Laboratory Investigation of Locally Produced Clay Brick Quality and Suitability for Load Bearing Element in Jimma Area, Ethiopia

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***Abstract*— Local construction material is one of the solutions for ever increasing housing demands for low income group in urban areas when standard construction materials such as wood, sand, stone and cement are not readily available nearby because of cost and transportation problem especially in developing countries like Ethiopia. In Jimma, one of the big town in Ethiopia, local traditionally produced clay brick is widely. However, its physical properties are not well studied compared to standards though it is used intensively often its quality is in question since it is produced in traditional way.**

Therefore, in this study, the existing physical properties of local clay brick was tested in laboratory and test results are collected and the extent is known. Combined Physical Clay Brick test results indicate that traditional local brick in Jimma are not qualified compared to Ethiopian, Indian, British and American standards.

However, closer look up to compressive test, result shows average compressive strength of local brick is 5.0Mpa, which is 50% of Burayu Brick. Water absorption is 33 % that exceeds the standard (20%) nearly by 65%.This result indicates also its compressive strength very competitive to that of higher class of Hollow Concrete Block of 5.5Mpa as wall load bearing according to Ethiopian standard. This strength of brick may be one of the fundamental reasons why local people use it in many ways as substitute in the absence of stone in Jimma town and surrounding. Nevertheless, its applicability will be very limited due to high water absorptions unless damp proof is used.

Finally, this study concludes that major quality problem is water absorption. This may be due to firing temperature and less compaction effort and hence firing and mold method has to be improved. In addition, detail standardization has to be done as whole in Ethiopia and in particular city like Jimma because dimensional differences has been observed which has impact on market demand supply to big contractors difficulties in quantity estimation and construction suitability.

***Index Terms*—: Local Material, Traditional Brick, Compressive strength, Water absorption, Strength, Water absorption, Load Bearing**

I. INTRODUCTION

Now days the urban population is increasing rapidly at the same time need for house increases from time to time, which in turn highly consumes construction materials. Construction material is one of the biggest challenges to construct house. This is because some cities are established far from source of construction materials such as wood, sand, stone and cement in which the problem is emphasized more in developing countries this time because urbanization is very new event. Therefore, knowing engineering properties of locally available materials and improving them may be alternative option rather only depending on standard materials like concrete. Design and construction used for a series of small residential buildings by adopting local materials the amount of energy used in building decreased by up to 215% and the impact of transportation by 453%[12]. Using locally produced building materials shortens transport distances, thus reducing air pollution produced by vehicles. Often, local materials are better suited to climatic conditions, and these purchases support area economies. It is not always possible to use locally available materials, but if materials must be imported they should be used selectively and in as small a volume as possible [14].

A good example may be Jimma city, south west of Ethiopia with high ground water table causing high damping problem, construction materials such as stone, sand and cement are not easily accessible [7], the one that can be obtained is mud soil, local clay brick and wood. In the case of wood, deforestation may be a big problem and whereas if mud soil used it is not safe since there is high ground water table. In Jimma as alternative traditional fired clay brick may be an option, which replaces stone in many parts of building except foundation part.

In Jimma for example, it can be observed many houses, existing old buildings and fences are intensively constructed using clay brick wall and columns, which are very durable though there also wood and mud houses. Especially old buildings brick columns and walls are very inspiring which exist today without significant failure and serving still today which may be had been built in late 1930 as shown in fig 1 may be standing evidences till today.

Fig 1. Existing Old Brick Buildings in Jimma town

Even though use of locally produced clay brick is very common in Jimma, it is observed that traditional way of brick production is very dominant which may be low quality and less quantity in which the engineering properties are not clearly quantified. The brick strength is often underestimated though is used continually as walling bearing materials in in low cost houses and partition walls in multi-story buildings.

Previous study, showed that Jimma locally produced in Boye is not so good due to inefficient method of firing and energy loss test showed that water the absorption capacity test results 31.085% since good brick water absorption shouldn't exceed 15% of its dry mass[18] though people continue to use it in building construction continuously. Other study on Burayu Brick near Addis Ababa suggests that, controlling the firing temperature during clay bricks production plays a decisive role in both quality and production costs [2].

Since Jimma City is home for Jimma University, construction materials is one of Jimma University Thematic Research Priorities under Technology adaptation and transfer thematic area[13].Therefore, this research paper focuses on the investigation of currently locally produced bricks strength engineering properties study in laboratory and identifying quality problems extent.

Furthermore, indicate possible ways to use locally produced clay bricks in different parts of building load bearing components without compromising safety. Using local material in appropriate way in building houses and make aware user the extent of quality problem and indicate ways of improving qualities since clay brick is widely used in Jimma so that it will replace construction material scarcity specially in load bearing wall materials for low cost houses.

II. OBJECTIVES OF THE STUDY

- Assess factors affecting locally Manufactured clay Bricks qualities and being alternative construction material
- Conduct laboratory test on Locally Produced Clay Brick in Jimma Area
- Identify how much their strength is weak when compared with the standard.
- Check Brick Suitability for different Building Elements

III. REVIEW ON CLAY BRICK AND HOLLOW CONCRETE BLOCK AS CONSTRUCTION MATERIAL

Brick as Construction Material

Brick is an extremely old building material, known to have been used in the Mesopotamia region since the third millennium BC[19].The term ''brick" encompasses a wide number of products obtained by mixing clay, preparing and moulding it, before slow drying and finally firing in an oven. As the temperature rises, mineralogical and textural changes occur. These are the result of the marked disequilibrium of a system that on a small scale resembles high-temperature metamorphic processes. The porosity of the brick depends directly on the mineralogical composition of the raw material and the firing temperature, but generally, bricks fired at high temperatures are more vitreous and undergo the greatest changes in size and porosity [10].

Brick has been used all over the world including Ethiopia in cities like , Addis Ababa, Dire Dewa, Jimma etc.For Quality controal Ethiopian standard has been set as in Table 1 showing different grades of Clay Brick.

Table 1. Ethiopian standard (ES 86:2001), bricks are classified as shown in Table [9]

Class	Minimum compressive strength		Maximum water absorption %		Maximum unit weight (Kg/m3)
	Average of five bricks Mpa	Individual brick Mpa	Average of five bricks	Individual bricks	
A	20	17.5	21	23	2200
B	15	17.5	22	24	
C	10	7.5	No limit	No limit	
D	7.5	5.0	No limit	No limit	

Hollow Concrete Block as Construction material

Compared to Clay Brick, Hollow Concrete Block (HCB) brick recent material produced by mixture of powdered Portland cement, water, sand, and gravel. The production of concrete blocks consists of four basic processes: mixing, molding, curing, and cubing. Hollow concrete block is an alternative wall making material in the building construction having one or more large holes with the solid material between 50 and 75 percent of the total volume of the block calculated from the overall dimension. Most hollow concrete blocks have one or more hollow cavity manufactured from a zero-slump mixture of mixture of Portland cement aggregates, water and sometimes admixtures. The Strength varies depending mix ratios and qualities of production component such as cement and fine aggregate or sand. Like many other countries in the world, the minimum Ethiopian Standard Compressive strength is given in table 2 for quality control.

Table 2. Ethiopian Standard Hollow minimum compressive strength requirements for block at age of 28 days [8]

Type of Hollow Concrete Block	Class	Minimum Compressive strength(N/mm^2)	
		Average of 6 units	Individual Units
Load bearing	A	5.5	5.0
	B	4.5	4.0
	C	3.5	3.0
Non load Bearing	D	2.0	1.80

Comparing Brick and Hollow Concrete Block to Jimma City Context

Brick widely used construction material around Jimma. Many low cost villa houses, fences, existing old buildings and fences are intensively constructed using brick wall and columns. Especially old buildings brick columns and walls are very inspiring that exist today without significant failure and serving still today, built in 1930s while the use of Hollow Concrete Block is very recent.

In India, comparative study between hollow concrete block masonry and brick masonry construction shows brick masonry wall has more strength than Hollow concrete block but it is expensive [17].

However, in Jimma local construction for Hollow Concrete making materials such as cement,sand,aggregates are not easily available [7] , which needs more transport costs and an impact on environment if long distances is a choice [14] &[12]

However, Hollow concrete block walling material has many advantages economically and some construction advantages, its usability may be limited in low cost houses in Jimma. In Jimma, it is easy get locally produced bricks in every home at least as decorating front side of houses .In addition many bricks are stronger than Hollow concrete block may be used also as masonry column in low cost houses in place of wood and stone

In general, aim of this study to assess the locally produced clay brick strength and compare with standard bricks, further verify its usability of local brick in comparison to Hollow Concrete Block also.

IV. CLAY BRICK PHYSICAL PROPERTIES

The most important physical properties of clay bricks such as standard dimension, Density, Compressive strength, Water absorption and Efflorescence. Physical properties of clay brick determine the quality of brick usability in building construction to be used as load either bearing or non-loading bearing which will be discussed in the next section.

Standard Dimension of Bricks and Density

Standardization can be defined as a rule set for some products to have same way of dimensioning though produced in different group in different places for easy use of customers [6].It is stated that most of builders and contractors do not want to buy locally made bricks because of lack of standard. In different small groups that produce different sizes of brick for instance one may produce 240mmx100mmx65mm while other 240mmx115mmx77mm which vary in form, size, and quality which hinder the contractor wanting to buy a lot of bricks with similar sizes but different groups produce small but different size which finally make them loose the market. In addition, standard sizes have advantage easy demand calculation for mass purchasing and construction benefits in making accurately opening sizes such as door and window in walls [6].

Similarly, problem of standardization may occur in local brick manufacturing sites in Jimma City. In design of walls thickness for architectural planning and estimation of quantities, estimation of dead load of brick in structural engineering design, dimension and density is very important, problem observed in Jimma Building Design experiences. This study investigated samples collected from two locally producing sites in in Civil Engineering laboratory.

Compressive strength of Clay Brick

For structural engineering, one of the most important thing in design of load bearing members is knowledge of material strength next to member forces. It is confirmed by laboratory test as shown in Fig 2.In the case of clay brick design strength is compressive strength which in turn affects the masonry strength built using bricks, Compressive strength is relevant to structural engineer calculating structural brickwork strengths in accordance with the recommendations of the Structural Masonry Codes of Practice. However, it is not an indicator of the brick's frost resistance or durability [5].Compressive strength of any individual brick shall not be less than the minimum compressive strength for the corresponding class of brick Bricks often have to withstand great compressive stresses. The durability of the masonry depends up on the strength of the bricks. As per [11] common building bricks should have a minimum strength of 3.5Mpa. In addition, the compressive strength of any individual brick should not fall below the average compressive strength specified for the corresponding class of brick by more than 20%. The average compressive strength of common burnt clay bricks as laid [11].

The recommended Standard strength of different countries is listed in tables 3, 4, 5, and 6 for Indian, Ethiopian, Britain, and American respectively. It can be observed that failure criteria varies from Ethiopia to America, the case of India more detailed for compressive strength minimum up to 3.5MPa while Ethiopia minimum value is 5.00Mpa with less detailed one for lower classes that may occur in real scenario. Whereas in American standard, effect of freezing is included which may irrelevant in case of in which most cities in Ethiopia does not temperature drop below zero for freezing effect.

Fig 2.Compression testing machine (Jimma University Civil Engineering Laboratory)

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Table 3. Indian Standard Compressive strength of common burnt clay bricks with water absorption less than 20% and 15% for higher Class Bricks [11]

Class designation	Average Compressive Strength	
	No less than N/mm^2	less than N/mm^2
350	35	40
300	30	35
250	25	30
200	20	25
175	17.5	20
150	15	17.5
125	12.5	15
100	10	12.5
75	7.5	10
50	5	7.5
35	3.5	5

Table 4. Ethiopian standard (ES 86:2001), bricks are classified as shown in Table [9]

Class	Minimum compressive strength		Maximum water absorption %		Maximum unit weight (Kg/m3)
	Average of five bricks Mpa	Individual brick Mpa	Average of five bricks	Individual bricks	
A	20	17.5	21	23	2200
B	15	17.5	22	24	
C	10	7.5	No limit	No limit	
D	7.5	5.0	No limit	No limit	

Table 5. British Standard Classification of Clay Bricks by Compressive strength and water absorption (BS 3921, 1985)

No	Classes Of Clay Bricks	Compressive strength(N/mm^2)	Water Absorption(% by Mass)
	Engineering A	>70	<4.5
	Engineering B	>50	<7.0
	Damp-Proof Course 1	>5	<4.5
	Damp-Proof Course 2	>5	<7.0
	All others	>5	No Limit

According to this standard specification ,damp proof course 1 are recommended for use in building construction while damp roof course 2 are recommended for external works for masonry construction which full fills the BS 5628:Part 3 :1985

Table 6. The American Society for Testing and Materials; Standard Specification for building Bricks (ASTM C62-97a) [1] Classification of Clay Bricks ASTM , Standard Specification for building Bricks (C62-97a),Clay Bricks are classified based on their compressive strength, water absorption and saturation coefficient

Designation	Minimum Compressive Strength , Gross area (Mpa)		Maximum Water Absorption by 5hr Boiling,(%)	
	Average of 5 Bricks	Individual Bricks	Average of 5 Bricks	Individual Bricks
Grade SW	20.7	17.2	17	22
Grade MW	17.2	15.2	22	25
Grade NW	10.3	8.6	No Limit	No Limit

On this specification

Grades classify bricks according to their resistance to damage by freezing when wet , as defined in note 1. Three grades are covered and grade requirements are listed in table above

i. Grades (Sever Weathering)-Bricks intended for use where high and uniform resistance to damage caused by cyclic freezing desired and where the brick frozen when saturated with water
ii. Grade(Moderate Weathering)-Brick intended for use where moderate resistance to cyclic freezing damage is permissible or where the brick may be damp but not saturated with water when freezing occurs.
iii. Grade NW(Negligible Weathering) –bricks with little resistance to cyclic freezing but which are acceptable for applications protected from absorbing and freezing

Note 1: The Word “Saturated” with respect to this standard, refers to condition of a brick that absorbed water to an amount equals to that resulting from submersion in room temperature water for 24hr.

Water absorption

According to [5], the absorption of bricks is not related directly to the porosity. Some of the absorption may be through the pores, which permit air to escape in absorption tests but others are cue-de-sac or even completely sealed and inaccessible to water under ordinary conditions. For these reasons, it is seldom possible to fill more than about 75% of the pores by simple immersion in cold water and boiling method is adopted for measuring complete absorption.

In both cold-water test and boiling water test, the specimen is dried in a ventilated oven at 110 °C 0 to 115 °C until it attains a substantially constant mass.

In cold-water test, the specimen is then kept immersed in clean water at 27 °C for 24 hours. It is weighed again to determine the weight of water absorbed and water absorption percentage is given by;

Water absorption percentage by weight = weight of water absorbed/weight of dried specimen*100

In the boiling water test after the dried specimen is immersed in a tank such that water can circulate freely on all sides of the specimen. Water is heated to boiling in one hour and boiled continuously for five hours. The water is allowed to cool to 27oC by natural loss of heat for 16 to 19 hours. The specimen is again weighted and the water absorption percentage is given by Water absorption percentage by weight = weight of water absorbed during boiling / weight of dried specimen *100 and average of 5 results shall be reported.

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Efflorescence

Efflorescence is the usual terms for deposit of soluble salts, formed in or near the surface of a porous material, as a result of evaporation of water in which they have been dissolved[15].According to [3], the presence of alkalies in bricks is harmful and they form a gray or white layer on brick surface by absorbing moisture.

- *Sources of efflorescence*

According to [16], Efflorescence requires three conditions to exist:

a. The presence of soluble salts
b. The presence of water
c. A path of migration of soluble laden solutions to the surface of evaporation

Fig 3.Effect Efflorescence

V. RESEARCH METHODS AND MATERIALS

STUDY AREA

The study area is located in Jimma area of Oromia National Regional State. Jimma is located at about 346 Km in the South West of Addis Ababa (Capital of Ethiopia) and has total surface area of 4,623 hectares.

DATA COLLECTION

First Jimma Area Sample Brick locally produced sample clay bricks around Jimma City two local production areas Site 1 and Site 2 named Boye and Bore respectively each 40 Pieces of clay brick collected. Secondly for better comparison additional 40 Pieces Burayu Clay Brick Standard Machine Factory near Addis Ababa are collected and tested in Civil Engineering laboratory and their quality verified against different brick standards qualities and the results obtained is examined for use it as load bearing wall strength of building.

METHODS

- Referring standard Brick manufacturing technical manuals
- Jimma town local Brick manufacturing brick sample collection sites (Boye and Bore)
- Addis Ababa (Burayu site) Brick manufacturing brick sample collection.
- Testing of collected samples and comparing the findings.
- Analyzing test results and comparing with standards
- Discuss the test results
- Suitability for different Building Elements

MATERIALS

- Reference materials on brick production
- Jimma town area clay soil Map
- Local brick manufacturing agencies

LABORATORY TESTS OF LOCAL BRICK

The Laboratory test is made for both locally produced clay and factory bricks in case the result may be different due to unnoticed laboratory equipment error.

DIMENSIONAL TOLERANCE AND DENSITY TEST

For each site sample collected, the dimension is measured and compared with standards**.** According to Indian Standard [11], the dimensions of bricks when tested in accordance with 6.2.1 shall be within the following limits per 20 bricks:
For non-modular size
Length 4 ,520 to 4, 680 mm (4,600 ± 80mm)
Width 2,240 to 2,160 mm (2,200±40 mm)
Height 1,440 to 1,360mm (1,400±40 mm)
(For 70 mm high bricks)
640 to 560mm (600±40 mm)
(For 30 mm high bricks)

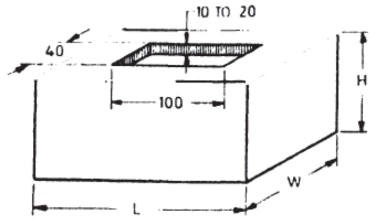

Fig 4 Single Brick Dimension adapted from [11]

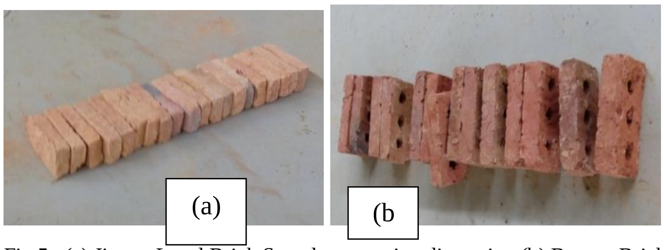

Fig 5. (a) Jimma Local Brick Sample measuring dimension (b) Burayu Brick Sample measuring dimension

COMPRESSION STRENGTH TEST

According to [3], this test conducted to know the compressive strength of brick. It is also called crushing strength of brick. Generally, five specimens of bricks selected randomly to laboratory and tested one by one. In this test, a brick specimen is placed on crushing machine and applied pressure until it fails. The ultimate pressure at which brick is crushed is taken into account. All five brick specimens are tested one by one and average result is taken as brick's compressive/crushing strength.

Procedure

a. The specimen brick is immersed in water for 24 hours.
b. The frog of the bricks is filled flush with 1:3 mortars and the brick is stored under damp jute bags for 24hours followed by immersion in clean water for three days.

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c. The specimen is then placed between the plates of the compression-testing machine.
d. Load is applied axially at a uniform rate of 14 N/mm^2 (140kgf/cm^2) and
e. the maximum load at which the specimen fails is noted for determination of compressive strength of brick given by

$$\text{Compressive Strength} = \frac{\text{Maximum Load at failure (N)}}{\text{Average area of bed face(mm}^2\text{)}} \quad (1)$$

Average of five results is reported

Fig 6. (a) Sample Preparation for compression test of Local Brick mortar capping (b) Sample Preparation for Compression Test

Fig 7. Testing Compression Test for Brick

Water Absorption Test

Procedure of test for water absorption**,** which was listed by [20]

a. Dry the specimen in a ventilated oven at a temperature of 105 °C to 115°C till it attains substantially constant mass.

b. Cool the specimen to room temperature and obtain its weight (M_1) specimen too warm to touch shall not be used for this purpose.

c. Immerse completely dried specimen in clean water at a temperature of 27+2°C for 24 hours.

d. Remove the specimen, wipe out any traces of water with damp cloth, and weigh the specimen after it has been removed from water (M_2).

Water absorption, % by mass, after 24 hours immersion in cold water in given by the formula,

$$W = \frac{(M_2 - M_1)x100}{M_1} \quad (2)$$

The average of result shall be reported.

TEST FOR EFFLORESCENCE

The efflorescence potential of fired clay products can be evaluated using the ASTM C67 procedures.

a. No preconditioning is required for this test and the specimen brick is placed on end in a dish filled with water, the depth of immersion being 25mm.
b. The whole arrangement is placed in a warm (20°C-30°C), well-ventilated room until all the water in the dish evaporates.
c. When the water has been absorbed and the brick appears to be dry, similar quantity of water is again filled in the dish and allowed evaporate.
d. The bricks are examined after second evaporation and the area of white patches on the specimen brick is measured. The liability of efflorescence with the following definition:
   - ✓ Nil: when there is no perceptible deposit efflorescence.
   - ✓ Slight: When n more than 10% of the area of the brick is covered with a thin deposit of salts.
   - ✓ Moderate; when there is a heavier deposit than that mentioned under slight, and covering up to 50% of the exposed area of the brick surface but unaccompanied by powdering of flaking of the surface.

VI. RESULTS, ANALYSIS, AND DISCUSSION

Jimma Local Brick Quality Analysis compared to Different Standards

Density and Dimension Check

Table 7 shows is non-uniformity of sizes in local produced clay bricks in Jimma. Boye is bigger than Bore Brick that may face problem of standardization as stated by [6].

Furthermore, Jimma local brick is different from the Factory Manufactured Brick Of Burayu which shows non uniformity of products which in turn affect quality of construction and market effects to purchase in mass from different sites of Jimma similar as in [6].From table 7 we can observe that the dimension is not with tolerance according to Indian Standard [11].

Table 7. Dimensional tolerance test Result According to Indian Standard

Sample Type per 20Pcs	Dimension sizes	Measured in Lab(mm)	Indian Standard (mm)	Remark
Jimma Site 1 Boye 20Pcs	L	4905	4520-4680	Bigger
	W	2390	2200-2160	Bigger
	H	1180	1440-1360	smaller
Jimma Site 2 Bore 20PCs	L	4735	4520-4680	Bigger
	W	2265	2200-2160	Bigger
	H	1140	1440-1360	smaller
Burayu Near Addis Ababa	L	4800	4520-4680	Bigger
	W	2340	2200-2160	Bigger
	H	1085	1440-1360	smaller

From Figure 9, the Bulk density all bricks locally produced Jimma Bricks, Burayu Brick near Addis Ababa are below standard of Ethiopia, 2200Kg/m3 [9] which may be very misleading in calculating the deadweight of brick wall for design of structures. It is also observed that the within Jimma local bricks, Bore is lighter than the Boye, may be incorrect to assume uniform values of bulk density.

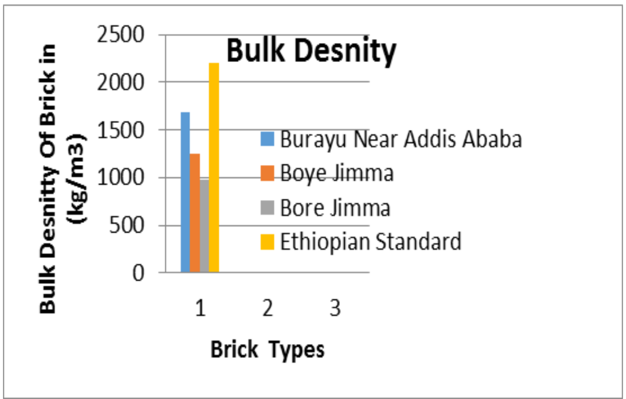

Fig 9. Clay Brick Bulk Density test according to Ethiopian Standard

Compressive strength of bricks Result Analysis Compared to different standards

Laboratory Compressive tests results of Table 8,(Jimma Boye),Table 9 (Jimma Bore) and Table 10 (Burayu) and compared to Ethiopian Standard [9] in Table 4 the Jimma Boye and Bore bricks are below the least standard 7.5MPa with average compression strength of 4.854MPa and 5.592MPa respectively. Whereas the Burayu brick classified as C class with average strength of 10.694Mpa a brick from standard Brick Factory.

On the other hand, compared to Indian standard [11] table 5 above, Jimma Boye Brick with average strength of 4.854MPa and Jimma Bore Brick with average compressive strength of 5.592MPa that may be in class 35 and class 50. But it fails since water absorption test as in table 12 is more than 20%, Boye 33.16% and Bore 34.87% which may great problem walls exposed to damping area, reduce the bearing capacity. However, Burayu Brick can be class 100 and with water absorption 18.11% less than 20% similar confirmation to Ethiopian Standard.

Similarly, according to British Standard [4] table 6, none of the Bricks meets standard to be used as external wall construction. This because of water absorption more than 7% though all compressive strengths are nearly 5.00Mpa.Here it is clearly observed that water absorption dominates compressive strength criteria.

Finally, according to ASTM Standard, Only Burayu Brick quality the Grade NW (Negligible Weathering), the local Jimma bricks are below standard compressive strength less than 10.3Mpa of ASTM but with no water absorption limit.

Furthermore, from summary Table 11, we can observe the compressive strength of the Jimma Brick is nearly half strength than its counterpart Burayu that is produced in factory in controlled ways. The Brick Compressive strength in Jimma is below standard as expected. Therefore, we can see that strength, density, and water absorption are related to compaction effects and burning temperature. Therefore, Jimma bricks need more burning to get better strength as it dominant construction material. Because the construction cost of brick of Burayu is nearly 3 times that of locally produced brick.

Table 8 Jimma Boye Brick Compressive Strength Test result

Sno	Sample site Jimma	Mass(Kg)	Unit Weight (kN/m^3)	Read Peak Load(kN)	Stress,σ (Mpa)
1	Boye	1.92	13.335	137.80	4.878
2	Boye	1.80	11.772	152.00	5.067
3	Boye	1.90	11.960	154.30	5.544
4	Boye	1.88	12.393	109.90	3.999
5	Boye	1.93	11.960	148.00	4.780
	Average	1.884	12.284	140.400	4.854

Table 9 Jimma Bore Brick Compressive Strength Test Result

Sno	Sample site Jimma	Mass(Kg)	Unit Weight (kN/m^3)	Read Peak Load(kN)	Stress (Mpa)
1	Bore	1.55	11.595	175.90	6.863
2	Bor	1.25	9.657	114.20	4.497
3	Bor	1.56	10.864	157.70	6.177
4	Bor	1.55	11.157	133.50	5.094
5	Bor	1.33	9.561	134.70	5.330
	Average	1.446	10.567	143.200	5.592

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Table 10 Jimma Boye Brick Compressive Strength Test Result

Sno	Sample site	Mass(Kg)	Unit Weight (kN/m^3)	Read Peak Load(kN)	Stress,σ (Mpa)
1	Burayu	1.96	16.354	271.10	11.529
2	Burayu	2.04	16.156	257.60	9.333
3	Burayu	2.09	16.393	234.20	8.412
4	Burayu	1.91	16.889	327.40	12.012
5	Burayu	2.13	16.996	327.40	12.180
	Average	2.02	16.558	283.54	10.694

Table 11 Brick Average Compressive Strength Summary of all Bricks Tested

Sno	Sample site	Mass (Kg)	Read Peak Load(kN)	Compressive Stress (Mpa)
1	Burayu	2.023	283.540	10.694
2	Boye	1.884	140.400	4.854
3	Bore	1.446	143.200	5.592

Water absorption Result and Analysis

Table 12 Water absorption test results Jimma and Burayu Bricks

Sno	Sample site 5 Pieces	Dry Mass Mass(Kg)	Wet Mass	Water Absorption %
1	Burayu	1.985	2.345	18.11%
2	Jimma Boye	1.754	2.334	33.16%
3	Jimma Bore	1.479	1.997	34.87%

Table 12 Shows Jimma Boye and Jimma Bore brick water absorption is 33.16% and 34.87% more than the standard 20% almost which require more burning which is similar finding of [18]. The water absorption 18.11%% less than 20% almost satisfy the minimum standard requirement.

Tests for Efflorescence and Analysis

From Figure 8 laboratory test of Efflorescence picture show that of Jimma Brick cannot be clearly identified since the brick was not well burnt has grey color by itself difficult to distinguish Efflorescence effect while that of Burayu Brick between 25% to 50% which is moderate .

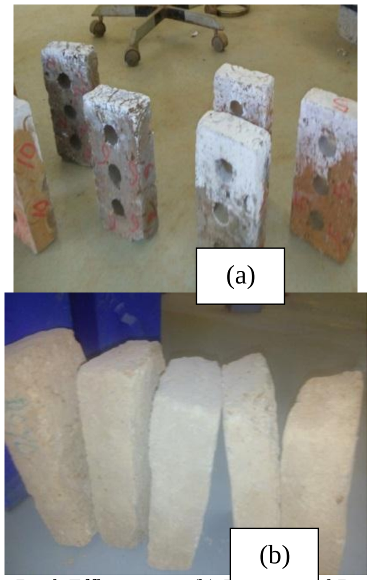

Fig 8. (a) Burayu Brick Efflorescence (b) Jimma Local Brick Efflorescence

VII. CONCLUSION AND RECOMMENDATION

This study concludes that, the local clay brick quality in Jimma is below the standard as expected mainly because of high water absorption, which may be because of less firing effect and less compaction effort for making many voids within brick. It needs good compaction effort and more firing temperature to burn.

Though local clay brick quality is confirmed poor quality, local people often use brick as better substitute of stone supply. Why this happened is one of the critical question in this research, why do people continue to use it. Not better than wood? No option? Is the idea of using local material [12]?

For this question to answer a very closer examination of the compressive strength of local test results shows nearly average of 5.00MPa and even higher can be achieved only with traditional brick making method. Surprisingly this strength is strength designation of load bearing between Class A and Class B Hollow Concrete Block table 2[8].In conclusion, it can be clearly deduced that there is a lot accumulated knowledge in the local people using not only using because of no option they use it because it is strong also, alternative to Hollow Concrete Block.

Therefore, if the damping effect protected by different mechanisms still the locally produced brick can be competent in its capacity at present for load bearing wall.

Another question of the research is by how much local brick is poor than standard bricks?

From this research one clearly observe that the brick strength the local brick that is only produced in traditional way has compressive strength of 50% standard bricks such as Burayu Brick and water absorption rate of 65% from the standard. This will give someone the margin of safety may be for designers, to use local brick as it is they can double area of section members to get the required strength one option using available resource at hands this idea is supported by[12],[13].

How to improve is another question, major problem as identified in the research is water absorption, which may be due to firing temperature and less compaction effort.

Therefore, it needs a lot of investment on brick as far many buildings consume it and further research required.

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