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A Study on Soil Cement Bricks with Addition of Thatch

Sanjaya Lamichhane[1*],Arjun Baniya[2]

[1] *Department of Civil Engineering Pokhara Engineering College, Pokhara, Nepal*

[2] *Associate Professor, Department of Civil Engineering, Pokhara Engineering College, Pokhara, Nepal*

**Corresponding email:* ersanzaylc@gmail.com

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Abstract
This study investigates the effects of thatch content on the characteristics of soil-cement bricks, offering valuable insights into thatch's potential application as an alternative to binder. Compressive strength, water absorption and cost analysis are the three primary research areas. The favorable effect of thatch as a binder on brick strength is demonstrated by the results, which indicate a considerable increase in compressive strength as thatch content rises in the 0-1% range. According to the Nepal National Building Code (NBC 109: 1994), hand-made bricks may absorb up to 25% of the total weight, but the average water absorption for all percentage mixes is still 23% overall, indicating the possibility of improved water resistance. A cost study further validates the economic viability of the soil-cement bricks, with production costs ranging from NRs 13 to 14, suggesting potential profitability for manufacturers. Collectively, our findings show the feasibility and advantages of use thatch as an alternative binder in the production of soil-cement bricks, offering the construction industry a cost-effective and sustainable choice.

Keywords: Soil- cement bricks, thatch, compressive strength, water absorption, cost

1. Introduction

Traditional rise residential construction often relies on clay bricks, which have been used as a building material since ancient times. Interestingly 30% of the population still resides in structures made from these bricks. This enduring popularity is due, to their simplicity, affordability, insulation for heat and sound, practicality and long lifespan(Al-Ajmi *et al.*, 2016). Moreover, clay can be returned to the earth without harming the environment. However, the conventional method of manufacturing bricks involves energy kiln firing processes that result in harmful pollutants being released into the atmosphere(Quezon *et al.*, 2017). In years there has been a growing demand for eco sustainable brick making techniques. One such alternative technique involves using a mixture of soil, cement, sand and thatch without any burning involved. The resulting bricks produced through this method are not of quality but also durable and environmentally friendly. Cement and sand act as binding agents while red soil provides the clay content for brick production. Additionally, incorporating materials, like thatch, straw or rice husk as reinforcement enhances the integrity of these bricks. Mud bricks, made from fibers like straw, have been strengthened since ancient times for their tensile strength and compressive strength. Fibers prevent deformation, protect surfaces, and improve elasticity. As fibers increase, their distribution becomes random, enhancing tensile strength and adaptability(Binici, Aksogan and Shah, 2005). Compressed earth blocks, also known as compressed soil blocks, are building materials made from damp soil compressed at high pressure. It uses local resources, consumes less energy, emits fewer greenhouse gases, and offers better thermal insulation. However, its strength and mechanical properties are not widely used('Final Report On The Study on Characteristics of Compressed Stabilized Earth Blocks (CSEB) using Chemical Stabilizer', no date).They are energy-efficient, environmentally friendly, and safe, making them a crucial component in reducing global energy consumption. These blocks can be stabilized with Portland cement, making them a popular choice for construction. Compressed Stabilized Earth Blocks (CSEB) offer benefits like local resource use, reduced transportation costs, high-quality housing accessibility, and local economic activity. They require less skilled labor, have good strength, insulation, and thermal properties, and produce low energy and carbon emission(BhaskaranPP and MohanKP, no date). Earth's short lifespan due to weak compressive strength is a disadvantage. Stabilization can improve soil's strength, dimensional stability, and durability for construction. To make bricks we mix red soil, cement, sand and thatch together. Press the mixture into brick shaped molds. Afterwards we let the bricks dry naturally in the sun of using a kiln. This process significantly reduces energy consumption and harmful emissions.

In order to meet Pokhara's housing needs and develop its infrastructure, brick production is essential. However, the traditional brick-making method, which involves burning, uses a lot of energy, contributes to air pollution, and raises environmental issues. To achieve sustainable and environmentally friendly construction methods, it is urgently necessary to fix the ratios of red soil, cement, sand, and thatch for low-cost brick production in Pokhara without the use of burning techniques. This research aims to identify the proper ratios of red soil, cement, sand, and thatch for low-cost brick production in Pokhara without burning. This will ensure the production of low-cost bricks that adhere to quality and strength standards. The Specific objectives of this research is to examine the physical properties and cost of soil cement bricks with addition of thatch.

(Binici, Aksogan and Shah, 2005)Investigated the mechanical characteristics of fibrous waste materials using stabilizers. The greatest increase in compressive strength was provided by plastic fibers (19% over straw and 36% over fabric made of polystyrene). The suggested combination complied with the minimum compressive strength standards of the Turkish Standard and ASTM. The results show promise for using waste materials in buildings. (Patowary *et al.*, 2015)The goal of the study was to identify the best soil for making CSSBs, or compressed stabilized sand bricks. The engineering features of CSSBs, such as compressive strength, durability, and water absorption, were studied in various stabilized materials, such as cement, coir, lime, fly ash, and chemicals. According to the study, stabilizing soil up to a certain amount improves its technical characteristics, producing a finished product that is more durable than conventional burnt clay brick. Although Black Cotton Soil did not meet the requirements for water absorption, it was discovered to have a favorable density index for the production of CSSB. The soil showed potential as a CSSB-appropriate material because its compressive strength was higher than that of a typical brick. (Jangid and Darade, 2017)The eco-friendly and non-burned CSEBs were the subject of the researchers' research. As a result, during manufacture, no hazardous gases are produced. This paper displays the test results for the soil that was used to produce CSEB. In the laboratory, highly compressed unburnt blocks with various compositions and varying ratios of sand (70%) to clay (20%) and stabilizers like cement (10%) had a compressive strength of 3.11 N/mm2, compared to standard fired brick's 3.984 N/mm2. However, these blocks are more cost-effective because they don't require burning. (Dawood *et al.*, 2021)In this project, clay was combined with natural fibers, sand, and cement to make eco-friendly, unfired bricks. The intention was to lessen shrinkage-related cracking and boost the brick's tensile strength. The resulting bricks, mortar, and masonry were tested for compressive and flexural strengths, and the behavior of unfired and fired clay brick prisms was compared. The results show that the maximum compressive strength for unfired masonry prisms was created by a mixture of clay, coarse sand, and straw, while the highest flexural strength for bricks was produced by a mixture of clay and sawdust. The compressive strength of the brick and mortar was also used to create a formula for determining the compressive strength of unfired brick masonry. Overall, the study sheds light on the potential of eco-friendly and non-fired bricks as a sustainable building material. (Muhammad Sajid Rehman, Masrur Momen, 2018) offers a thorough investigation into the compressive strength of several compressed stabilized earth block kinds. Nine different types of mixtures were used to prepare 101 compressed earth block specimens. As a soil stabilizer, cement was employed in each of them. Using universal testing equipment, prepared mixes were compressed under a 20-ton load. The goal was to examine the impacts of admixture addition and the water-cement ratio. A test of compressive strength was conducted after 7, 28, 60, and 90 days. For several sample types, the compressive strength test findings weren't what was anticipated; they revealed a drop in compressive strength 28- or 60-days following sample preparation. (Salah and Din, 2020)Earth is a popular building material in impoverished nations, but its receptivity to water can negatively impact its strength. Cement, lime, fly ash, and other stabilizers are used to make earthen constructions weather-resistant. This study aimed to determine the 28-day compressive strength of a locally accessible cement-based soil stabilizer reinforced with bale straw. The soil sample from Zangali, Khyber Pakhtoon Khwa, was stabilized using 10% cement and 1% straw bale. The cement content was maintained at 10% in all samples. Exams showed that using 10% stabilizer and 1% straw bale resulted in a decline in compressive strength, while adding additional straw bale increased it. (‘Final Report On The Study on Characteristics of Compressed Stabilized Earth Blocks (CSEB) using Chemical Stabilizer’, no date)This study investigated the structural features of compressed stabilized earth block (CSEB) masonry by performing compressive and shears strength tests on soil samples from five distinct locations. The compressive strength of CSEB brickwork in cement mortar was found to be satisfactory and promising on all sites. The compressive and shear strengths of masonry were heavily impacted by the mortar and CSEB component strengths. The study sheds light on the structural properties of CSEB masonry as well as soil variations in various areas, which can aid in the creation of sustainable and cost-effective housing options. Nawalparasi has the highest 28-day compressive strength of 16.71 N/mm2 and the highest CSEB masonry compressive strength of 4 N/mm2. Surya Binyak had a shear strength of 1.16 N/mm2, whereas Chovar had a maximum compressive strength of 4.15 N/mm2. These results show how useful CSEB may be as a sustainable building.

This study does have limitations; that is, mixing of varying percentages of red soil, cement, sand, thatch where bricks were tested not more than 28 days strength which did not involve efflorescence test, Durability test, weathering test

2. Materials and Methods

2.1 Material

The material used in this study include locally available red soil, cement, sand, thatch and water.

2.1.1 Red Soil

Locally Available red soil which is rich in iron oxide was extracted from pokhara metropolitan city at a depth of 30 cm, crushed and dried in sun. Its properties, including particle size distribution, plasticity, and mineral composition, affect workability and strength. The tests done for red soil are given below('Field Tests on Soil To Determine Suitability of Soil for Brick', 2022);Sedimentation Test, moisture content (IS:2720 (Part 2)-1973, 1973),Liquid Limit (IS: 2720 (part 5):1985, 1985),Plastic Limit, Particle size distribution (IS : 2720 (Part 4 - 1985), 1985), textural classification of soils (Any *et al.*, no date)

2.1.2 Cement

Standard OPC cement of 43 and 53 grade is used for all type of mixes. The physical properties of the cement at room temperature 27^0c used are given in. The test performed for the cement were fineness test, consistency test, setting time test accordance to (IS: 1727, 2013).

2.1.3 Sand

Sand is a fine aggregate that is often added to the mixture of red soil and cement to improve the overall quality of the bricks. Sand helps reduce shrinkage during the drying process and enhances the workability of the mixture. It also contributes to better compaction and minimizes cracking as the bricks cure. The addition of sand helps achieves a smoother and more uniform texture on the brick's surface. There are different methods for testing the quality of sand at the construction site for the manufacture of unburnt bricks. Among various tests, we conducted a silt content test (IS 2386- Part III, 1963) and Bulking of Sand (IS 2386- Part III, 1963).

2.1.4 Thatch

Thatch is a natural material used in unburned bricks, enhancing structural integrity, reducing cracking and increasing durability by binding and strengthening the mixture. It is typically made from dried plant fibers like straw, reeds, grasses, or palm leaves. Firstly, we collected thatch from the study area. After collection, it is cleaned, chopped, and sun-dried for two days. The Size of thatch varies from 10mm to 20mm and the width from 2mm to 5mm.

2.1.5 Water

Normal water available is used in this experiment.

2.2 Preparation of Specimens

2.2.1 Material Selection and Proportions:

Soil mix design is the process of determining the proper ratios of soil, cement, sand and thatch for unburnt Bricks to produce desired strength in constructions. Soil Mix = Soil: Cement: Sand: Thatch can be used to describe the design of a Soil mix. Based on previous studies, we determine the proper mix proportions, which numerous procedures, mathematics, and laboratory testing. The specific ratios may vary depending on factors such as type of soil, use of brick and location condition.

2.2.2 Mixing the Dry Ingredients:

Consulting with brick manufacturers, contractors, engineers, clients, geologists etc. we found dry weight of fried brick approximately ranging from 2.8kg-3.2kg. On basis of traditional manufacturing process of fried bricks, approximate weight is taken base for producing unburnt bricks.Red soil is first extracted at a depth of 30 cm, devoid of any organic materials, debris, or large stones. The soil is then left outside to dry in the sun, removing any moisture or other impurities. Then soil passing from IS sieve 1.18mm is considered for manufacturing. Fine sand (Passing from IS sieve 1.18mm) from neighbouring rivers will be gathered. Ordinary Portland Cement from nearby market was collected. Add chopped or shredded thatch that has been sun-dried. Use the trial-and-error method to mix the proportions in a specific ratio. Gradually add water to the mixture while continuously mixing. Start with a moderate amount of water and adjust as needed to achieve the desired workability and consistency. The different mixtures are placed in brick mould as per Nepal National Building Code on required sizes given on table below(Mahal and Kathmandu, 2070). During a process, the mould is compacted (either manually or mechanically) to eliminate air pockets and ensure proper shape. In this experiment the mixture is placed under universal testing machine (UTM). A compressive load of 25kN is applied at uniform rate. After it has been compacted, it is extracted out from UTM and covering them with plastic to stop them from drying out too quickly. The bricks should next be air-dried for 7 to 14 days exposed to direct sunshine. Test the physical properties of brick.

Figure 1: Sample weighting and Hand mixing

Fig 2: Mould Design **Fig 3:** Calculating percentage of samples

Figure 4: Placement of mixture in mould

2.2.3 Mixing Design

The mixing process was carried out on an iron plate with a trowel and shovel. The materials used in the mixing process were weighted using a high-precision electronic measuring balance. The weight of materials to be added is obtained from the trial-and-error method. By taking different samples from various brick factories such as Machhapuchre Brick factory,Jamune Bhanjyang.tanahu, Gorkha chyangling bricks, Gorkha district,) Pokhareli brick factory,Jamune Bhanjyang,tanahu, Pokhara Eco Red Bricks, Polyang, Kaski (PERP). The weight of more than 50 samples before burning from the different factories was found to be in the range of 2.5kg-2.9kg. Taking reference to this data, we tried to take a minimum range of weight due to including ingredients such as red soil, cement, sand, and thatch in our product. The proportion of red soil, Cement, Sand, Thatch, and Water is tabulated below on basis of previous literature reviews. Based on our observation the total weight of soil was 2.5kg per sample. our product consisted (85%, 80%, and 75%) of red soil, 10% cement, various percentages of Sand given in design mix and (0%, 0.25%, 0.50%, 0.75%, 1%) thatch, where cement, sand, thatch, and water ratio were identified on basis of red soil percentage.

Figure 5: Placing mould in UTM

Table 1: Mix Design (Group A)

S.N	Soil	Cement	Sand	Thatch	Water	Remarks
1.	75 %	10%	15%	0%	28%	A1
2.	75 %	10%	14.75%	0.25%	28%	A2
3.	75 %	10%	14.50%	0.50%	28%	A3
4.	75 %	10%	14.25%	0.75%	28%	A4
5.	75 %	10%	14%	1.00%	28%	A5

Table 2: Mix Design (Group B)

S.N	Soil	Cement	Sand	Thatch	Water	Remarks
1.	80 %	10%	10%	0%	28%	B1
2.	80 %	10%	9.75%	0.25%	28%	B2
3.	80 %	10%	9.50%	0.50%	28%	B3

4.	80 %	10%	9.25%	0.75%	28%	B4
5.	80 %	10%	9%	1.00%	28%	B5

Table 3: Mix Design (Group C)

S.N	Soil	Cement	Sand	Thatch	Water	Remarks
1.	85 %	10%	5%	0%	28%	C1
2.	85 %	10%	4.75%	0.25%	28%	C2
3.	85 %	10%	4.50%	0.50%	28%	C3
4.	85 %	10%	4.25%	0.75%	28%	C4
5.	85 %	10%	4.00%	1.00%	28%	C5

2.3 Test on Physical properties.

The physical properties of bricks are essential factors that determine their suitability for various construction applications. These properties play a crucial role in ensuring the strength, durability, and overall performance of brick structures. Here are some important physical properties of bricks.

2.3.1 Shape and Size Test

In this test a specimen brick should be closely inspected. It should be of standard size (Mahal and Kathmandu, 2070)and its shape should be truly rectangular with sharp edges. The standard brick size of 230 x 115 x 57 mm with 10 mm thick horizontal and vertical mortar joints is preferable. Tolerances of -10 mm on length, -5 mm on width and ±3 mm on thickness shall be acceptable for the purpose of thick walls according to NBC 205:MRT RCC without masonry infill.

2.3.2 Hardness Test

This test is conducted by making a scratch on brick surface with the help of finger nail. If no impression is left on the surface; the brick is treated to be sufficiently hard

2.3.3 Water Absorption Test.

For ordinary burnt clay bricks, there are two procedures to measure the water absorption percentage by mass as per the five-hour boiling water test and the 24-hour immersion cold water test. These are each mentioned below(of Indian Standards, no date).

3. Results and Discussions.

This research aims to create sustainable, environmentally friendly earth bricks for construction and disaster reconstruction. It examines the effectiveness of red soil with cement, sand, and thatch. The soil identification test determines the appropriateness of creating compressed earth bricks. The behaviour of soil stabilized with cement is studied using different ratios of red soil, sand, and thatch to know the Physical characteristics of stabilized earthen bricks. This page presents test specimen images and compares the physical characteristics of stabilized soil bricks. Based on these tests and field observations, construction guidelines for stabilized bricks are suggested for low-cost housing in Pokhara along with graphs and charts for visual representation.

3.1 Sedimentation Test.

After collecting soil samples, we determine the proportion of clay, silt, and sand in terms of percentage which is tabulated below:

Table 4: Observation Table of Sedimentation Test

Description	Unit	Container No.		
		1	2	3
Height of Clay (H1)	mm	23.33	15	22
Height of Silt (H2)	mm	7.66	10	12
Height of Sand (H3)	mm	49.01	53	56
Height of Soil (H)	mm	80.00	78	90
Percentage of Clay	%	29.16	19.23	24.44
Percentage of Silt	%	9.58	12.82	13.33
Percentage of Sand	%	61.26	67.97	62.22

3.2 Atterbgs limit of soil sample

For the classification of soil Atterberg limit test was performed. Moisture content, Plastic limit test, Liquid limit, and Plasticity Index test were performed. These tests are performed using an air-dried powder soil sample. After testing several times, the moisture content, plastic limit, liquid limit, and plasticity index of the soil sample were found to be 17.60%, 34.42%, 28.93% and 16.81% respectively.

3.3 Textural Classification of Soil

From sedimentation tests, the percentage of clay, silt, and sand were found to be 30%, 10%, and 60%. These values are located on the triangular chart of the textural soil classification system. The soil samples were sandy loam which was suitable for making bricks

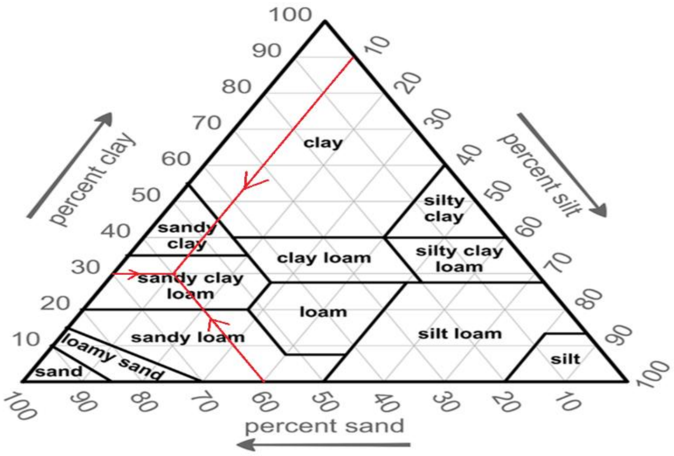
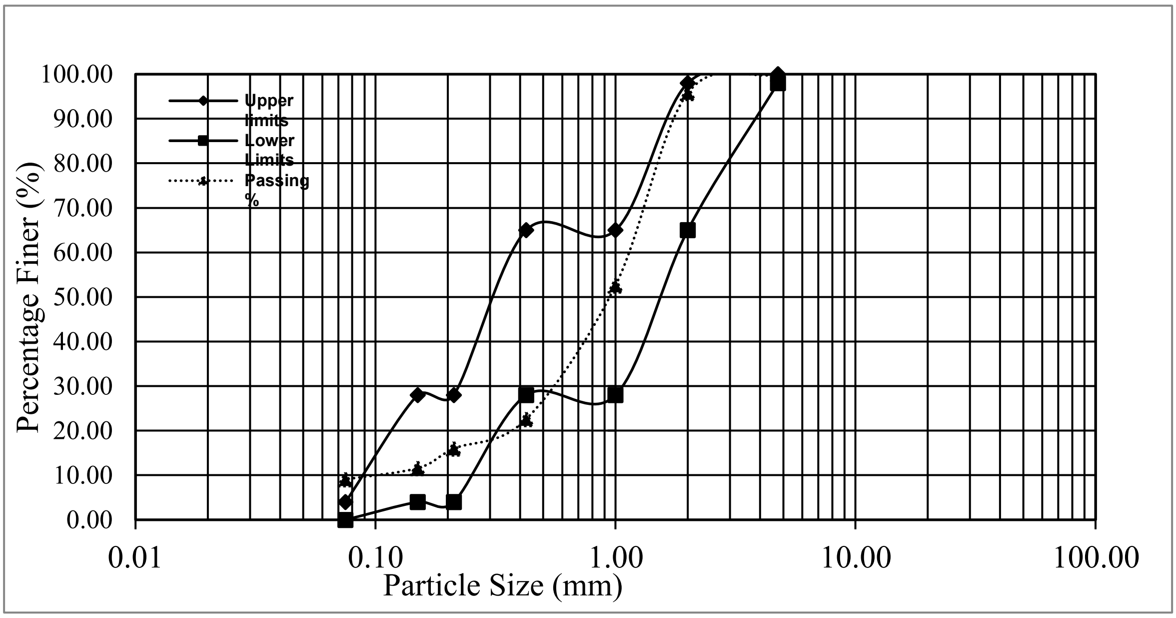


Figure 6: Textural Classification of Soil

3.4 Particle size distribution system.

As the soil is basically sandy loam-type soil, sieve analysis was performed to determine the properties of soil samples. The soil samples taken were oven dried which was sieved using listed sieve sizes.



Percentage of Gravel =>4.75 mm, Percentage of coarse Sand = 4.75mm -2.00 mm, Percentage of medium Sand = 2.00 mm – 0.425mm, Percentage of Fine Sand =0.425 mm – 0.075 mm, Percentage of Silt-Clay fraction = <0.075mm

3.5 Cement Test

The quantity of cement that was used for making bricks were tested and result obtained was 32 percent consistency, 3 percent fineness, 135 minutes initial setting time and 387 minutes final setting time.

3.6 Silt content test.

The silt content present in sand were tested according to relevant code where three samples were taken and clay lumps on sand was found to be 13.12 percent on sand.

3.7 Bulking of sand.

The Bulking of sand was tested according to relevant code where three samples was placed in beaker and average was found to be 54.46 percent.

3.8 Shape and size test of brick

The manufactured brick was closely inspected which was rectangular with sharp edges whose standard size was measured and tabulated below.

Table 5: Observation Table for shape and size test (Group A)

Brick Class	A1	A2	A3	A4	A5	Standard Size (as per NBC)
Length	230	230	230	230	230	230
Breadth	115	115	115	115	115	115
Height	57	55	65	60	55	57

Table 6: Observation Table for shape and size test (Group B)

Brick Class	B1	B2	B3	B4	B5	Standard Size (as per NBC)
Length	230	230	230	230	230	230
Breadth	115	115	115	115	115	115
Height	57	55	65	60	55	57

Table 7: Observation Table for shape and size test (Group C)

Brick Class	C1	C2	C3	C4	C5	Standard Size (as per NBC)
Length	230	230	230	230	230	230
Breadth	115	115	115	115	115	115
Height	57	55	65	60	55	57

*Note: All size is in mm

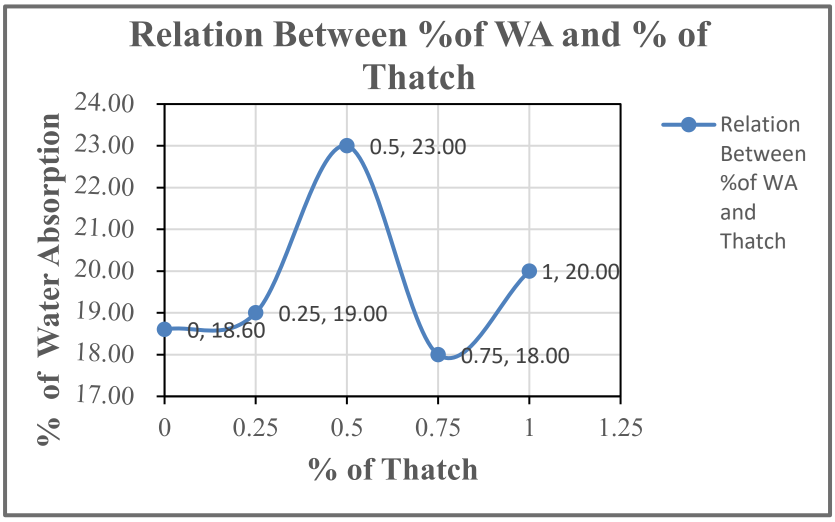
Figure 7: Sample of brick

3.9 Hardness test

The manufactured brick was tested for hardness and no scratched or impression was left on the surface Which treats brick as sufficiently hard.

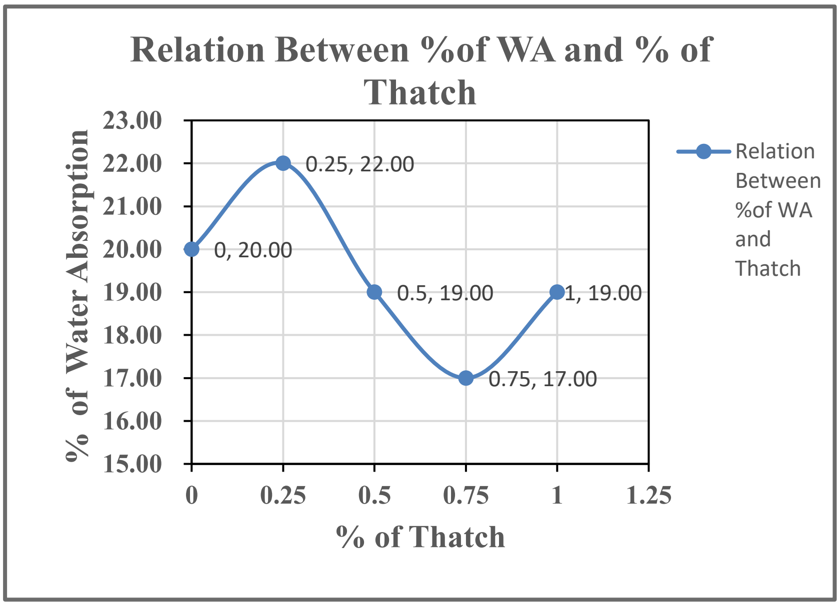
3.10 Water Absorption Test

If the water absorption capacity of a brick is more its strength will be comparably low for first class brick, the water absorption capacity should not be more than 20% by weight. However, a brick shall not absorb more water than 15 % of its weight after 24 hours of soaking in water at normal temperatures. However, hand-made bricks may have water absorption up to 25 % of their weight according to Nepal national Building code NBC 109: 1994. A triplicate brick samples of each group were tested for water absorption where water absorption varies with percent of thatch on different mixes presented in graph below: The figure below shows that changing percentage of soil (75,80,85) % on different thatch ratios varies water absorption and average tested value was found to be 23 percentages as required to mentioned code.



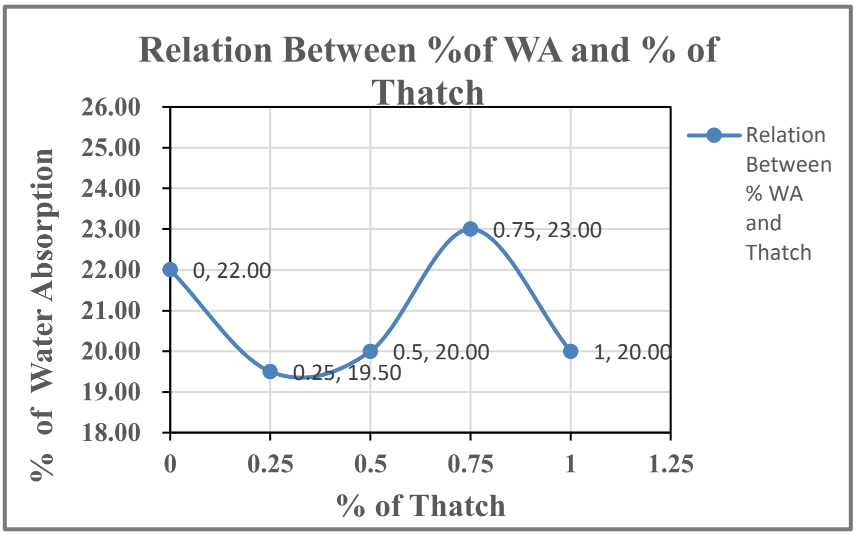
% Of Thatch	% Of WA
0	18.6
0.25	19
0.50	23
0.75	18
1	20

Figure 8: Soil (75) and Thatch (0, 0.25, 0.50, 0.75) **Percentage**



% Of Thatch	% Of WA
0	20
0.25	22
0.50	19
0.75	17
1	19

Figure 9: Soil (80) and Thatch (0, 0.25, 0.50, 0.75 and 1) Percentage



% Of Thatch	% Of WA
0	22
0.25	19.5
0.50	20
0.75	23
1	20

Figure 10: Soil (85) and Thatch (0, 0.25, 0.50, 0.75 and 1) Percentage

4. Compressive Strength Test

Compressive strength is the ability of a material to resist compressive loading. It is an important property of brick, as bricks are often used in load-bearing structures. It's an important factor to consider when choosing bricks for a project. The required compressive strength of the bricks will depend on the type of structure being built and the load that the bricks will be subjected to. Different brick samples of each group were tested for compressive strength which is presented in the graph below.

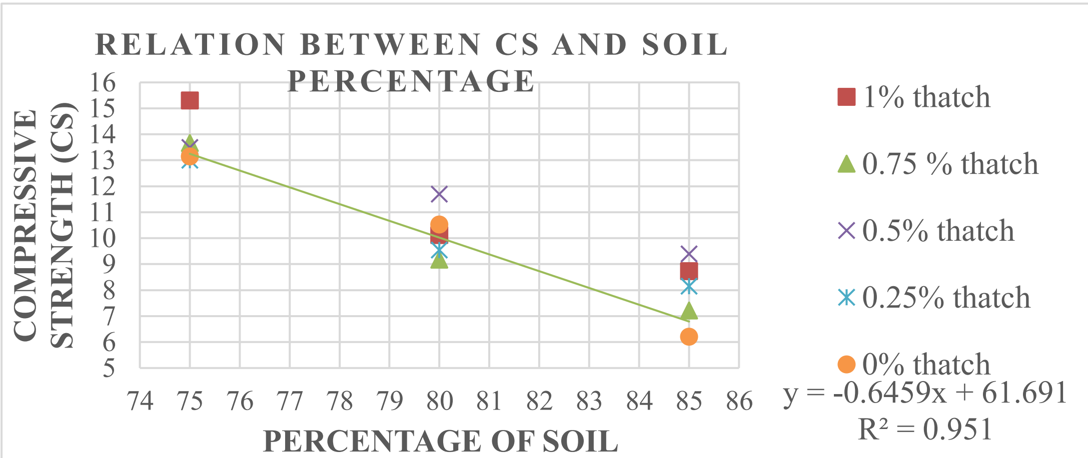


Figure 11: Relation between CS and Soil Percentage

Figure 12: Compressive strength Test

From figure 5, as a percentage of soil decreases and sand changes with respect with constant cement and water ratio relative to changes in thatch ratio increases compressive strength. All range of tested values on various percentage of soil with addition of thatch from zero to one percentage show a non-significant relation on various samples.

5. Cost Analysis

Another element that we considered is cost analysis, since manufacturers are always concerned with profit. Here, we examined the cost for typical unburnt bricks, so that we could get a clear number of how much each brick costs. The rate analysis of soil cement bricks are done according to different manuals and codes('KASKI-DISTRICT-RATES-2080-81.pdf', no date). The following table presents the rate analysis of brick manufacturing process(Darshan Shrestha, 2012) of 1000 brick per day production.

Table 8: Rate analysis for unburnt bricks with 75% soil

S. N	MATERIAL	QUANTITY	UNIT	RATE	AMOUNT
A.	**Material**				
1	Red Soil	1.31	cum	614.00	805.88
2	Cement (OPC)	3.78	bag	697.50	2636.55
3	Sand	0.20	cum	2425.50	477.52
4	Thatch	1	Mutha	234.28	234.28
5	water charge	367.5	lit	0.25	91.88
		Sub Total (A)			**4246.10**
B.	**Labour charge**				
6	Skilled	3	M/day	1214	3642.00
7	Unskilled	5	M/day	852	4260.00
		Sub Total (B)			**7902.00**
C.	**Equipment/ Miscellaneous**	**Per year**		**Total Cost**	**Cost/Day**
8	Investment Cost (Interest on fixed deposit)	12	%	308000	101.26
9	Equipment Depreciation (Press Lifespan)	19.6	%	1000000	536.99
10	Building Depreciation (Site duration)	50	%	50000	68.49
11	Maintenance cost (Press lifespan)	per lifespan		8500	23.29
12	Miscellaneous (5%of sum of A& B)	5	%	12148.10	607.41
		Sub Total (C)			**1337.43**
		Grand Total (A+B+C)			**13485.53**
		Cost of unit Brick (NRs)			**13.49**

Table 9: Rate analysis for unburnt bricks with 80% soil

S. N	MATERIAL	QUANTITY	UNIT	RATE	AMOUNT
A.	**Material**				
1	Red Soil	1.40	cum	614.00	859.60
2	Cement (OPC)	4.03	bag	697.50	2812.32
3	Sand	0.14	cum	2425.50	339.57
4	Thatch	1	Mutha	234.28	234.28
5	water charge	392	lit	0.25	98.00
		Sub Total (A)			**4343.77**
B.	**Labour charge**				
6	Skilled	3	M/day	1214	3642.00
7	Unskilled	5	M/day	852	4260.00
		Sub Total (B)			**7902.00**
C.	**Equipment/ Miscellaneous**	**Per year**		**Total Cost**	**Cost/Day**
8	Investment Cost (Interest on fixed deposit)	12	%	308000	101.26
9	Equipment Depreciation (Press Lifespan)	19.6	%	1000000	536.99
10	Building Depreciation (Site duration)	50	%	50000	68.49
11	Maintenance cost (Press lifespan)	per lifespan		8500	23.29
12	Miscellaneous (5%of sum of A& B)	5	%	12245.77	612.29
		Sub Total (C)			**1342.32**
		Grand Total (A+B+C)			**13588.09**
		Cost of unit Brick (NRs)			**13.59**

Table 10: Rate analysis for unburnt bricks with 85% soil

S. N	MATERIAL	QUANTITY	UNIT	RATE	AMOUNT
A.	**Material**				
1	Red Soil	1.49	cum	614.00	913.33
2	Cement (OPC)	4.28	bag	697.50	2988.09
3	Sand	0.07	cum	2425.50	180.40
4	Thatch	1	Mutha	234.28	234.28
5	water charge	416.5	lit	0.25	104.13
		Sub Total (A)			**4420.22**
B.	**Labour charge**				
6	Skilled	3	M/day	1214	3642.00
7	Unskilled	5	M/day	852	4260.00
		Sub Total (B)			**7902.00**
C.	**Equipment/ Miscellaneous**	Per year		**Total Cost**	**Cost/Day**
8	Investment Cost (Interest on fixed deposit)	12	%	308000	101.26
9	Equipment Depreciation (Press Lifespan)	19.6	%	1000000	536.99
10	Building Depreciation (Site duration)	50	%	50000	68.49
11	Maintenance cost (Press lifespan)	per lifespan		8500	23.29
12	Miscellaneous (5%of sum of A& B)	5	%	12322.22	616.11
		Sub Total (C)			**1346.14**
		Grand Total (A+B+C)			**13668.35**
		Cost of unit Brick (NRs)			**13.67**

6. Conclusions

- For 0 to 1% thatch content, the result showed that Compressive strength of soil cement brick increase with increasing thatch content which proves that thatch as an alternative binder influenced brick characteristics.
- For zero to one percent thatch content overall average water absorption for all percentage of mixes in accordance to tested samples were 23% where hand-made bricks may have water absorption up to 25 % of their weight according to Nepal

National Building code NBC 109: 1994.

- As per the cost analysis, soil cement brick was found to be in range of NRs 13 to 14 for the manufacturer and may lead towards profit.

References

- Al-Ajmi, F. et al. (2016) 'Strength Behavior of Mud Brick in Building Construction', Open Journal of Civil Engineering, 06(03), pp. 482–494. Available at: https://doi.org/10.4236/ojce.2016.63041
- Any, Sand et al. (no date) 'Activity 31 : Determining a Soil ' s Textural Classification Maine Geological Survey Time : Background :
- BhaskaranPP, B. and MohanKP, M. (no date) 'Study On Compressed Stabilized Earth Blocks By Using Chemicals', IOSR Journal of Applied Geology and Geophysics, 6(3), Available at: https://doi.org/10.9790/0990-0603035156.
- Binici, H., Aksogan, O. and Shah, T. (2005) 'Investigation of fibre reinforced mud brick as a building material', Construction and Building Materials, 19(4), pp. 313–318. Available at: https://doi.org/10.1016/j.conbuildmat.2004.07.013.
- Darshan Shrestha, H. (2012) 'Standard Norms and Specification for CSEB Block'
- Dawood, A.O. et al. (2021) 'Investigation of Compressive Strength of Straw Reinforced Unfired Clay Bricks for Sustainable Building Construction', Civil and Environmental Engineering, 17(1), pp. 150–163. Available at: https://doi.org/10.2478/cee-2021-0016
- 'Field Tests on Soil To Determine Suitability of Soil for Brick' (2022), pp. 1–11
- 'Final Report On The Study on Characteristics of Compressed Stabilized Earth
- (CSEB) using Chemical Stabilizer' (no date), pp. 1–34
- Gubasheva, S. (2017) 'Adobe bricks as a building material', pp. 1–50
- IS : 2720 (Part 4 - 1985) (1985) 'Methods of Test for Soils, Part 4: Grain Size Analysis', Bureau of Indian Standards, New Delhi, India., Reaffirmed(2006), pp. 1–38
- IS: 1727 (2013) 'Methods of test for pozzolanic materials', Bureau of Indian

Standards, New Delhi New Delhi, (February), pp. 1–55

- IS: 2720 (part 5):1985 (1985) 'Determination of Liquid limit and Plastic limit of soil', Bureau of Indian Standards, New Delhi, India., Reaffirmed(2006), pp. 1–16.
- IS:2720 (Part 2)-1973 (1973) 'Determination of water content of soil', Bureau of Indian Standards, New Delhi, India., Reaffirmed(2010), pp. 1–17
- IS 2386- Part III (1963) 'Method of Test for aggregate for concrete. Part III- Specific gravity, density, voids, absorption and bulking', Bureau of Indian Standards, New Delhi, p. (Reaffirmed 2002)
- Jangid, S. and Darade, M. (2017) 'Study on Compressed Stabilized Earth Block', International Research Journal of Engineering and Technology [Preprint]. Available at: www.irjet.net
- 'KASKI-DISTRICT-RATES-2080-81.pdf' (no date)
- Mahal, B. and Kathmandu, N. (2070) N E P A L N A T I O N A L B U I L D I N G C O D E READY TO USE GUIDELINE FOR DETAILINGS OF LOW RISE REINFORCED CONCRETE BUILDINGS WITHOUT MASONRY INFILL Government of Nepal Ministry of Urban Development Department of Urban Development and Building Construction
- Mauloud, Y.I. (2007) 'Straw Stabilized Local Clay Bricks', Zanco Journal of Pure and Applied Science, 10(2)
- Muhammad Sajid Rehman, Masrur Momen, A.S. (2018) 'Department of civil engineering bangladesh university of engineering and technology dhaka 1000, bangladesh october, 2018', p. 74
- Nagaraja, A., Shilpa, S. and Hegde, R. (2018) 'Study on Compressed Stabilised Earth Blocks By Using Chemical Admixtures', International Research Journal of Engineering and Technology (IRJET), 5(6), pp. 5–7. Available at: https://doi.org/10.9790/0990-0603035156
- of Indian Standards, B. (no date) IS 3495-1 to 4 (1992): Methods of tests of burnt clay building bricks: Part 1 Determination of compressive strength Part 2 Determination of water absorption Part 3 Determination of efflorescence, Part 4: Determination of warpage

- Patel, M. (2013) '4 Advantages and Disadvantages of CFD
- Patowary, B.N. et al. (2015) 'Study of Compressed Stabilised Earth Block', International Journal of Scientific and Research Publications, 5(6). Available at: www.ijsrp.org
- Profile, S.E.E. (2018) 'USING NATURAL FIBRE A Thesis Submitted by Md . Imran Hossain Student ID .: 0904037 In partial fulfillment of the requirement for the degree of Under the supervision of Professor Dr . Mohammad Shariful Islam Department of Civil Engineering Bangladesh Unive', (September 2015). Available at: https://doi.org/10.13140/RG.2.2.23877.14563
- Quezon, E.T. et al. (2017) Comparative Study on Compressive Strength of Locally Produced Fired Clay Bricks and Stabilized Clay Bricks with Cement and Lime Construction Project Management View project Modeling Labor Productivity using SD-Hybrid Framework View project Comparative Study on Compressive Strength of Locally Produced Fired Clay Bricks and Stabilized Clay Bricks with Cement and Lime. Available at: www.globalscientificjournal.com
- Salah, E. and Din, U. (2020) 'International Journal of Advance Engineering and Research', International Journal of Advance Engineering and Research Development, 6(December 2019), pp. 270–276. Available at: https://doi.org/10.21090/IJAERD.39611
- Soil, C. and Soil, R. (2018) 'A Study on Manufacturing of Bricks using Black', 3(5), pp. 229–235
- Zultiniar et al. (2018) 'Fabricaton of brick without burning process', in IOP Conference Series: Materials Science and Engineering. Institute of Physics Publishing. Available at: https://doi.org/10.1088/1757-899X/345/1/012017