Diploma	4	40	-
BSc.	2	20	40
Master	2	20	60
Ph.D.	0	0	80
Others	2	20	80
Total	10	100	100

Table 4-12: Highest Certification of respondent at Mariam Sefer site

Certification	Quantity	Each Sample (%)	Total Sample (%)
Diploma	4	40	-
BSc.	3	30	40
Master	1	10	70
Ph.D.	0	0	80
Others	2	20	80
Total	10	100	100

Table 4-13: Highest certification of respondent at Habitat Sefer site

Certification	Quantity	Each Sample (%)	Total Sample (%)
Diploma	3	30	-
BSc.	2	20	30
Master	2	20	50
Ph.D.	0	0	70
Others	3	30	70
Total	10	100	100

This indicates that majority of the respondents have at least Diploma or its equivalent in construction/ environmental related activities. The certification of respondents were recorded in Table 4.9 result indicated that Diploma has the maximum of respondents while Ph.D. has the lowermost.

Table 4-14: Highest academic certification of respondent at Dashen site

Certification	Quantity	Each Sample (%)	Total Sample (%)
Diploma	3	30	-
BSc.	2	20	30
Master	2	20	50
Ph.D.	0	0	70
Others	3	30	70
Total	10	100	100

This indicated that majority of the defendants have at least a Higher Diploma or its equivalent in construction/ environmental related activities. The qualifications of respondents were noted in Table 4.10 result shows that Higher Diploma has the maximum of defendants while Ph.D. has the lowest.

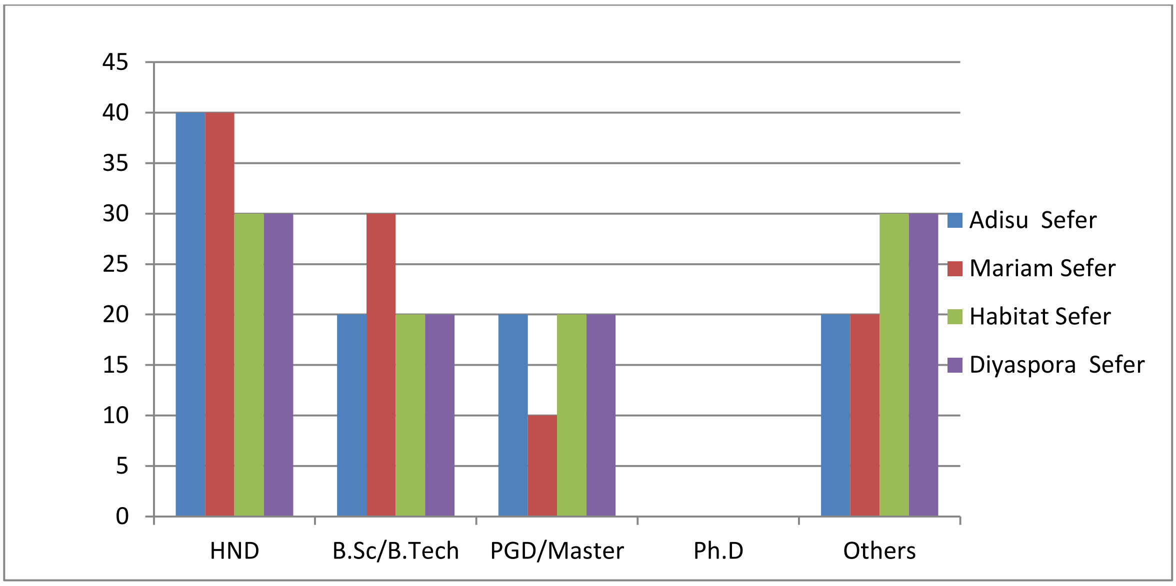


Figure 4-19: The percentage of the respondent in qualification level

Table 4-15: Professional discipline of respondents

Profession	Quantity	Each Sample (%)	Total Sample (%)
Contractor	15	37.5	_
Builder(client)	12	30	37.5
Consultant	3	7.5	67.5
Engineer	7	17.5	75
Architect	3	7.5	92.5
Total	40	100	100

Table 4.15 Shows the professional discipline of the respondents and the result indicate that contractor have the highest number of respondent while Architect and Engineer have the lowest. The Builders, Architects, Civil Engineers are more involved in the design and production of building in the study area.

Table 4-16: Working experience of respondents in the house construction industry.

Work experience(years)	Quantity	Each Sample (%)	Total Sample(%)
0-5	15	37.50	-
5-10	8	20.00	37.50
10-15	7	17.50	57.50
15-20	6	15.00	75.00
Above 20	4	10.00	90.00
Total	40	100.00	100.00

This suggests that most of the workers in the construction sector are knowledgeable and can be trained as worker on environmental impacts on house construction industry.

Table 4.15 shows the working experience of respondents in the construction house . The result indicated that 37.5% of the total numbers of respondents have been practicing in the construction house for about 10 years.

Table 4-17: Results of ranking wood house constructions related factors that causes environmental impacts

Wood House Construction environmental Impacts	Degree of Harmful answered by 40 Respondents					Total point	Relative important Index (RII)	Rank
	5	**4**	**3**	**2**	**1**			
Increase of Desertification	18	12	5	3	2	161	4.03	**6th**
Vegetation Destruction	20	11	7	2	0	170	4.25	**1st**
Removal of Waste	17	11	9	3	0	151	3.78	**9th**
Loss of Soil	11	17	7	3	2	152	3.80	**8th**
Consumption Material	18	10	10	2	0	164	4.10	**2nd**
Sound from action.	20	8	6	4	2	160	4.00	**7th**
effect of Greenhouse	13	19	8	7	1	148	3.7	**10th**
Consumption of Energy	17	9	11	3	0	160	4.00	**7th**
Trash of Water	16	12	2	9	1	153	3.83	**7th**
Increase of Global Warming	15	10	7	5	3	149	3.73	**11th**
Dust particle	9	14	9	8	0	144	3.60	**12th**
Flood	12	15	9	2	2	153	3.83	**8th**
Contamination of Air	19	10	1	5	5	153	3.83	**8th**
Disturbance of Visual	19	13	4	2	1	164	4.10	**3rd**
Disaster of Natural	16	12	9	3	1	163	4.05	**4th**
Spillage	12	13	7	4	4	151	3.78	**9th**
Change of Climate	18	10	5	3	2	161	4.03	**5th**
Wild life Loss	16	12	5	5	0	161	4.03	**5th**

Table 4.17 presents the list of the factors considered to contribute to the environmental impacts (destruction of vegetation, material waste, visual disturbance, and natural disaster) are the highest impact due to wood house construction while (dust, global warming, greenhouse effect, and spillage) are the lowest value due to house of construction. All the causes of environmental impacts listed are above the mid (RII)

index of 2.5 suggesting that there are all significant causes' environmental impact and environmental degradation due to wood frame house. The average (RII) of all significant indexes (3.92) above the average of mid (RII) indexes (2.5).

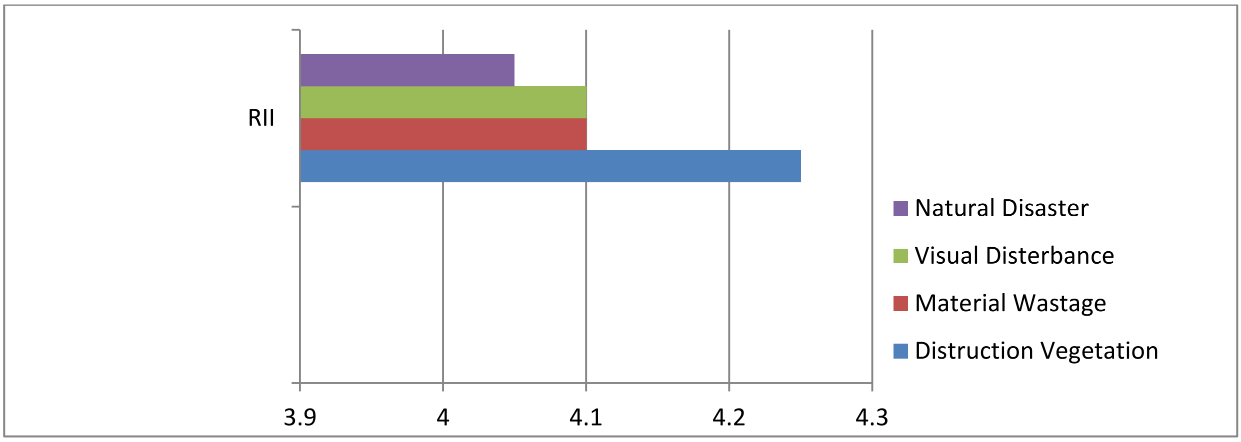


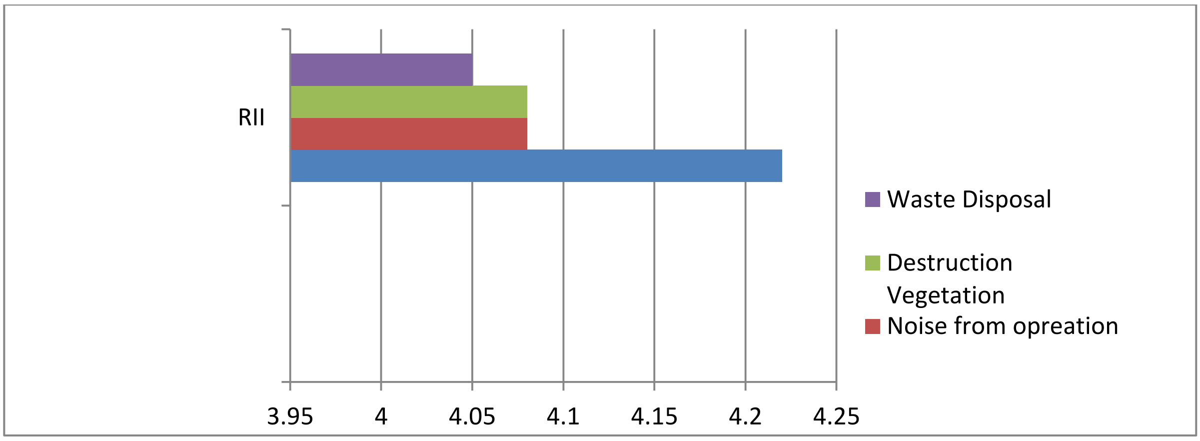
Figure 4-20: Results of relative importance index (RII) of wood house construction related factors that causes environmental impacts

Table 4-18: Results of ranking of concrete house constructions related factors that causes environmental impacts

Concrete Structure House Environmental impact	Degree of Hazardous answered by 40 Respondents					Total point	Relative important Index (RII)	Rank
	5	**4**	**3**	**2**	**1**			
Increase of Desertification	19	11	5	3	0	163	4.08	3rd
Vegetation Destruction	18	12	4	2	1	155	3.90	8th
Disposal of Waste	17	13	5	5	0	162	4.05	4th
Erosion of Soil	11	17	7	3	2	151	3.80	9th
Wastage Material	20	11	7	2	1	169	4.22	1st
Noise from operation.	18	10	10	1	0	163	4.08	2nd
effect of Greenhouse	16	12	9	3	1	162	4.05	5th
Wastage of Energy	19	7	6	4	2	159	3.9	7th
Pollution of Water	15	13	2	9	1	152	3.80	8th
Increase of Global Warming	15	10	7	5	3	149	3.73	11th
Dust particle	9	14	9	8	0	144	3.60	12th
Flood	13	14	9	2	2	154	3.85	7th
Pollution of Air	17	13	5	3	2	160	4.00	6th

Disturbance of Visual	18	8	11	3	0	161	4.03	6th
Disaster of Natural	14	10	8	7	1	149	3.73	10th
Spillage	12	13	7	4	4	151	3.78	9th
Change of Climate	19	11	5	3	2	163	4.08	3rd
Wild life Loss	18	12	9	3	0	150	3.75	10th

All the sources of environmental impacts listed are above the mid (RII) index of 2.5 suggesting that there are all significant causes' environmental impact and environmental degradation due to wood frame house. Table 4.18 presents the list of the factors measured to subsidize to the environmental impacts (material waste, noise from operation, and destruction vegetation and waste disposal) are the highest impact due to concrete house construction while (dust, global warming natural disaster and spillage) are the lowest value due to house of construction. The average (RII) of all significant index (3.89) above the average of mid (RII) indexes (2.5).



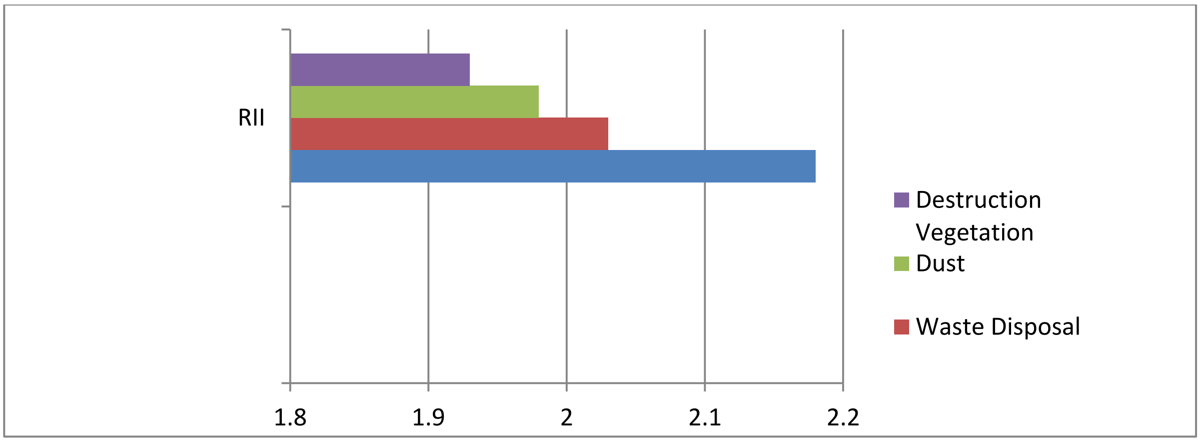
Figures 4-20: Results of relative importance index (RII) of concrete house construction related factors that causes environmental impacts

Table 4-19: Results of ranking of steel house constructions related factors that causes environmental impacts

Steel Structure House Environmental impact	Degree of Hazardous answered by 40 Respondents					Total point	Relative important Indicator (RII)	Rank
	5	**4**	**3**	**2**	**1**			
Increase of Desertification	0	5	5	12	18	77	1.93	4th

Vegetation Destruction	0	2	7	10	21	70	1.75	9th
Disposal of Waste	3	0	9	11	17	82	2.03	2nd
Erosion of Soil	0	0	7	17	16	71	1.88	6th
Wastage Material	0	0	8	13	19	69	1.73	10th
Noise from operation.	0	0	2	8	20	42	1.05	13th
Effect of Greenhouse	0	0	10	13	17	73	1.83	8th
Wastage of Energy	0	5	10	11	15	87	2.18	1st
Pollution of Water	0	0	10	14	16	74	1.85	7th
Increase of Global Warming	0	0	9	16	15	74	1.85	7th
Dust particle	0	3	7	13	17	79	1.98	3rd
Flood	0	0	10	15	15	65	1.63	7th
Pollution of Air	0	0	1	20	19	62	1.55	12th
Disturbance of Visual	0	0	10	13	17	73	1.83	8th
Disaster of Natural	0	0	10	11	19	90	1.75	10th
Spillage	0	0	7	14	19	68	1.7	11th
Change of Climate	0	5	5	11	19	76	1.90	5th
Wild life Loss		0	0	10	30	50	1.25	5th

All the causes of environmental impacts listed are below the mid (RII) index of 2.5 signifying that there are all non-significant causes' environmental impact and environmental degradation due to steel frame house. Table 4.19 presents the list of the factors considered to contribute to the environmental impacts (Energy wastage, noise from operation, dust and destruction vegetation and) are the highest impact due to steel house construction while (noise from the operation, air pollution, spillage and natural disaster) are the lowest value due to house of construction. The average (RII) of all non-significant indexes below the average of mid (RII) indexes.



Figures 4-21: Results of relative importance index (RII) of steel house construction related factors that causes environmental impacts.

Table 4-20: Results of ranking of environmental protection measures in Debre Birhan

Environmental Protection Measure	Degree of Hazardous answered by 40 Respondents					Total point	Relative important Indicator (RII)	Rank
	5	**4**	**3**	**2**	**1**			
Waste Management system	15	10	8	5	2	159	3.98	**1st**
Pollution Control system	17	11	4	5	3	154	3.85	**2nd**
Conservation of Ecological	10	14	9	4	3	144	3.60	**3rd**
Conservation of Energy	15	8	7	6	4	144	3.60	**3rd**

The resource efficiency of building materials would be increased if there were measures put in place to reduce waste in the manufacture process. All the actions are significant with RII above 3.0 Construction house impacts are generated from the Construction materials, demolition and from accidental wastage on site.

Table 4.20 below, shows the various methods of environmental protection considered in relation to their respective level of significance in dealing with various environmental impacts caused by house construction.

Table 4-21: Shows that the various agencies adopted country for planning and for determining the potential environmental.

Tool and Establishment	Degree of Hazardous answered by 40 Respondents					Total point	Relative important Indicator (RII)	Rank
	5	4	3	2	1			
Ethiopia Environment Protection Authority	14	9	8	8	1	147	3.68	**2nd**
NGO Environment Protection	12	11	9	5	3	144	3.60	**3rd**
Ethiopia Environment And Forest Institute	15	10	6	9	0	151	3.78	**1st**

Table 4.21 shows that the various agencies adopted the country for planning and for determining the potentials environmental and social effect of a proposed development for the purpose of environmental protection.

It is shown on the table that environmental protection authority ,NGO of Environment protection and Ethiopia environment and forest institute are the most three important agents used to control, sensitize and regulate environment disasters in Ethiopia. This body protects environmental assessment impact (EIA) document which is one of the forerunning tools to study, identify, and improve on past, present and future environmental hazards Ethiopia Environmental Protection authority (EEPA) is a national tool established under the Decree use to guide beside the abuse of the environment by Ethiopia.

This body is in charge of waste management, sewage maintenance, as well as maintenance of other public utilities. Ethiopia environment and forest institute (EEFI) is an organization sponsored by both government and non-government bodies to assist government agencies to develop and monitor the strict adherence to environmental protection laws.

(EEFI) was established in 1991 with the help of United Nation habitat as well as other international conservation bodies. There is a broad consensus that these agencies will reduce environmental degradation and enhance sustainable environment.

CHAPTER 5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

In this study a detailed analytical study of the three type house construction with the sustainability measurement has been work out. Based on literature review, the resultant analysis cost estimation of house building and resultant of the questionnaire, conclusions are drowned. The following sustainability the three house conclusion can be representing from the obtaining results:

1. The total construction time obtained from the use of steel system is about 16.21% of the total construction cost of a building using concrete house. In addition to the economic benefits gained the application of this system is believed to solve problems associated with delays in the construction industry, since construction delays are one of the main causes of disputes. The cost comparison and environmental analysis shown that steel structure system of construction using deck slab is faster, less expensive, and eco-friendly than the wood and concrete structure system. Even though total construction of the steel structure the highest than wood and concrete house system, it is compensate by construction time saving and more eco-friendly house system for the area.
2. Furthermore, the risk level of impacts is an appropriate measure for understanding the impact level of house construction processes on the environment and economic for justification of such effect, which may lead to effective sustainable show.
3. The outcomes of this research can be significant assessment tool to contribution house construction practitioners to improve the sustainable house construction. The construction house practitioners will be able to achieve a comprehensive perception of the environmental, economic, and social impacts of house construction processes during the construction house.
4. On side of the analysis of environmental impacts for wood, concrete house and steel are listed overhead the average (RII) index of 2.5 suggesting that there are all significant environmental impact and reasons of environmental deprivation by two house construction. Therefore the increasing threat of environmental impacts of house construction on the ecosystem needs revolutionary justifying measures in all results.

5. Finally the outcome of this study can help organizations and managers prepare proper sustainability plans and also to increase the knowledge of partner's in house construction through training and awareness programs. Further research desires to explore the on-site sustainable performance measurements using identified environmental impacts in advance.

5.2 Recommendations Future Study for Area

1. Whit regard to steel, the absence of steel production and special steel construction workman ships are another reasons that why steel is not considered as a structural building material in Debre Birhan city construction sector. Furthermore, the deficiency of deliberation of sustainability in building materials is a main reason of why alternative material is not used more frequently. Therefore, as this research shows, it is required to study steel alternative materials to achieve sustainability.
2. In this present study the house impact both environmental and economic based on literature review, questionnaire, and economical analysis. This is not enough to study the impact the house system to know the complete impact of house structure at the area, we should able to study the impact detail life cycle analysis of the construction of material of the house system.
3. This study is limited to wood, concrete and steel house system on environmental and economic. But there is a future scope of study on the impact all construction project type in the city.
4. The city administrative should encourage business to fabricate steel gauge and precast deck ribbed slab sheeting type.
5. The progress and promotion of using steel in building construction in Ethiopia will lead the country forward to reach sustainability and development. Consequently, this thesis could also be useful for the future researchers who are willing to study sustainability of house material related issues.
6. The Ethiopian building design and construction should be able to accommodate various uncertainties in the future so that it will not become early obsolete. This includes buildings should incorporate the features of sustainable house building practice.

7. In general, conferences and seminars can be useful and be reliable sources for the architects, constructors and specialists in the construction sector, and also it can assist them to be up-date with new house construction materials.

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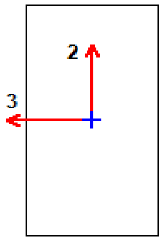
APPENDIX A Concrete Beam Design

ETABS 2016 Concrete Frame Design

Eurocode 2-2004 Beam Section Design



Beam Element Details Type: DC High

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (mm)	LLRF
Story2	B10	78	Beam	DCon18	3900	4000	1

Section Properties

b (mm)	h (mm)	b_f (mm)	d_s (mm)	d_{ct} (mm)	d_{cb} (mm)
200	400	200	0	40	40

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	E_s (MPa)	f_{yk} (MPa)	f_{ywk} (MPa)
31000	25	1	200000	300	300

Design Code Parameters

γ_C	γ_S	α_{CC}	α_{CT}	α_{LCC}	α_{LCT}
1.5	1.15	1	1	0.85	0.85

Design Moment and Flexural Reinforcement for Moment, M_{Ed3}

	Design -Moment kN-m	Design +Moment kN-m	-Moment Rebar mm²	+Moment Rebar mm²	Minimum Rebar mm²	Required Rebar mm²
Top (+2 Axis)	-1.1391		9	0	308	308
Bottom (-2 Axis)		12.3826	0	127	308	308

Shear Force and Reinforcement for Shear, V_{Ed2}

Shear V_{Ed} kN	θ deg	Shear V_{Rdc} kN	Shear V_{Rds} kN	Rebar A_{sw} /S mm^2/m
3.4176	45	33.2165	22.5391	266.67

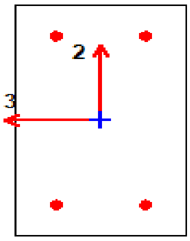
Torsion Force and Torsion Reinforcement for Torsion, T_{Ed}

Torsion T_{Ed} kN-m	T_{cr} kN-m	Area A_k cm^2	Perimeter, u_K mm	Rebar A_t /s mm^2/m	Rebar A_{sl} mm^2
0.019	6.5976	384	880	0	1

APPENDIX B Concrete column Design

ETABS 2016 Concrete Frame Design

Eurocode 2-2004 Column Section Design



Column Element Details Type: DC High

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (mm)	SOM	LLRF
Story2	C16	column	DCon18		2600	3000	Nominal Stiffness	1

Section Properties

b (mm)	h (mm)	dc (mm)	Cover (Torsion) (mm)
200	350	47	20

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	E_s (MPa)	f_{yk} (MPa)	f_{ywk} (MPa)
31475.81	25	1	200000	413.69	413.69

Design Code Parameters

γ_C	γ_S	α_{CC}	α_{CT}	α_{LCC}	α_{LCT}
1.5	1.15	1	1	0.85	0.85

Axial Force and Biaxial Moment Design For N_{Ed} , M_{Ed2} , M_{Ed3}

Design N_{Ed} kN	Design M_{Ed2} kN-m	Design M_{Ed3} kN-m	Minimum M2 kN-m	Minimum M3 kN-m	Rebar Area mm²	Rebar % %
13.4329	0.8137	9.878	0.2687	0.2687	700	1

Axial Force and Biaxial Moment Factors

	M_{0Ed} Moment kN-m	M_{add} Moment kN-m	Minimum Ecc mm	β Factor Unitless	Length mm
Major Bend(M3)	3.9512	0	20	1	2600
Minor Bend(M2)	0.3307	0	20	1	2600

Axial Compression Ratio

Conc Capacity (α_{CC} *A*f_{cd}) kN	Compressive Ratio N_{Ed} /(α_{cc} *A*f_{cd})	Comp Ratio Limit	Seismic Load?	Ratio OKay?
1166.6667	0.013	0.55	Yes	Yes

Shear Design for V_{Ed2} , V_{Ed3}

	Shear V_{Ed} kN	Shear V_{Rdc} kN	Shear V_{Rds} kN	tan(θ) Unitless	Rebar A_{sw} /s mm^2/m
Major, V_{Ed2}	14.7478	34.0806	0	0.4	0
Minor, V_{Ed3}	16.9257	34.3681	0	0.4	0

Joint Shear Check/Design

	Joint Shear A_{sh} kN	Shear V_{Ed} , Top kN	Shear V_{jhd} kN	Shear V_{Rd} Conc kN	Joint Area cm^2	Shear Ratio Unitless
Major Shear, V_2	0.0954	0	80.2945	368.64	512	0.218
Minor Shear, V_3	0.2679	0	80.2945	193.0896	268.2	0.416

(1.3) Beam/Column Capacity Ratio

Major Ratio	Minor Ratio
N/A	N/A

Notes:

N/A: Not Applicable

APPENDIX C Steel Beam Design

ETABS 2016 Steel Frame Design

Eurocode 3-2005 Steel Section Check (Strength Summary)

Element Details (Part 1 of 2)

Level	Element	Unique Name	Length (mm)	Location (mm)	Combo	Design Type	Element Type	Section
first	B10	34	2425	2272.4	DStlS1	Beam	DCM EBF	edit beam

Element Details (Part 2 of 2)

Classification	Rolled
Class 1	No

Design Parameters

National Annex	Combination Equation	Analysis Type	Reliability
CEN Default	Eq. 6.10	Method 2 (Annex B)	Class 1

Design Code Parameters

γ_{M0}	γ_{M1}	γ_{M2}	A_n / A_g	LLRF	PLLF	Stress ratio Limit
1	1	1.25	1	1	0.75	0.95

Section Properties

A (cm^2)	I_{yy} (cm^4)	i_{yy} (mm)	$W_{el,yy}$ (cm^3)	$A_{v,y}$ (cm^2)	$W_{pl,yy}$ (cm^3)	I_{yz} (cm^4)	I_t (cm^4)
50.6	8370.2	128.6	551.8	20.4	613.6	0	13.8

I_{zz} (cm^4)	i_{zz} (mm)	$W_{el,zz}$ (cm^3)	$A_{v,z}$ (cm^2)	$W_{pl,zz}$ (cm^3)	I_w (cm^6)	h (mm)
764.2	38.8	92.6	33.7	141.4	164122.7	303.4

A_{eff} (cm^2)	e_{Ny} (mm)	e_{Nz} (mm)	$W_{ef,yy}$ (cm^3)	$W_{ef,zz}$ (cm^3)
50.6	0	0	551.8	92.6

Material Properties

E (MPa)	f_y (MPa)	f_u (MPa)
210000	275	430

Stress Check Forces and Moments

Location (mm)	N_{Ed} (kN)	$M_{Ed,yy}$ (kN-m)	$M_{Ed,zz}$ (kN-m)	$V_{Ed,z}$ (kN)	$V_{Ed,y}$ (kN)	T_{Ed} (kN-m)
2272.4	-1.565	-4.8348	-0.0842	23.8533	0.0922	-0.0009

Demand/Capacity (D/C) Ratio 6.3.3(4)-6.62

D/C Ratio = $N_{Ed} / (\chi_z N_{Rk} / \gamma_{M1}) + k_{zy} [M_{y,Ed} / (\chi_{LT} M_{y,Rk} / \gamma_{M1})] + k_{zz} [M_{z,Ed} / (M_{z,Rk} / \gamma_{M1})]$

0.036 = 0.001 + 0.034 + 0.001

Basic Factors

Buckling Mode	K Factor	L Factor	L Length (mm)	L_{cr}/i
Major (y-y)	1	0.874	2119.7	16.487
Major Braced	1	0.874	2119.7	16.487
Minor (z-z)	1	0.874	2119.7	54.566
Minor Braced	1	0.874	2119.7	54.566
LTB	1	0.874	2119.7	54.566

Axial Force Design

	N_{Ed} Force kN	$N_{c,Rd}$ Capacity kN	$N_{t,Rd}$ Capacity kN	$N_{byy,Rd}$ Major kN	$N_{bzz,Rd}$ Minor kN
Axial	-1.565	1392.6	1392.6	1392.6	1069.9928

$N_{pl,Rd}$	$N_{u,Rd}$	$N_{cr,T}$	$N_{cr,TF}$	A_n / A_g
kN	kN	kN	kN	Unitless
1392.6	1567.8144	4814.3553	4814.3553	1

Design Parameters for Axial Design

	Curve	α	N_{cr} (kN)	λ	Φ	χ	$N_{bd,Rd}$ (kN)
Major (y-y)	b	0.34	38610.7274	0.19	0.516	1	1392.6
MajorB (y-y)	b	0.34	38610.7274	0.19	0.516	1	1392.6
Minor (z-z)	c	0.49	3525.012	0.629	0.803	0.768	1069.9928
MinorB (z-z)	c	0.49	3525.012	0.629	0.803	0.768	1069.9928
Torsional TF	c	0.49	4814.3553	0.538	0.727	0.822	1144.1569

Moment Designs

	M_{Ed} Moment	$M_{Ed,span}$ Moment	$M_{c,Rd}$ Capacity	$M_{v,Rd}$	$M_{n,Rd}$	$M_{b,Rd}$ Capacity
	kN-m	kN-m	kN-m	kN-m	kN-m	kN-m
Major (y-y)	-4.8348	-4.8348	168.737	168.737	168.737	141.6543
Minor (z-z)	-0.0842	-0.0842	38.8835	38.8835	38.8835	

Moment Designs

	Section	Flange	Web	ε (Unitless)	α (Unitless)	ψ (Unitless)
Compactness	Class 1	Class 1	Class 1	0.924	0.502	-0.998

	Curve	$α_{LT}$	$λ_{LT}$	$Φ_{LT}$	$χ_{LT}$	C_1	M_{cr} (kN-m)
LTB	c	0.49	0.506	0.703	0.839	1.19	658.4216

	C_{my}	C_{mz}	C_{mLT}	k_{yy}	k_{yz}	k_{zy}	k_{zz}
Factors	0.921	0.4	0.921	0.921	0.24	1	0.4

Shear Design

	V_{Ed} Force (kN)	$V_{c,Rd}$ Capacity (kN)	T_{Ed} /Torsion (kN-m)	Stress Ratio	Status Check
Major (z)	23.8533	323.5123	-0.0009	0.074	OK
Minor (y)	0.0922	534.424	-0.0009	1.726E-04	OK

Shear Design

	$V_{pl,Rd}$ (kN)	η (Unitless)	λ_W (Unitless)
Reduction	323.5123	1.2	0.591

End Reaction Major Shear Forces

Left End Reaction (kN)	Load Combo	Right End Reaction (kN)	Load Combo
20.0159	DStlS18	23.8533	DStlS18

ETABS 2016 Steel Frame Design

Eurocode 3-2005 Steel Section Check (Strength Summary)

Element Details (Part 1 of 2)

Level	Element	Unique Name	Length (mm)	Location (mm)	Combo	Design Type	Element Type	Section
ground	C8	80	3000	1348.3	DStlS1	Column	DCM EBF	edit column

Element Details (Part 2 of 2)

Classification	Rolled
Class 3	No

Design Parameters

National Annex	Combination Equation	Analysis Type	Reliability
CEN Default	Eq. 6.10	Method 2 (Annex B)	Class 1

Design Code Parameters

γ_{M0}	γ_{M1}	γ_{M2}	A_n / A_g	LLRF	PLLF	Stress ratio Limit
1	1	1.25	1	1	0.75	0.95

Section Properties

A (cm^2)	I_{yy} (cm^4)	i_{yy} (mm)	$W_{el,yy}$ (cm^3)	$A_{v,y}$ (cm^2)	$W_{pl,yy}$ (cm^3)	I_{yz} (cm^4)	I_t (cm^4)
121.5	21886.6	134.2	1421.7	32.9	1565.3	0	83.8

I_{zz} (cm^4)	i_{zz} (mm)	$W_{el,zz}$ (cm^3)	$A_{v,z}$ (cm^2)	$W_{pl,zz}$ (cm^3)	I_w (cm^6)	h (mm)
7306.1	77.6	478.6	94	724.5	1562218	307.9

A_{eff} (cm^2)	e_{Ny} (mm)	e_{Nz} (mm)	$W_{ef,yy}$ (cm^3)	$W_{ef,zz}$ (cm^3)
121.5	0	0	1421.7	478.6

Material Properties

E (MPa)	f_y (MPa)	f_u (MPa)
210000	275	430

Stress Check Forces and Moments

Location (mm)	N_{Ed} (kN)	$M_{Ed,yy}$ (kN-m)	$M_{Ed,zz}$ (kN-m)	$V_{Ed,z}$ (kN)	$V_{Ed,y}$ (kN)	T_{Ed} (kN-m)
1348.3	-119.9463	-0.2295	-0.4089	0.2445	1.0719	-0.0001

Demand/Capacity (D/C) Ratio 6.3.3(4)-6.62

D/C Ratio = N_{Ed} /(χ_z N_{Rk} /γ_{M1}) + k_{zy} [$M_{y,Ed}$ /(χ_{LT} $M_{y,Rk}$ /γ_{M1})] + k_{zz} [$M_{z,Ed}$ /($M_{z,Rk}$ /γ_{M1})]

0.051 = 0.044 + 0.002 + 0.006

Basic Factors

Buckling Mode	K Factor	L Factor	L Length (mm)	L_{cr} /i
Major (y-y)	1.698	0.899	2696.6	34.113
Major Braced	0.846	0.899	2696.6	17
Minor (z-z)	1.375	0.899	2696.6	47.809
Minor Braced	0.795	0.899	2696.6	27.641
LTB	1.375	0.899	2696.6	47.809

Axial Force Design

	N_{Ed} Force kN	$N_{c,Rd}$ Capacity kN	$N_{t,Rd}$ Capacity kN	$N_{byy,Rd}$ Major kN	$N_{bzz,Rd}$ Minor kN
Axial	-119.9463	3340.2958	3340.2958	3102.689	2719.6812

$N_{pl,Rd}$ kN	$N_{u,Rd}$ kN	$N_{cr,T}$ kN	$N_{cr,TF}$ kN	A_n /A_g Unitless
3340.2958	3760.5657	12615.119	12615.119	1

Design Parameters for Axial Design

	Curve	α	N_{cr} (kN)	λ	Φ	χ	$N_{bd,Rd}$ (kN)
Major (y-y)	b	0.34	21634.2922	0.393	0.61	0.929	3102.689
MajorB (y-y)	b	0.34	87106.352	0.196	0.518	1	3102.689
Minor (z-z)	c	0.49	11013.9968	0.551	0.738	0.814	2719.6812
MinorB (z-z)	c	0.49	32951.1289	0.318	0.58	0.94	2719.6812
Torsional TF	c	0.49	12615.119	0.515	0.709	0.835	2788.5033

Moment Designs

	M_{Ed} Moment kN-m	$M_{Ed,span}$ Moment kN-m	$M_{c,Rd}$ Capacity kN-m	$M_{v,Rd}$ kN-m	$M_{n,Rd}$ kN-m	$M_{b,Rd}$ Capacity kN-m
Major (y-y)	-0.2295	-0.5591	390.9588	390.9588	390.9588	367.9503
Minor (z-z)	-0.4089	-1.8542	131.6191	131.6191	131.6191	

Moment Designs

	Section	Flange	Web	ε (Unitless)	α (Unitless)	ψ (Unitless)
Compactness	Class 3	Class 3	Class 1	0.924	0.579	-0.928

	Curve	α_{LT}	λ_{LT}	Φ_{LT}	χ_{LT}	C_1	M_{cr} (kN-m)
LTB	c	0.49	0.316	0.578	0.941	2.147	3923.9518

	C_{my}	C_{mz}	C_{mLT}	k_{yy}	k_{yz}	k_{zy}	k_{zz}
Factors	0.528	0.4	0.528	0.531	0.403	0.998	0.403

Shear Design

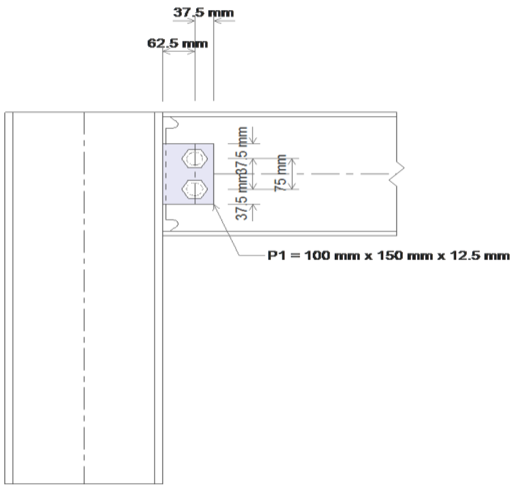
	V_{Ed} Force (kN)	$V_{c,Rd}$ Capacity (kN)	T_{Ed} /Torsion (kN-m)	Stress Ratio	Status Check
Major (z)	0.2445	522.6667	-0.0001	4.677E-04	OK
Minor (y)	1.0719	1492.9642	-0.0001	0.001	OK

Shear Design

	$V_{pl,Rd}$ (kN)	η (Unitless)	λ_W (Unitless)
Reductin	522.6667	1.2	0.35

APPENDIX D Beam –Column Moment Major Axis Connection Design

ETABS DESIGN CODE AISC 360-10



Beam –column moment major axis connection

APPENDIX E Steel Column Design

Summary of results

	Design Check Type	D/C Ratio	Result	Reference
1	Concrete bearing strength	0.044	Passed	
2	Base plate thickness	0.272	Passed	

Material Properties

Column edit column	column S275	F_y = 39.89 ksi	F_u = 62.37 ksi
Base Plate	A992Fy50	F_y = 50 ksi	F_u = 65 ksi

Geometric Properties

Column edit column	t_w = 0.38976 in	d = 12.12 in	t_f = 0.6063 in	b_f = 12.02 in

Bolts, Plate & Weld

Anchor rod	Diameter = 1.26 in	Head/Nut type = Square	Material = ASTM F1554 Grade36
Base Plate	Width = 20 in	Height = 20 in	Thickness = 1.18 in

Pedestal

Dimensions	Width = 23.94 in	Height = 23.94 in

APPENDIX F Domestic Wood House Cost Estimation

Item	Description	Unit	Qty	Rate	Amount
	A. Sub –Structure				
	1. Excavation And Earth Work				
1.1	Ordinary soil to a depth not beyond initial from RL Excavation for footing foundation in	m^3	5.40	150	810.00
1.2	Site clearing to a depth of 20 cm top soil	m^2	140.00	15	2100.00
1.3	Bulk excavation to reduce level to an average depth of 60 cm	m^3	70.56	50	3528.00
1.4	Back fill around masonry with from the site from outside and well ram in layers not exceed 40 cm thick.	m^3	30.375	150	4556.25
1.5	50 cm starting from reduce level Trench foundation excavation in ordinary soil not exceeding	m^3	29.40	100	2940.00
1.6	Ditto selected borrowed material from out side	m^3	84.00	150	12600.00
1.7	Fill behind retaining wall with deferent gravel size	m^3	-	-	-
1.8	excavated material to an appropriate tip Cart away surplus	m^3	49.08	75	3681.00
1.9	basaltic or equivalent stone hard core well rolled consolidated and blinded with crushed stones 25 cm thick	m^2	49.08	250	12270.00
	Total to summary……………………	**Birr**			**42,485.00**
	1. Concrete Work and Masonry Work				

2.1	5 cm thick lean concrete class C-5, with under foundation minimum cement content of 150 kg /m3	m^2	29.40	150	4410.00
2.2	Wall bedded in cement Sand mortar 1.2.6 us Ataye sand. 40 cm thick stone masonry foundation not less than 60 cm depth	m^3	14.11	250 0	35275.00
2.3	Masonry wall shall be bedded in cement Sand mortar external surface left for Pointing use Ataye sand. 40 cm thick semi dressed stone masonry not less than 1.2 m depth Wall built to a height above N. G. L. the	m^3	28.22	250 0	70,550.00
	Total to summary	**Birr**			**110,235**
	B. SUPER STRUCTURE				
3.1	Supply Structural tree wood ‘’kuami” (material cost only)	Pcs	50.00	155	7750.00
3.2	Supply Structural tree wood wall‘’mager” (material cost only)	Pcs	40.00	105	4200.00
3.3	Corrugate Galvanized Nails for super structure	Kg	15.00	75	1125.00
	Total to summary	**Birr**			**13,075.00**
	4.Roofing				
4.1	Supply G32 Corrugated Galvanized Iron Sheet Flushing- 0.4 mm thick, girth 33 cm – Akaki.	Pcs	95.00	270	25,650.00

4.2	Supply G30 galvanized iron sheet roof gutter [devt] Length =33cm] welded at joints provide Slope towards down pipe price shall include	Pcs	12.00	107	1284.00
	Total summary	Birr			**26934.00**
	5. Wood Structure Roofing				
5.1	50 x70 Zigba wood purlins At c/c 90 cm with purlins Measured in horizontal projection	Pcs	95.00	220	20,900.00
5.2	Diameter 10 mm eucalyptus upper and lower member	Pcs	30.00	150	4500.00
5.3	Diameter 8 mm eucalyptus vertical member	Pcs	15.00	212	3180.00
	TOTAL TO SUMMARY	**Birr**			**28,580.00**
	6. Water Proofing Work				
6.1	Equivalent water proofing material tor top roof slab Bitumen with 4 mm thick sand finished or	m	25.00	450	11,250.00
	TOTAL SUMMRY	**Birr**			**11,250.00**
	TOTAL GRAND	**Birr**			**260,961.00**

APPENDIX G Steel House Cost Estimation

Item	Description	Unit	Qty	Rate	Amount
	Sub -Structure				
	1 .Excavation And Earth Work				
1.1	site clearing to a depth of 20 cm top soil	m^2	140.00	15	2100.00
1.2	Average depth of 60 cm Bulk excavation to reduce level to an	m^3	84.00	50	4200.00
1.3	In ordinary soil to a depth not exceeding 1.20 cm starting from RL Excavation for footing foundation	m^3	15.19	150	2278.50
1.4	Trench foundation excavation in ordinary soil not exceeding 50 cm starting from reduce level	m^3	29.40	100	2940.00
1.5	From outside and well ram in layers not exceed 20 cm thick under hard core back fill around foundation with from the site	m^3	84.00	150	12,600.00
1.6	Ditto selected borrowed material from out side	m^3	42.00	150	6300.00
1.7	Fill behind retaining wall with deferent gravel size	m^3			
1.8	Cart away surplus excavated material to an appropriate tip	m^3	113.18	85	9620.73
1.9	25 cm thick basaltic or equivalent stone hard core well rolled consolidated and	m^2	168.00	50	

	blinded with crushed stones.				8400.00
	Total to summary……………………	**Bir**r			**48,439.23**
	2. concrete work				
2.1	5 cm thick lean concrete class C-5, with minimum cement content of 150 kg /m3 under foundation	m^2	20.25	150	3037.50
2.1.1	In footing	m^3	1.72	3570	6140.40
2.1.2	In grade beam	m^3	4.18	3570	14922.60
2.2	Sand mortar 1.2.6 us Ataye sand. 40 cm thick stone masonry foundation not less than 60 cm depth Wall bedded in cement	m^3	14.11	2500	35275.00
	Shear connecter M32 hs=125 mm	Pcs	100.00	30	3000.00
	Bending, placing in position and tying wires. Reinforcement steel bar according to St. drawing price includes cutting				
2.1.1	Dia. 14 mm bar	kg	147.63	37	5462.31
2.1.2	Dia. 10 mm bar	kg	116.30	23	2674.90
2.1.3	Dia. 8 mm bar	kg	17.01	38	648.00
2.1.4	Column Base Plate, 355.6.4x355.6, Thick 25.4 mm	Pcs	9.00	3000	27000.00
2.4	Expansion joint 10x2 cm chip wood between G. beam and slab painted with bitumen asphalt.	m	31.25	40	1250.00
	TOTAL TO SUMMARY	**Birr**			**82,851.41**

	B. SUPER STRUCTURE				
3.1	Supply and Fix Hot Rolled Structural steel, for beam S275 Column section Depth D=303.4 Width W=165.0 Web thickness tw=6 mm Fange thickness tf=10.2 mm	m	88.10	1200	105,720.00
3.2	Supply and Fix Hot Rolled Structural steel Column S275 FY=275 FU= Column section Depth d= 203.2 Width w=203.2 Web thickness tw=7.2 Flange thickness tf=11	m	56.25	1300	73,125.00
3.3	Supply and Fix Hot Rolled Structural steel secondary beam S 275 FY=275 Fu=410 Column section Depth d= Width w= Web thickness tw= Flange thickness tf=	m	67.42	1050	70,791.00
3.4	Supply and fix composite Deck slab Concrete Class C-25 poured on the profiled sheet as per the design depth d=130 mm.	m^3	4.87	2570	21716.50
3.5	Ribbed cost including forming into EGA-700 and indenting. Steel sheet profile of 1 mm	Kg	523.23	17	8894.91

	thickness Embossments on the surface of the sheets.				
	TOTAL TO SUMMARY	**Birr**			**280,247.41**
	4.ROOFING				
4.1	(Roof cover measured in actual projection and purlin measured separately) Supply and Fix Galvanized Ribbed sheet & Accessories EGA 300, 0.4 mm thick	m^2	60.80	425	25840.00
4.2					
4.3	7 cm average thick light weight concrete over concrete- slab with 2% slope towards down pipe.	m^2	15.00	250	3750.00
	TOTAL TO SUMMARY………………….	**Birr**			**29590.00**
	5.Roof steel structure				
5.1	Supply ,make, and mount RHS steel truss all according to structural drawing price includes all necessary work for secure installation & two				
5.2	Size 40cmx40cmx1.5mmx6 Purlin lattice type And its accessories	Pcs	45.00	365	16,425.00
5.3	RHS (rectangular hollow sections) and its accessories 30cmx30cmx1.5mmx6m	Pcs	32.00	235	7520.00
	TOTAL	**Birr**			**53,535.00**

	SUMMARY………………….				
	6.Water proofing work				
6.1	Bitumen with 4 mm thick sand finished or equivalent water proofing material tor top roof slab	m	25.00	450	11,250.00
	TOTAL TO SUMMARY………………….	**Birr**			**11,250.00**
	GRAND TOTAL TO SUMMARY	**Birr**			**476,323.05**

APPENDIX H concrete house cost estimation

Item	Description	Unit	Qty	Rate	Amount
	Sub –Structure				
	1. Excavation And Earth Work				
1.1	20 cm top soil site clearing to a depth of	m^2	140.00	15	2100.00
1.2	An average depth of 120 cm Bulk excavation to reduce level to	m^3	168.00	50	8400.00
1.3	20 cm thick under hard core back fill around foundation with from the site from outside and well ram in layers not exceed .	m^3	30.375	150	4556.25
1.4	In ordinary soil not exceeding 50 cm starting from reduce level Trench foundation excavation	m^3	29.40	100	2940.00
1.6	Selected borrowed material from outside.	m^3	84.00	250	21,000.00
1.7	Fill deferent gravel size behind retaining wall.	m^3			
1.8	Cart away surplus excavated material to an appropriate tip	m^3	226.37	85	19,241.45
1.9	25 cm thick basaltic or equivalent stone hard core well rolled	m^2	50.76	250	12690.00

	consolidated and blinded with crushed stones.				
	TOTAL SUMMARY	**Birr**			**70,887.70**
	2. Concrete Work and Masonry Work				
2.1	Minimum cement content of 150kg m^3 under foundation with 5 cm thick lean concrete class C-7,.	m^2	20.25	150	3037.50
2.2	Footing pad	m^3	3.44	3570	12280.80
2.4	Retaining wall	-	-	-	-
2.5	Grade beams	m^3	4.18	3570	14922.60
2.6	40 cm thick stone masonry foundation not less than 60 cm depth Wall bedded in cement Sand mortar 1.2.6 us Ataye sand.	m^3	14.11	2500	35275.00
2.7	Reinforcement steel bar according to St. drawing price includes cutting, bending, placing in Position and tying wires.				
	a)Dia 16 mm bar	Kg	978.49	45	44,032.05
	b)Dia 14 mm bar	Kg	670.73	45	30182.85
	c)Dia 8 mm bar	Kg	135.59	45	6101.55
	d)Dia 6 mm bar	Kg	6.60	45	297.00
2.8	Expansion joint 10x2cm chip wood between G.beam and slab painted with bitumen asphalt	m	124.00	45	5580.00
	TOTAL TO SUMMARY………	**Birr**			**116,434.35**
	B. SUPER STRUCTURE				

	3.Concrete Frame				
3.1	RCC class-25,360kgs cement/m2 filled into formwork and vibrated around reinforcement bars and form work separately				
	a) In elevation column	m^3	4.02	3570	14,351.40
	b) In floors beams	m^3	8.36	3850	32186.00
	c) In water tower slab	m^3	0.20	3570	714.00
	d) In stair case	m^3	1.87	3570	6683.04
	e) In water towers beams	m^3	0.25	3570	892.50
	f) In top tie beam	m^3	8.36	3850	16478.00
	g)slab	m^3			
3.2	Provide cut and fix in position sawn zigba wood formwork which ever appropriate				
	a) In elevation column	m^2	35.10	35	1228.50
	b) In floor beams	m^2	63.28	30	1898.40
	c) In water tower slab	m^2	0.50	30	15.00
	TOTAL TO SUMMARY	**Birr**			**74,446.84**
	a. **Roofing**				
4.1	Supply and Fix Dekera Roof tiles & Accessories (Roof cover measured in actual projection and purlin measured separately)	m^2	60.60	725	43935.00
4.2	Galvanized plain steel sheet & accessories- Flushing- 0.4 mm thick, girth 3 cmm	ml	18.00	80	1440.00
	Average thick light weight concrete over concrete- slab with	m^2	22	220	

	2% slope towards down pipe.				4840.00
	TOTAL TO SUMMARY	**Birr**			**50,215.00**
	b. Roof Wood Structure				
	Supply and fix makes, and mount wood truss all according to structural drawing price includes all necessary work for secure installation.				
5.1	Size 50x70 zigba wood purlin c/c 90 cm	Pcs per 6m	45.00	212	5040.00
5.2	Diameter 10 Eucalyptus truss	Pcs	32.00	212	3584.00
5.3	Size 40x50 x mm zigba ceiling battens	Pcs	20.00	80	1600.00
5.4	8 mm thick chip wood ceiling	m^2	84.00	350	29,400.00
	Headed dome shape nails	kg	10.00	80	800.00
	TOTAL TO SUMMARY………………….	**Birr**			**40,424.00**
	6.Water Proofing Work				
4.1	Bitumen with 4 mm thick sand finished or equivalent water	m	25.00	450.00	11,250.00

	proofing material tor top roof slab				
	TOTAL SUMMARY………………….	**Birr**			**11,250.00**
	GRAND TOTAL TO SUMMARY	**Birr**			**363,657.89**

APPENDIX I Questionnaire Survey

ADDIS ABABA UNIVERSITY

ADDIS ABABA INSTITUTE OF TECHNOLOGY

SCHOOL OF CIVIL AND ENVIRONMENTAL ENGINEERING

Questionnaire Survey for Thesis paper on

Alternative Structural Sustainable House System (Case Study in Debre Birhan in City)

I am presently pursing a Master of Science Degree in Civil and Environmental Engineering under Structural engineering at Addis Ababa University, School of Graduate Studies.
The aim of this questionnaire is to study the Impact of the Wood and Reinforced Concrete **Alternative Structural Sustainable House System** in Debre Birhan City and Its Surrounding. Please answer all questions where possible. All the information gathered will be kept strictly confidential and will be used only for academic research and analysis without mentioning the names of individuals companies involved. Thank you in advancing for your time and kind cooperation

PART ONE

PERSONAL INFORMATION;

Please tick (x) on your choice

A. Your' Educational Qualification: ☐PHD ☐ MSc ☐ BSc. ☐other specify…..

B. Your Profession (Working as): ☐ Architect ☐Civil Engineer ☐Environmental Engineer ☐ Urban planner ☐ Academia ☐ Mechanical Engineer El ☐ Electrical Engineer ☐Construction technology & management ☐ Other please (specify)…………………..

C. Years of Experience: ☐-10 ☐10-15 ☐15-20 ☐ More than 20 years.

D. Company's scope of service: ☐ Contractor ☐ Consultants ☐ Academic institution ☐ Real estate Developer ☐ Government Firm ☐ other please (specify)………………

1. **Information on the house:**

a. Structural Type house made

a) Concrete b. Wood c. Steel

b. If other than the above please mention………………………………

A. **House construction environmental impact related questionnaire**

1. How do you evaluate the house construction on **Destruction vegetation** in the area?

a) extremely severe b) very severe c) severe d) slightly severe e) not severe

What is your reason(s)

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2. Do you think Debre Birahn city house construction consequence increase **desertification**?

a) extremely severe b) very severe c) severe d) slightly severe e) not severe

What is your reason(s) and how

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3. Do think the environment polluted due to the construction material **waste disposal** in your city?

a) extremely severe b) very severe c) severe d) slightly severe e) not severe

What is your reason(s) and how?

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4. Do you think undesirable **soil erosion** consequence due to construction the residential buildings?

a) extremely severe b) very severe c) severe d) slightly severe e) not severe

If you say extremely severe or very severe what your reason?.

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5. Do you think how the environment is affected with the manufacturing construction **material waste** of the house?

a) extremely severe b) very severe c) severe d) slightly severe e) not severe

If you say extremely severe or very severe what your reason?.

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6. Do you think how the environment in is affected with the **noise** from operation construction of the house?

a) extremely severe b) very severe c) severe d) slightly severe e) not severe

If you say extremely severe or very severe what your reason?

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7. Do you think in how much the environment affected due to destruction green area for house construction?

a) extremely severe b) very severe c) severe d) slightly severe e) not severe

What are your reason(s)?

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8. Do think the surrounding city affected due to the **Energy waste** for construction of the residential house?

a) Extremely severe b) very severe c) severe d) slightly severe e) not severe

What your reason(s)?

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9. Do you think residential house construction around affected **water quality**

a) extremely severe b) very severe c) severe d) slightly severe e) not severe

How you explain it and what do you think is the problem?

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10. Is how much the construction housing lead to increasing to **global warming**?

a) extremely severe b) very severe c) severe d) slightly severe e) not severe

How you explain it and what do you think is the problem?

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11. How much you think the due to house construction building affect by **flooding**?

a) extremely severe b) very severe c) severe d) slightly severe e) not severe

How you explain it and what do you think is the problem?

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12. Do you think the energy consumption for the construction residential building affect the environment by **polluted Air quality**?

a) extremely severe b) very severe c) severe d) slightly severe e) not severe

How you explain it and what do you think is the problem?

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13. Is there a **visual disturbance** due to the construction house building?

a) extremely severe b) very severe c) severe d) slightly severe e) not severe

How you explain it and what do you think is the problem?

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14. Do you think is there a **natural disaster** due to the construction house building?

a) extremely severe b) very severe c) severe d) slightly severe e) not severe

How you explain it and what do you think is the problem?

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15. Do you think is there high **spillage** due to the construction house building?

a) extremely severe b) very severe c) severe d) slightly severe e) not severe

How you explain it and what do you think is the problem?

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16. How do you evaluate the **climate change** due the construction?

a) extremely severe b) very severe c) severe d) slightly severe e) not severe

How you explain it and what do you think is the problem

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17. Do you think is there high amount **dust particles** due to the construction house building?

a) extremely severe b) very severe c) severe d) slightly severe e) not severe

How you explain it and what do you think is the problem

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B. Environmental Protection Measures in Debre Birhan

1. Do you think city **waste management** system has role to for sustainable house building?

a) Strongly important; b) Important; c) Neutral; d) Not important; e) Strongly not important

2. Do you think the city has a mechanism **to pollution** control system for house building?

a) Strongly important; b) Important; c) Neutral; d) Not important; e) Strong

3. Do you think city has **ecological conservation** role to for sustainable house building city?

a) Strongly important; b) Important; c) Neutral; d) Not important; e) Strongly not important

2. Do you think city has **energy conservation** system has role to for sustainable building)

a) Strongly important; b) Important; c) Neutral; d) Not important; e) Strongly not important

C. Various agencies adopted country for planning and for determining house construction the potential environmental in Debre Birhan

1. Do think the Ethiopia environment protection authority work in city related to residential house construction effect on the environment?

a) Strongly important; b) important; c) neutral; d) not important; e) strongly not important

2. Do think the residential house construction builder obey **Ethiopia environmental law proclamation?**

a) Strongly important; b) Important; c) Neutral; d) Not important; e) Strongly not important

3. Do think the city municipality administrative work with Ethiopia environment and forest institute?

a) Strongly important; b) important; c) neutral; d)not important; e) strongly not important