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INVESTIGATION ON HARARI TRADITIONAL AGED HOUSES MAINTENANCE WORK ENCIRCLED BY JUGOL WALL IN HARAR

BY

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INVESTIGATION ON HARARI TRADITIONAL AGED HOUSES MAINTENANCE WORK ENCIRCLED BY JUGOL WALL IN HARAR

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DECLARATION

I declare that this research report entitled ***"Investigation on Harari Traditional Aged Houses Maintenance Work Encircled by Jugol Wall in Harar"*** is original work of my own, has not been presented for a degree at any other university and that all sources of material used for the thesis have been duly acknowledged.

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This thesis has been submitted for examination with my approval as university advisor.

Prof. Dr. -Eng Abebe Dinku

DEDICATION

I dedicate this work to Harari people who have lived together for centuries in peace and harmony respecting their diversity.

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Abstract

Historic buildings have a lot of contributions to the development and prosperity of a city. The primary contribution of these historic buildings is to provide the city's historical information such as past events, continuity of change through time, periods of ascendancy of remarkable events, or ruptures in the urban fabric as a result of conflict or transformation. In this thesis, the writer attempts to carry out an investigation on Harar Jugol aged traditional houses by studying the characteristics of the original materials used to construct the houses and by examining the maintenance work being carried out at present. These two major objectives show the importance of these historical buildings in its historical and current contributions.

One significant problem of the historic Harari traditional Houses is the lack of timely and appropriate maintenance for these invaluable and unique buildings for which Harar is registered as fortified historic city by UNESCO. The investigation is carried out by direct questioning of the stake holders such as Harari cultural and Youth office, Harari cultural and historical monument and the residents of the aged traditional houses. Since the residents as well as the characteristics of the original materials used to construct the traditional houses are directly responsible for the damage of the houses, the study focuses on the Investigation on Harari Traditional Aged Houses Maintenance Work examination of the problems of earthen materials or soils by making a test on physical, chemical and mechanical properties of the four types of soils (Gogoba, Kuyesa, Browinish soils and Sandy soil).

As already clearly stated, everybody agrees that these buildings need maintenance because of the damage coming from environmental factor and the old age the building passed through. Therefore, special maintenance care must be taken by studying the original materials and the technology used to construct the buildings. This helps to make proper maintenance which conforms to the original quality of the buildings. To examine the effectiveness of the maintenance work, investigation is carried out on one hundred houses by using proportion sampling method to address all the houses. Finally, the paper concludes with the result gain of determining the quantity of water used for making soil mud required as a paste to stick the stone one to the other and the problems encountered by using cement paste for maintenance by the inhabitants which is different from the original materials out of which the houses were constructed. This paper also shows the current status of the houses and suggests the maintenance work to make effective technical output and the responsibility of the local government as well as the residence of the houses.

Key words: Degraded, Effective Maintenances, Original Historical Appearance and Traditional Houses.

CHAPTER ONE

INTRODUCTION

1.1. The Study Overview

All the key national and international documents, which provide guidelines for the protection of historic buildings, emphasize the pivotal role of regular systematic maintenance (ICOMOS, 1987). For Example, the annual meeting at France-Paris (UNESCO, 2015) defines conservation as being "…The processes of looking after a place so as to retain its cultural significance and goes on to state …A principle of conservation is that the cultural significance of a place is embedded in it fabric, its setting and its contents…". Other international charters, for example the Venice Charter, the Amsterdam Charter, the New Zealand Charter and the Guidelines for the Management of World Cultural Heritage Sites, make similar points.

The nature of historical buildings maintenance, which is in some avoidable degree of degradation and decay, maintenance is the single most significant approach that can ensure the prolongation of the building's life span. Hamilton & Salleh (2001) state that systematic management and continuous maintenance works are necessary for mitigating the decaying process that will lead to unsafe condition. Besides the benefit to the building's life span, the execution of the maintenance works on a building and its services system when continuously and progressively undertaken in a long run will be profitable to the organization.

Based on the list of heritage sites registration of UNESCO and under National Heritage Act 2005 (Act 645) Proclamation record compiled by Negarit Gazeta (2007) show that there are about 14 heritage sites in total including those on tentative list for registration. These include forts, stones, caves, wells, cemetery and other sporadically located within nine regional states of Ethiopia. Out of these, only four are UNESCO registered buildings, as mentioned in Table-1 below. Undoubtedly, these buildings are important in portraying the historical past of the nation but given the age of the buildings at present, these structures will not be standing for too long unless proper maintenance works are carried out as have been seen on most of Harar aged traditional houses. The lack of proper maintenance works and identification of historical buildings may

contribute to decaying of buildings thus resulting to decrement in the number of historical buildings. Rapid urbanization process is the main threat for historical buildings, for instance, the demolished houses in the last decade in Harar reaches 14 in number (Phang & Puah, 2006).

Table-1. List of Heritage building sites registered on the 2nd Session of the World Heritage Committee, held in Washington, D.C. in 1978.

No	Descriptions	Regions	Date	Description
1	Axum	Tigray	1980	The ruins of the city of Aksum, dating from the 1st to the 13th century, mark the heart of ancient Ethiopia and what was the "most powerful state between the Eastern Roman Empire and Persia". It includes monolithic obelisks, giant stele, royal tombs, and ruins of former castles.
2	Fasil Ghebbi,	(Amhara) Gonder	1979	The fortress was the residence of the Ethiopian emperors during the 16th and 17th century. The city remains, which feature buildings with Hindu and Arab influences, were later remodeled with Baroque-style architecture by Jesuit missionaries.
3	**Harar Jugol**	**Harar**	**2006**	**The city is on a plateau and surrounded by gorges and savanna. It contains 82 mosques, 102 shrines, and unique interior design in the town houses reaches around 2000. Harar is said to be the fourth-holiest city of Islam.**
4	Rock-Hewn church (Lalibela)	(Amhara) Wallo	1978	The site contains eleven medieval cave churches from the 13th century.

On this paper, special attention and acknowledgment is given to the need of a systematic maintenance of historical buildings. This research work is, therefore, a vital approach to highlight and to assist the improvement on the maintenance of historical buildings within the local context. This research intends to integrate two key elements, namely, the importance and

the needs of maintenance, with the purpose of helping to develop a framework for a systematic maintenance program for historical traditional aged houses in Harar.

The focus of this research is on the historical traditional aged houses of Harar that have undergone the conservation works be it major or minor and investigation on material construct.

1.2. Research Overview

Ethiopia is one of the countries which have great history and ancient civilization. Our historical monuments and buildings are alive testimonial evidences for our country's great history and ancient civilization. These historical monuments and buildings are great tourist attractions today. The Lalibela Rock Hewn Churches and Harari Jugol traditional buildings can be cited as example.

However, our historical buildings and monuments share many problems in common such as:

- ✓ Lack of plan on time maintenance
- ✓ Direct damage from the natural factors such as weathering, erosion and etc.
- ✓ Secondary risks that arise during recovery and reconstruction, including rescue and relief measures that are carried out with no regard to heritage value of damaged areas (e.g. water damage from rain and debris accumulation); looting of historic buildings; and reuse of cultural and religious practice centers resident houses;
- ✓ Infrastructure repair or replacement (e.g. road widening) disregards or encroaches upon cultural assets;
- ✓ Illegal and uncontrollable relocation and reconstruction of spoil heritage landscapes or damage other assets;
- ✓ Authenticity and integrity lost because of inadequate repair and retrofitting measures.

The problems listed above have the subject of many discussions over the last period. This research work also plans to focus on an investigation on a topic related to Maintenance issues of Hareri Jugol Aged Traditional Houses which most of the problems listed above share in common with other historical buildings and monuments.

1.3. Research Problem

Most of our historical buildings are exposed to damage and deterioration and therefore need maintenance before they lose their original appearance and structural strength. The major and common problems that appear on our historical buildings, especially on Hareri Jugol aged traditional houses are:

- ✓ Lack of document that deals or give information about the materials that are used to construct the buildings. Such documents would have great contribution to the work of maintenance today.
- ✓ Though the condition of the buildings is deteriorating, they are still used as residences and this makes maintenance difficult. Therefore, to make the building safe and durable, serious attention needs to be given to the condition under which these buildings are found.
- ✓ In addition, the past practice of construction technology may contribute to our maintenance work today. All in all, since most of the construction materials required can abundantly be found locally, maintenance work can be carried out with low cost and can be environmentally friendly.

1.4. Research Goal

This research attempts to study why the Harari Traditional Houses stayed long keeping their appearance up to now and how the maintenance work is taking place at current time. In addition, the property of the construction materials used for both constructing and maintaining will be studied and solutions will be found.

1.5. General Objective

To investigate and examine the characteristics of the materials originally utilized to construct the buildings and the effectiveness of the maintenance work on Harar aged traditional houses.

1.6. Specific Objectives

The specific objectives of this particular research are believed to lead to the attainment of the research goals. These are:

1. To identify the characteristics of construction materials.
2. To assess whether the maintenance assures the long life as it appears and prevents further damage.
3. To assess the efforts put so far to maintain these historic buildings keeping their originality
4. To analyze the construction advantages of earthen materials from the perspective of modern curing and formwork practice of construction of concrete.
5. To assess the future prospects of historic buildings in connection with existing development plan.

1.7. Research Questions

This study has thus following arising queries for investigation:

- ✓ Why do these buildings have such long life with minor maintenances?
- ✓ What is the contribution of the original building materials to the long life of the buildings?
- ✓ How is the current maintenance work taking place?
- ✓ What lessons do we gain from the past construction practice?
- ✓ What advantages do we get from these buildings that can be used for current buildings?

1.8. Methodology

Data collection: the data, materials and experiment needed to complete this research is collected with the help of experimental or laboratory tests.

In Harar, there are 5115 traditional historic residences. Out of these, two thousand houses are in Jugol constructed by different people at different periods. There are 82 mosques in the city three of which were constructed in the 10th century according to Hecht (1982).

These traditional houses and mosques mentioned above are selected for the research with precious sampling to address or represent the whole research area. As a result, gathering abundant information is very essential. Therefore, in order to achieve the objectives of the study, gathering both quantitative and qualitative primary and secondary data becomes essential.

Organizations, like the Authority for Preservation and Conservation of Cultural Heritage, Harar Culture and Tourism Bureau, NGOs and various Tour and Travel Agencies are major sources of secondary and primary data for this study.

1.8.1. Primary Data

Primary data has been received from first hand sources such as: direct personal observation, interview, Laboratory, and survey etc.

i. Personal observation

Observation is used as one means of generating primary data in this study. It is conducted using cameras which reinforce the qualitative information gathered by interviews and questionnaires.

ii. Interview

Interview on base assessment is planned to roughly estimate the age of those houses which have no document files. And the data received is also used to evaluate the effectiveness of the maintenance. The interview is conducted to obtain responses from historical building restoration and preservation office of Harari Tourism office and aged traditional houses residents (those who live in the houses).

iii. Laboratory

Laboratory experiments have been conducted to identify the strength, and property of the materials used to build the houses. Significant soil tests (which are soils used for maintenance as well as for constructing the houses early in the past) have been conducted on the constituent material to determine,

- ✓ The Unconfined compressive strength (UCS) of the paste that was prepared from naturally found four soil types (Brownish soil, sand, Gogoba (local name), Kuyesa (local name)).
- ✓ Dampness resistance (permeability) of the building parts (like the Roof) that could indicate whether the houses have good ventilation in order to preserve the necessary room temperature that could come weather changes in the day. That means, the room temperature would be cool when the outside temperature is hot and vice versa. For this type of ventilation system, permeability of the house's wall takes the largest percent. Therefore, it needs to test the permeability of the wall.
- ✓ Study physical and chemical properties of the soil.

Physical Tests

1. Natural Moisture Content (by method of BS Test 1(A)
2. Atterberg's limit (by method of BS Test 2(A) & (B))
3. Grain size Analysis (by method of BS Test 7(B))
4. Specific Gravity (by method of BS 1377: 1967 Test 6(B))
5. Linear Shrinkage Limit (by method of BS Test 5)
6. Unconfined compressive Strength (UCS)(by method of ASTM D 2166)
7. Linear Shrinkage Limit (by method of ASTM D 2937)
8. Permeability (by method of ASTM D 2434)

Chemical Test

Geochemical Laboratory Complete Silicate Analysis (by the method of LIBO2 FUSION, HF ATTACK, GRAVIMETERIC and AAS)

1.8.2. Secondary Data

Secondary data are collected from published and unpublished sources. The major sources include books, official documents, reports, researches, magazine, newspapers and publication of Harar Culture and Tourism Bureau.

All primary data collection methods except questionnaire data collection and all secondary data collection method used for this research work.

CHAPTER TWO
REVIEW OF LITERATURE

2.1. General

Historical buildings are indeed valuable and should be appreciated for their Historical significance. The significance of these buildings is portrayed in the forms of their aesthetical characteristics, historical, social, spiritual and symbolical values (Fielden, 2003). For their significances, these historical buildings should be preserved purposely to be shared and cherished by all **(**Selam T., 2011).

ICOMOS (1987) defines maintenance as the continuous caring performance to prevent the structure, fabric and the positioning of the buildings and differs from the concept of repair works which include the restoration works or reconstruction works and these require comprehensive planning. Maintenance is considered as one of the primary principles for conservation of historical buildings. It is a method or an approach to preserve the existing fabric of the historical buildings. Dunn (2000) also expresses that proper maintenance will upgrade the status and value of the historical buildings. In addition, systematic implementation of the maintenance works will raise the interests amongst the public and becomes political issue (Mocevic, 2012). Up to present date, there is a positive change in the public's perspectives on the issue of maintenance. Maintenance is now being largely accepted and recognized as the best approach to ensuring the prolongation of the buildings' lifespan, a strategy for slow renewal and decay prevention; and, maintaining utility and economic return (Fram,1992).

For some of the buildings, the main purpose of executing the maintenance works is to protect the function, the asset's value and the appearance (Hills, 2006). The differences on the types of maintenance for historical buildings are due to the value of the buildings themselves, which often have their own cultural importance (Nooraldeen, 2003).

Maeer (2012) describes that maintenance process includes all practical and technical approaches which are deemed necessary to ensure that the condition of the buildings or the site where it is located is to be maintained to its original and that the works undertaken will not degrade the

building's value and significance. These processes recommend being progressive and continually undertaken to ensure that the lifespan of the buildings can be prolonged (Matarasso, 2008).

The differences in approaches and opinions on the aspect of maintenance for historical buildings are due to the continuous debate on the exacting nature and the value of these heritages. In general, the expression on the value of the historical buildings is clearly stated in Article 1 of the Burra Charter (ICOMOS, 2007). The content states that the fabric of some historical buildings may contain the cultural importance of which the buildings itself shall be viewed as valuable artefacts. Based on this statement, the main purpose of the conservation is to maximize the conservation of the cultural importance by performing one of its key principles, namely, the continual improvement. Article 1 of the Burra Charter (ICOMOS, 2007) also states that if buildings are evidently found to possess the cultural importance, maintenance works therefore should be performed to retain the buildings.

Kerr (2005) expresses his opinion that maintenance is part of the conservation process. He further elaborates that maintenance is an important conservation process, citing that prevention is better than cure. Ozdemiroglu (2012) highlights in his research that somewhere along the line, there is a bond between conservation and maintenance works as the latter is an approach to prolong the lifespan of the buildings whilst at the same time if works undertaken are poorly performed, it may contribute to the loss of the original building fabric (Olsson, 2010). Passamar (2009) strongly supported this view by stating that the replacement on the historical building's fabric, if not being properly detailed out or cared for, will give a certain negative impact to the building's fabric and value.

2.2. What is Heritage?

Different authors tried to define the concept of heritage. The following section provides what heritage means and what items should be considered to be called a heritage.

As Herbert cited in Amanuel (2007), heritage is a word with many meanings, most relating to its general interpretation "which is inherited from the past". The term "heritage" has been used in relation to the natural world, referring to mountains and rivers, buildings and monuments, arts

and social customs and tradition. In the Oxford English Dictionary (2003) and Cambridge International Dictionary (2002), heritage has been derived from inheritance, and is defined as that which has or may be inherited such as traditions, languages or historical buildings, which still exists from the past which have a historical importance.

According to the proclamation of Ethiopia 209/2000:"Heritage means anything tangible or intangible which is the product of creativity and labor of man in pre-historical and historical times, that describes and witnesses the evolution of nature, and which has major value in its scientific, historical, cultural, artistic and handicraft content, a human work or a place that gives evidence of human activity or a place that has spiritual or cultural meaning, and that has been determined to be of historical value to the province, a community, or an aboriginal people".

The World Bank as well tried to define heritage in a broad sense of physical cultural resources: "Movable or immovable objects, sites, structures, groups of structures, and natural features and landscapes that have archeological, paleontological, historical, architectural, religious, aesthetic, or other cultural significance".

The World Bank also recognizes that: "Physical cultural resources are important as sources of valuable scientific and historical information, as assets for economic and social development, and as integral parts of a people's cultural identity and practices" (World Bank, 2010).

Heritage is the memory of nation, including its events, which have been historically affected by economic, social, cultural, spatial and constructional condition. Hishama Mortada (2008) considers the following: `monuments, architectural works, works of an archaeological nature, inscriptions, cave dwellings and combination of the features, which are of outstanding universal value from the point of view of history, art or science, groups of buildings, groups of separate or connected buildings which, because of their architecture, their homogeneity or their place in the landscape (Prats, 2011).

2.2.1. Selection Criteria for a Historical Building Heritages

Until the end of 2013, UNESCO puts six criteria for cultural heritage and four criteria for Historical building heritage (Ermias Nimani, 2009). Currently, these 10 criteria are used to establish outstanding universal value. Properties being nominated for inscription on the world heritage list must meet one or more of the following criteria.

i. Represent a masterpiece of human creative genius
ii. Exhibit an important interchange of human value, over a span of time or within a cultural area of the world, on development in architecture or technology, monumental arts, town planning or landscape design
iii. Bear a unique or at least exceptional testimony to a cultural tradition or to a civilization which is living or which has disappeared
iv. Be an outstanding example of a type of building, architectures or technological ensemble or landscape which illustrates a significant stage(s)in human history
v. Be an outstanding example of a traditional human settlement, land use, or sea-use which is representative of cultural (cultures), or human interaction with the environment especially when it has become vulnerable under the impact of irreversible changes
vi. Be directly or tangibly associated with events or living traditions with ideas, or with beliefs, with artistic and literary works of outstanding universal significance
vii. Contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance.
viii. Be outstanding examples representing major stage of earth's history, including the record of life, significant ongoing geological process in the development of landforms, or significant geomorphic or physiographic features.
ix. Be outstanding examples representing significant ongoing ecological and biological process in the evolution and development of terrestrial, fresh water, coastal and marine ecosystems and communities of plants and animals.
x. Contain the most important and significant natural habitats for situ conservation of biological diversity, including those containing threatened species of outstanding

universal value from the point of view of science or conservation (Derek Worthing and Stephen Bond 2008).

Harar as a whole has been registered as UNESCO historical heritage after these criteria are expanded from four to ten. Whatever these criteria have expanded to, Harar fulfills all the ten requirements mentioned above to be registered as frontier historic town because of tangible historic heritage buildings (like Aged Traditional Harari House, the three Mosques and tombs goes back and were constructed at the 10th century) (Rebanks, 2009).

2.3. The Importance of Historical Heritages' Preservation and Conservation

Historic buildings and sites bring past history into our daily lives. Past economic, social, architectural and cultural development is included in these structures and sites which serve as important measures of our progress. The style and construction of a building provides an excellent mirror which reflects the values and circumstances that shape it. Designation of heritage buildings as protected heritage property is a legislative tool which ensures their remaining legacy for future generation (Ripp, 2011).

One important element in many definitions of heritage focuses on preservation. However, conflict often arises among different institutions and the community as pressure is being placed on the landscape due to increasing urbanization and population. The demands for facilities including land fill sites and excavation of the area for providing infrastructures and buildings, damage the archaeological ruins even in environmentally sensitive areas (Amunuel Weldegerima, 2012)

Nevertheless, there are a number of reasons that support actions for the preservation of these historic edifices which are described below.

2.3.1. Cultural, Social and Economic Values

People have always the need to refer to their history in order to ensure the continuity of a common identity that evolves over time (Greiner, 2006). Many cities have reinvented themselves

to develop this heritage platform by building and emphasizing their historical roots and cultural assets (Hari, 2012).

Heritage is a collective property which tells the history of a people, a city, or a territory, and is transmitted from one generation to the next. Heritage makes it possible for the present generations to understand their place in history and to better cope with the constant mutations in society. It is an element of stability in a rapidly changing world. Heritage is also an essential element that makes it possible for a people to show its uniqueness, to manifest its own way of perceiving the world and to express its capacity for cultural creativity. The culture of a community is an original creation, which manifests itself in every dimension of life – the everyday activities and the periodic events, involving the use of ordinary objects as well as the most sophisticated productions (Jokilehto, 2011).

A good heritage conservation strategy is critical to build a strong urban identity and pride in our cities and towns (Harry,2008). Therefore, Cultural Heritage, classic and contemporary, contributes to the identity and branding of territory, so relevant in an age of globalization and fierce competition. This identity constitutes the base for sustainable and endogenous development (Elisabeth, 1982).

The valorization of the Historic buildings' assets of a given city or territory constitutes a factor of attraction, not only for the tourists but also for a number of investors, which could contribute to boost the local economy through the implementation of new activities such as service industries and development projects (Aleppo, 2004).

Tourism center on well-preserved heritage assets of all the kinds of historic buildings, cultural and natural, represents a major potential for local and national economic development [FRANCE-UNESCO, 2006]. The benefits may include the potential for profitable domestic industries - hotels, restaurants, transport systems, souvenirs, handicrafts and guide services. In addition, there is not quantified gain of tourist expenditure due to their abandoned formally registration in macro-economic scales. Through this, money earned through informal employment such as street vendors, informal guides, rickshaw drivers, etc…. is return to the

local economy. It has a great multiplier effect as it is spent over and over again. The World Travel and Tourism Council (WTTC) estimates that the indirect contribution of tourism equals 100% of that of direct tourism expenditures (Giorgo, 2005)

It is important, therefore, to place the issues of heritage conservation within the overall process of urban development, as well as, interlink it with other issues such as tourism development, revitalization of the local economy and local governance. In responding to pressures for the future, which encompass development pressures, economic conditions and the drive towards modernization, it is vital not only to protect tourism resources, but also to promote community development that focuses on cultural landscapes (Ammi, 2003).

2.3.2. Architectural Value

Architecturally, much beauty can be found in these buildings. The harmony of materials changes of open and close surfaces, the variation in porches and balconies, richly decorate molding and fascia boards or other distinctive feature give every building its own particular appearance. The buildings and their architecture will have a real impact on the future. Buildings tell their own stories about past events. They are glories, tragic or just reminders of the way people lived before, and during the year's new layers that have grown in and around the building and have become part of everyday life. As time passes, their value grows, and if they are also part of the future, their existence will be an experience for the future generation (Ermias, 2009).

2.3.3. Job Creation

The preservation of heritage can also generate new employment opportunities: The heritage sector has a large job potential because, it is labor-intensive (European Union). The goal of job creation is particularly important either directly in the heritage program itself (for example, in maintenance construction or archaeological digs etc.).

Job creation can be tourism-related if preserved well (for example, hospitality, transportation etc.), and handy craft related (in the creation and in the marketing of handicraft items) or other types of jobs (Kerr, 2005).

2.3.4. Poverty Alleviation

Heritage conservation strategies in an area of older buildings and street patterns, boundary walls and other features represent an important record of the area's social and economic history and an amenity for local residents. Such features are a vital element in maintaining a stimulating environment for local people as well as attracting visitors and new business investment. Such strategies provide opportunities for the local community, and also ensure in the conservation and preservation of the heritage assets, thus alleviating poverty in the long-run (Parks, 2003).

2.4. Strategies to protect Historical Building Heritages

2.4.1 Education, Awareness Creation

It is necessary to improve awareness towards Historical Building Heritage assets and the ethics of its care in study curricula and to identify tools that can be developed to help communities to better understand and conserve their heritage. Heritage education needs to be developed in schools and through informal education. Students will appropriate of their tangible and intangible Cultural Heritage visiting and using the resources of the site, and understanding the importance of past and contemporary heritage as common elements (Mahadi, 1979)

Preserving and protecting the architectural heritage requires that, citizens learn to value historically significant historic buildings. Many people think that you have to be old enough to value history, but seeds of appreciation for architectural history need to be sown early so that adults who make good choices can sprout **(**Selam T., 2011).

2.4.2. Roles of Institutions in protecting Historical Buildings

While the involvement of the national government remains fundamental (national governments are usually responsible for the promulgation of heritage policies), the articulation between heritage and the development of urban and territorial projects is still carried out at a local level (Nahoum, 2001).

Having an effective and enabling institutional and policy environment goes a long way in creating the necessary incentives need to priorities heritage conservation. Developing special conservation plans and zoning controls and integration into the city's overall master plans is important. So is the need for laws, legislations, rules and building codes (Mesfin, 1970).

This can be done using existing local organization and governance structures, or special units, commissions or agencies can be set up to deal specially with heritage conservation, with full legislative and administrative/financial banking of the local government (Aylin, 2000).

2.4.3. The Activity of Professionals (Urban Planners)

A conservation plan is a tool for managing heritage sites on the bases of key ideas that, in order to manage effectively, it is vital that, an understanding of why the site is significant, and how the different elements of that site contribute to that significant set out, is explained and justified (Milena, 2008).

According to Larkham (2013), direct and indirect agents of change on townscape, architects and designers must have the upper hand as influential professional group. In addition, designers are seen as the professional group most influential in making changes: local authority planners and amenity societies on the other hand become the only indirect influential in their role of development control and processing of planning applications. The quality of expertise is vital to sensitive development and to effective management.

Local planning departments and local disaster management agencies are responsible for the implementation of the instruments in disaster management plans and urban development plans. They should be involved when heritage conservation issues arise in a post-disaster situation, as should historical societies involve in protection of the affect cultural assets, academic institutions involve in heritage conservation issues arise in a post-disaster situation, as historical societies involve in heritage research and local government and arts (Derek, 2008)

Urban planning and conservation should, therefore, be viewed as symbiotic; neither can be complete without the other. When this outlook is adopted, new buildings not only influence the

area with new life, but also maintain existing urban structure. Plans that do not integrate a solid legal foundation for reinforcing urban patterns with a clear vision of future simply postpone problems of urban continuity. This is the reason for shifting the focus from individual building to a more general contextual, collective and cultural outlook. Proper interpretation of the urban context will guide planners as to how to incorporate the new into the old (Rypkema, D., 2010).

2.5. Different Countries Experience

Under this section, experience of different countries in relation with historical heritage preservation, conservation and their contribution for urban development is reviewed. To show the gap, the Ethiopian experience is also included.

2.5.1. Asia- Pacific Region Katmandu

The rich cultural historic buildings heritages of the Katmandu valley region include the cities of Katmandu, Lalitpur and Bhaktapur. The responsible local government-Katmandu Municipal Corporation (KMC) has clearly realized the need for integrating cultural heritage conservation into a broad process of community and citizens' participation.

Two reasons are put forth for good preservation of the historic buildings heritages are, the first one is the importance of community involvement for the success of any heritage initiative and the second is the implication for civic pride and building the city's image among citizens.

Preservation of cultural historic buildings heritage is directly linked to the city's economy, with tourism being the major activity. The medieval city integrates its population with the city's cultural and historical attributes. These, in terms of religion, rituals and cultural activities, are the essence of the city's economic and physical form. They are closely integrated into life in the city. The compatibility of these elements with modernization needs to be tested, but its future lies in integration, rather than separation.

Recognizing the importance of cultural heritage preservation and conservation, KMC established the heritage and tourism department in 1997. KMC has been developing several strategies for heritage conservation, such as education and awareness programs for an informed public,

heritage tours for school children and the media (radio and television). It has encouraged responsible tourism, community participation, public-private partnerships and financial incentive.

KMC also encourages the local community to raise funds to support their own conservation activities (Mesaye Demessie et al., 2009).

2.5.2. The Old City of Aleppo, Syria

Aleppo is one of the oldest historic buildings continuously inhabited cities in the world. The enormous treasures of urban history, the unique urban fabric, the large traditional souks, the authentic oriental life as well as the large number of remarkable historical buildings and monuments render the Old City of Aleppo (OCA), one of the most beautiful and attractive oriental cities (GTZ,2004).

The Old City of Aleppo encompasses a large housing stock. There are about 10,000 private houses, out of which more than 3,000 require urgent structural repairs to avoid dilapidation entailing further out-migration of Old Cities' residents. In order to solve this problem, GTZ and other intentional institutions are involved (Kerr, 2005).

In the interest of preserving residential use by improving living conditions in the Old City, house owners and tenants are given financial and technical support for rehabilitation purposes. In addition, successful applicants are exempted from municipal building permit fees (OCA, 2009).

In order to monitor implementation and guarantee the application of international standards, specific building guidelines have been developed and forced to be mandatory for beneficiaries of the housing funds. By the beginning of 2009, the fund has financed 688 cases (Salahe Z, 2005).

2.5.3. The Old Town Antalya, Turkey

The old town of Antalya is an early example of conservation planning: the project launched in 1973 is also one of the earliest tourism development projects in Turkey and the first to consider the historic urban area of this scale. The project involves, the rehabilitation of the redundant

harbor to create a marina complex and recreational area, and the restoration of some of the larger houses forming the backdrop to the harbor for use as guest accommodation, with a future objective of supporting building conservation in the residential neighborhoods (Larsen, C. (2011).

In 1977, the harbor and old town scheme was incorporated into the Antalya tourism development project, which aims to provide high levels of infrastructure and control over tourist facilities. Conservation in the harbor and old town has been clearly influenced by tourism growth, and much of the outcome has been the result of tourism-center decision-making (Giorgo, 2005).

The first phase plan was initiated by the Ministry of Culture and Tourism, and funded by the Tourism Bank. A team of seven architects and planners are appointed to the project, and with the backing of the Bank the project was quickly completed. A new infrastructure is provided for the 5.5 hectare area and the harbor is developed into a marina, allowing space for local fishing boats as well. Derelict buildings were converting into shops, café and restaurants while a four-storey warehouse was converted into a medium-size hotel run by the Tourism Bank (Aylin Orbasli, 2000).

2.5.4 Lamu, Kenya

Lamu town is a small town on Lamu Island, which in turn is a part of the Lamu archipelago in Kenya. Situated 341 km by road northeast of Mombasa. Lamu is Kenya's oldest continually inhabited town, and was one of the original Swahili settlements along coastal east Africa, founded in 1370.

The town contains the Lamu fort on the seafront, which commenced construction under Fumo Madi Ibn Abi Bakr, the sultan of pate, and was completed after his death in the early 1820s. Lamu is also home to 23 mosques, including the Riyadha mosque, built in 1900. Lamu old town was inscribed on the world heritage list in 2001.

Lamu is the oldest and best-preserved living settlement among the Swahili towns on the east Africa cost. Its buildings and the applied architecture are the best preserved and carries a long

history that represents the development of Swahili technology. The old town is thus a unique and rare historical living heritage with more than 700 years of continuous settlement.

Since the 19th century, Lamu has been considered as an important religious center in east and central Africa due to the '*tarike'* activities introduced by Habib Swaleh, a Sharif descendants of the prophet Mohamed. There are many dependents of the prophet in Lamu. Their presence has kept up that tradition, which continues to the present day Lamu in form of annual festivals known as *"Maulidi"* (Nomination Dossier, 2000).

2.5.5. Harar, Ethiopia

Harar has been established in its present urban form in the 16th century as an Islamic town characterized by a maze of narrow alleyways and forbidding facades. From 1520 to 1568 it was the capital of the Harari Kingdom. From the late 16th century to the 19th century, Harar was noted as a centre of trade and Islamic learning. In the 17th century, it became an independent emirate. It was then occupied by Egypt for ten years and became part of Ethiopia in 1887. The impact of African and Islamic traditions on the development of the town's specific building types and urban layout make forth particular character and even uniqueness of Harar (World Heritage Scanned Nomination, 2006).

The Harari people are known for the quality of their handicrafts, including weaving, basket making and book-binding, but the houses with their exceptional interior design constitute the most spectacular part of Harar's cultural heritage. This architectural form is typical, specific and original, different from the domestic layout usually known in Muslim countries. It is also unique in Ethiopia.

The Cultural and Tourism Bureau of the city so far identified around 5115 houses as historical buildings. At the current time, the Federal government and the Harari People's National Regional State have developed a proclamation to keep these historical heritage buildings from destruction. Nevertheless, the present situation of these some traditional aged houses are under questions according to The 30th Session of the World Heritage Committee (2006).

2.6. Challenges of Historic Buildings Heritage Conservation and Preservation

The challenges of preservation are clear, and so are the solutions. The important work of preserving the missions is underway, but much more needs to be done. Time and money must be devoted to ensuring the historical integrity of these centuries-old missions. Careful and appropriate repairs are expensive and mandatory for historically accurate preservation and adherence to government standards for historical properties. In addition to time and money, the following could be the main challenges and risk of preserving historical heritages (Kurt, 2011).

- ✓ Historic building heritages are affected by primary risk, which is direct damage from the natural disaster.
- ✓ Historic building heritages are also threatened by secondary risks that arise during recovery and reconstruction, including: rescue and relief measures that are carried out with no regard to heritage value of damage areas (e.g., water damage from firefighting and debris removal with no regard to heritage value).
- ✓ Infrastructure repair or replacement (e.g., road widening) disregards or encroaches historic buildings cultural assets.
- ✓ Temporary camps are sited without regard to Historic building heritages landscapes or damage other assets
- ✓ Financial assistance policies encourage demolition of heritage historic buildings.
- ✓ Authenticity and integrity may be lost because of inadequate repair and retrofitting measures

CHAPTER THREE
MATERIAL AND METHOD

3.1. Description of Study Area

The fortified historic town of Harar is located in the eastern part of the country on a plateau with deep gorges surrounded by deserts. Harar is the only city in Ethiopia which is registered by UNESCO as historical city. Among the things which help for register are: the walls surrounding this scare Muslim city constructed between the 13th and 16th centuries. Harar Jugol, encompasses 82 mosques out of which three older once containing 102 shrines were built in the 10th century. (H. M. Jara, 1989).

The most common houses in Harar Jugol are traditional townhouses consisting of three rooms on the ground floor and service areas in the courtyard. Another type of house, called the Indian House, built by Indian merchants who came to Harar after 1887, is a simple rectangular two-story building with a veranda overlooking either street or courtyard. A third type of building was born of the combination of elements from the other two (Asefaw M, 1988).

The external wall which encircles the old city of Jugol separating it from the modern one is perhaps the most impressing sign of the ancient splendors. 82 mosques of different dimensions and beauty; more than one hundred holy graves, tombs, and worship places, and nearly more than two thousand traditional Harari houses which are constructed with mud and special type of stone (typical private houses of particular cultural and artistic value) and historical buildings coffer all over the old city are evidence of its great past history (Robert, 2003).

3.1.1. Description of Ancient Harar City

Harar is one of the oldest Islamic cities in Africa, and is considered as the fourth holiest city in Islam, on the fact of King Negus of Abyssinia (Nejashi) welcomed and protected the followers of Prophet Mohamed during their migration to Abyssinia. This has contributed a strong impact on the history and culture of Harar for centuries to come. Indeed, the way the city was planned and developed, and the styles of its mosques, shrines and traditional dwellings indicate that Harar has

a special traditional Islamic heritage and way of life, which is still preserved and practiced (Burton, Richard, 1856).

As shown on the map of Figure-1, the structure of the city with its central heart (Jugol) and commercial and religious buildings reflect the traditional Islamic architecture of the city. It is a cultural product and a distinctive way to show demographic changes although people of Harar stick to their religious identity till today. Harar is also one of the largest historical cities in Africa, dating back to the tenth century AD. Sheikh Abadir, who is considered to be its founder, established the city to be a major center of trade. The city is an important scientific and commercial center in East Africa, and scientists and students used to come from all over the world and East Africa. Some sources also suggest that the establishment of historic Harar city goes back to the seventh century AD, when Arab groups have migrated from Hadhramaut, Yemen (Elisabeth, 1982).

Harar features a unique pattern of architecture reflecting the impact of Islamic culture and African traditions, which together give the city a distinct character. This has helped it to withstand the forces of change over time. However, the city's ability to keep conservatively has come under doubt because of the winds of rampant globalization, and like other historic cities, Harar will lose its identity unless it is maintained. As previously noted, the International Council of Monuments and Sites (ICOMOS, 2008) has reported several changes that threaten the architectural character of the area.

3.1.2. Geology and Topography of Harar

Harari People's National Regional State is one of the nine Regions in the country which is located in the eastern part of the country, 560 km away from the capital, Addis Ababa. Astronomically, it is located between 9^0 11' 49" and 90 20' 31'' North Latitude and 42^0 03` 30'' and 42^0 16' 24'' East Longitude. According to the Harari Planning and Economic Development Bureau Report (2000), the Region has an area of about 343.2 sq.km in which the rural area constitutes 323.7 sq.km while the urban area has about 19.1 sq. km.

Administratively, the Region is divided into nine rural Kebeles and sixteen urban Kebele administrations.

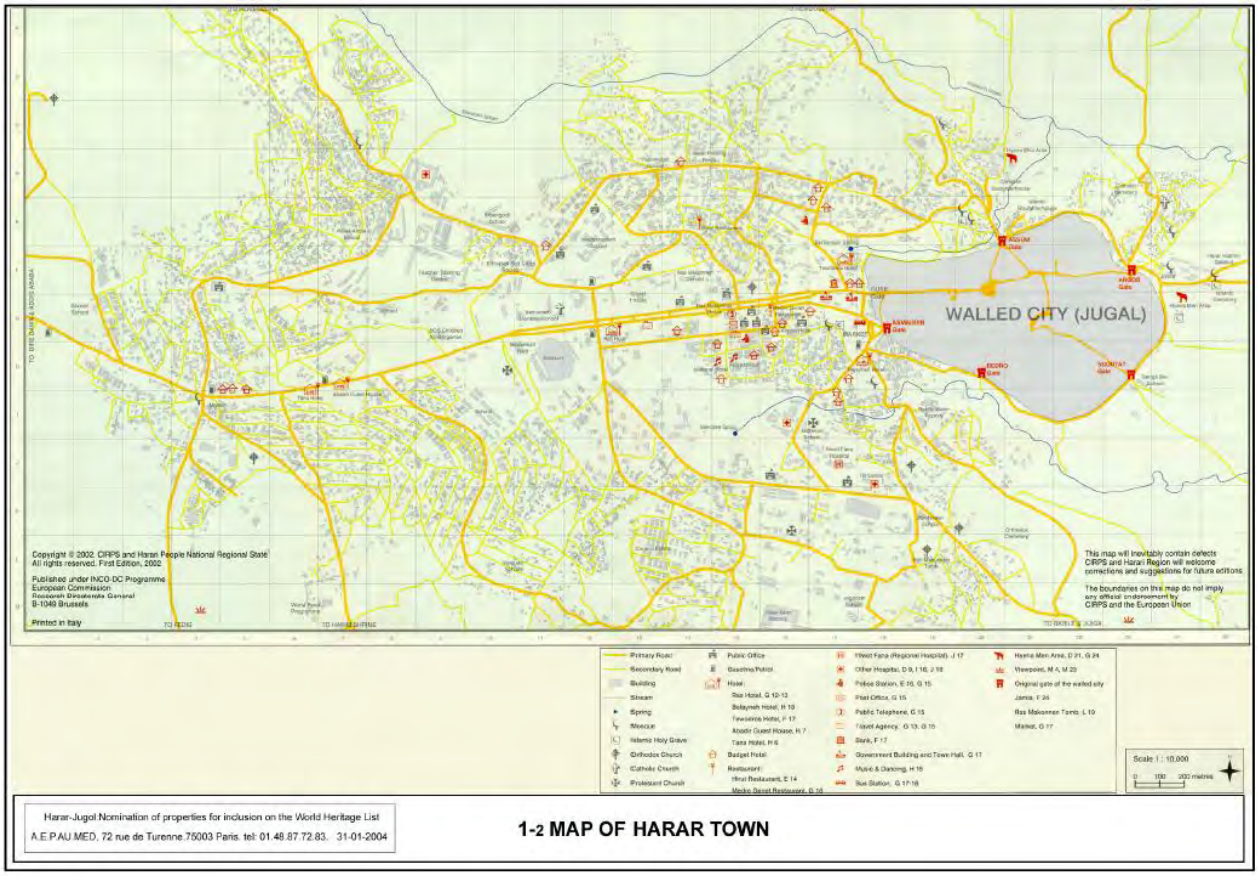

Figure. -1. Map of Harar

(Source: The 30th Session of the World Heritage Committee,16 July 2006)

i. **Topography**

The altitude of the Region ranges from 1300 m.a.s.l. in Kille peasant association in Erer Valley to 2200 m.a.s.l. in Hakim Mountain. Large part of the Region's topography is covered by an altitude which ranges from 1800 to 2000 m.a.s.l. (see Table 2).

In terms of the traditional climatic classification, 76% (276 sq.km) of the Region can be categorized as a Weyna Dega while the remaining 24% as Kolla climatic zone.

Table 2: Altitudinal range by area coverage, HPNRS

No.	Altitudinal range	Approximate area coverage	
		Area (sq.km)	Per cent
1	<1400	36.7	10.7
2	1400-1600	78.3	22.8
3	1600-1800	79.6	23.2
4	1800-2000	91.4	26.6
5	> 2000	57.2	16.7
Total		343.2	100

(Source, Report on Harar Integrated Development Plan Project, 2006)

ii. **Climate**

The precipitation figures of the Region from the years between 1977 and 2013 indicate a mean monthly rainfall of 67.1mm and mean annual rainfall of 804.7 mm. The mean annual daily temperature of the Region is 19.2 ^{0}c. The coldest months are November, December and January (Report of HPNRS, 2014).

3.2. Urban and Architectural Characteristics of Historic Harar

The city is characterized by authenticity, urban fabric and rich heritage of traditional Islamic culture historical buildings (houses). The section of the historic city (Jugol) is surrounded by a historical fence. Most of the buildings, from the thirteenth and fourteenth centuries, still exist. Yet, some modern buildings affect the unity of this traditional architecture. During this era, the Indian traders living in the city had constructed houses with large wooden balconies, which give a new character to the city (H. M. Jara, 1989).

Some of them are so special like "Rimbaud" house which has recently been rehabilitated and used as a cultural center and library (Figure.-2). Despite the relative newness of these houses, most of them were constructed in the late nineteenth century and early twentieth century, and

being qualitatively different from the traditional Harar houses, they are considered as a unique addition to the historic architecture of the city. And now they are part of the heritage of Harar.

Figure. -2. Arthur Rimbaud House

(Source: Harari cultural heritage conservation library)

As for the urban fabric of Harar, it has remained the same except for the addition of a street under the Italian occupation at the western gate till the main square in the city center. This street allows cars to access its heart. This has contributed to the creation of new activities and adds vitality to the city. Harar has retained about 90% of the urban fabric without change. The urban tissue is distinguished by a complex network of narrow streets and cul-de-sacs. The walls of the roads are constructed from bricks and free from any openings except the doors to provide privacy to residents (Abate, 2004).

Most of Harari buildings, and in particular mosques, are in good conditions except the main mosque whose façade is reconstructed poorly. Harari housing is one of the most important components of its heritage and its most wonderful and best visual value. Almost each house is characterized by distinct features that distinguish it from other houses. First, the entrance door is the only house opening to the street, leading to a courtyard by the brick beds. The house is also having elements of decoration from the local dishes and wicker baskets, which give a distinct

character to the house. In fact, the architecture, decoration, and handicrafts that together form the distinctive character that the people of Harar are proud of. The city's wall has six gates; five of them are historical and the sixth is new. The locations of these gates are determined by the main streets linking the city with the surrounding. These five gates are open to the streets that flow into the city center and face by five neighborhoods (Abbas, 2002).

The historical city (Jugol) has a pattern of traditional Islamic urban layout surrounded by a fence, and the mosque and market are located in the center. Until 1887, all public buildings located in the center are delimited by triangular sides matching municipality building (west), the main mosque (east), and the main market (south). The center also connects to the Western Gate Road, which is the latest straight road across the city and surround by stores. The market area is linked with a road surrounded by traditional stores. The concentration of commercial activities around the main street has helped to leave the rest of the city for residential uses. The city includes a large number of mosques and shrines. Most mosques are small and have a single space for prayer and as well as a small courtyard. In general, 85% of Harar traditional houses are in good condition (ICCROM, 2007).

3.3. The Research Design and Methodology

3.3.1. Overview of the Research Process

Owing to the desire of the researcher to undertake an applied research, which aims at contributing knowledge towards solving a practical problem, the research starts by investigating a practical problem. Experience, observations and results of international studies form the ground for formulating the research statement of the problem and the research investigation test areas.

Based on the statement of the problem, first an extensive review of literatures on the subject was undertaken. Next, an investigation on the Harari Traditional houses durability and maintenance related issues which are being carried out now, with the view of discovering whether the maintenance matches to what has been discussed in the literature or not depending on the test result contributed by the materials. Results of the investigation give clear picture of the existing practice and assist in identifying the major shortcomings and limitations of the practice, which

have great contribution to propose the improvement for good restoration and preservation of houses.

3.3.2. Approach of the Study and Research Instruments

As described earlier, the objective of the research has emanated mainly from observations of the historic Harar city buildings which may answer questions like: why the buildings stayed this long period of time with minimum maintenance, is the maintenance taking place currently effective and compatible with the material construct before? But, the need for proving the existence of the problem demand a methodological approach for realistic judgment on the investigation and interpreting the test result data related to the subject under consideration.

3.3.3. Method of Data Collection

The population of the study has a limit to traditional aged historical Houses of Harar. These traditional aged residence houses were constructed at different times and during different regimes. And these large numbers of houses demand the implementation of an integrated and efficient maintenance to preserve. Accountable organizations related to the research are: Harar historical and cultural office, municipality and urban development office of Harar city and federal minister of cultural and historical buildings study office of Ethiopia. As the research focuses on traditional historical houses, investigating their durability mystery and the effectiveness of the maintenance work taking place at the current time are essential for the research study and for sample taking which will be used for proportionate stratify sampling method. Proportionate sampling refers to the selection from each sampling unit of a sample that is proportionate to the size of the unit. Advantages of this procedure include representativeness with respect to variables used as basis for classifying categories and increasing chances of being able to make comparisons between strata. According to the sampling method required, the classification was carried out in four classes' relation to their current status requirement for maintenance. This is shown in Table-3 below.

Table-3. Houses classification according to their maintenance requirement (Excerpt from the Decisions of the 30th Session of the World Heritage Committee, 2006).

No	*Type of maintenance required by the historic house*	*Number of the houses*	*Percentile out of the total population it take*	*Number of Sample proportion for research study (*)*	*Remark*
1	Corrective Maintenance	793	43.9	44	*Used to investigate the Durability*
2	Emergency Maintenance	140	7.7	8	*Use to investigate the effectiveness of the maintenance*
3	Preventive Maintenance (**)	493	27.3	27	*Use to investigate the effectiveness of the maintenance*
4	Demolition	383	21.1	21	*The same as No. 2 and No. 3*
	Total no of the houses or population sample	1809		100	

*The sample size reduces down proportionally from 1809 to 100 for my research

**The preventive maintenance work includes both recurring maintenance and component renewal.

Note

All the four types of maintenance discuss on chapter Four.

CHAPTER FOUR
DISCUSSION ON HARARI AGED TRADITIONAL HOUSES

4.1. Looking at the Ancient Construction Development Indicators of Harar City

Harar expresses the influence of a long period (almost ten centuries) of an original Islamic culture on the development of a city and its typical urban planning. The creation of religious buildings, as mosques and tombs, as well as specific original houses in Harar gives evidence of Harari cultural tradition still alive, practiced (especially the religious and social one) and well preserved by the inhabitants (Abriham,2010).

The city offers a very good and complete example of a traditional human settlement which illustrates a significant Islamic culture of Ethiopian history. The structure of the city, with its central core being occupied with commercial and religious buildings, refers to the traditional Islamic urban structure presenting its original housing typology and a very significant cultural artifact. It is an outstanding example of human settlement whose occupancy in the territory represents a specific culture, now vulnerable with contemporary demographical mutations (Sheibani, 2007)

Out of the ancient construction development works listed below, three are discussed here and the last one is discussed in detail in the next chapter. As already known, the main target is dealing or making an investigation on the Engineering aspect of the traditional houses. But it indirectly means making investigation for all ancient construction development since the materials used for construction are similar and they display similar architecture view all over the period they were constructed in (Nooraldeen, 2006). These construction work which inter relate are list below.

i. The City Walls and Gates
ii. The Mosques
iii. The Muslim Tombs
iv. The Traditional Harari House

i. The City Walls and Gates

The city walls are called *"Jugol"* in Harari—the term refers, at the same time, to the enclosure and the inner city itself within the walls.

According to the description of many writers, Harar is surrounded by walls from the time of Emir Nur Ibn Al-Mujahid (1551-68) who had decided to build the walls in order to protect the city from the Oromos whose pressure was becoming stronger and stronger, as well as from the Christian threat. *He requested help from the Sheriff of Mecca who had sent him Fakhraddin Yonis in order to properly carry out this wall construction* (Harar Jugol, the Fortified Historic Town, 2006)**.**

The wall measures 3,342 meters in circumference and average four meters in height. At the time it was constructed with "*Hashi* stone"—a limestone extract within the Harari area (mainly around Mount Hakim) that was used for building houses, mosques, and tombs in the city. The wall isn't whitewash. The oldest part of the wall located at its foundations was constructed with large uncut stones that are hold together by a mortar of mud and reinforcements of wood incorporate at regular intervals of one meter. In the upper part are found stones of smaller dimension, hold together by mortar of mud (Hecht, 2007).

The positioning of the five gates on the wall, whose names are mentioned in the table below (Table-4)—in the North, in the East, in the Southeast, in the South and in the West—is determined in function of strategic aspects of defense, but also correspond to the directions of trade routes and to the proximity of ponds around the city. Historical accounts concerning the finding of the city also relate to the choice of the figure five referring to the five pillars of Islam. **(**Harar Jugol, the Fortified Historic Town, 2006).

The city gates were always guarded, locked at nightfall and reopened in the morning. Near to each of the gates stands a small house traditionally used for surveillance and for the stocking of arms used to defend the city from Oromo attackers. These houses still exist in the case of the North Gate (Assum Bari), the East Gate (Argob Bari) and the Southeast Gate (Suqutat Bari).

Originally all five gates carry Arabic names, but there exists a quantity of other names and today those most currently used are in Harari and in Amharic. All the names are summarized here under

Table-4: Name of the five gates of Jugol with respect to their direction or location

	Arabic	**Somali**	**Oromifa**	**Amharic**	**Harari**
North	Bab al-Fath Babzayla	Errida Fuldano	Khararra Fallana	Follana Ber	Assum Bari
North-East	Babar-Rahman	Errida Erere	Kharra Ere	Erer Ber	Argob Bari
South-East	Bab as-salam		Kharra Sufi	Songa Ber	Suqutat Bari
South	Bab al-Hakim	Bab Bida	Kharra Badrowa	Buda Ber	Badro Bari
South-West	Bab an-Nasr	Errida Hamaraisa	Kharra Hamaraisa	Shoa Ber	Asmaadin Bari

(Source: The 30th Session of the World Heritage Committee, 16 July 2006)

The walls, modified and reconstructed on numerous occasions due to alterations of nature and mankind, have lost their historic homogeneity. Those portions originally constructed of limestone only represent 10.16%, or 338.25 meters in all. The portion of the original walls integrated with housing on the periphery of the city represents 38.54%, or 1294.40 meters. 19%, or 625 meters, are whitewashed by the Italians while 4.17% (138.80 meters) are reconstructed in limestone without mortar. Those portions of the walls that have partially collapsed, but authentically dated from the beginning, represent 11.13% of the whole, or 380.90 meters. 8.10% (269.50 meters) have been reconstructed and bound with cement mortar by local authorities (Ralph, 2008).

ii. The Mosques

The mosques which are the historical center of Harar are constructed between the 10th and the 19th century. According to the inventory carried out by the Department for Preservation, Collection and Inventory in the Office for Culture and Sports, at the moment there are 82 mosques within the wall of Jugol. However, according to an oral tradition, it appears that the

town has 99 mosques before the urban transformations of the 20th century (T. Berhane, 2007). Their construction combines the use of the local stone, *Hashi* and quicklime stones, *Nora* ensuring their perfect integration into the urban landscape of the town. The construction differs from the other urban constructions of Arabian mosques (Sheibani, 2007).

4.2. The Materials and Construction Techniques of Jugol walls and Mosques

All the mosques in Harar are constructed from stone (granite and limestone), a material which is plentiful in the region, and which is assembled with a mud mortar, prepared from soils locally called *Gogoba, Kuyesa, Bunama Afere and sand.* The doors and the structure of the prayer rooms are in juniper wood, the *Wanza Inchut*, known for its resistance to termites (Aalund, UNESCO, 2010).

The four walls of an average height of four meters are constructed from limestone, the lightness and porosity of which ensure protection against dampness. At every meter, a plank of horizontal wood is set in to consolidate the masonry. The walls are whitewashed (Abdullahi, 2000).

Most of the mosques were constructed in the same way. For example, in most of the mosques, the inside structure construction techniques look like this: two pillars of a diameter of 80 cm on average support an intermediary beam, the *Hamil,* roughly 5 meters long, parallel to the wall of the *Qibla*. Rafters are supported by this beam and the two parallel walls (north and south). In order to fix them to the beam, a mixture of small stones and mud is applied between each rafter. This stage in the construction of the structure is called the '*Mersa'*. Then, perpendicular to the rafters, wooden logs known as '*Kebel* 'are laid; finally, a layer of dry grass is applied to improve water tightness. This traditional structure which is watched in all the traditional buildings in the town is known as the '*Darbi'*. The last stage is to cover the terrace with a mud mortar, the *Gogoba* (Annual report of UNESCO, 2010).

The terrace roof slopes slightly to enable the rain water runoff. A parapet 50 centimeters high protects the wall from infiltrations and erosion of the roof. The maintenance which takes place twice a year consists of removing the weeds and applying a new layer of Gogoba soil layer on the top of the roof.

iii. The Tombs

In Harar, the tomb is the tomb of saints having lived there during the 12th century and whose rituals and cult practices participate in the construction of Harari culture. Such tombs are called *Awach* by the inhabitants and can be found in various forms: purely natural elements, construct forms, and sites. These can be found just as easily inside as outside the limits of the historic city, although they are most numerous in Jugol. The department of conservation collection, and inventory of the Bureau of Culture and Sports has established a list of ninety-five tombs located intra-mires construct in the 10th century (Burton, 2006).

These elements contribute to the singularity and the beauty of the urban landscape as they are integrated into all spheres of space: public, private and religious. For the construct forms, the use of local materials such as *Hashen* of lime, Nora, and pieces of wood to construct the walls and mosques and their harmonious integration makes the walls and the mosques attractive and durable. Since the same technique is used to construct other buildings of the city, the homogeneity of the city looks spectacular (Kamil, 2007).

iv. Houses in Harar

The Houses can be distinguished in to three types in terms of their respective time of construction and the people who constructed them. These are:

i. The Traditional house,
ii. The Mixed house, and
iii. The Indian house

i. The Traditional Harari Houses: form the bulk of the architectural heritage of Harar city and are considered as the city's historic symbol. Harar includes around 5115 residences within the fence. They congregate a complex of several separate or connected units. In the past, combine houses were used by members of the same family. Currently, this has changed as relatives are not necessarily to reside in the same complex. The elevations of these houses are almost similar (Kamil, 2007).

Figure. -3. Mahdi Adous's house (on the straight of Jegula Hospital), an example of traditional houses
Source: Harari cultural heritage conservation library

ii. Mixed House, this type combines traditional housing with later additions of the Indian style on the first or second floor**.** Access to the added rooms is through a wooden corridor which opens to the courtyard or street. It is the popular housing type in Harar. The added part is usually a rectangular building on one side of the courtyard and includes rooms' stack side by side overlooking the courtyard through the windows. The mixed house does not have the same degree of architectural quality of the original house. The upper floor has the same pattern of distribution of rooms that has access via an external wooden corridor through a wooden ladder (Figure.-4).

iii. Indian House, Indian traders brought this style to Harar after 1887, and most of these houses were built in the highest areas of Harar city, which then dominate the city landscape. A house of this type consists of a simple rectangle of two floors characterized by a cover with wood porch in the first floor facing the courtyard or street. One of the most famous and beautiful Indian houses is Rimbaud house which was constructed in the early twentieth century. The local authorities recently renovated it with the assistance of France. Nowadays, the house is used as a cultural center and library. Currently, there are about 12 houses of this type in Harar and they are all in the highest area of the city. The residence of Ras Tafarri (Figure.-5) is one of them but needs rehabilitation. The major difference between the Indian-style and traditional style is that Indian-

style unlike the traditional, opens to the outside landscape as opposed to the Harari one which is a very introverted enclosed space (Richard, 2005).

Figure.-4. Khadija Ahmed's house (near to the residence of Ras Tafarri), an example of mixed house

Source: Harari Cultural Heritage Conservation Library

Figure.5. Rimbaud and Ras Tafari's house respectively, an example of Indian house

(Source: Harari Cultural Heritage Conservation Library)

The Indian and the mixed houses are not only different from the Harari traditional ones, but even opposed to it. (The Indian house is widely open to the landscape as oppose to the Harari one which is a very introvert enclose space). We have to consider these two housing types as part of the architectural heritage of the city. Therefore, the rehabilitation policy has to integrate the

housing heritage with its multiple, Harari Traditional Houses, Indian and mixed historical aspects (Brereton, 2001).

The locally available materials used for the foundation and walls of the houses are *Hashen* and wider. *Hashen* is sort of rubble stone, a rather irregular block constructed with stones to which are added small stones or wider. The construction is heavy with the sandy earth of the region mixed with red clay. The structure of the roof terrace constructed with beams in pine is covered by a layer of *Gogoba*, a mixture of grasses, wood shavings and clay soil brought from nearby riverbeds (Richard F. Burton, 2006).

4.3. Current Status of the Harar Aged Traditional Houses

The state of preservation of the traditional houses is relatively good. According to the plan realized by CIRPS, University of Rome 2007 "La Sapienza", there are about two thousand traditional houses (family unit block). The status of the traditional houses at the current time as shown below by the report of the 30th Session of the World Heritage Committee by UNESCO, 16 July 2006.

i. 793 are in good condition: 43. 9%
ii. 493 are in fair condition: 27. 3%
iii. 140 are in poor condition: 7.7 %
iv. 383 have been modified: 21.1%

Then, we can safely say that almost half of the traditional houses have been preserved well, which is a pretty good proportion and represents a good quality of conservation, especially if it is compared to other Arab cities in which about three quarters of the traditional houses have been reconstructed with concrete structure and contemporary materials (Hecht E.D, 2007).

A significant part (almost one quarter) of these houses are in fair conditions, which means that they have been little transformed and that few repairs can be enough to restore them. Only 140 houses are in poor condition, which is a low proportion. These houses suffer from water damages: from the roof licks and from the water rising in the masonry walls (due partly to the

fact that many streets are not yet paved and that water infiltrates in the ground and badly affects the foundations (Abdullahi M. A., 2000).

4.4. Factors Affecting the life of Harari traditional aged houses

A. Development Pressures

It is the "human" factors that cause the most damage to housing. Actually Jugol—the population of which is about 34,000 inhabitants on 48 hectares—suffers from a high population density, in which about 700 individuals have settled per each hectare. Although its area represents barely 2.7% of the total metropolitan area, the concentration is nevertheless nearly 37 % of the total population of the city. 47.4 % of the houses have only been a single room as of Harari Municipal report on 2013, accommodating large families emanating from various social strata. Such concentration doesn't exist without jeopardizing good housing conservation. This, in turn, is directly linked to the occupancy density which is at the origin of housing modifications carried out by the inhabitants to their houses:

- ✓ New additional rooms (whether living or service) are constructed to the detriment of the courtyard, a factor that is accompanied by saturation of the plot of land.
- ✓ New additional rooms are constructed on upper floors, which transform the urban landscape, using, among other things, materials differing from the original ones.
- ✓ New lean-tos of the hut or shack type lean against the façades of traditional blocks, tending to make the dwelling resemble a "shanty town."

B. Environmental Pressure

The property and the area proposed as a *"buffer area"* are at the moment subjected to constraints linked to the environment; these are primarily due to pollution problems created by the poor management of domestic and industrial refuse.

1. Solid refuses in Jugol

The urban landscape in the Old Town and outside the ramparts is litter with heaps of rubbish. This state of affairs is partly due to the local authority's poor management of refuse disposal and partly to the inhabitants' lack of discipline. In Jugol, there are two institutionalized systems of town cleaning. One is done by teams of donkey-driven carts which collect the rubbish and the other is done by starlight sweepers who sweep the streets and squares. Although these two systems are in action every day, a number of areas in the town remain dirty: this is particularly the case of unpaved streets which the teams cannot go up and down. Moreover, there are some areas in the town which have become illegal rubbish-dumps and are never cleaned. This is especially the case for the *sheruga* (small streets with open sewers) where people throw their rubbish. The refuse, therefore, stagnates in some parts of the town, the tombs which are localized in the public space, suffer particularly from this. Moreover, the introduction of plastic bags in the past few decades is in evidence everywhere (Report on Harar - the Analysis and Strategies (partial) Phase: June 20, 2006, Harar)

The refuse problem is serious. Outside the ramparts, solid refuse contributes to the pollution of the rivers. In Jugol, refuse is a feature of public space and the populations are in contact with it. Thus, the rubbish is the origin of a considerable number of illnesses and, at the same time, contributes to the deterioration of public space by presenting an image of the town clutter with rubbish and spoilt by filth.

2. Waste water

The two main categories of waste water have to be differentiated: domestic water and the liquid waste from industries and hospitals in the town. Domestic waste water mainly comes from bathing, washing clothes and dishes and other linked activities such as house work. The waste water which comes from the town's industries is more pernicious; it contains all sorts of chemical products, detergents, acids and heavy oils which have very harmful effects on the skin and the whole digestive tract. It is very difficult for the ground to absorb and filter this type of waste water. The poor functioning of the drainage network and the total absence of treatment has

catastrophic repercussions on the environment and the population. The river which lies below *Badro Bari* is the first one to be affected by liquid industrial waste. The streets of Jugol suffer from a pollution caused by the poor evacuation of domestic water. [Report on Harar the Analysis and Strategies (partial) Phase, June 20/2006, Harar]

The whole principle of water drainage in Jugol seems to be based on the topographical and geographical characteristics of the town. The town tends to use the design of the streets which link the top of the town with the ramparts below. This system endeavors to evacuate liquid waste through the low walls into the river-sewers which flow to the South and the North of the town.

i. Number of inhabitants within the aged traditional houses, buffer zone

Harari authorities and in particular the population bureau of the city of Harar are currently completing a population study for the year 2008. However, the figures are not yet available.

Thus in 1995, 26,328 inhabitants are counted for Jugol and 76, 378 inhabitants for the Harar agglomeration. Forecasts for the year 2000 indicate a figure of 34, 326 inhabitants for Jugol, thus an increase of approximately 13% in five years. Population increase is foreseen for the decades to follow—the population for the city of Harar as of 1995 (2006 estimate) is about 120, 496 inhabitants.

C. Economic Pressure/ insufficient Income for upkeep

In 1974, all the Land lords of Harar were expropriated from their houses at the time of the nationalization of property under the.Derg regime. Each family was given the right to keep only one house. Out of the 5115 houses that the city of Harar counts today, 39.8% belong to the *kebele* (administrative units) and 30.2% are private properties. As the *kebele* have very little financial means and since rents collected are minute, inhabitants aren't able to meet the required expenditures for the work necessary to upkeep the houses. Thus, 4.8% are rent from housing agencies and 14.0% are rent from private houses. 9.7% are rent free (H.M. Jara, 1990). Certain numbers of traditional residences are in a critical state of conservation due to the lack of resources for maintenance. For example, the terrace of houses roofed in the traditional way,

needs maintenance each year, with a layer of *Guguba* (very clayey soil brought from river beds) that guarantees its being waterproof. This kind of upkeep is disappearing little by little due to the expensiveness of the soil. Thus, the heavy precipitation that hits the area from April to September causes great damage to the houses. Presently, a number of terraces are falling apart. Similarly, 68 houses have completely collapsed and 300 others have declared uninhabitable following the rains of 1983, which badly damaged the Houses (Aalund, 2005). Such degradation has affected about 1700 people within the old city (50% of these houses fell within the jurisdiction of private house). Following this trend, note that houses used to be whitewashed each year, which assure a protective layer on the walls of the house, lessens the effects of erosion, wind and rain. According to the same study and following statistics obtained by the *kebele* in 1996, 75% of the houses in the city of Harar are in good shape, while 21% require undertakings for upkeep. According to this same study, 4% ought to be demolished (Jara Haile Maryam (2011).

Moreover, the growing prices of building materials such as corrugated iron as well as the disappearance of traditional materials because of their scarcity and high cost play a part in seriously transforming the aspect of the houses. This is especially true for sycamore (*wanza),* which helps to make doors and ceilings. Wood is now becoming a rare material in the region and a log (*kebel*) costs, at the moment, 180 Ethiopian birr (or roughly 6 Euros). The limestone which is to be found 6 kilometers away from the town is not exploited for lack of means. The cost of quarrying and transporting stone is also getting more and more expensive. Building a traditional roof terrace of about 15m^2 costs more than 40,000 birr (This figure is for information only and represents the cost of labor for five days, the necessary time for five workmen with their helpers to build a roof);. While building it with a metal structure and a sheet of corrugated iron comes to only a few hundred birr (Jara Haile Maryam (2011).

4.5. Conservation and Restoration Works Taking Place on Harar Traditional Aged Houses

In order to measure the state of conservation of Jugol in all objectivity, the responsibility given to the Office of Harar Sports and Culture has perfect conservation record charts with the help of the Authority for Research and Conservation of Culture of Addis Ababa. These record charts

make possible the inventory of properties to be preserved and how to measure their evolution over time. The record charts are kept up to date when work is carried out, that make it possible to measure the possible changes that have transpired since the last follow-up visit. These potential evolutions can be measured on the basis of the general structure of the house as well as on the basis of the "secondary work". The transformation of a traditional house can be judged in the first place by the replacement of a roof terrace by corrugated iron, or the addition of a separate building in the courtyard. The record charts carried out by the office of culture also enable noting the replacement or transformation of doors and elements of traditional woodwork (Alund, 2010).

They are also informative about irregularities and potential alteration to the structure, basically due to the infiltration of water through the roof and to the infiltration of humidity in the foundation walls. At the same time, an Atlas of the condition of houses in Jugol is drawn up by the CIRPS (2001). The Atlas, representing (in most detail way) the various types of houses and their present states of conservation, can be a basis for working out a means of saving them. The straight away enables taking into account the state of preservation of Jugol and how to pinpoint the most sensitive sectors, those which the city should attend to first of all. **Table-5** shows the conditions of the houses on Atlas drawing summary quantity.

These documents give local authorities the first keys for measuring the state of conservation of Jugol.

- ✓ In the first place, they present an exhaustive inventory of the houses in Jugol and their actual state of conservation.
- ✓ The additional work carried out by the Harar workshop in 2003 (EAPS and Université de Paris-X-Nanterre, 2003) has shown possible and complete inventory of the mosques and tombs in Jugol and the demonstration of their state of conservation.

These undertakings contribute possible revelation of a number of factors that enable measuring the state of conservation of the property and following its evolution. Mosques and houses suffer first of all from the effects of water. The integrity of the structure as a whole can also be put into question by examining transformations and the addition of annex elements in the courtyards.

- ✓ Have roofs of earth been replaced by roofs of iron?
- ✓ Have walls of stone been covered by a coating of cement?
- ✓ Have there been additions or consolidations in pare?
- ✓ Have constructions been added in the courtyard of the traditional house or in the examined mosques?
- ✓ Are elements of the mosque, wooden doors and shutters always in place?

Table-5: The state of conservation of the traditional Harari houses.

Description	Good status	Fair status	State in Need of Restoration
Traditional Harari Houses	39.65%	35.7%	24.65% have been Modified

Source: Own Survey

4.6 Actions Required to Preserve the Current and Future conditions

4.6.1. Preservation Measures and Means of Implementation in the Current Time

In Harar, the preservation of the material and spiritual cultural heritage is the focus of local organization. The Harari region is represented by the *Harari People's National Regional State*. This regional authority includes a chamber of representatives and a Harari Council. The single aim of the latter is the preservation and the promotion of Harari Culture.

There are five committees (history, language, archives, heritage and law) containing 14 members who have direct relationship with the President of the region.

1. The Federal Law

A law applicable to the regions as a whole setting up the federal Ethiopian State passed in 2000: which is the "Research and Conservation of Cultural Heritage", proclamation no. 209/2000 of the 27.06.2000. This proclamation insists on the need to seek and protect the entire movable and land property belonging to the cultural heritage of the country, and to organize its administration. It is a governmental authority (*Authority for Research and Conservation of Cultural Heritage*)

under the supervision of the Ministry for Communication and Culture which is responsible for this national policy.

2. Local Initiatives

The Federal law in 2000, the Harari Council had already drawn up a proclamation for the creation of a conservation office in Harar, "The Establishment of Harar Heritage Conservation Office", and proclamation no. 21/1992. Eleven years ago before this new local authority was in charge, the preservation of the Harari movable and land property effectively showed the light of today. It has only just been created in September 2003 with Madame Afiza Badri as president.

This new Council, under the direct authority of the vice president of the region, includes an Administrative Council which draws up the general policy and a Conservation Office which establishes a plan for preservation in the short-term, the medium-term and the long term. The Administrative Council encompasses the representatives of the Harari Council, civil society and the associations (*Afocha*, women's associations …), the directors of the various offices of the executive bodies, the heads of the *Kebele*, a president and a director, making a total of 46 members. According to the new organ, the bureau has a special place within the executive body. It has the same level as the offices of the economic and urban sectors. But, being in direct relation to the organization in charge of the preservation of heritage (the *Harari Council*) it able, through it, to have an influence on the economic and urban sectors (Annual magazine of Harari cultural and tourism office, 2009).

The Conservation Office is the controlling body which is responsible for ensuring the follow-up of the preservation policy within Jugol. Its director has been appointed by the council of administration. It is assisted in its task by a secretariat and a team of technicians who are doing an in-service training course. This training is aimed at enabling them broaden their knowledge and their skill in the preservation of the cultural heritage (Jara Hailemariyam, 1990).

The responsibilities and the authority of this Office are implemented at various levels. These are:

- ✓ Transform the conservation activity into a self-administer unit with a local resource base

- ✓ The creation of awareness among people about their heritage by using different media
- ✓ Facilitate the participation of people in new policy activities for the conservation of the Jugol heritage.
- ✓ Design how experts can be trained to take care of the movable cultural heritage in its original location.
- ✓ Create and facilitate ways in which the construction materials for the construction and maintenance of old and new houses in the old town can be found easily.
- ✓ Create effective ways and means to control the construction of unsightly and illegal additions and constructions.
- ✓ Make sure the Federal authority's recommendations and decisions concerning the conservation of Jugol are translated into practice.
- ✓ Study and apply the way to repatriate historical houses nationalized by the 1967 edict.
- ✓ Follow up and control any maintenance activity carried out by the private sector or government, with the respective authorities
- ✓ Control the building of new houses on vacant space in Jugol.
- ✓ Manage the proper expansion of houses by applying strict control.
- ✓ Study and recommend ways to minimize the population congestion problem in Jugol and the possible ways to relocate the population outside the walls.
- ✓ Follow up the preservation of all public and government properties which are registered as heritage
- ✓ Document studies and records about the Jugol heritage
- ✓ Design ways and means for collection of funds for the preservation of Jugol heritage from national government, international partners and local communities.
- ✓ The council has legal rights to own properties, to sue and be sued.

At the same time, a series of edicts have been issued in a proclamation which is an adaptation of the federal law for the specificity of the Harari cultural heritage. This is the "Heritage Conservation Draft Proclamation of Harari People National Regional State" which is defined as a heritage to protect all the old movable and immovable property produced by human activity in the region; in particular, everything built in Jugol, with its walls, doors, mosques, tombs,

traditional houses as well as the manuscripts and other objects associated with worship and domestic activities. This proclamation sets out a certain number of duties towards this heritage as well as the prerogatives of the Conservation Office. This are:

- ✓ The owner of a property recognized as being part of the cultural heritage must register it with the Conservation Office who will then give the owner a certificate of registration. The owner has to see to its maintenance according to the rules defined by the Office.
- ✓ Any restoration work must be done in accordance with the instructions of the Conservation Office.
- ✓ In a zone containing a registered property, no building can be carried out without the permission of the Conservation Office.
- ✓ No new building or any destruction can take place in Jugol without the permission of the Harari Council.

Till now, the Sport and Cultural Bureau (with the Mosques' Committee) was in charge of carrying out the preservation projects in the old city. Within the department of Culture, a coordinator, a person in charge of the inventory and a technician are interested in listing and protecting the movable and immovable heritages in Jugol. But, as they do not have a regular budget line, their actions in restoration have been limited. Nevertheless, their main duty is to carry out an exhaustive inventory of the mosques and the tombs, which is a base for future restoration projects. The scope and prerogatives of the present department of culture will be transferred to the new Conservation Office.

The policy for preservation in Harar is therefore an ongoing policy. The local authorities have posed the bases and the orientations a long time ago. The new Conservation Office is the main body. It is capable of ensuring the link between the population and the local authorities and will ultimately be the special correspondent of the international bodies in terms of the protection of the local heritage as annual report of the house of Harari region parliament reported in 2010.

CHAPTER FIVE

DISCUSSION ON TEST RESULT OF THE SOILS USED FOR THE ORGINAL CONSTRUCTION AS WELL AS FOR MAINTAINANCE

5.1. Overview of the Original Materials Used to Construct the Traditional Houses.

The Harari houses, which represent the most important part of the architectural building structures of the city, are the most spectacular and valuable elements of the traditional heritage of Jugol.

Their styles are unique to Ethiopia and their interior designs are quite exceptional. When Harari people mention the "Harari culture" they actually refer to the beauty of their houses, which they are very proud off. At the end of the 19th century, Indian merchants constructed new houses whose wooden verandas define a different urban landscape and influence the construction of Indian/Harari houses. Their architectural and ornamental qualities are now part of the Harari cultural heritage. Few modern buildings have damaged the traditional architectural typologies (Kamil, 1997).

This paper mainly focuses on aged Traditional houses which were constructed before the Indian house construction style came at the end of 19th century. Since the main target of this paper is to investigate the maintenance practices taking place at the current time, emphasis is given to the efforts of Harari Administrative Council to maintain these invaluable cultural heritages.

All of the aged traditional historical houses were constructed from locally available materials such as:

i. Hashi stone or lime stone (as masonry stone),
ii. Soil Mud or Paste material prepared from Sand, Brownish soil, Gogoba and Kuyesa
iii. Zigba wood for reinforcement and construction joint.

- Gogoba soil is also used as roof cover because of the nature of its soil property.

According to many investigators and writers, the materials listed above were also used for other construction works like mosques, tombs and shrines at the time.

5.2. Material Analysis – Earthen Soils as Construction Materials

Tom.M, (2001) notes that earthen soil is one of the oldest materials used for building construction in rural areas. In addition, earthen soils have the following list of advantages and disadvantages when used as construction materials.

Advantages of using earthen soils as construction materials

1. It is resistant to fire.
2. It is cheaper than most alternative wall materials, and is readily available at most building sites.
3. It has a very high thermal capacity, which enables it to keep the inside of a building cool when it is hot outside and *vice versa*.
4. It absorbs noise well.
5. It is easy to work using simple tools and skills.
6. It is available in most regions
7. Its easy workability
8. It is sustainable as construction material for most parts of the building.
9. Better control of indoor air moisture content.
10. It minimizes wastes
11. It makes low energy input in processing and handling.
12. It is environmentally friendly

These qualities encourage and facilitate self-help and community participation in house building. Despite its good qualities, Earthen Constructions has the following drawbacks as a building material:

1. It has low resistance to water penetration, resulting in crumbling and structural failure.

2. It has a very high shrinkage/swelling ratio, resulting in major structural cracks when exposed to changing weather conditions.
3. It has low resistance to abrasion, and requires frequent repairs and maintenance when used in building construction.
4. Lack of standards: the soil must be known beforehand and carefully analyzed
5. Excessive water absorption may lead to shrinkage and cause cracks: although the use of stabilizers and compaction could reduce or exclude water absorption and reinforce the soil with fibrous material (Stulz & Mukerji, 1993)
6. Earth elements must be protected against rain and water

However, there are several ways to overcome most of these weaknesses that make earth a suitable building material for many purposes.

5.3. Main Problem on Earthen Soil Materials for Constructing Houses (including *Harar Traditional Houses*)

Impact on Services: The installation of services such as plumbing and electrical systems may be more complicated when tried to pass through the wall systems. The cavities in which services are typically installed may not be available, alternative locations may need to be used, or modifications to the new system may be required.

There may also be implications for interfaces with other components in the house. For example, kitchen cabinets are hung on the walls in a standard wood-frame house; for straw-walled houses, there is no backing or solid materials on which to hang the cabinets.

These details must be anticipated and accounted for early in the construction process in order to reduce complications later. Similar arguments are true for both interior and exterior finishes and how much extra it may cost for their installation, and even whether or not some finishes are appropriate for some.

5.4. Soil Test Result Analysis Used in Maintaining the Aged Traditional Houses of Harar Jugol

Understanding material characterization is extremely important for implementing proper interventions on maintenance related issues of any Historical Building. However, there is a step between material diagnosis and treatment to analyze the effectiveness of the maintenance going on at the current time using the locally available material as well as using modern construction materials and investigation must be carried out on the suitability of the material—in this case the soil—used for the original construction of a particular site. The question, "Is this soil good for the construction of this site?" is a very important one in order to further understand material diagnosis and, particularly, to see the causes of deterioration (Greiner, 2003).

Even though the existence of historic sites can prove that soils are suitable to last for centuries, it is important to understand that the soil selected for a particular technique was not carried out by chance. Most probably, ancient civilizations tried several techniques before perfecting the ones we know currently. Furthermore, the occurrence of natural disasters also likely helped ancient peoples to modify and adapt the techniques to better withstand such disasters over time (Asmamaw, 2007).

Soil suitability on the base of engineering properties of soils such as permeability, plasticity, compatibility, bulk density, among others, has been defined by engineers working mostly for low cost housing project purpose or like adobe blocks (Satprem, 2007).

These investigations which show properties of soils for the analysis and understanding of historic buildings and the correlation of them with ancient construction techniques is very important to preserve the historic buildings. Recent studies, however, particularly for new construction, have provided useful information on the type of soil suitable for specific earthen construction techniques (Guillaud, 2004).

Soils can be processed into twelve different states of physical reaction with water varying from solid to liquid. These physical state can be gain by limiting the amount of water depending on the Atterburg limit result: *rocky concretion, friable concretion, solid concretion, friable aggregation,*

dry soil, moist soil, solid paste, semi-solid paste, semi-soft paste, soft paste, mud, and *slurry*. The main target among the states mentioned above is the *mud* one, which can be used as a paste between the *Hashen* stones and for plastering purpose.

This section shows analysis on the main ideas and concepts which help for the investigation.

- ✓ Classify and characterize soils by texture (organic, gravely, sandy, silty, and clayey soils)
- ✓ Identify the characteristics of soil mud (strength, permeability and shrinkage limit)
- ✓ Build wet, plastic, humid, and compressed earthen molds using different types of soils and determine the water content of each
- ✓ Understand the relationship between the different states of the soil mud, the material characterization, and the type of construction for which it can be used

The suitability of a soil for a particular application and its associate construction technique is determined by the combination of its:

i) Texture, mostly linked to particle size distribution;
ii) Hydration state, driven by the amount and the type of reaction to water at the molecular level; and,
iii) Its stabilization, which determines its resistance to erosion, compression, flexural stress, and other chemical and mechanical properties.

5.5. Construction Material Test Analysis

In this investigational paper, testing works are held in two broad ways, one on the soil characteristics and property as it is, and the other the blend soil in mud state which is in the plastic state.

Soil types that are used as a paste when mixed up with water are similar in use with the modern cement mortar. Also a compressive strength test for the paste material must be carried out (The main test parameters selected once for the soil's characteristics study are the physical property of the soil, the mechanical property of the soil, and the chemical property of the soil).

5.5.1. Soil's Test Result Analysis Based on Their Physical Test Results.

I. Index Properties

Those soil properties which are not of primary interest to the Geotechnical Engineer but which are indicative of the engineering properties are called index property.

Index properties are classified in to two:

1. Properties of soil mass (Specific Gravity)
2. Properties of individual particles (Particle Size Distribution)

1. Specific Gravity

The specific gravity of solid particles is defined as the ratio of the mass of a given volume of solids to the mass of an equal volume of water at 4 ^{o}C. Or the specific gravity of a soil mass is indicated, as the average value of all the solid particles present in the soil mass.

The term "solid particles" used in geotechnical engineering is typically assumed to mean naturally occurring mineral particles that are not very soluble in water. Therefore, the specific gravity of materials contains extraneous materials such as cement, lime, etc and water-soluble matter such as Sodium Chloride, and soils containing matter with a specific gravity of less than one, typically require special treatment or qualified definition of specific gravity.

Specific gravity of soils is an important parameter and can be used for the determination of void ratio and particle size. Table-6 gives the average values of different soils, which we can determine the soil types used according to their test results. Table-7**,** also portrayed all the four soil types with their respective specific gravity of 2.6

Table-6: Typical values of specific gravity of soil particles

S.No	Soil Type	Specific Gravity
1	Gravel	2.65-2.68
2	Sand	2.65-2.68
3	Silty sands	2.66-2.70
4	Silt	2.66-2.70
5	Inorganic clay	2.68-2.80
6	Organic clay soils	Variable, may fall below 2.00

Source: soil mechanics and foundation engineering, book of Dr. K.R. Arora,2000.

Table-7: The test result of specific gravity for four soils used in original construction and for maintenance at the current time.

S.No	Soil Type	Specific Gravity
1	Gogoba	2.62
2	Kuyesa	2.55
3	Sandy	2.61
4	Brownish	2.62
Average specific gravity		2.60

Note: The smaller the specific gravity values, the coarser the grain particle will be.

2. Soil Particles Size Distribution

As we know, a sample of naturally occurring soils will rarely have particles of just one size. The usual situation is that it contains a variety of sizes in different proportions. In this research paper work, the soils grain size distribution determined by hydrometer test. We can categorize the soils size as **uniformly graded** soil and **gap-graded** soil from the test result**.**

We can also classify the soil type by using the soil classification triangle (Figure. 6), which shows**,** for example, that a sandy clay loam is defined as soil that contains 50–80 percent sand, 0–30 percent silt and 20–30 percent clay.

The soil materials in Table-8 below seldom occur separately, and this necessitates a further classification according to the percentage of each contained in the soil.

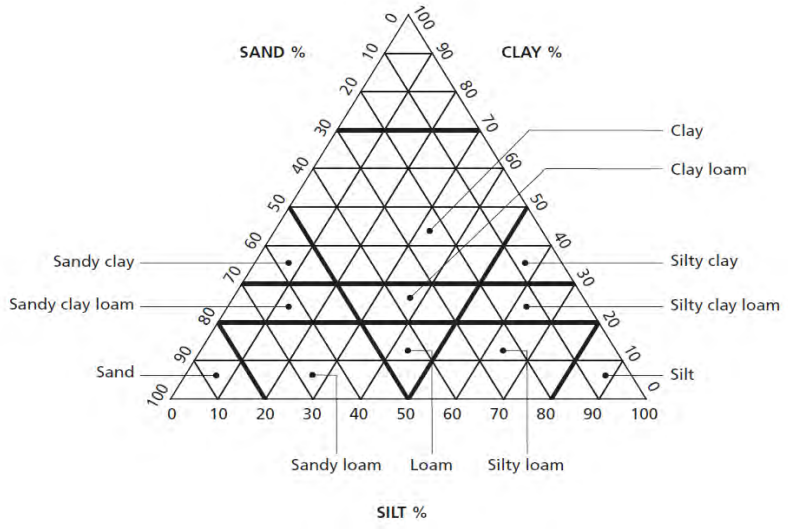

Figure 6. Soil Classification triangle

Source: soil mechanics and foundation engineering, book of K.R. Arora (Dr.),2000.

Table-8: Classification of soil particles.

S.No	Materials	Size of particles	Means of field identification
1	Gravel	60–2 mm	Coarse pieces of rock, which are round, flat or angular.
2	Sand	2–0.06 mm	Sand breaks down completely when dry; the particles are visible to the naked eye and gritty to the touch.
3	Silt	0.06–0.002 mm	Particles are not visible to the naked eye, but slightly gritty to the touch. Moist lumps can be Molded but not rolled into threads. Dry lumps are fairly easy to powder.
4	Clay	Smaller than 0.002 mm	Smooth and greasy to the touch. Holds together when dry and is sticky when moist.
5	Organic	Up to several Centimeters	Spongy or stringy appearance. The organic matter is fibrous, rotten or partially rotten, several centimeters deep, with an odor of wet, decaying wood.

Source (Eldridge, H.J. 1974. *Properties of building materials.*Lancaster, Medical and Technical Publishing Co.Ltd.)

Only a few mixes can be prepared successfully for building construction in the state in which they are available. In table-9, below some suitable uses are list. Among the lists our four soils types used for constructing and maintaining are the no. 4 on the table, which is "Ideal, General Purpose Mix". However, many mixes can be improved to make good building material by correcting the mix and/or adding stabilizers.

Table-9: Soil Grading Suitable for Construction

Use	**Clay %**	**Silt %**	**Clay & Silt %**	**Sand %**	**Gravel %**	**Sand & Gravel %**	**Cobble %**	**Organic matter %**	**Soluble Salts%**
Rammed Earth walls	15-20	10-30	15-35	35-80	0-30	50-80	0-10	0-03	0-1.0
Pressed soil blocks	5-25	15-35	20-40	40-80	0-20	**60-80**	-	0-03	0-1.0
Mud bricks (adobe)	10-30	10-40	20-50	50-80	-	**50-80**	-	0-03	0-1.0
Ideal, general purpose mix	15	20	35	60	5	**65**	-	0	0

Source (Satprem. M, 2006. *Properties of building materials.*)

The clay fraction is of major importance in earthen construction because it binds the larger particles together. However, soils with more than 30 percent clay tend to have very high shrinkage/swelling ratios which, together with their tendency to absorb moisture, may result in major cracks in the end product. High-clay soils require very high proportions of stabilizer or a combination of stabilizers (Casagrande, 2008).

i. Analysis on test result

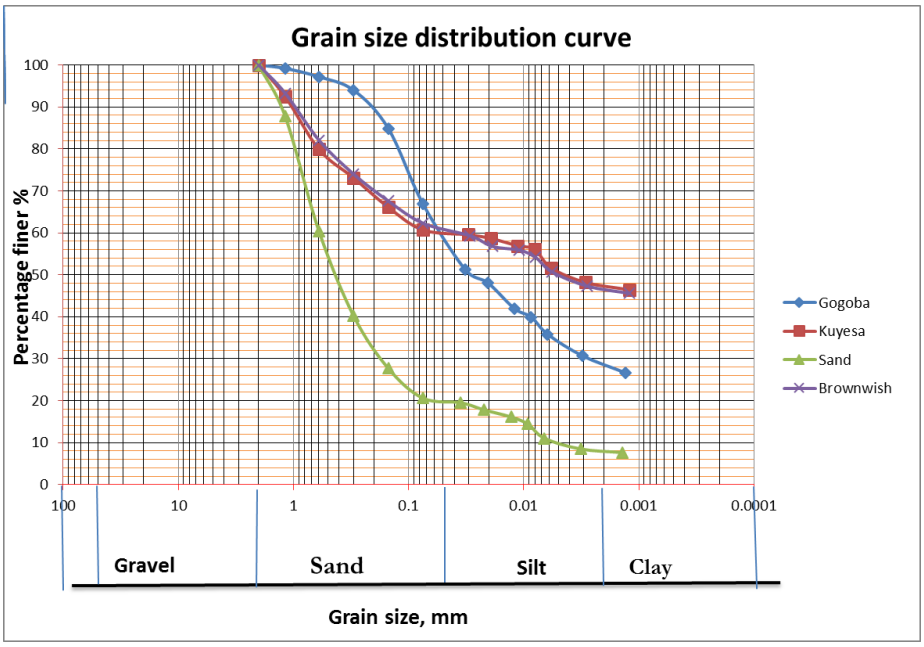

Figure 7. showing Grain Size Distribution of Four Soil Types

- ✓ Analysis for the grading test result for the four soils used for construction and maintenance work is summarized by the graph below **(Figure. 7).**
- ✓ Soils containing more than two percent organic material are usually considered unacceptable for cement treatment. So all the four types do not need any stabilization treatment.
- ✓ Kuyesa and Bunama afere (Brownish soil) is considered as gap graded soils and Gogoba and Sandy soil considered as uniformly or poorly graded soils.

As shown in the table 10 below, soils used as construction materials and their percentage content soil type content according to hydrometer test indicated. The test result also helps to examine the suitability of the soils to consider as Earthen construction material as the recommendation in Table 10 above.

Table-10: Shows the total average content of the soils used as a mud to construct the house as well as to maintain.

S.No	Materials	Content (%)
1	Clay	32.6
2	Silt	20.02
3	Sand	47.37

II. Engineering Property

1. Plasticity index

The Plasticity Index (PI) is a measure of how much water a soil can absorb before dissolving into a solution. Plastic soils containing clay have PIs of 10 to 50 or more. And note that the higher the PIs of a soil, the more plastic and weaker the material.

Clays vary greatly in their physical and chemical characteristics. Although the extremely fine particles make it very difficult to investigate their properties, some can be conveniently expressed in terms of plasticity using standard tests.

Depending on the amount of moisture it contains, a soil may be liquid, plastic, semi-solid or solid. As a soil dries, the moisture content decreases, and so does the volume of the sample. With very high moisture content, the soil will flow under its own weight and is said to be liquid. At the liquid limit, the moisture content has fallen to the extent that the soil ceases to flow and becomes plastic; it is continuously deformed when a force is applied on it, but retains its new shape when the force is removed (Das, 2004).

A further reduction of the moisture content will eventually cause the soil to crumble under load and not deform plastically. The moisture content at this point is known as the 'plastic limit'. The numerical difference between the moisture content at the liquid limit and at the plastic limit is called the 'plasticity index'. Both the liquid limit and the plasticity index are affected by the amount of clay and the type of clay minerals present (Head, 2000).

Table-11: The plasticity index of the four soils test result is summarized below

S.No	Soil types	Liquid limit (%)	Plastic limit (%)	Plasticity index (%)
1	Gogoba	41.49	16.43	25.06
2	Kuyesa	49.40	27.57	21.83
3	Brownish	46.95	25.05	21.90
4	Sand	32.55	-	-

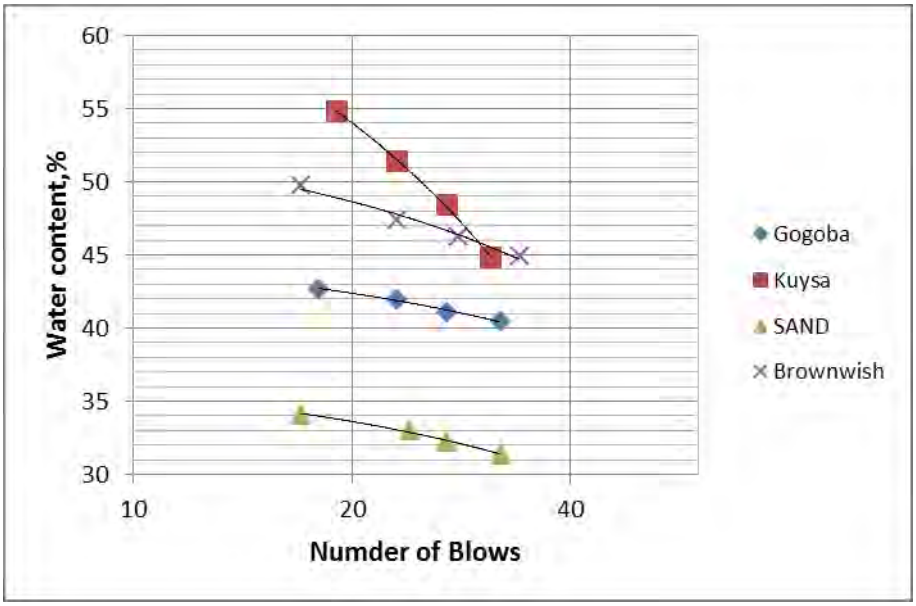

Figure-8. Flow curve summarizing the four soil types

Test Result

- ✓ From the summary of the table-11 we can see that the plastic index percentage of Gogoba soil is greater than the other soil samples; which means it has high amount of clay. From the investigation on the site, the writer noticed that this soil type is used as a roof cover

after the roof is sealed with Zigeba wood and covered with Brownish soil because this soil has high clay content next to Gogoba soil**.** At last they finish it by covering with Gogoba soil. Please look at fig. 8 which shows the entire summary.

- ✓ The high liquid limit and plasticity index indicates the soil that has great affinity for water and will therefore be more susceptible to moisture movements, which can lead to cracks. This problem is mitigated by mixing sand which has a zero plastic index. So the blend mix made from the four soil types are well treated each other by sharing properties.

5.5.2. Atterberg Limit Soils Tests Result Analysis

We should start by selecting the mud that is used as a binding agent or as a mortar to bond the inert material (calcareous tuff stone) used to construct the wall of the houses as well as to maintain.

- ✓ So our mud should be workable to mold or to deform as we like. Then to have a plastic state behavior, the *liquidity index* I_L value should be between 0 and 1.
- ✓ Choose a soil type which has least liquid limit since the ability of the soil mud to deform continuously without rapture depends on the liquid limit.
- ✓ Select a soil with lower Plastic limit since the amount of water infiltrated or the amount of water required changing the soil to plastic state depends on it and because the silica sheet and alumina sheet layer are held relatively tightly and water cannot infiltrate easily.
- ✓ Select a soil which has least plasticity index since the range of the water contents over which the soil deforms plastically is determined by the plasticity index, I_P.

By default, the maintenance workers prepare the mud from the four soils putting water and mixing for the first time and continue it by remixing it for each end of the week for a month. This means, by default they select the minimum liquid limit to prepare the mud mix rather than selecting the maximum one out of the four. If we use the maximum liquid limit, those who have minimum liquid limit pass the limit and goes to liquid state and flow.

So the traditional maintenance workers default choice goes with the Engineering property of the soil. They use the soil which has minimum liquid limit and mix up it by adding water at each end of the week for a month. Between this time duration all gains water even kaolinite clay type soil present and change into Plastic state mud which has a property of intermediate strength, soil deformation like a plastic material.

Here, from the above suggestions we can use the Gogoba clay type soil plastic limit percentage value to determine the amount of water content required. The limit value is maximum not exceed from it. If its liquid limit increases from the value, the soil particles we choose will be washed out. *16.45%* is our percentage value out of the total mixing materials to determine the amount of water.

5.5.3. Determining the Amount of Water Used to Prepare Good Quality Mud

The physical and mechanical behavior of fine-grain soils is linked to four distinct states – solid, semi-solid, plastic, and liquid – in order of increasing water content. Let us consider a soil in a liquid state that is allowed to dry uniformly. If we plot a diagram of volume versus water content as shown in Fig.-9, the original liquid state can be located at point A and the dried soil sate at point D, the content reduces and so consequently its volume (Gooding, 2003).

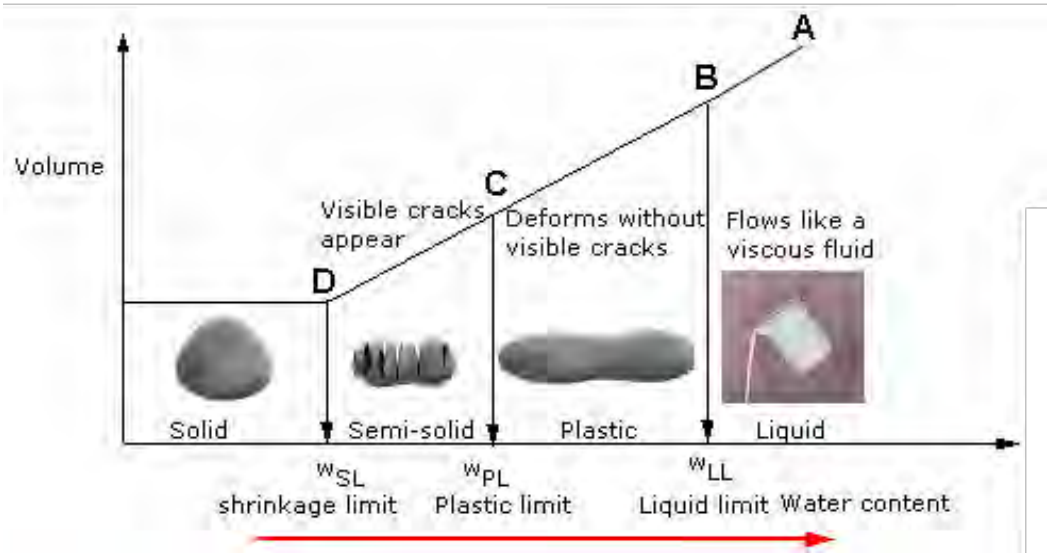

Figure. -9. Change in soil states as a function of soil volume and water content

(Source): soil mechanics by Gooding, 2003

At point *B*, the soil becomes so stiff that it can no longer flow as a liquid. The boundary water at point *B* is known as the ***liquid limit***; it is denoted by w_{LL}**.** As the soil continues to dry, there is a range of water content at which the soil can be molded into any desired shape without rapture. The soil at this state is said to be exhibiting plastic behavior – the ability to deform continuously without rapture. But if drying is continued beyond the range of water content for plastic behavior, the soil becomes a semi-solid. The soil cannot be molded now without visible cracks appearing. The water content at which the soil changes from a plastic to a semi-solid state is known as the *plastic limit*, denoted by w_{PL}. The range of the water contents over which the soil deforms plastically is known as the plasticity index, I_P (Holtz, 2001).

$$I_P = W_{LL} - W_{PL} \quad \text{.....Eq. 5.1}$$

As the soil continues to dry, and it comes to a final state called the solid state. At this state, no further volume change occurs since nearly all the water in the soil has been removed. The water content at which the soil changes from the semi-solid to a solid is known as the *shrinkage limit*, denoted by w_{SL}. The shrinkage limit is useful for the determination of the swelling and shrinkage capacity of soils. The liquid and plastic limits are called *Atterberg* limits (also known as *consistency* limits) (Rigassi, 2005).

The water content changes according to the fine-grained soils. Since engineers are interested in the strength and deformation of materials, we can associate specific strength characteristics to each of the soil states. At one extreme – the solid state – the soil has the largest strength and the lowest deformation. A measure of soil strength using the Atterberg limits is known as the *liquidity index* (I_L) (Satprem, 2006) and is expressed as:

$$I_p = (W_{LL} - W_{PL}) / I_P \quad \text{.....Eq.5.2}$$

The liquidity index is the ratio of the difference in water content between the natural (or in situ) water content of a soil (w) and its plastic limit (W_{PL}) to its plasticity index (I_P). Table-11 shows a description of soil strength based on values of I_L.

Depending up on the Atterberg limit test roughly we can categorize the four clayey soils as Montmorillonite and Kaolinite. Which shows the minerals structures shape in the clay soil type contribute for their water tightness property.

If montmorillonite is the predominant material, the liquid limit can be greater than 100%. The bond between the layers in montmorillonite is weak and large amounts of water can easily infiltrate the spaces between the layers. Kuyesa and the Sandy clay soil are classified as montmorillonite depending on the test result and their characteristics.

In the case of kaolinite, the layers are hold relatively tightly and water cannot easily infiltrate between the layers in comparison with montmorillonite. Therefore, we can expect the Atterberg limits for kaolinite to be, in general, much lower than either montmorillonite or illite. Here also Gogoba and the Brownish soils (Bunama Afer) can be classified as kaolinite depending on the test result and their characteristics.

Table-12: Description of soil strength based on liquidity index

Values of I_L	Description of soil strength
$I_L < 0$	Semisolid state – high strength, brittle (sudden) fracture is expected.
$0 < I_L < 1$	Plastic state – intermediate strength, soil deformation like a plastic material.
$I_L > 1$	Liquid state – low strength, soil deforms like a viscous fluid.

5.5.4 Shrinkage limit

Soil building materials swell in prolong contact with water and shrink on drying. The shrinkage and swelling of the soil is also determined by clay type and amount and grading of the soil. Various methods of shrinkage control can be employed depending on the building requirements of the soil. The absorption of humidity from the air does not lead to these physical changes (Becky Little.B. et al, 2001).

The further limit defined by Atterberg limit is the shrinkage limit. The shrinkage limit is "the water content that is just sufficient to fill the pores when the soil is at the minimum volume it can attain by drying".

The shrinkage limit of the four soil sample blend together and give a shrinkage limit of 1036 millionths when compared with the shrinkage limit of cement paste which have a value limit of 520 to 780 millionths. This large difference in value contributes to the maintenance work by the cement paste defect full like cracks and fails down or tears down (Abebe, 2007)..

5.5.5. Problems on Maintenance with Portland cement

As defined above, shrinkage limit of a soil shows the amount of water taken out of the soil in its dry state until it reaches saturated state to fill the pores space. The reduction in volume indirectly tells us the shrinkage limit. This volume change exposes the wall surface to shrinkage cracks.

The reduction in volume indirectly tells us the shrinkage limit. The shrinkage limit of the mud that is used as a mortar binding agent prepared by blending up the four soils have a shrinkage limit of 10.36%. This value shows a great volume reduction due to the water lost.

On the other hand, the mortar prepared from Portland cement and sand that is used to maintain the houses are originally constructed from the above blended soils. The cement mortar has a very minimum shrinkage change volume due to the hydration reaction occurring between the cement particle and water at a microscopic scale (Rigassi, 2005).

If the change in volume between the two mortars types are not balanced, the house plastered with the cement mortar faces cracks which requires frequent maintenance. Even the durability of the houses fails because the soil mud paste falls down due to frequent maintenance.

5.5.6. Permeability

Permeability is the property of a porous medium that allows water to flow through it. The porous mediums of interest are soil and rock.

Water moves through the voids between soil particles and, with few exceptions, through joints, fractures, and solution cavities in rock. In some rocks, such as certain sandstones, water moves through the rock mass. The symbol for permeability is K, and it is given as a velocity through the total soil mass at a gradient of one (Asmamaw, 2007).

The permeability of the blended soil mud used for construction as well as for maintenance have $4.15x10^{-7}$ cm per sec. which is relatively good. The permeability of the soil is responsible for the durability of the houses. Compared to that of the permeability of mature, good-quality concrete is approximately 1 x 10^{-10}cm per sec (Abebe D, 2007). The houses constructed from this blended soil mud have well resistive strength to weather effect from the environment.

5.5.7. Material Analysis of the Soils Based On Their Mechanical Load Test Result

The Unconfined Compressive Strength (UCS) prepared for the blend soil sample was taken from the quarry site. The water content used is the average of the four samples determined by using Atterburg limit test, which is 42.82% of the total blend mass soil sample. The graph in Fig. 10 shows the UCS result with water content 42.82% and equal proportion of the soil sample gives a maximum value of 289.51 kpa.

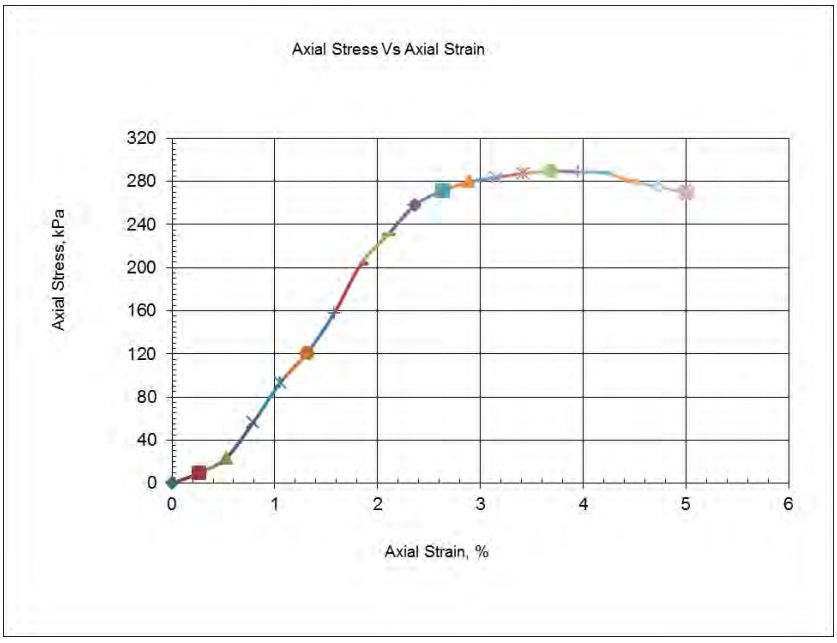

Figure. 10 UCS test result graph for the soil sample after blended

The UCS test is almost similar to the compressive test of concrete. So it is possible to interrelate the corresponding result to the property of good quality cement paste and to that of the blend mud soil. Good quality cement paste needs to have properties like the maximum strength, lower permeability, increasing resistance to weathering, reducing drying shrinkage and cracking and less volume change from wetting and drying. These properties required for cement paste have great role for the durability of a building. The above cement paste properties are also required for our earthen construct buildings from mud paste. The above mentioned properties of a good cement paste depend on water content used. Similarly, the property of good mud soil has direct proportion to the water content used. That means the less water we use, the better the quality of the mud paste would be (Terre, 2001).

To make a good quality soil mud, the water content must be proportional to the plastic limits of soils used. The water content makes the soil mud to have cream like texture which is workable. So this moisten soil texture determine depends on the Atterberg limit test result.

To have creamy texture mud soil, the water content should not be more than the plastic limit value of the soils; otherwise, the soil texture changes to fluid type texture mud. The other assumption is to use the least plastic limits values among the four soil samples. If the plastic limit is a bit greater than that of the four samples which have less plastic limit, the soil mud will wash out.

So the recommended water content for the maintenance blende soil samples mud is 16.43% (which is the least plastic limit for Gogoba soil).

The soil mud mixing preparation task is to be done for one month by making a remixing with an interval of one week. This practice is used in the olden days as well as currently. Little change is made on the practice except in the modification of their mud preparation. By using equal proportion of soils and water content of 16.43% (this amount of water brought from the plastic limit of Gogoba soil) it gives 310 kpa UCS which is shown under (Fig 11) below.

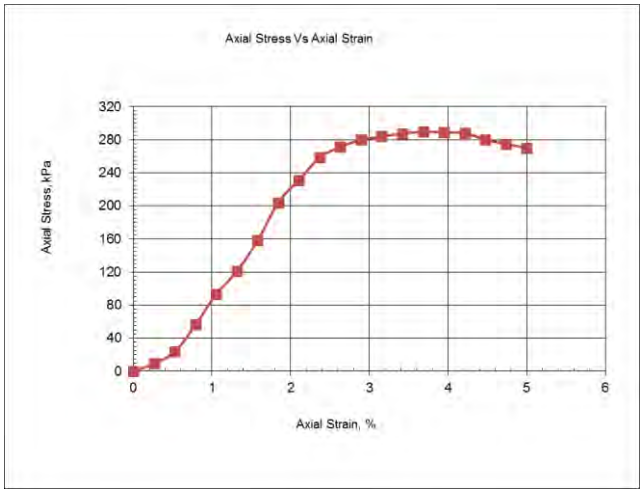

Figure-11. UCS test result graph after the adjusted water content.

5.6. Material Analysis of the Soils Based On Their Chemical Test Result

As already known soils are formed by the disintegration (weathering) of rocks. These fragmented rock materials, produced by mechanical weathering may change their mineral composition by chemical weathering. Clay soils are formed in this way (chemical weathering of the clay minerals). Clay soil particles chemically consist of silica and alumina sheets driven or formed from clay minerals rich with silica tetrahedron and alumina octahedron. The difference in charge between the two clay soil particle compounds help to attract each other and behave a water tight property to the soil particles (Casagrande, 2010).

The test result of Table-12 suggests that the four sample soils are clay. Because the chemical composition test shows that SiO_2 and Al_2O_3 are the major components of all soil particles, clay soils behave as water tight character than other soil types. Table-13 also suggests that the clay soil types can be supposed to be based on the chemical composition results common minerals type it resamples.

These soils abundantly exist in Harar neighborhoods. Among the reasons why selecting constructing materials should be based on chemical composition outcomes of the soil particles or clay soils are:

- ✓ Resistant to weathering. Clay soils are weather resistant
- ✓ Abundantly found locally
- ✓ Have very high thermal capacity
- ✓ resistant to fire

Table-13: Chemical Composition of the four soils used for construction as well as for maintenance

Field no.	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	MnO	P_2O_5	TiO_2	H_2O	LOI	Cl	So_3
Kuyesa	62.00	17.44	5.46	1.48	0.83	1.18	0.98	0.10	0.04	0.78	2.87	6.69	<0.01	0.04
Sand	69.11	16.56	3.12	1.86	0.82	2.14	1.28	0.09	0.03	0.57	0.42	2.92	<0.01	0.03
Brownish	61.02	16.82	7.04	1.18	0.70	0.58	0.68	0.10	0.05	1.01	3.79	8.43	<0.01	0.05
Gogoba	66.19	13.61	4.44	3.48	1.06	0.44	0.56	0.09	0.06	0.87	3.11	7.42	0.07	0.06

(Source: Laboratory test result)

Table-14: Common soil minerals

No	Name	Chemical Formula	Importance	Soil type	Remark
1	Quartz	SiO2	Abundant in sand and silt	Sand	
2	Feldspar	(Na, K)AlO2[SiO2]3 CaAl2O4[SiO2]2	Abundant in soil that is not leached extensively	Gogoba	Because of this character the soil can be used as a roof cover.
3	Amphibole	(Ca, Na, K)2,3(Mg, Fe, Al)5(OH)2 [(Si, Al)4O11]2	Easily weathered to clay minerals and oxides	Brownish	When react with water have a strong binding character.
4	Pyroxene	(Ca,Mg, Fe, Ti, Al)2(Si, Al)2O6	Easily weathered	Kuyesa	Fine textured used as filler materials
5	Olivine	(Mg, Fe)2SiO4	Easily weathered	Kuyesa	Fine textured used as filler materials
6	Epidote	Ca2(Al,Fe)Al2(OH)Si3O12	Highly resistant to chemical weathering	Gogoba	This property of the soil contributes to be durability of the houses.
7	Tourmaline	NaMg3Al6B3Si6O27 (OH, F)4	Highly resistant to chemical weathering	Gogoba	This property of the soil contributes to the durability of the houses.

Source: Casagrande, A. (2008). "Classification and identification of soils,"

CHAPTER-SIX
INVESTIGATION ON THE MAINTENANCE WORK HELD AT CURRENT TIME TO PRESERVE THE TRADITIONAL HOUSES

6.1. Maintenance

Every building requires maintenance, especially buildings whose materials are sensitive to rain, sun,etc (Rypkema, 2005). The resistance of materials may be reduced as a consequence of weathering and deterioration due to chemical reaction (Guirgi Croci, 2005). When minor cracks and wear are regularly taken care of, major damage will not easily appear. If maintenance and repair are not carried out properly, further problems will arise (MCSA, 1985).

In this study, out of the total sample of 100 historic buildings, 56% responded that they attempted to maintain their buildings while 44% of the respondents claimed that they didn't try to maintain.

Table-15: Attempts to maintain the historic buildings

Attempted	Number	Percent (%)
Yes	56	56.0
No	44	44.0
Total	100	100

Source: Field survey compilation by World Heritage Committee, 16 July, 2006

Table-15 shows those who respond NO or those who have never attempted to maintain the historic building for different reasons. Some describe that some part of the building is taken by the government and therefore they need permission from the government before starting to entirely maintain the buildings. Others confirmed that since they do not have the financial means for maintenance, they are unable to take the move.

Even through proclamation 209/2000 article 18 sub article 1 suggests that any person who possesses a cultural heritage has the duties to preserve and protect the cultural heritage properly on his own expense, there is no sign of any resident doing the job.

The picture below shows that some of the historic buildings that can be taken as evidences for maintenance keeping originality is being carried out after the implementation of conservation ethics (Fig.-12 and Fig.-13). This can be taken as evidence to show that the maintenance of buildings is possible without altering their historical value.

a) Maintenance on starting stage **b) First floor maintenance completed**

Figure 12: Evidences of Maintenance keeping Originality (Imir Abdulahi guest House.)
(Source: Harari cultural heritage conservation library) [2006]

Amir Abdulahi guest House is found in Jugol around Senga-Bere gate. It was constructed in 1612. The construction material is "*chikka or Mud*", with a variety of wooden elements: elaborate glazing windows including wooden shutters, gingerbread decoration following the roof eaves (Harar Cultural and Heritage Database, 2009).

Arter Rambaud's house (Fig-13 above) was constructed around 1800. *Arter Rambaud* was a technician who came to Harar from India. The residence was designed and constructed by the Indian Architect Woli Mohammad and was therefore influenced by Indian Architecture (Harar Cultural and Heritage Database, 2009).

(a)Before **(b)After**

Fig.13. Rimbaud House Maintenance work

Source: HCHTO,2000

6.2. The Need of Permission from the Concerned Authority to Maintain the Historic Buildings

One of the significant causes of damage to historic buildings is inappropriate repair and alternation (ICOMOS, 1987). According to the proclamation number 209/2000, any conservation and restoration shall be carried out with the prior approval of the authority. Nevertheless, according to the writer from the total of 100 respondents those who tried to maintain their buildings about 38.10% conformed that they got permission from the responsible authority while the other 14.29% have indicated that they have maintained their buildings without permission and the rest (47.61%) claimed that they are not even aware of whether permission is needed or not. This shows that most of the buildings were maintained negligently by the owners.

6.3 The Importance of Maintenance

The importance of material integrity in a heritage building is obvious. Whenever the option presents itself, preserving an original building element is preferred to a replica. To ensure that a building maintains its integrity, it is critical that maintenance takes a leading role in a building owner's plans and activities (Bond, 2009).

Maintaining heritage sites should include repairing, cleaning, or correcting defects. Here we are not only preventing deterioration of precious original materials, but also ensure the avoidance of possible hazards (Fram, 2002).

The relationship between maintenance and repair is basically, if maintenance is too late repair will be too expensive. Occasionally, materials such as roof shingles will require replacement. However, the implementation of a diligent maintenance program will limit the need to repair or replace on a large scale and extend the life of those original materials (Randall, 2005).

6.4. Maintenance Categories

Maintenance can be broken down into three categories according to Annual Report of (France-UNESCO, 2006)

1. **Corrective Maintenance:** work necessary to bring a building to an acceptable level (often recommended by a conservation plan), such as treatment for moisture.

Corrective maintenance may include:

- ✓ Inspecting the exterior for suspect water penetration - exterior leaks eventually cause interior damage.
- ✓ Fixing obvious leaks and water penetration, including downspout problems.
- ✓ Inspecting for and exterminate termites and other wood-destroying insects.

In developing a treatment for a specific condition, be sure to address all of the causes of the deterioration and not just the symptoms.

2. **Emergency Maintenance:** work that must be done immediately for health, safety or security reasons or that may result in the rapid deterioration of the structure or fabric if not done, such as roof repairs after a storm or repairing broken glass.

Emergency maintenance may include:

Eliminating fire hazards:

- ✓ Exposed or otherwise improper wiring
- ✓ overloaded electrical circuits
- ✓ Thorough electrical inspection by a licensed electrician
- ✓ Inspect and repair boiler and chimney.

Eliminating additional personal injury hazards such as:

- ✓ Broken steps
- ✓ Electrical shock hazards
- ✓ Loose building elements
- ✓ Immediate, obvious health hazards such as loose, crumbly asbestos, airborne lead dust from chipped paint

3. **Planned Maintenance:** work to prevent problems which can happen predictably within the life of a building, such as cleaning gutters or painting.

Where Should the Maintenance of a Historical Building Start?

This is a familiar question to anyone who has to face the sheer volume of work to be done and who try to prioritize the needs of a conservation project and try to answer by planning the activities to be carried out. According to the *Standards and Guidelines for the Conservation of Historic Places by UNESCO,* five steps of the conservation processes are identified. These steps will apply to any conservation project, not only maintenance tasks, but also for reviewing whenever considering maintenance work of historic building.

Step 1: Identify the Heritage Value and Character-Defining Elements

Before planning any maintenance to a historic place, it is essential to understand its heritage value and to recognize its character-defining elements, so that you can know what is important to protect.

For most designate sites, a Statement of Significance (a brief report on what makes the site important, use on the UNESCO Register of Historic Places, www.2013) will provide details on why a place is important and what physical elements are most important. Pay particular attention to the character-defining elements. These building features will give you clearer direction on the most significant physical aspects of a historical building, and help to prioritize the conservation efforts.

If your property is not designated, you can conduct your own physical survey so that you have list of building features that will need to be considered in your conservation planning.

- ✓ Start with the building's overall features such as the form, scale and massing.
- ✓ Look at the immediate site, gardens and landscaping that may directly affect the building.
- ✓ Look more closely at the exterior and record the materials used.
- ✓ Finally, it is important to look inside the historical building and record the interior features, finishes and notable details.

Step 2: Review the Standards and Guidelines

UNESCO offers result-oriented guidance for sound decision-making when planning for, intervening in and using historic places. These guidelines are not intended to replace the role of conservation specialists or to provide detail technical instructions, but can help through the process of making decisions about your property.

The Standards are the fundamental principles of conservation applicable to all types of heritage resources, including archaeological sites, landscapes, buildings or engineering works.

The Guidelines provide practical advice for decision-making when interventions are undertaken on historic places. Recommending interventions to historic places should be detailed in ascending sequence from minimal to major interventions.

Step 3: Do an Inspection

The purpose of inspection is to get an overall accurate view of the entire property. This will help to set goals and objectives to fulfill your needs. Begin with a complete inspection, which will give a detail critical review of all parts of the building and grounds. This should be done by someone who has a broad and detail knowledge of the building trades, both past and present. An understanding of how the building is meant to work when it was constructed and a knowledge of modern technologies are both necessary to accurately determine conditions.

It may be valuable to hire a professional for your first maintenance cycle. Once the initial assessment work investigation is complete, the cyclical plan should be manageable for you to handle.

Additionally, past records or reports can be very useful to understand the historical building and its maintenance needs. Inspection and/or condition reports or structural assessments from the past (if available) pinpoint chronic problems or areas that shall be monitored.

Step 4: Complete Corrective or Emergency Maintenance

After the initial inspection is complete, it will be important to prioritize what immediate attention and what can be needs to be included in the regular maintenance planning cycle. The immediate needs can be categorized as corrective or emergency maintenance.

Corrective maintenance includes tasks that stabilize the building to stop deterioration. To repair is to take a step further to eliminate previous damage. Decide in every case whether to stabilize only and defer repair – or whether it makes more sense to go ahead with a complete and proper repair.

Step 5: Determine Primary Treatment: Preservation, Rehabilitation or Restoration.

When conducting corrective or emergency maintenance, ensure that you are doing minimal work to stabilize the immediate problem. According to *the Standards & Guidelines for the Conservation of Historic Places by UNESCO as shown on (Fig-14)*, it is recommended that any intervention, including temporary repairs or stabilization, should involve the least intervention possible, and should be reversible. Be sure that a temporary repair does not cause more damage than it prevents. If the temporary repair will be expensive or if it could cause additional damage, it will be better to do a proper repair immediately.

I-Preservation

"The action or process of protecting, maintaining and/or stabilizing the existing materials, forms integrity of a historic place, or of an individual component, while protecting its heritage value."

- ✓ Materials and features are essentially intact and no extensive repair or replacement is necessary

II-Rehabilitation

"rehabilitation is the action or process of making possible a continuing or compatible contemporary use for a historic place, or of an individual component, through repair, alterations and or additions, while protecting its heritage value" (Kurt, 2011).

- ✓ More than just minor repairs are required
- ✓ May include the replacement of missing elements and/or the introduction of new features.

III-Restoration

"it is the action or process of accurately revealing, recovering or representing the state of a historic place, or of an individual component, as it appears at a particular period in its history, while protecting its heritage value" (Agnew, 2003).

- ✓ The depiction of a particular period of the historic place outweighs the potential loss of material

May include the removal of features and/or the reconstruction of missing features

Figure.-14.Intervention for deterioration of historic buildings

Source: **Fram, Mark**. (1992).

Most maintenance tasks will be classified as preservation because the plan work is typically about stabilization, with no major replacement of original material. The level of intervention is a sliding scale depending on the type of work being complete.

6.5 Develop a Cyclical Plan for Maintenance

The best type of protection is to do regular and routine maintenance, to prevent extensive and expensive repairs. Maintenance planning must be consistent with your needs and respectful to the financial means, while ensuring that your buildings evaluated annually. A plan that is too complicated or ambitious will not simply get completed (South, 2012).

Much of the work encouraged in this manual is planned maintenance. In the initial phases of developing a maintenance plan, there may be corrective or emergency maintenance that must be done before a routine, cyclical approach can be adopted.

The maintenance cycle diagram (Fig.-15) is one method to seasonally develop your regular maintenance plan. It is divided into incremental tasks that you may be able to tackle yourself, or at least plan for, on a regular basis.

The Cyclic Maintenance Answers Questions Mention Below

What are your needs? Make a list of the problems during inspection. Use a camera to record any identification problems.

When should it be done? Prioritize the tasks. Problems that raise safety issues, suggest structural instability or that allow water to enter the building need to be dealt with first.

Who will do the work? To do some of the work and recognize the problems, it is best to bring in a professional.

How much will it cost? In the long run, the costs associate with regular maintenance will be less than waiting to do repairs, which is more disruptive.

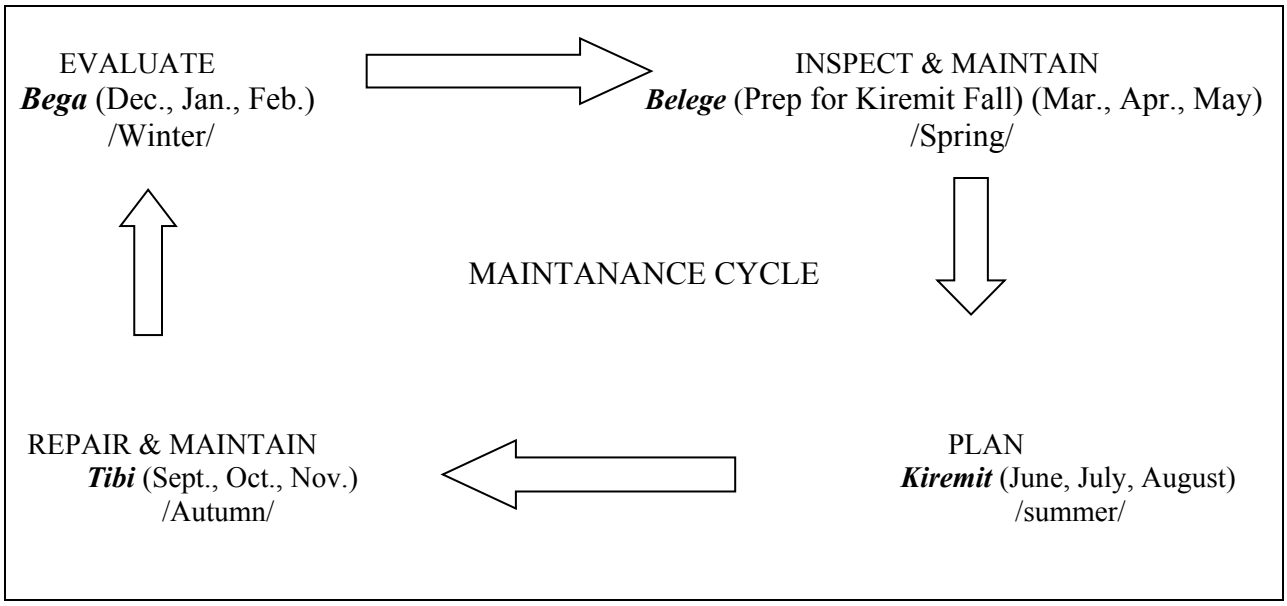

Figure. -15. Maintenance cycle for Hrari Traditional houses

Source: Fram, Mark. (1992).

6.6. Cost Estimation for Maintenance of the Harari Aged Traditional Houses

The cost estimation for historical buildings maintenance work needs a special care since every unique historical building has its own material character and exposure to external damage factors. Cost estimation of maintenance of Harar aged traditional houses and similar heritage

buildings are shown on Table-15**.** The budget allocation increases from year to year but not seen significant preservation work rather the same trend of work implement from year to year. The difference in cost of maintenance between historic buildings and modern buildings is summarized on Table-16.

This research investigates the maintenance work according to the sampling classification. The maintenance required for building is depicted in figures Figures-16, 17, 18 & 19 below.

i. Corrective Maintenance:

Figure. -16, Buildings under corrective maintenance and requiring corrective maintenance

Source: Harari cultural heritage conservation library

ii. Emergency Maintenance:

Source: Harari cultural heritage conservation library

Figure. -17, Building requiring emergency maintenance like plastering and painting

iii. Preventive Maintenance

(a)

(b)

Figure. -18 (a) and (b): Building requiring Preventive maintenance

Source: Harari cultural heritage conservation library)

iv. Demolition

Source: Harari cultural heritage conservation library

Heritage building maintenance work neglected out or given less attention faces chance of demolishing which is disastrous to the cultural heritage.

Table-16: Maintenance Cost and Allocation from Year 2004-2008.

	Items	**Maintenance cost & Allocation Budget**				
		2004	**2005**	**2006**	**2007**	**2008**
	Repair Works					
a	Building Maintenance cost	65,231,143.00	61,856,892.00	68,908,345.00	76,149,192.00	78,903,890.00
b	Service system	3,567,786.00	3,564,890.00	3,962,962.00	6,980,743.00	6,987,902.00
	Total	68,798,929.00	65,421,782.00	72,871,307.00	83,129,935.00	85,891,792.00

Source: Harari cultural and tourism office Property Maintenance Budget Unit, section of Finance, Harar ; 2008.

6.7 Technical Maintenance cost for Harari Traditional Houses

i. Formwork Cost

Formwork cost in modern concert structure work exceed 50% the total building cost according to ACI-347. To have good formwork output asks to have skilled labor and high cost. But when we come to that of the construction and maintenance work on Harari traditional houses it costs almost Zero. Because Have no structures like Columns, beams, Parapet, Suspended Slab which require support until it comes dry and resist load by its own and help to form shape. Only required formwork on the arched gate parapet which have cost. So we can say the cost of Formwork for maintaining Harari Traditional house is almost costs Zero.

ii. Scaffolding Cost

Scaffolding help for temporary building structural support while building and repairing. As the same as modern construction work uses the scaffolding also the traditional houses maintenance uses. In other words, as the same cost it asks for both. The scaffolding requirement for both cases works also.

iii. Curing cost

Since the maintenance work held by Earthen materials doesn't require curing rather required to become dry early by realizing the moisture in the mud. But the water required for curing compensate by using it for mud mixing. When we comparing the water requirement from that of concrete work of modern construction is too less in Earthen construction works.

iv. Building Depreciation

If building depreciation is too fast the cost maintenance increase as well as the maintenance cycle becomes fast (directly means increases cost due to frequent maintenance).

Table-17: Core cost estimate samples comparison between heritage buildings vs modern building.

No.	Description	Cost for historic building	Cost for Modern building
1	Formwork cost	Zero cost	Depend on the damage
2	Scaffolding	Same cost	Same cost
3	Curing cost	Zero cost	Needs curing
4	Reinforcement bar cost	Zero cost	High cost
5	Painting type	Less cost	High cost

6	Trained or skilled Man power	Expensive	Depend as the work complex
7	Recovery time	Takes time	Quick
8	Cement consumption	No cement requirement	Large amount
9	Zigeba wood	Use as reinforcement	No need
10	Building Depreciation	Fast	Slow

CHAPTER- SEVEN
RESEARCH SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

8.1. Research Summary

Through the investigation of this thesis work, there are five main outcomes.

1. Discussed in detail the factors that damages the historical buildings
2. The investigation shows the current status of the traditional aged houses as require maintenance work (Corrective, Emergency and Protective maintenance)
3. Guide line requirement for maintaining each specific heritage building.
4. As clearly discussed in the paper, cement mortar maintenance on earthen construct houses have a damaging effect rather than preservation or restoration (Discussed on shrinkage limit chapter).
5. The amount of water required or water content recommended for good type of mud which is creamy like texture to have the blended soil should be mixed with the amount of plastic limit.

8.2. Conclusions

As the thesis work shows that the historical buildings and monuments of many developing countries have lost their appearance due to negligence of timely maintenance for the damaging of human and natural factors. Ethiopia is one of the countries among which have lots of historical buildings and monuments and has to face the problems reported on most of them. Harar aged traditional house buildings are one of the examples which need an attention to be urgently restored and preserved because they are on the danger of deterioration.

From the investigation carried out in these thesis paper, the following conclusions are drawn.

1. The soil particle size distribution test concludes that all the soil types are clay; even the soil considered as sand resembles to clay. The clay nature of soils makes the house resistant to weathering deterioration factors.

2. The Maintenance work by the inhabitants with cement paste causes deterioration of the houses. Because of the shrinkage limit difference between the cement paste and soil mud paste (that is used as a paste to join the Hashi-stone as well as for plastering), cracks may appear in traditional houses maintained with cement paste (The shrinkage limit of the four-soil sample blend give a shrinkage limit of **1036** millionths and shrinkage limit of cement paste which have a value limit of **520 to 780** millionths). This large difference in value made the maintenance work by the cement paste deceitful which may result in cracks and fails down or tears down.
3. This investigational research attempts to come up with some concluding remarks on the Good stay status and maintenance taking place on the historical buildings at the current time. Historical heritage buildings are identities of societal development through time. Besides this, if treated well they are source of income. The research has a great role for visitors of the old city of Harar and may help them to know why these traditional buildings are standing still. Answers to such questions can be found through investigation carried out on tests of constructing materials.
4. Concerning the first three specific objectives of the investigation, the material used for construction is tested and of the effectiveness of the maintenance work are being carried out at present on Rimbaud House and Ras Teferi's House and the efforts put forward to maintain theses invaluable historical buildings is assessed.
5. The fourth specific objective is achieved by determining the optimum water amount required to prepare a mud which has greater UCS and workable. This objective work was carried out on the Atterberg Limit result, which is adjusting the water to give a mud creamy like texture by using plastic limit.
6. The other thing the investigation and analysis carried out by this paper shows that durability comes from character agents of the soils such as permeability, UCS, shrinkage cracks etc. And the other test showing the drawbacks related to maintenance with cement is viewed by shrinkage limit comparison between the cement paste and soil mud (that is used as a paste to join the Hashi-stone as well as for plastering) which resulted in cracks when the traditional houses are maintained with cement paste because of the shrinkage limit difference between the two pastes.

7. Maintenance is required by all types of buildings for proper functioning and long life of the structure. Here, historical buildings maintenance requires special attention rather than maintaining modern buildings, because historic buildings differ in the material they are constructed from and the technology applied to build them. Even the maintenance time schedule or frequency depends on the above mentioned factors. In this paper, investigation is made on the Requirements of maintenance type and current status of the Harari Traditional Houses classified according to the maintenance type required by UNESCO's maintenance types mentioned. The maintenance work which is taking place at the current time uses the same material used during the original construction.
8. The cost of maintenance for Earthen Harar Jugol Houses is less but the maintenance frequency or the maintenance cycle is faster than the modern construction. Here, one should note that when the maintenance cycle is faster, the cost increases because the work becomes labor intensive compared to the maintenance of modern buildings which are cheaper because it is labor extensive.

8.3. Recommendations

Based on the findings of the research, the following recommendations are suggested to key role players of maintaining work of Harari Aged Traditional Houses.

1. It is important to realize that once a building has been designated under the Heritage Resources Act, a heritage permit must be granted by the municipal and/or provincial government before any major physical alterations take place. However, most of what would be classified as maintenance should not need a heritage permit, as it should not dramatically interfere with the physical integrity of the building constructed before. Even such minor maintenance works are not taking place at the current time by the residents. So most of the traditional aged houses of Harar need urgent response to save them from this type of damage.
2. The non-existence of specific guidelines based on an organized maintenance program, contributed to the slowing of meaningful maintenance work. Even there is no general guide line and standards to be followed for maintenance. Therefore, the need to prepare a

specific guideline and standard for each historical building is very essential because the materials from which each building is constructed and the environmental factors facing each building differ from one historical building to the other. The writer of this study observed that the maintenance work of the investigation area is being carried out without any guide line and standard to be followed by the workers. They are simply given traditional training to execute the work.

3. As mentioned above, one of the disadvantageous of earthen constructed houses is that they have insolation fixing problems like cables of electric city and other service cables installed to the houses which start to fail in large space rather than smaller space required. These problems can even be faced when trying to change worn out door and window.
4. The other main problem is that the earthen constructed buildings need timely maintenance rather than other modern construction buildings. Because one little failure on a building expands rapidly (like small crack unless otherwise treated rapidly it may cause the whole collapse of a house) timely repair is very important.
5. We can generalize the above recommendations as the absence of the enforcement of a schedule or periodic inspection by the authorities on historical buildings is the main issue associated with the decaying condition of the historical buildings. It is found out that the main maintenance works being carried out on these buildings are mainly repair or replacement works. In fact, the works normally concern the services systems, not the building fabric or the structural or non-structural elements.
6. Some house owners modify the internal sections of the houses in their own interest. For example, they join two small sized houses and make them one large house by demolishing the internal partition walls. Such activities should be overviewed by taking monitoring and supervising actions on the buildings since these types of activities may lead to structural collapse of the houses.
7. According to the responses of the interviews carried out with the house holders, they maintained their houses by dissimilar materials to that of the materials used in the original construction because the cost of using the original materials such as Gogoba and Kuyesa is very high due to the distance from which these materials are transported. Here, the writer suggests that necessary supports needs to be given to the residence by

responsible authorities so that they can repair and maintain their houses with the same materials out of which the houses have been originally constructed.

When concluded the research work we would like to recommend; if proper and planned and timely maintenance work not held we lose this historic fortified city also cause a damage on life and property since these historic traditional houses construct from Earthen materials which easily damage by weather factors needs urgent response of preservation work.

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APPENDIX A (SOIL TEST RESULT)

በውሃ ሥራዎች ዲዛይንና ቁጥጥር
ድርጅት የላብራቶሪ አገልግሎት ንዑስ
የሥራ ሂደት
የአፈር ምህንድስና ክፍል
Tel. 251 - 116 - 18 55 16/61 45 01
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Water Works Design and
Supervision Enterprise
Laboratory Service Sub
Process
Soil & Material Testing Section

1.0 Introduction

This report presents Summery of laboratory test results of soils brought from Ato Kaleb Getachew. The test results are Specific gravity, Grain Size analysis, Atterberg Limit (liquid limit, plastic limit & linear shrinkage limit), Natural Moisture content, Unconfined compression test, Unit weight and Permeability of Guguba type soil.The soil test is carried out following the appropriate sample preparation and testing procedures. The following are the standard procedures followed to carry out the analysis.

1.1 Standard Procedures

S.No.	Type of Test	Standard
1	Specific gravity	BS 1377:1967 Test 6(B)
2	Grain Size Analysis	BS Test 7(B)
3	Atterberg's limit	BS Test 2 (A)&2(B)
4	Natural Moisture Content	BS Test 1(A)
5	Linear Shrinkage Limit	BS Test 5
6	UCS	ASTM D 2166
7	Unit weight	ASTM D 2937
8	Permeability	ASTM D2434

በውሃ ሥራዎች ዲዛይንና ቁጥጥር
ድርጅት የላብራቶሪ አገልግሎት ንዑስ
የሥራ ሂደት
የአፈር ምህንድስና ክፍል

Water Works Design and
Supervision Enterprise Laboratory
Service Sub Process
Soil & Material Testing Section

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Addis Ababa
Ethiopia

Kaleb Getachew
Summary of Soil Test Results
Date: 02/06/2015

Parameters Conducted	Gogoba Soil Lab No: 671/07	Kuyesa Soil Lab No: 672/07	Sandy type soil Lab No: 673/07	Brownish soil Lab No: 674/07
Specific gravity	2.62	2.55	2.61	2.62
Hydrometer Analysis				
Clay %	28.67	47.30	8.06	46.43
Silt %	38.26	13.39	12.5	15.92
Sand %	33.07	39.31	79.44	37.65
Atterberg Limit				
Liquid limit %	41.49	49.4	32.55	46.95
Plastic Limit %	16.43	27.57	Non-PL	25.05
Plasticity Index %	25.06	21.83	-	21.90
Shrinkage Limit (%) (Blended from the four samples)	10.36			
Natural Moisture Content (%)	29.73	30 .17	26.82	29.55
UCS(Kpa) (Blended from the four samples)	289.51			
Bulk Unit Weight	1.77	1.76	1.72	1.75
Permeability	4.15×10^{-7}	-	-	-

Checked by: _____

Approved by: _____

በውሃ ሥራዎች ዲዛይንና ቁጥጥር ድርጅት የላቦራቶሪ አገልግሎት ንዑስ የሥራ ሂደት
የአፈር ምህንድስና ክፍል

Water Works Design and Supervision Enterprise Laboratory Service Sub Process
Soil & Material Testing Section

Project : Research Thesis
Client : Kaleb Getachew
Location :
T.Pit. No. Gogoba soil
Depth(m) :

Sample Type : Disturbed
Test Type : Hydrometer
Date :27/4/2015
Lab. No : 671/07

Total mass of sample, g 50

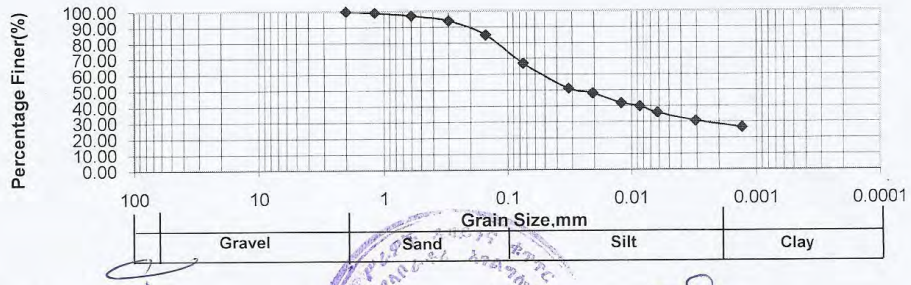
Sieve No	*Sieve Opening(mm)*	*Mass of Sieve(g)*	*Mass of sieve + Ret .soil(g)*	*Mass of Ret. soil (g)*	*Percentage Retained*	*Cumulative % Retained*	*Percentage Passing*
No 10	*2*	*551.1*	*551.1*	*0.00*	*0.000*	*0.00*	*100.0*
No 16	*1.18*	*538.9*	*539.3*	*0.41*	*0.834*	*0.83*	*99.2*
No 30	*0.6*	*516.7*	*517.7*	*0.97*	*1.973*	*2.81*	*97.2*
No 50	*0.3*	*488.2*	*489.8*	*1.59*	*3.234*	*6.04*	*94.0*
No 100	*0.15*	*481.9*	*486.4*	*4.45*	*9.051*	*15.09*	*84.9*
No 200	*0.075*	*459.2*	*468.0*	*8.84*	*17.980*	*33.07*	*66.9*
pan		*425.5*	*425.5*	*0.00*	*0.000*	*0.00*	

Hydrometer Analysis

Specific Gravity of soil 2.62 *Test Temperature, deg.c* 21.0

Elapsed Time (min)	*Actual Hydrometer Reading*	*Tenprature deg.c*	*Corrected Hydrometer Reading*	*Effective Depth (cm)*	*Coefficient K*	*Grain Size (mm)*	*Percentage Finer Combined*
2	*31.5000*	*21.0*	*25.0000*	*11.15*	*0.01360*	*0.0321*	*51.20*
5	*30.0000*	*21.0*	*23.5000*	*11.40*	*0.01360*	*0.0205*	*48.13*
15	*27.0000*	*21.0*	*20.5000*	*11.90*	*0.01360*	*0.0121*	*41.99*
30	*26.0000*	*21.0*	*19.5000*	*12.00*	*0.01360*	*0.0086*	*39.94*
60	*24.0000*	*21.0*	*17.5000*	*12.40*	*0.01360*	*0.0062*	*35.84*
250	*21.5000*	*21.0*	*15.0000*	*12.80*	*0.01360*	*0.0031*	*30.72*
1440	*19.5000*	*21.0*	*13.0000*	*13.15*	*0.01360*	*0.0013*	*26.63*

Grain Size Distribution Curve,BS



Tested by : _____ *Checked by :* _____
Processed by : _____ *Approved by :* _____

Works Design and Supervision Enterprise Laboratory Service

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Water Works Design and Supervision Enterprise Laboratory Service Sub Process
Soil & Material Testing Section

Project : Research Thesis
Client : Kaleb Getachew
Location :
T.Pit. No. Kuyesa soil
Depth(m) :

Sample Type : Disturrbed
Test Type : Hydrometer
Date :27/4/2015
Lab. No : 672/07

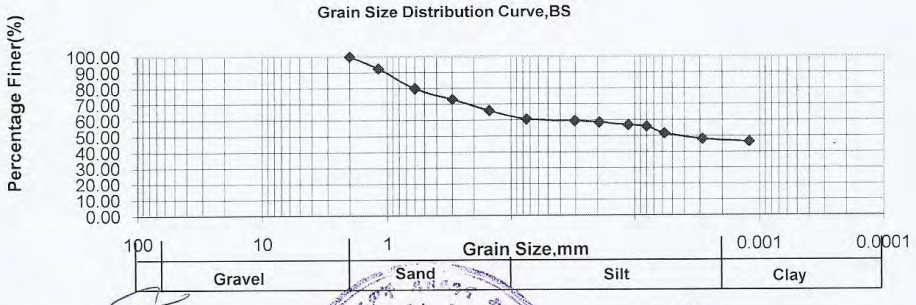
Total mass of sample, g 60

Sieve No	Sieve Opening(mm)	Mass of Sieve(g)	Mass of sieve + Ret .soil(g)	Mass of Ret. soil (g)	Percentage Retained	Cumulative % Retained	Percentage Passing
No 10	2	551.1	551.1	0.00	0.000	0.00	100.0
No 16	1.18	538.9	543.3	4.40	7.524	7.52	92.5
No 30	0.6	516.7	524.1	7.36	12.585	20.11	79.9
No 50	0.3	488.2	492.2	4.00	6.840	26.95	73.1
No 100	0.15	481.9	486.0	4.08	6.977	33.93	66.1
No 200	0.075	459.2	462.4	3.15	5.386	39.31	60.7
pan		425.5	425.5	0.00	0.000	0.00	

Hydrometer Analysis

Specific Gravity of soil 2.55 Test Temperature, deg.c 21.0

Elapsed Time (min)	Actual Hydrometer Reading	Tenprature deg.c	Corrected Hydrometer Reading	Effective Depth (cm)	Coefficient K	Grain Size (mm)	Percentage Finer Combined
2	40.5000	21.0	34.0000	9.60	0.01391	0.0305	59.55
5	40.0000	21.0	33.5000	9.65	0.01391	0.0193	58.68
15	39.0000	21.0	32.5000	9.90	0.01391	0.0113	56.93
30	38.5000	21.0	32.0000	10.00	0.01391	0.0080	56.05
60	36.0000	21.0	29.5000	10.40	0.01391	0.0058	51.67
250	34.0000	21.0	27.5000	10.70	0.01391	0.0029	48.17
1440	33.0000	21.0	26.5000	10.90	0.01391	0.0012	46.42



Tested by :
Processed by:
Checked by :
Approved by :

Water Works Design and Supervision Enterprise Laboratory Service

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Water Works Design and Supervision Enterprise Laboratory Service Sub Process
Soil & Material Testing Section

Project : Research Thesis
Client : Kaleb Getachew
Location :
T.Pit. No. Sand type soil
Depth(m) : 0.3-3.0

Sample Type : Disturrbed
Test Type : Hydrometer
Date :27/4/2015
Lab. No : 673/07

Total mass of sample, g 60

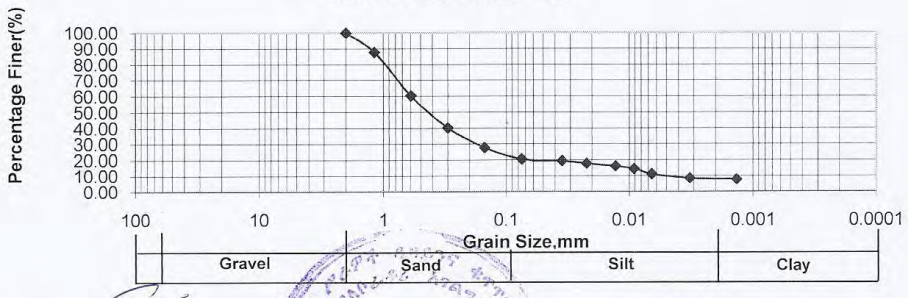
Sieve No	*Sieve Opening(mm)*	*Mass of Sieve(g)*	*Mass of sieve + Ret .soil(g)*	*Mass of Ret. soil (g)*	*Percentage Retained*	*Cumulative % Retained*	*Percentage Passing*
No 10	*2*	*551.1*	*551.1*	*0.00*	*0.000*	*0.00*	*100.0*
No 16	*1.18*	*538.9*	*546.2*	*7.27*	*12.223*	*12.22*	*87.8*
No 30	*0.6*	*516.7*	*533.0*	*16.30*	*27.404*	*39.63*	*60.4*
No 50	*0.3*	*488.2*	*500.2*	*11.99*	*20.158*	*59.78*	*40.2*
No 100	*0.15*	*481.9*	*489.3*	*7.43*	*12.492*	*72.28*	*27.7*
No 200	*0.075*	*459.2*	*463.5*	*4.26*	*7.162*	*79.44*	*20.6*
pan		*425.5*	*425.5*	*0.00*	*0.000*	*0.00*	

Hydrometer Analysis

Specific Gravity of soil 2.61 *Test Temperature, deg.c* 21.0

Elapsed Time (min)	*Actual Hydrometer Reading*	*Tenprature deg.c*	*Corrected Hydrometer Reading*	*Effective Depth (cm)*	*Coefficient K*	*Grain Size (mm)*	*Percentage Finer Combined*
2	*18.0000*	*21.0*	*11.5000*	*13.30*	*0.01364*	*0.0352*	*19.52*
5	*17.0000*	*21.0*	*10.5000*	*13.50*	*0.01349*	*0.0222*	*17.82*
15	*16.0000*	*21.0*	*9.5000*	*13.70*	*0.01349*	*0.0129*	*16.12*
30	*15.0000*	*21.0*	*8.5000*	*13.80*	*0.01349*	*0.0092*	*14.42*
60	*13.0000*	*21.0*	*6.5000*	*14.20*	*0.01349*	*0.0066*	*11.03*
250	*11.5000*	*21.0*	*5.0000*	*14.35*	*0.01349*	*0.0032*	*8.48*
1440	*11.0000*	*21.0*	*4.5000*	*14.50*	*0.01349*	*0.0014*	*7.64*

Grain Size Distribution Curve,BS



Tested by : *Checked by :*

Processed by: *Approved by :*

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Water Works Design and Supervision Enterprise Laboratory Service Sub Process

Soil & Material Testing Section

Project : Research Thesis
Client : Kaleb Getachew
Location :
T.Pit. No. Brownish soil
Depth(m) :

Sample Type : Disturbed
Test Type : Hydrometer
Date :27/4/2015
Lab. No : 674/07

Total mass of sample, g 60

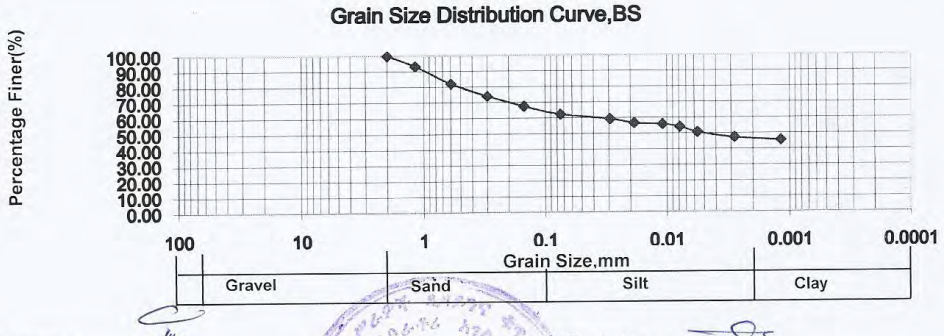
Sieve No	Sieve Opening(mm)	Mass of Sieve(g)	Mass of sieve + Ret .soil(g)	Mass of Ret. soil (g)	Percentage Retained	Cumulative % Retained	Percentage Passing
No 10	2	551.1	551.1	0.00	0.000	0.00	100.0
No 16	1.18	538.9	542.8	3.92	6.694	6.69	93.3
No 30	0.6	516.7	523.3	6.56	11.202	17.90	82.1
No 50	0.3	488.2	492.9	4.72	8.060	25.96	74.0
No 100	0.15	481.9	485.7	3.80	6.489	32.45	67.6
No 200	0.075	459.2	462.3	3.05	5.208	37.65	62.3
pan		425.5	425.5	0.00	0.000	0.00	

Hydrometer Analysis

Specific Gravity of soil 2.62 *Test Temperature, deg.c* 21.0

Elapsed Time (min)	Actual Hydrometer Reading	Tenprature deg.c	Corrected Hydrometer Reading	Effective Depth (cm)	Coefficient K	Grain Size (mm)	Percentage Finer Combined
2	41.0000	21.0	34.5000	9.30	0.01360	0.0293	59.33
5	39.5000	21.0	33.0000	9.40	0.01360	0.0186	56.75
15	39.0000	21.0	32.5000	9.60	0.01360	0.0109	55.89
30	38.0000	21.0	31.5000	10.10	0.01360	0.0079	54.17
60	36.0000	21.0	29.5000	10.40	0.01360	0.0057	50.73
250	34.0000	21.0	27.5000	10.70	0.01360	0.0028	47.29
1440	33.0000	21.0	26.5000	10.90	0.01360	0.0012	45.57

Grain Size Distribution Curve,BS



Tested by : _____ *Checked by :* _____

Processed by: _____ *Approved by :* _____

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Water Works Design and
Supervision Enterprise
Laboratory Service Sub Process

የአፈር ምህንድስና ክፍል
Soil & Material Testing Section

Tel. 251 - 116 - 18 55 16/61 45 01
Fax. 251 - 116 - 61 53 71/61 08 98
e-mail w.w.d.s.e@ethionet.et

P.O.Box 2561
Addis Ababa
Ethiopia

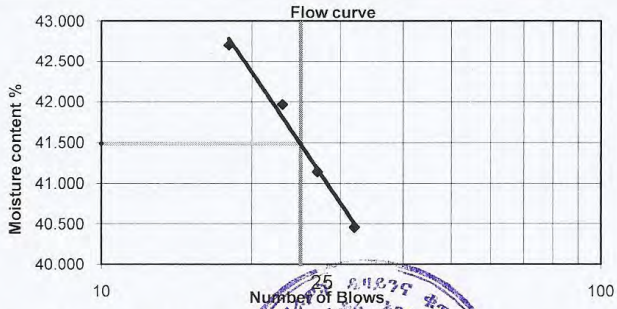
Project : Research Thesis
Client : Kaleb Getachew
Location :
Test Pit : Gogoba
Depth (m): _

Sample No
Sample type : Disturbed
Test type : Atterberg Limit
Date : 21/4/2015
Lab. No : 671/07

LIQUID AND PLASTIC LIMIT
DETERMINATIONS
DATA AND COMPUTATION SHEET

Type of test	LL	LL	LL	LL
Conteiner No.	364	210	331	24
No. of Blows	32	27	23	18
Wt.of sample + Tare wet	31.410	33.100	30.400	34.300
Wt.of sample + Tare dry	26.450	27.920	25.830	28.450
Wt.of water	4.960	5.180	4.570	5.850
Tare	14.190	15.330	14.940	14.750
wt.of dry soil	12.260	12.590	10.890	13.700
Water content %	40.457	41.144	41.965	42.701

Type of test	PL	PL	
Conteiner No.	207	364	
Wt.of sample + Tare wet	28.200	28.360	
Wt.of sample + Tare dry	26.340	26.420	
Wt.of water	1.860	1.940	
Tare	14.850	14.790	
wt.of dry soil	11.490	11.630	
Water content %	16.188	16.681	16.434



Result
L.L 41.49%
P.L 16.43%
P.I 25.06%

Tested By Bekelech
Checked By
Processed By
Approved By

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Water Works Design and
Supervision Enterprise
Laboratory Service Sub Process

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Soil & Material Testing Section

Tel. 251 - 116 - 18 55 16/61 45 01
Fax. 251 - 116 - 61 53 71/61 08 98
e-mail w.w.d.s.e@ethionet.et

P.O.Box 2561
Addis Ababa
Ethiopia

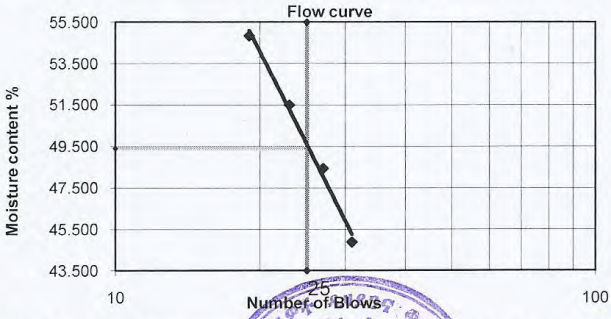
Project : Research Thesis
Client : Kaleb Getachew
Location :
Test Pit : KUYESA
Depth (m): _

Sample No
Sample type : Disturbed
Test type : Atterberg Limit
Date : 21/4/2015
Lab. No : 672/07

LIQUID AND PLASTIC LIMIT
DETERMINATIONS
DATA AND COMPUTATION SHEET

Type of test	LL	LL	LL	LL
Conteiner No.	275	298	220	206
No. of Blows	31	27	23	19
Wt.of sample + Tare wet	36.780	38.210	40.280	43.630
Wt.of sample + Tare dry	30.000	30.500	31.500	33.560
Wt.of water	6.780	7.710	8.780	10.070
Tare	14.890	14.580	14.450	15.200
wt.of dry soil	15.110	15.920	17.050	18.360
Water content %	44.871	48.430	51.496	54.847

Type of test	PL	PL	
Conteiner No.	176	230	
Wt.of sample + Tare wet	30.180	30.470	
Wt.of sample + Tare dry	26.800	26.930	
Wt.of water	3.380	3.540	
Tare	14.380	14.250	
wt.of dry soil	12.420	12.680	
Water content %	27.214	27.918	27.566



Result
L.L 49.40%
P.L 27.57%
P.I 21.83%

Tested By Bekelech Checked By

Processed By Approved By

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Water Works Design and
Supervision Enterprise
Laboratory Service Sub Process

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Soil & Material Testing Section

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Fax. 251 - 116 - 61 53 71/61 08 98
e-mail w.w.d.s.e@ethionet.et

P.O.Box 2561
Addis Ababa
Ethiopia

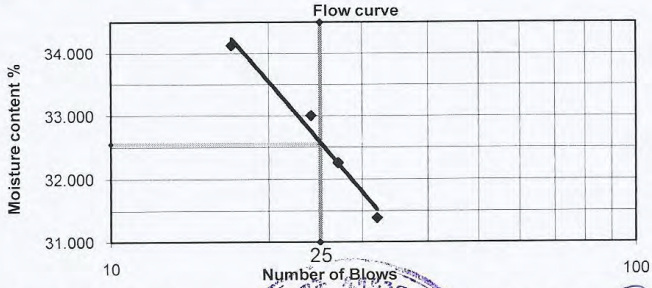
Project : Research Thesis
Client : Kaleb Getachew
Location :
Test Pit : SAND TYPE SOIL
Depth (m):

Sample No
Sample type : Disturbed
Test type : Atterberg Limit
Date : 21/04/2015
Lab. No : 673/07

LIQUID AND PLASTIC LIMIT
DETERMINATIONS
DATA AND COMPUTATION SHEET

Type of test	LL	LL	LL	LL
Conteiner No.	201	213	11	256
No. of Blows	32	27	24	17
Wt.of sample + Tare wet	30.510	34.060	37.520	39.170
Wt.of sample + Tare dry	26.750	29.350	31.860	33.010
Wt.of water	3.760	4.710	5.660	6.160
Tare	14.770	14.750	14.710	14.960
wt.of dry soil	11.980	14.600	17.150	18.050
Water content %	31.386	32.260	33.003	34.127

Type of test	PL	PL	
Conteiner No.			
Wt.of sample + Tare wet			
Wt.of sample + Tare dry			
Wt.of water			
Tare			
wt.of dry soil			
Water content %			N.P



Result
L.L 32.55%
P.L Non PL
P.I _____

Tested By Bekelech
Checked By
Processed by
Approved By

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Water Works Design and
Supervision Enterprise
Laboratory Service Sub Process

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e-mail w.w.d.s.e@ethionet.et

P.O.Box 2561
Addis Ababa
Ethiopia

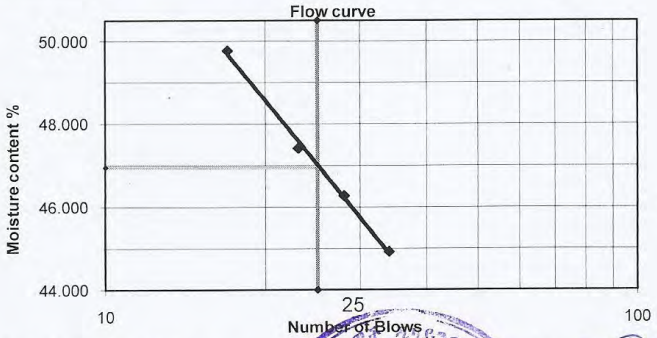
Project : Research Thesis
Client : Kaleb Getachew
Location : _
Test Pit : BROWNISH SOIL
Depth (m):

Sample No
Sample type : Disturbed
Test type : Atterberg Limit
Date : 21/4/2015
Lab. No : 674/07

LIQUID AND PLASTIC LIMIT
DETERMINATIONS
DATA AND COMPUTATION SHEET

Type of test	LL	LL	LL	LL
Conteiner No.	258	6	106	342
No. of Blows	34	28	23	17
Wt.of sample + Tare wet	34.260	37.290	39.940	42.170
Wt.of sample + Tare dry	28.290	30.280	31.780	33.200
Wt.of water	5.970	7.010	8.160	8.970
Tare	15.000	15.130	14.570	15.180
wt.of dry soil	13.290	15.150	17.210	18.020
Water content %	44.921	46.271	47.414	49.778

Type of test	PL	PL	
Conteiner No.	101	338	
Wt.of sample + Tare wet	27.620	27.970	
Wt.of sample + Tare dry	25.050	25.450	
Wt.of water	2.570	2.520	
Tare	14.870	15.310	
wt.of dry soil	10.180	10.140	
Water content %	25.246	24.852	25.049



Result
L.L 46.95%
P.L 25.05%
P.I 21.90%

Tested By Bekelech
Checked By
Processed By
Approved By

UNCONFINED COMPRESSION TEST DATA SHEET

Sample Data:

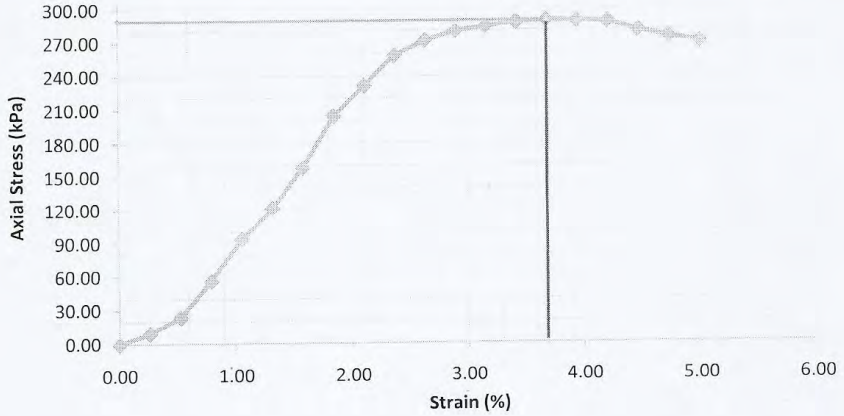
Project: - Research Thesis
Client: Kaleb Getachew
BH No: - Blended from the four samples
Depth(m) _
Dia(mm)= 38.00
Length(mm)= 76.00
Rate (mm/min) 1.50
Ring Factor (N/div)= 0.0107
Mass of Soil(gm) 177.77

BH No: -	Blended from the four samples	
Depth(m)		
Container No	IZ	
Wt of Wet Sample + Container(gm)	177.77	
Wt of Dry Sample + Container(gm)	153.63	
Wt. Of Water(gm)	24.14	
Wt. Of Container (gm)	16.07	
Wt of Dry Sample (gm)	137.56	
Water Content(%)	17.55	
Average Water Content(%)	8.77	

Area,A_0 (mm^2)=	**1133.54**
Volume, (mm^3)=	**86149.04**
Bulk Density(gm/cc)=	**2.06**
Dry Density(gm/cc)=	**1.90**

Unconfined Compression Test Data

Deformation Dial Reading	Load Dial Reading	Sample Deformation, ΔL(mm)	Strain(ε)	% Strain	Corrected Area A'	Load (kN)	Stress (kPa)
0	0.00	0.00	0.00	0.00	1133.540	0.000	0.00
20	1.00	0.20	0.003	0.263	1136.523	0.011	9.41
40	2.50	0.40	0.005	0.526	1139.506	0.027	23.48
60	6.00	0.60	0.008	0.789	1142.489	0.064	56.19
80	10.00	0.80	0.011	1.053	1145.472	0.107	93.41
100	13.00	1.00	0.013	1.316	1148.455	0.139	121.12
120	17.00	1.20	0.016	1.579	1151.438	0.182	157.98
140	22.00	1.40	0.018	1.842	1154.421	0.235	203.91
160	25.00	1.60	0.021	2.105	1157.404	0.268	231.12
180	28.00	1.80	0.024	2.368	1160.387	0.300	258.19
200	29.50	2.00	0.026	2.632	1163.370	0.316	271.32
220	30.50	2.20	0.029	2.895	1166.353	0.326	279.80
240	31.00	2.40	0.032	3.158	1169.336	0.332	283.67
260	31.50	2.60	0.034	3.421	1172.319	0.337	287.51
280	31.80	2.80	0.037	3.684	1175.302	0.340	289.51
300	31.80	3.00	0.039	3.947	1178.285	0.340	288.78
320	31.80	3.20	0.042	4.211	1181.268	0.340	288.05
340	31.00	3.40	0.045	4.474	1184.251	0.332	280.09
360	30.50	3.60	0.047	4.737	1187.234	0.326	274.88
380	30.00	3.80	0.050	5.000	1190.217	0.321	269.70



Tested by: - Getu

Cecked by: -

Processed By:-

Approved by:-

APPENDIX B

CHEMICAL COMPOSITION OF THE FOUR ORIGINAL SOIL SAMPLE TYPES

Geological Survey of Ethiopia; Geoscience Laboratory Directorate Form G0004
Geochemical Laboratory Complete Silicate Analysis Report Format
FILE ID :- 10142-15pvt Originator :- Kalebe Getachew Amenu
Sample type:- Soil Date submmitted:- 5/5/2015
Preparation: -200 MESH **Element to be determined Major Oxides & Minor Oxides**
NUMBER OF SAMPLES: 4
Analytical Method: LIBO2 FUSION , HFattack,GRAVIMETERIC and AAS
Analytical Results in PERCENT

FIELD NO	Lab No	SiO2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	MnO	P_2O_5	TiO_2	H2O	LOI	Cl	SO3
Kuyesa	10142/15	62.00	17.44	5.46	1.48	0.83	1.18	0.98	0.10	0.04	0.78	2.87	6.69	<0.01	0.04
Sand	10143	69.11	16.56	3.12	1.86	0.82	2.14	1.28	0.09	0.03	0.57	0.42	2.92	<0.01	0.03
Brownish Soil	10144	61.02	16.82	7.04	1.18	0.7	0.58	0.68	0.10	0.05	1.01	3.79	8.43	<0.01	0.05
Gugub	10145	66.19	13.61	4.44	3.48	1.06	0.44	0.56	0.09	0.06	0.87	3.11	7.42	0.07	0.06

Analysts **Checked By** **QUALITY CONTROL** **DATE REPORTED**

Tizta Zemene
Getahun Bikila
Gosa Haile

Worede Sahilu

15/6/2015

Geological Survey of Ethiopia Central Geological Laboratory

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APPENDIX C

Key Informants Unstructured Interview

I. Interview for Heritage Experts

1. What are the responsibilities of the Harari Administration office?
2. Do you get any support or awareness creation session from the concerned governmental body regarding the contribution of historic buildings in Harar?
3. What efforts have been done by the Harari Administration office to create awareness to the public?
4. How many historic buildings maintained legally?
5. How many historic buildings are saved from illegal maintenance by the Administrative body?
6. What kind of measures did the Administration take when one building maintained illegally?
7. How many historic buildings bulldoze in jugol till now? Can you tell me the reasons?

II. Interview for urban planning institution

1. What are the future prospects of historic buildings in connection with the existing development plan?
2. What are the organization responsibilities when one historic building demolished?
3. Are there any historic buildings that are intended to be demolished in the near future?
4. How many historic buildings are demolished till now?
5. What efforts have been made to harmonize preservation with modernity?
6. What are the procedures to demolish the historical buildings that are in conflict with the existing development plan?

III. Interview for Harar Heritage Experts

1. What are the responsibilities of your organization?
2. What efforts have been done to preserve historic buildings to keep their originality?
3. Is there any rules and regulation that help the owners or the responsible organs to maintain the buildings?
4. Is there adequate budget and man power assignment to keep the historic buildings and if not what extent these things have affected the development of the tourism sector?
5. Are there any historical buildings that your organizations try to save it from bulldozing?
6. What efforts have been made by the responsible agencies to create public awareness?
7. If some historic building is getting bulldozed though they are not contradicting with the exiting development plan what will be the responsibility and the response of your organization?

Thank you very much!