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Experimental investigation compressive behaviour of strawbale bricks

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ABSTRACT

The strawbale house can be one of the best alternatives for the country like India where agriculture is still the main source of income. It is obvious that people want to live in eco-friendly houses making it as a part of environment and their life. The strawbale houses are effective in cost with high health value, aesthetic value, thermal performance, fire resistance, light weight and eco-friendly in nature. We can go with the various techniques of construction as load bearing strawbale construction or non-load bearing strawbale construction as per the circumstances. It can be one of the best alternatives for all kind of people for constructing an economic building with a sustainable material. This project gives in brief, the result of the compression strength, absorption test, impact test, hardness test on the strawbale bricks. This project includes the compression testing machine to determine the crushing strength and weighing machine to determine the weight of the bricks.

Keywords— *Strawbale, Eco-friendly house, High health and aesthetic value, Sustainable material*

1. INTRODUCTION

The advancement in the field of technology have influenced environment in utmost extend so everyone is worried about the environment and its tremendous impact in our life. It is necessary that people want to live in an eco-friendly house making it as a part of its life and environment. Straw bale house is one of the best alternatives for the country like India where agriculture is the main source of income. As architects and home owners look for innovative ways to help reduce the carbon footprint in the campaign against climate change, straw bale could become a new tool in the building industry.

This study strives to make an exhaustive review of straw bale performance in different climate and respective improvements from an energy efficiency perspective. The study concluded that at the time when the important of the building sustainably is widely accepted, it would seem imperative that the potential of building systems like this that use renewable resources, readily available and have low embodied energy is further study. Straw is a natural fiber which we get as a by-product from the agriculture. It is a plant structure between the root crown and the grain head which is composed of cellulose, hemi celluloses, lignin, sand and silica. It is being produced by the process of photosynthesis, a natural and a non-polluting process by solar energy. We can get this from wheat, rice, oats, hops, barley. Among this rice straw is the toughest one due to high silica content. It is an annually renewable agricultural residue which is being produce in ample amount in most of the countries. It is also considered as the waste product and is being wasted by burning or any other way which is having impact on the environment directly or indirectly.

Burning of straw leads to black cloud which causes serious chronic chest diseases and carbon evolved from and it affects the environmental quality. The world's largest straw producing countries like China, India and other agricultural countries have not been able to utilize it for productive work up till now. In India the straws may be used for the purpose of production of papers and for other purposes but they are not utilized properly and they are wasting it in an ample amount. Straw bales were first used by the settles of the sand hill region of Nebraska. They commenced this straw bale for building buildings, churches, schools, offices, and stores. Thus, they focus in the stability of the bale wall system, structural stability, plastering and moisture control. So, straw bale construction has been an alternative for the economic environment.

Straw is simply a bundle of straw which is arranged in square, rectangular or round shape attached with twins. Bale density varies according to the type of grains, its moisture level and the degree of compaction provided by the baler. Straw bale has an ultimate scope in India in which agriculture is the main source of income. As 46% of the total land (32, 87, 590sq.km) of India is agriculture land so out of total population 58.4% is solely depended upon agriculture as per 2010 study. According to the 1995 report from Department of Energy (DOE) House of straw adds that the construction cost of a structural straw bale wall is about one fourth that of comparably insulted conventional wall. Contemporary use of strawbale in construction has increased significantly in recent years. Example of strawbale buildings dating from the last 20 years can be formed in many countries around the world.

1.1 Advantages

(a) A high insulation value (R-30 or more)
(b) Recycling what is often considered a waste product.
(c) The materials are natural, bio- degradable and have a low embodied energy.
(d) The walls are thick and the bales are shapeable, which allows for the creation of window seat, benches, shelves and more.
(e) The results are beautiful.

1.2 Disadvantages

(a) The moisture susceptibility of the strawbale.
(b) Maintaining of the structure.
(c) Structural movement may suffer.
(d) Acceptance problems

2. TESTING OF THE STANDARD CLAY SOIL

2.1 Plastic Limit

The plastic limit (PL) is determined by rolling out a thread of fine portion of the soil on the flat and a non-porous surface. The procedure is defined in ASTM standard D 4318. If the soil is at the moisture content where its behavior is plastic will retain its shape down a very narrow diameter. The sample then be re-molded and the test is repeated. The plastic limit is defined as the moisture content where the thread breaks apart at a diameter of 3.2mm (about 1/8 inch). The soil is considered non plastic if the thread cannot be rolled out sown to 3.2mm at any moisture possible.

Calculation

Calculate the average of two water content and round the nearest whole number. This value is the Plastic limit (PL). Repeat the test if the difference between the two trial plastic limits is greater than the acceptable range for two results.

Sample 1

Water content = Weight of water / Weight of dry soil x 100
= 2/6 x 100
= 33.3%

Sample 2

Water content = 2/6 x 100
= 33.3%

Sample 3

Water content = 1/9 x100
= 11.1%

Average water content = 33.3 + 33.3 + 11.1 / 3
= 25.9%

Plasticity index = Liquid limit – Plastic limit
= 59.4 – 25.9
= 33.5%

Toughness index = I_p / I_f
= 33.5 / 6.67
= 5.02

2.2 Liquid Limit

The liquid limit is the moisture content at which the groove, formed by a standard tool into a sample of soil taken in the standard cup, closes for 10mm on being given 25 blows in a standard manner. The liquid limit also known as the upper plastic limit, is the water content at which soil changes from the liquid state to a plastic state. The liquid limit is significant to know the stress history and the general properties of the soil met with construction. Form the results of liquid limit, the compression index may be estimated. The compression index value will help us in settlement analysis.

When water is added to dry soil, it changes its state of consistency from hard to soft. If we add water to a fine grained soil, the water will change its consistency from hard to semi-hard. Liquid limit states that "It is the minimum water content at which the soil is still in the liquid state, but has a small shearing strength against flow". If the natural moisture content of the soil is closer to the liquid limit, the soil can be considered as soft. If the moisture content is less than the liquid limit, the soil can be considered as brittle and stiffer. As it is difficult to get exactly 25 blows in a test, 3 to 4 tests are conducted and the number of blows required in each test is determined.

Liquid limit (LL): the water content, in percent, of a soil at the arbitrarily defined boundary between the semi-liquid and plastic state. A semi-log plot is then drawn between log N and water content W. The liquid limit is the water content corresponding to N = 25, as obtained from the plot.

Calculation

Plot the relationship between the water content (on Y axis) and the number of blows (on X axis) on semi-log graph. The curve obtained is called the flow curve. The moisture content corresponding to 25 drops (blows) as read from the represent liquid limit. It is usually expressed to the nearest whole number.

Flow index (I_f) = $W_2 – W_1/\log10(N_1/N_2)$
= Slope of the flow curve.
W_1 = 36
W_2 = 38
N_1 = 28
N_2 = 56

$I_f = W_1–W_2/\log_{10}(N_2/N_1)$
= 36-38 / $\log_{10}$(56/28)
= 6.67

Trail 1

Water content = Weight of water / Weight of dry soil x 100
= 1/3 x 100
= 33.3%

Trail 2

Water content = 3/4 x 100 = 75%

Trail 3

Water content = 7/10 x 100 = 70%

Average liquid limit = 33.3 + 75 + 70 / 3 = 59.4%

2.3 Site selection

For the manufacturing of the strawbale bricks the site should be selected based on some important considerations such as,

- The ground should be of plain surface.
- The site should be connected with communicating roads for transporting materials etc.
- Good brick earth should be easily available.
- The site should offer all facilities to the workers.

Hence that Villiabakkam is been selected.

Fig. 1: Site Location

Preparation of clay for strawbale brick manufacturing is done in six basic steps:

- Un-soiling of clay: We need a pure clay material for the brick manufacturing. The top layer of the soil may contain impurities, so the clay in the top layer of soil is about nearly 200mm depth is thrown away. This is known as unsoiling.
- Digging: After the removal of top layer the clay is dug out from the ground and spread on the plain surface.
- Cleaning: In this stage, the clay is cleaned of stones or any other vegetable matter etc. If large quantity of vegetable matter is present, then the clay should be washed thoroughly and screened.
- Weathering: The cleaned clay is exposed to the atmosphere for softening. The period of weathering may be of 3 to 4 weeks. Basically, the clay should be dug out before raining season for larger projects.
- Blending: If we want to add any ingredients to the clay, it is to be added in this stage by making the clay loose and may spread the ingredients over it. At last take small portion of the clay into the hands and turning it up and down in the vertical direction. This process is known as the blending of clay.
- Tempering: In this stage, the water is added to the clay and mixed. The pressing will be done by cattle or with the feet of the men for small scale projects.

Fig. 2: Preparation of clay

2.4 Addition of Strawbale

Thus, finally after finishing the preparation of the clay process the addition of strawbale is proceeded. By adding straw bale to the clay material, the clay thus gets stitched with the straw bale producing a consistency texture. The straw bale is added to the clay in replacement of silica content. The silica is added to the clay to get a proper consistency of the mixture. The straw bales are used here in replacement of the silica. The silica is added to about 50 to 60 percentage in the normal sandcrete bricks. The same ratio is followed in the strawbale bricks. Thus, the strawbales are added to the clay in replacement of the silica content in the manufacturing of the straw bale bricks.

Fig. 3: Addition of strawbale

2.5 Molding of the Clay

In the mold process, prepared clay is mold into brick shape (generally rectangular). This process can be done in two ways according to scale of project. They are of two types:

(a) Hand molding (for small scale)
(b) Machine molding (large scale)

For hand moulding the tempered clay is forced in the mould in such a way that it fills all the corners of the mould. Thus the extra clay may be removed by using wooden strike or the frames with the wires. At last, the mould can be lifted up and the raw bricks are left on the ground itself. For machine moulding it is used where large number of bricks is to be made up. The machines used for moulding of bricks are of two types. They are dry clay machines, plastic clay machines. The prepared quantity of clay and the strawbales are mixed and they are molded in the mould of size 19x9x9 cm.

2.6 Drying process

After molding processes, the strawbale bricks contain some amount of moisture content in it. Thus, drying of the strawbale bricks is necessary otherwise cracks may be formed while burning. Thus, the drying of strawbale bricks is made up by natural process. The brick is laid in the stacks. A stack may consist of 8 to 15 stairs. The bricks in these stalks should be arranged in such a way that circulation of air in between the bricks may feel free. The period of drying may be 3 to 10 days. It may also depend upon the weather conditions. The drying yards are also prepared on the higher level than the normal ground for the prevention of bricks from rain water. In some situations, the artificial drying is also adopted under special dryers or hot gases.

Drying is usually done by placing of the bricks in sheds with the open sides so that it can ensure the free circulation of the air protection from the bad weather and from the rains. The drying of bricks is allowed for the period of 5 to 7 percent moisture content. The time period for drying of bricks may vary from 7 to 14 days. If the damp bricks or the green bricks are directly taken to burning process they are said to be cracked and they are distorted. To increase the strength of the raw bricks that they can be handled and stacked in greater heights in the kiln for burning without any damages. To remove the excess moisture from the brick and to save time and fuel during burning process.

Fig. 4: Drying of Bricks

2.7 Burning of Bricks

In this kind of process of burning, the dried bricks are burned either in the clams (small scale) or kilns (large scale) up to a certain degree or temperature. In this manufacturing of strawbale bricks C has been used as the temperature. In this stage, the straw bale bricks will gain hardness and strength so it is important stage in the manufacturing of the straw bale bricks. The temperature required should be less than that of the normal bricks. The normal sandcrete brick requires to C for manufacturing. If the temperature exceeds the limit, the straw bale bricks may be brittle and they are easy to break. If they are burnt under the limit, they will not gain full strength and allow the chances to absorb moisture content from the atmosphere. Hence burning should be done properly to meet the requirements of the good straw bale bricks.

3. TEST ON BRICKS

3.1 Tests for strawbale bricks

Since the bricks are made from variable naturally occurring materials, the care should be carried out for the importance on the test results obtained on a single sample. For test results to be meaningful and useful in the evaluation of the materials properties the tests have to be carried out according to the prescribed methods and even more importantly the samples have to be representing the materials to be tested. The following are the testes to be carried out for the straw bale bricks:

(a) Compression strength
(b) Water absorption test
(c) Impact test
(d) Soundness test
(e) Size and shape test
(f) Efflorescence test
(g) Hardness test

Fig. 5: Compression Test

3.1.1 Compression test: The compression test on the strawbale bricks shall not exceed in the compression test for the appropriate class of bricks. The compressive strength on bricks IS carried out to determine the load carrying capacity of the bricks under compression. The test can be conducted by using the compression testing machine. Thus, it is important to know the compressive strength of the bricks to check for its suitability for construction of buildings.

Calculation: Note the load at which the brick fails. This load (P) is divided by the cross-sectional area (A) of the brick gives the compressive strength (C_o)

Crushing strength= Load applied on the brick/ Area of the brick

$$C_o = P/A = 114 \times 10^3 / (190 \times 90)$$
$$= 6.67 \text{ N/ mm}^2$$

The arithmetic mean of the compressive strength of the bricks shall be taken as the compressive strength of that lot bricks represented by the test samples. The brick shall be classified accordingly on the basis of the crushing strength obtained. The compressive strength of the first-class brick is 10.5 N/mm^2 The compressive strength of the 2nd class brick is 7 N/mm^2

The compressive strength of the common building brick is 3.5 N/mm^2

Result: Thus the compressive strength for the straw bale brick is 6.67 N/mm^2 .

3.1.2 Water absorption test: Water absorption test on bricks are conducted to determined durability property of bricks such as the degree of burning, quality, and behavior of bricks in weathering. A brick with water absorption of less than 7% provides better resistance to damage by freezing. The degree of compactness of bricks can be obtained by water absorption test as water may be absorbed by pores in bricks. The water absorption by bricks increase with increase in pores. So, the bricks which have water absorption less than 3 percent can be as vitrified.

Fig. 6: Water Absorption test

Procedure:

- Take three whole bricks randomly.
- Dry these samples to a constant weight by placing it in a ventilated oven at
- C C. his make hours or more time.
- After cooling these specimens are weighed individually.
- The dry and the weighted samples are then immersed in the water at room temperature for at least 24 hours.
- After 24 hours the specimens are taken out.
- Each sample is wiped dry and then weighed individually within three minutes after it is taken out from the water.

Calculation: Absorption value is calculated by the simple relationship.

Absorption percentage = $W_2 – W_1 / W_1 \times 100$ where,

W_1 =1.897kg (Dry weight of the sample)

W_2 =1.687kg (Wet weight of the sample)

$$= 1.897 – 1.687/ 1.687 \times 100$$
$$= 12.5\%$$

The average of three values for the three samples shall be taken as the water absorption of the brick. It shall be within the specified limits for the classification of the bricks.

Result: Water absorption of the straw bale brick is 12.5%.

3.1.3 Impact test: In this test, few bricks are dropped from 1m height.

- If bricks are broken, it indicates low impact value and acceptable for construction work.
- Good quality bricks do not break at all.

Result: Hence the strawbale bricks were not broken when they are dropped from a height of 1m, thus it shows it is a good quality brick.

3.1.4 Hardness test: Hardness test is a simple test. A good brick will be more resistance to abrasion. Procedure

- A good brick should resist scratches against sharp things.
- For this test a sharp tool or finger nail or a one-rupee coin is used to make a scratch on the brick.
- If there may not occur any scratches impression on the bricks then it is said to be a hard brick.

Result: Hence the straw bale brick has not created any impression when it was scratched by a one-rupee coin.

3.1.5 Soundness test: Soundness test is a simple test. Soundness test of bricks shows the nature of bricks against sudden impact. Procedure

- In this test, the two bricks are taken and they are struck with each other.
- The bricks should not break and a clear ringing sound should be produced. Then it is said to be a good brick.

Result: Hence, the straw bale brick produces a clear metallic sound and does not break when the bricks are allowed to struck each other.

3.1.6 Shape and size test: Following procedure is followed to test the shaper and size of the brick.

- Shape and size of bricks are very important consideration. All the bricks used for construction should be of same size. The shape of the bricks should be purely rectangular with the sharp edges.
- Standard brick size consists of length x breadth x height as 19 x 9 x 9 cm.
- For performing this test, select 20 bricks randomly from brick group and stack them along its length, breadth, height and compare. So, if all the bricks similar size then they are qualified for construction work.

Result: Thus, the straw bale brick consists of standard size of 19 x 9 x 9 cm and they are purely rectangular.

3.1.7 Color test: A good brick should possess a bright and a uniform color throughout its body.

Result: Thus, the straw bale brick produces a clear, bright and uniform color.

4. CONCLUSION

The optimized model of the expected strawbale brick has been finalized in this project report. The process has been supplemented by a model to get a clear idea about the structural stability of a strawbale brick. The test on bricks have been taken into very serious consideration as they form the basis of working on this project as a result of methodology followed has been formulated accordingly. It mainly depends on the compression test on bricks, which forms the most fundamental elements of the study. By this project, we conclude that this may be very extensive such that a brick used in this project were found to be very useful in ready using the effort of strawbale and thus providing stability and reliability to the building structures.

5. REFERENCES

[1] Bruce king, "Load bearing strawbale construction" – A short review of plastered strawbale structures published on 25th October 2015.
[2] B.C. Punmia and Ashok kumar Jain, "Building construction", Eleventh edition published by Laxmi Publications Pvt Ltd.
[3] Larisa Brojan, Alija Petric, "A comparative study of bricks and strawbale wall systems form environmental, economic and energy perspectives" published on August 1990.
[4] Monika Shekar Gupta, "Strawbale construction a revolutionary building material in low cost housing for rural areas" published on December 2013.
[5] Pragyanbhattaraj, "Strawbale in construction building and its future in India" published on January 2015.
[6] IS: 2720- Part 5-1985 - Indian Standard Code of practice for Determination of Liquid and Plastic limit (Second revision)
[7] IS1077-1992 - Common Burnt Clay Building Bricks-Specification
[8] IS3495-Part 1 to 4-1992 - Methods of tests of clay building bricks

