The International Journal of Engineering and Science (IJES)
|| Volume || 9 || Issue || 12 || Series I || Pages || PP 46-53 || 2020 ||
ISSN (e): 2319-1813 ISSN (p): 20-24-1805

Mechanical Properties of Adobe Stabilized With Cow-Dung and Gamba-Straw Waste

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ABSTRACT

Adobe buildings when exposed to the elements of weather underperform due to mechanical properties deficiency. Hence, this study examines the mechanical properties of adobe stabilized with cow dung &Gamba-straw with a view to improving its mechanical properties. Experiments were conducted to examine the permeability properties of the constituents' of adobe, Cow-dung and Gamba-straw. Afterwards, 3 samples of adobe stabilized with cow-dung, cow-dung &Gamba-straw, and Gamba-straw were respectively moulded; each sample contains 4 cubes. The cubes were subjected to compressive and flexural strengths in accordance with EN 196-1 and ASTM C-305(1, 41) standards. Result shows that the constituents of adobe, Cow-dung, and Gamba-straw possessed properties that can effectively enhanced plasticity, reduced permeability, increased compressive & flexural strengths, and ensures environmental friendliness. Adobe stabilized with Cow-dung & 4% Gamba-straw (mix ratio; of 6:90) (6% Cow-dung) records the highest compressive strength of 1.75N/mm^2 at 28days compared to adobe stabilized with Cow-dung only (0.52 N/mm^2) and Gamba-straw only (0.49N/mm^2). Similarly, adobe stabilized with Cow-dung & 4% Gamba-straw (mix ratio; 11:85) (11% Cow-dung) records the highest flexural strength of 0.05Mpa at 28days. This is higher than the flexural strength of 0.043 Mpa and 0.03 Mpa recorded for adobe stabilized with Gamba-straw and Cow-dung respectively. Stabilization of adobe with Cow-dung &Gamba-straw improves the mechanical strength of adobe. Moreover, the inherent properties of adobe are environmentally friendly. Hence, more experiment should be conducted to ascertain the optimum compressive and flexural strengths of adobe when stabilize with Cow-dung & higher percentage of Gamba-straw.

Keywords: *Adobe, cow-dung, Gamba-straw, mechanical properties, stabilization, traditional materials.*

Date of Submission: 05-12-2020 Date of Acceptance: 20-12-2020

I. INTRODUCTION

Earth is one of man's oldest building materials used for construction purposes in many different forms involving use of local materials and techniques developed as per the needs of people in consideration with region, climate, and culture factors (Niroumand, Zain, & Jamil, 2013). Earth has the potential to be comfortable, functional, durable, and energy efficient and satisfies modern standards of living (Bui*et al.*, 2009). Earth buildings are highly durable, have good humidity regulation and sound insulation, and are non-toxic, non-allergic and fire proof (Adam & Agib, 2001). Given these advantages, the major techniques generally employed in earth construction include adobe (mud brick), cob, pressed earth brick. Others are wattle and daub, rammed earth and poured earth (Bui *et al.*, 2009). Earth is used in many forms as per the geographical factors of the area (Niroumand, Zain, & Jamil, 2013). Architecture of the area specifies use of earth in different ways for building purposes (Sharma, Vinayak, & Marwaha, 2016).

Adobe is essentially a dried mud brick, combining the natural elements of earth, water, and sun. It is an ancient building material usually made with tightly compacted sand, clay, and straw or grass mixed with moisture, formed into bricks, and naturally dried or baked in the sun without an oven or kiln (Adam & Agib, 2001). Adobe as a building material has been in existence since 4300BC and is still widely used today. Adobe is economically beneficial, it requires simple tools and less skilled, it encourages self-help construction, suitably very strong and secured, it save energy, it balances and improves indoor air humidity and temperature which ensure thermal comfort, it has good fire resistance, it create local job opportunity, it is environmentally sustainable, easy to design, provide noise control, and promotes local culture and heritage (Adam & Agib, 2001).The greatest merits of adobe is its significant advantages in hot and dry climates. They remain cooler during the day and warmer during the night, as adobe stores and release heat very slowly. Besides, adobe construction offers a way for people to feel and actually become more meaningfully connected to nature because it is a form of natural architecture built with environmentally friendly materials (Illampas, Ioannou, & Charmpis, 2009).

However, despite the advantages offered by adobe as a traditional building material, it is being replaced by construction materials with better mechanical properties (Szoboszlai, 2015). The deficiency in the mechanical properties of adobe is attributed to firstly to its low-strength, brittle material, which yields under much lower stresses than modern materials, such as steel, concrete and conventional masonry and secondly, traditional adobe houses are often poorly constructed and maintained due mainly to resource and skill limitations. These features mean that poorly construction and maintenance of adobe structures are more vulnerable to damage. Solutions to address these weaknesses have included plastering and drainage at the base of adobe walls. Besides, Bock-Hyeng *et al.* (2016) and (Adedeji, 2009) advocated that researchers should focused on suitable additives for stabilizing adobe that will enhanced its mechanical properties so as to curtail the inherent weaknesses of adobe Bock-Hyeng *et al.*, 2016;Adedeji, 2009). Hence, this study examines the mechanical properties of adobe bricks stabilized with cow dung and Gamba straw with a view to improving its mechanical properties

II. REVIEW OF LITERATURE

2.1 Properties of Earth as a Building Material

Earth is made up of grains that are classified according to their size Jokhio*et al.*, 2018). The granulometry' techniques classified earth as: coarse (2cm to 20cm); gravelly (2mm to 2cm); sandy (60 microns to 2cm); silty (2 microns to 60 microns); and clayey (below 2 microns). According to (Adam & Agib, 2001), earth is a ready building material which requires little further processing. Clay as a constituent of earth when mixed with water becomes malleable, plastic or liquid, and allowing it to be shaped; clay acts as cement (Jokhio*et al.*, 2018).

2.2 Properties of Cow-dung as a Building Material

Cow-dung is basically the excretory products of herbivorous animals which is acted upon by symbiotic bacteria residing within the animal's rumen (Bock-Hyeng*et al.*, 2016). The main components of cow-dung are plant fibres (essentially composed of cellulose, hemicelluloses and lignin), amine organic compounds, and fragments of intestinal tissues (Milligo*et al.*, 2016). The most important chemical component of cow-dung that possesses cementitious property is lime with a composition of 0.36% in the sample. This contributes to the reduction of the number and size of pores which enhanced the improvement of compressive strength.

2.2 Properties ofGamba-strawas a Building Material

The components of Gamba-straw are cellulose, hemicellulose, lignin, pectin, waxes and water-soluble substances. The cellulose, hemicellulose and lignin are the basic components of Gamba-strawgoverning the physical properties of the fibres. The chemical composition of Gamba-straw is important because it can affect their ultimate utilization. Sjorstrom(1993) reported that the chemical constituents of Gamba-straw have specialized functions in the cell wall: cellulose forms strong and stiff crystalline regions, cellulose and hemicellulose form semi-crystalline regions which provide necessary flexibility while the amorphous regions of lignin give toughness and cohesion.

III. MATERIALS AND METHODS

This study's approach is experimental design and collects adobe samples from Billiri Local Government Area of Gombe State, Nigeria. The experiments were conducted to determine the permeability properties of adobe as well as, test its compressive and flexural strengths. The experiments were conducted in accordance with EN 196-1 and ASTM C-305 (5, 41) standards. Materials used are: adobe samples, cow-dung, Gamba-straw, grass, soil. Equipments for the experiment includes: auger, concrete mixing bay, wooden form, compression machine, universal flexural Machine, and metallic plates. Three different block samples of dimensions 300mm x150mm x100mm were moulded with the following combinations: Cow dung & earth; Cow dung, Gamba-straw & earth; and Gamba-straw & earth. The procedure in moulding the adobe bricks samples are: collection of soil, batching of materials, mixing of constituent materials, moulding, and hardening & curing.

3.1 Collection of soil samples for adobe

The soil samples used for the adobe were collected from Kalmai, a town located in Billiri LGA of Gombe state. The soil samples were randomly collected at 0 to30 cm depth using soil auger to avoid any contamination of the soils. The samples were air dried, ground, and passed through sedimentation test in accordance with Ibrahim *et al.* (2011) procedure. The compositions of the soil are: sand (19-33%); silt (26-

36%), clay (38-48%), and organic matter (0-3%).The Cow-dung samples were collected from corrals in the surrounding area of Kalmai town. Cow-dung composition comprised of: water (80.4%), organic matter (15.2%), mineral matter (3.6%), nitrogen (0.30%), phosphorus (0.18%), potash (0.18%), and lime (0.36%).Gamba-straws were harvested from surrounding areas in Kalmai town. The straws were chopped to lengths of 6cm.The composition of the Gamba-straw contain: moisture (8.95%), cellulose (48.05%), and 1lignin (6.48%),pentosane (27.80%), ash (6.91%), and silica (9.10%).Water used for producing the adobe is portable drinking free from impurities.

3.2 Batching of Materials

Tables 1, 2 and 3 show the ratios and quantity of each component material used for moulding four bricks for each type of the four categories of bricks. The mix ratios used to combine the constituent materials for the disparate adobe in order to find the material combination that produces the peak strength was arbitrarily in accordance with the work of Sharma *et al*. (2015). A preliminary test conducted on the mix ratios revealed that the third mix ratios in tables 1, 2, and 3 produced the highest mechanical strength: 15:85 (cow dung: earth); 7.5:7.5:85 (cow-dung: Gamba-straw: earth); & 15:85 (Gamba-straw: earth).

Table 1: **Volumes of Constituent Materials for Cow-Dung and Gamba Straw Adobe Brick Specimens**

Type of material	Volume of cow-dung: laterite in litres				
	5:95	10:90	15:85	20:80	Total Vol. (l)
Cow dung (%)	5	10	15	20	12.5
Earth (%)	95	90	85	80	87.5

Table 2: Volumes of Constituent Materials for Cow-Dung and Gamba Straw Adobe Brick Specimens

Type of Material	Volume of cow-dung: Gamba-straw: Laterite in litres				
	2.5:2.5:95	5.5:5.5:90	7.5:7.5:85	10:10:80	Total Vol (l)
Cow-dung (%)	2.5	5.0	7.5	10.0	6.25
Gamba-Straw (%)	2.5	5.0	7.5	10.0	6.25
Earth (%)	85	90.0	85.0	80.0	87.5

However, the mix ratio for cow-dung: Gamba-straw: earth were adjusted to meet the specification given by Stulz and Mukerji(1993), which stipulated that 4 % by volume is the minimum proportion of straw to be used as stabilizer. Hence, the mix ratio for cow-dung: Gamba-straw: earth was adjusted to include a minimum proportion of 4% Gamba-straw. This results in a mix ratio of 11:4:85 (cow-dung: Gamba-straw: earth).

Table 3: Volumes of Constituent Materials for Gamba-Straw Adobe Brick Specimens

Type of Material	Volume of Gamba straw: Laterite in litres				
	5:95	10:90	15:85	20:80	Total Vol (l)
Gamba-straw (%)	5.0	10.0	15.0	20.0	12.5
Earth (%)	95.0	90.0	85.0	80.0	87.5

3.3 Mixing of Constituent Materials

The constituent materials were measured according to the required volumes and placed on clean concrete platform for mixing. Materials were mixed to ensure uniform distribution of material components for each mix. Water was added to conventional adobe specimens to produce the required workability in the mix. While for adobe stabilized with cow-dung specimens, the cow-dung was added to the soil and kneaded together by leg to achieve a uniform mix. While adobe stabilized with Cow-dung & Gamba-straw, the straw were chopped to 6 cm lengths, and mixed thoroughly with the soil as prescribed by Stulz and Mukerji (1993) before moulding.

3.4 Moulding of Bricks

The wet adobe mixture was placed in wooden forms lying on level ground. Adobe were formed in cubical shapes of300mm x150mm x100mm sizes. This complied with the minimum standard depth for load bearing walls (Norton, 1997). Adobe forms were created in a single brick forms filled with a shovel, and the corners compacted with a piece of metal. Further compaction on the material was enhanced by repeatedly banging the heavy metal lid on the sample until the lid fitted exactly in its lowest position. The forms were removed by holding the pallet under it when the adobe is dry enough to support itself, and set in place for hardening and curing. Four cubes were moulded for each sample. A total of 16 cubes were moulded: 4 control cubes, 3 cubes of adobe stabilized with Cow-dung only, 3 cubes of adobe stabilized with Cow-dung & 4% Gamba-straw, and 3 cubes of adobe stabilized with Gamba-straw.

3.5 Hardening and Curing of the Specimens

According to Norton(1997), the curing period for adobe stabilized with natural fibres should be at least three times more than the one used for cement (normally 28 days). The bricks were allowed to air dried for 7, 14, 21, and 28 days respectively in an open field because at 28 days the adobe would have been practically suitable for handling and safe for use in building construction. The adobe was covered with grasses during the curing period to avoid spontaneous drying that would cause shrinkage and cracks. Laboratory test commenced after 7, 14, 21 and 28 days of curing the specimen in an open field. The 28 days curing period allowed the bricks to completely dry.

IV. RESULTS AND DISCUSSIONS

The results and discussions capture composition of cow-dung, Gamba-straw, and earth soil, as well as the compressive and flexural strengths of the 3 samples of adobe.

4.1 COMPOSITIONS OF COW-DUNG

Table 4 presents the result of the compositions of cow-dung. The cow-dung constituents and their proportions are water (80.18%), organic matter (15.2%), mineral matter (3.6%), nitrogen (0.30%), phosphorus (0.18 %), potassium (0.18%), and lime (0.36%). The result reveals that water has the highest proportion (80.18%). This agrees with the finding of Milligo *et al*. (2016).

Table 4: Compositions of Cow-dung

S/N	Constituent materials	Compositions (%)
1	Water	80.18
2	Organic Matter	15.20
3	Mineral Matter	3.60
4	Nitrogen	0.30
5	Phosphorus	0.18
6	Potassium	0.18
7	Lime	0.36

4.2Compositions of Gamba-straw

Table 5 shows the composition of Gamba-straw to include moisture (7.34%),cellulose (43.2%), Lignin (19.4%), pentosane (14.7%), Ash (9.26%), and Silica (6.10%). This result agrees with the findings of (Ajiji, Nyako, & Ashom, 2013).

Table 5: Compositions of Gamba straw

S/N	Constituent materials	Compositions (%)
1	Moisture	7.34
2	Cellulose	43.2
3	Lignin	19.4
4	Pentosane	14.7
5	Ash	9.26
6	Silica	6.10

4.3 Compositions of the earth soil

Table 6 shows the composition of the earth soil used for the production of adobe. It composition include sand, silt, and clay. Their pH value shows that it is slightly a base. These constituents enable adobe to be plastic and durable (Adam & Agib, 2001).

Table 6: Compositions of the Earth Soil

S/N	Sand (%)	Silt (%)	Clay (%)	Organic (%)	pH (%)
1	55	21	22	2	7.9
2	50	24	20	6	7.5

3	58	18	19	5	7.2
Range	50-58	18-24	19-22	2-6	7.2-7.9

4. 4 Compressive Strength of Adobe Stabilize with Cow-dung

The compressive strength tests were carried out on the Universal Testing Machine. For this purpose, the British standard for compressive strength tests for concrete cubes (BS EN 12390:3-2002) was adapted for adobe. Table 7 presents the compressive strength test performed on the adobe stabilized with cow-dung specimens.

Table 7: Compressive strength of adobe stabilized with Cow-dung

% replacement	Compressive Strength (N/mm^2)			
Control 0 %	0.04	0.11	0.21	0.3
5%	0.08	0.16	0.25	0.36
10%	0.09	0.17	0.26	0.37
15%	0.16	0.25	0.38	0.52
20%	0.15	0.19	0.34	0.43
Curing days	7	14	21	28

The highest average compressive strength of the bricks with cow-dung percentages of 5%, 10%, 15% and 20% to earth were 0.36N/mm^2, 0.37N/mm^2, 0.52N/mm^2, and 0.43N/mm^2 respectively. The results show that, at 5% and 10% cow-dung contents, the bricks recorded very low average compressive strengths of 0.36N/mm^2 and 0.37N/mm^2 respectively. The strength however increased to a maximum of 0.52N/mm^2 when the cow-dung percentage was increased to 15%. The average compressive strength, however, reduced at cow-dung percentage of 20% at 0.43N/mm^{2}comformed to (Adinkrah-Appiah & Kpamma, 2015).

4.5 Compressive Strength of Adobe Stabilize with Gamba-straw

Table 8 shows the compressive strength test on adobe stabilize with Gamba-straw. Adobes stabilize with 4%, 6% and 8% Gamba straw records corresponding compressive strengths of 0.32N/mm^2, 0.49N/mm^2, and 0.40N/mm^{2}at 28 days. This result is the highest compared to other curing periods of 7 days, 14days, and 21day. The peak compressive strength achieved is 0.49N/mm^2 (6% Gamba-straw).These results indicate that the fibres serve to reinforce the interlocking forces between the fibres and the soil surface as adhesion properties so that the soil is not easily collapse. This result agrees with the findings of Milligo *et al*. (2016).

Table 8: Compressive strength of adobe stabilize with Gamba-straw

% replacement	compressive strength (N/mm^2)			
Control 0 %	0.04	0.11	0.21	0.30
4%	0.08	0.15	0.24	0.32
6%	0.16	0.26	0.36	0.49
8%	0.11	0.17	0.29	0.40
Curing days	7	14	21	28

4.6Compressive Strength of Adobe Stabilize with varying % of Cow-dung &4% Gamba-straw

Table 9showsthe result of the compressive strength of the adobe stabilized with cow-dung andGamba-straw waste. The cow-dung proportion was replaced by 4% by Gamba-straw content, whereas the earth proportions remain unchanged.

Table 9: Compressive strength of adobe stabilize with Cow-dung &Gamba-straw

% replacement	compressive strength (N/mm^2)			
Control 0 %	0.04	0.11	0.21	0.3
1%	0.23	0.44	0.55	0.75

6%	0.38	0.57	0.71	1.39
11%	0.29	0.39	0.5	0.65
16%	0.09	0.13	0.25	0.37
Curing days	7	14	21	28

The cow-dung percentages of 1%, 6%, 11% and 16% when mixed with 4% Gamba-straw recorded their highest average compressive strength at 28days curing period. The respective compressive strength are 0.75N/mm^2, 1.39N/mm^2, 0.65N/mm^2, and 0.37N/mm^2.It reveals thatthe strength increased initially from 0.75N/mm^2 to a maximum of 1.39N/mm^2 at 1% and 6% cow-dung proportions respectively. However, it decreased to 0.65N/mm^2 and 0.37N/mm^{2}when the cow-dung percentage increased to 11% and 16% respectively. Thus, the peak compressive strength recorded was 1.39N/mm^{2}at 6% of cow dung. These results indicate that cow-dung serves to react with water in (cementation process) to form a solid granule. While the fibres serve to reinforce the interlocking forces between the fibre and the soil surface as adhesion properties so that the soil is not easily collapse. This phenomenon also contributes to mechanical property of the brick. The external surface of the Gamba-straw fibrils form offers extra anchoring points by which the fibres can accept stresses from the adobe and becomes more effective reinforcing elements. However, the increase in compressive strength of the brick specimens was because of moderate distribution of the stabilizers that produce strong bond between the stabilizers and the earth which makes it a strong brittle material. Whereas the decrease in compressive strength was because of too much organic content, which are not evenly distributed most of which reacts with each other and few of which reacts with the surrounding earth resulting in tough material having weak bond and lacking strength.

4.6 Flexural Strength Tests

The flexural strength tests experiment was conducted on the 3 different adobe samples was in accordance with ASTM C-305 (5, 401). Tables 10, 11 and 12 show the results of the averageflexural strength tests of adobe stabilized with Cow-dung, adobe stabilized with Gamba-straw, and adobe bricks stabilized with Cow-dungand 4% Gamba-straw respectively. Table 10 shows adobe stabilize with 5%, 10%, 15%, and 20% cow-dung records corresponding flexural strength values of 0.02Mpa, 0.02Mpa, 0.03Mpa, and 0.02Mpa at 28days curing period. This shows an increased in flexural strength of the adobe stabilized with Cow-dung compares to the conventional adobe (control) flexural strength of 0.004Mpa. The highest flexural strength of 0.03Mpa was achieved with a mix ratio of 15:85 (15% Cow-dung) at 28days curing period. The peak flexural strength is achieved with a mix ratio of 20:80 (20% Cow-dung) at 14days curing period. However, at 21days curing period the brick is not matured for building. This result agrees withColin, Goodhew annd Griffiths(2011) findings, which attributed the increased in flexural strength to the interaction between the matrix and fibres.

Table 10: Flexural strengthofadobe stabilized with Cow-dung

Mix ratio	flexural Strength (Mpa)			
Control				0.004
0 %	0.002	0.002	0.003	
				0.02
5:95	0.003	0.01	0.01	
				0.02
10:90	0.04	0.004	0.02	
				0.03
15:85	0.01	0.02	0.03	
				0.02
20:80	0.004	0.043	0.01	
Curing Days	7	14	21	28

Table 11 shows that adobe stabilized with 10%, 15% and 20% Gamba-straw, records flexural strengths of 0.04Mpa, 0.043Mpa and 0.03Mpa at 28days curing period respectively. The peak flexural strength 0.043Mpa was recorded at the mix ratio of 15:85.

The results show an improved flexural strength of the bricks compared to the conventional adobe. The increased in the flexural strength of the adobe stabilized with Gamba-straw is attributed to the presence of fibre in the Gamba-straw which increased the insulation value of the adobe. The results showed a little decrease in tensile strength for the mix ratio of 5:95, 10:90 and 20:80. This were found to be owing to the interaction between the matrix and fibres as reported by Jokhio*et al.,* 2018).

Table 11: Flexural strength ofadobe stabilized with Gamba-straw

Mix ratio	7 Days	14Days	21 Days	28 Days
Control 0%	0.002	0.002	0.003	0.004
10:90	0.02	0.002	0.03	0.04
15:85	0.02	0.04	0.04	0.043
20:80	0.002	0.03	0.03	0.03

Table 12 shows that adobe stabilized with Cow-dung & 4% Gamba-straw mixed at the ratios of 6:90, 11:85 and 16:80 records the highest flexural strength of 0.03Mpa, 0.05Mpa and 0.03Mpa at 28days respectively. The peak flexural strength (0.05Mpa) was achieved with a ratio of 11:85 at 28days curing period. The flexural strength of the adobe brick stabilized with Cow-dung & 4% Gamba-straw is higher than that of the adobe bricks stabilized with Cow-dung only and Gamba-straw only.

Table 12: Flexural strength of adobe stabilized with Cow-dung& 4% Gamba-straw

Mix ratio	7 Days	14Days	21 Days	28days
Control 0%	0.002	0.002	0.003	0.004
6:90	0.01	0.002	0.02	0.03
11:85	0.02	0.04	0.04	0.05
16:80	0.01	0.02	0.03	0.03

The appreciation in its flexural strength is attributed to the structural hemicelluloses, lignin and cellulose that are contained in the Gamba-straw, as well as the small fibre contain in the Cow-dung. This result concurs with the result of Collin (2011). Moreover, fibres contained in Cow-dung and Gamba-straw have a rough surface, which improves the adherence between these fibres and the soil in adobes, and thus their mechanical strength.

V. CONCLUSIONS AND RECOMMENDATIONS

This study examines the mechanical properties of adobe bricks stabilized with cow-dung & Gamba-straw with a view to improving its mechanical properties. The study is experimental and it assesses the permeability properties of adobe, and tests the compressive and flexural strengths of adobe. Three samples of adobe were stabilized with cow-dung only, cow-dung only& Gamba-straw only and Gamba-straw only were used for the tests. The tests were in accordance with ASTM (C- 305) and EN 196-1 standards. Findings revealed that the constituents of soil used for adobes comprised of sand (62%), silt (15%), clay (18%) and organic matter (5%). The constituents of Cow-dung comprised of organic matter (15.5%), mineral matter (3.6%), nitrogen (0.30%), phosphorus (0.18%), potassium (0.18%) and lime (0.36%). While Gamba-straw contains cellulose (65%), lignin (19%), and ash content (2%). Their compositions contain properties that enhanced plasticity, reduced permeability, increased compressive and flexural strengths, and ensures environmental friendliness.

Adobe stabilized with Cow-dung & 4% Gamba-straw using a mix ratio of 6:90 (6% Cow-dung) records the highest compressive strength of 1.75N/mm^2 at 28days compared to other adobe stabilized with Cow-dung only (0.52 N/mm^2), and Gamba-straw only (0.49N/mm^2). Similarly, adobe stabilized with Cow-dung & 4% Gamba-straw using a mix ratio of 11:85 (6% Cow-dung) records the highest flexural strength of 0.05Mpa at 28days curing period. This is higher than the flexural strength of 0.043 Mpa and 0.03 Mpa recorded for adobe stabilized with Gamba-straw and adobe stabilized with Cow-dung respectively. These results revealed that adobe with Cow-dung and Gamba-straw improves mechanical strength of adobe. Moreover, the inherent properties of adobe are environmentally friendly. This study recommends more experiment to ascertain the optimum compressive and flexural strengths of adobe stabilize with Cow-dung & higher percentage of Gamba-straw.

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