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Influence of Different Curing Conditions on Some Properties of Nigerian Building and Road Research Institute (NBRRI) Leterite Interlocking Bricks

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ABSTRACT

The study aimed to determine the influence of different curing conditions on some properties of Nigerian building and road research institute (NBRRI) literate interlocking bricks. The constituent materials were tested and batched by weight, using 1:6, as mix proportion as suggested in the Nigerian National Building Code and Nigerian Building and Road Research Institute. The bricks with dimensions 250 × 130 × 220 mm3 were cast using NBRRI semi-automatic brick production machine. The bricks were cured using seven different curing conditions. The seven curing regimes adopted in the work were Condition "A": Using tarpaulin and covering bricks and sprinkling water morning and evening twice a day. Condition "B": wet curing throughout (by complete immersion in portable water and covering with tarpaulin Condition "C": Using water and air-tight polythene bags. Condition "D": Use wet hessian and polythene sheets to cover the bricks. Condition "E": By keeping the bricks under dry laboratory conditions. Condition "F": By curing the bricks in the open air under direct sunshine. Condition "G": keeping in the open air under a shed. For all other curing conditions, the tests conducted on the bricks were bulk density, water absorption, durability and compressive strength at the end of every curing period. It was concluded that the highest gain in average bulk density, water absorption, durability and compressive strength was recorded for bricks completely covered with water and air-tight polythene bags. The bricks cured in the open air under direct sunshine recorded the lowest strength. Based on the results of the study the curing condition "C" is regarded as the best curing condition regime

1. Introduction

Literate brick is the simplest and oldest of all building materials that has been used for housing constructions in rural areas as well as in some urban areas for many centuries. The global nature of the economy has increased the use of literate as a building material. Durability, relatively low cost, good sound and heat insulation, acceptable fire resistance, adequate resistance to weathering and good-looking appearance are the most acceptable properties offered by literate bricks as a building material [8]. Interlocking bricks is a unique newly improved walling material designed and fabricated using cement as stabilizing agent mixed with literate soil in a predetermined proportion to increase the strength of the literate. NBRRI interlocking brick is an improved brick using NBRII technology which was designed to interlock with one another. The bricks do not require mortar usage during bricklaying work. Since they do not require mortar, the bricklaying work is faster and requires less skilled labour than the conventional blocks [15].

Figure 1. NBRRI Interlocking Bricks

The strength and durability of NBRRI literate bricks can be attained through adherence to the right curing technique. Curing simply means the practice of keeping the literate bricks moist (control of temperature and moisture) to allow complete hydration to ensure gain in full durability and strength [10]. Curing should begin immediately after the finishing operation. If the right curing technic is not adopted, the strength of the brick will be very low, due to water vaporises and hydration. When the curing regime did not reserve enough moisture, the laterite bricks will not develop extreme strength, and the bricks may crack. Inadequate hydration of the cementation material may also reduce the durability of the laterite bricks. The moisture and thermal structure of newly cast literate bricks can be affected by ambient atmospheric curing conditions. Avoidance of moisture and water loss in literate bricks results in reduced resistance to abrasion, plastic shrinkage and increased permeability.

Advantages of proper curing include reduced permeability and attack by chemicals; prevention of formation of plastic shrinkage cracks, caused by rapid surface drying; production of more water-tight bricks, increased abrasion resistance as the surface brick will have a higher strength and significant reduction in scaling problems. Several researchers have reported that cement-stabilised literate can be used in building and road construction [2]. The earlier study carried out by the Nigerian Building and Road Research Institute (NBRRI) involved the production of literate bricks that were used for the construction of a bungalow [13]. The mix ratio adopted for bricks production according to the NBRRI standard was 1:6, i.e., one part of cement to six parts of fine aggregate (lateritic soil). NBRRI suggested the following minimum specifications as a requirement for literate bricks, a bulk density of 1810 kg/m3, water absorption of 12.5%, compressive strength of 1.65 N/mm2 and durability of 6.9% with a maximum cement content fixed at 5%.

The curing of literate bricks and concrete according to [11] can be influenced by continuously spraying water over the literate bricks, covering the literate bricks with waterproofing sheets, spraying with coatings or leaving forms in place and covering the exposed surface. [17], summarized that water curing is subdivided into pounding, wet covering, immersion, spraying or fogging, membrane curing and application of heat. The other methods used comprise covering the surface of the literate bricks and concrete with an intersecting polyethene cover. This method of curing is termed the water barrier technique.

To ensure effective curing of stabilized interlocking bricks, [9] suggested the use of tarpaulin to shield green bricks for twenty-four hours, before uncovering temporarily to permit watering twice a day (morning and evening), for 28 days. Though, this method demands a high quantity of water for use and in an area where portable water is insufficient or not available this method cannot be practised efficiently in a majority of rural areas in the country.

According to [15] on their work. ‘‘Comparison of different curing effects on concrete strength’’. The curing conditions used in the study comprise dipping the concrete in portable water, using polythene and hessian sheet to shield the concrete, curing the concrete under workshop settings, curing the bricks in exposed surrounding, and keeping the concrete under steam. The compressive strength tests of the concrete were tested at 28 days of curing for all conditions except for curing the bricks in exposed surrounding which were tested at the age of 3 days. The result of the study revealed that the highest compressive strength was tested on curing conditions using polythene and hessian sheet to shield the concrete and the lowest strength was tested on curing conditions under keeping the concrete under steam. The study concluded that curing regimes has an impact on the strength property of concrete.

2. Materials and Methods

2.1 Materials

The materials used in the production of bricks were laterite, cement and water.

Cement: The cement used is Ordinary Portland Cement (Dangote Cement) with properties conforming to BS 12 (British Standards Institution, 1996). The brand of cement was obtained from the kofar ruwa market in Kano.

Water: Water for mixing and curing was bore-hole water fit for drinking, obtained from NBRRI zone office Kano. The water is drinkable and free from impurities such as acids, oils, alkalis, sugar, etc. as specified in BS 3148 (1980).

Literate soil: The literate sample used was dug at a deepness of 1.5 m to 2.5 m from a current borrow pit from Dawakin tofa, 34km from Kano state, Nigeria. The literate was riddled with a 6mm aperture.

Mix ratio: The mix proportion adopted for the study was 1:6 by volume, as suggested in the Nigerian National Building Code and Nigerian Building and Road Research Institute.

2.2 Methodology

Sample Preparation

Literate samples were obtained from an existing borrow pit from dawakin tofa local government area, 34km from Kano state, Nigeria. The sample was allowed to dry in a cool, dry place, for seven days and then taken for sieve analysis test. A wire mesh screen with an aperture of about 6 mm in diameter was used as a sieve. The fine constituents that passed through the sieve were regarded for brick production while those retained in the sieve were discarded away.

Figure 2. Literate Soil

2.3 NBRRI lateritic interlocking bricks production

The recommended amount of literate samples and cement were mixed systematically on a clean solid platform using shovels. The water was added gradually to the constituent’s mixture using a watering can while mixing until the optimum moisture content was attained in addition to a uniform consistency. NBRRI semi-automatic brick production machine was used for the production of

NBRRI interlocking bricks. The machine produces bricks with dimensions of 230mm x230mm x120 mm.

Figure 3. NBRRI Semi-Automatic Brick Production Machine

The production method comprises batching, mixing and compaction of Literate. The productions were carried out by Nigerian National Building Code and the Nigerian Building and Road Research Institute Manual. Batching of literate, cement and water was done according to NBRRI standards. The bricks were cured for 3, 7, and 28 days using different curing methods. Tests and experiments were carried out at the NBRII laboratory's North-west zonal office, Kano.

Figure 4. NBRRI Bricks after Curing

To investigate the influence of curing conditions of NBRRI interlocking bricks. Five bricks were chosen for every curing regime and tested for bulk density, water absorption, durability and compressive strength. The curing regimes employed were:

Condition “A”: Using tarpaulin and covering bricks and sprinkling water morning and evening twice a day.

Condition “B”: wet curing throughout (by complete immersion in portable water and covering with tarpaulin).

Condition “C”: Use water and air-tight polythene bags and cover the bricks.

Condition “D”: Use wet hessian and polythene sheets to cover the bricks.

Condition “E”: By keeping the bricks under dry laboratory conditions.

Condition “F”: By curing the bricks in the open air under direct sunshine.

Condition “G”: By curing the bricks in the open air under a shed.

2.4 Testing Procedure

Bulk density, water absorption, durability and compressive strength tests were conducted on the bricks at the end of every curing period.

2.4.1 Bulk density test

Bulk density also called apparent density or volumetric density is the total mass of the brick, water and air per unit volume. The bulk densities of the brick samples were tested at the end of curing ages and carried out in line with Nigerian Industrial Standard (NIS 87, 2004). Five brick samples were selected at random, each sample was weighed and documented. The volume of the sample was obtained by multiplying the length, breadth and height of the brick. The density of the brick sample was computed as;

Kg/m3 …………………………………… (1)

Thus:
M = Mass of the brick.
V = Volume of the brick.

2.42 Durability Test

The durability of the bricks was determined through an abrasion test, to determine the brick's resistance to tiring due to ecological factors such as rain and wind. The test was carried out in line with the Association of State Highway and Transportation Officials (ASHTO-T 96, 2010). The test was conducted at 7-day, 14-day and 28-day curing ages. Five bricks from each batch were weighed and the weight was recorded as M1. The samples were then wire-brushed to and fro 50 times on a hard and smooth surface. To maintain an even load on the wire brush, a 3 kg load was secured firmly at the back of the wire brush, the samples were weighed, and their weight was recorded as M2. The durability sample was calculated as;

× 100 ……………………………………

× 100 …………………………………… (2)

Thus
M1 = mass of original bricks M2 = mass of abraded bricks

2.43 Water Absorption Test

The test was carried out after the bricks had attained the curing ages of 7-day, 14-day and 28 – days. Five bricks were selected at random and weighed. The weight dry sample recorded Md. The samples were then deep totally for 24 hours in a tank containing drinkable water. The samples were removed and reweighed and recorded as Mw (wet mass). The was calculated as;
The water absorption by bricks could be computed as;

× 100 …………………………………… (3)

Thus
Wa = Water absorption. Ws = weight of a wet brick. Wd = weight of dry brick

2.42 Compressive Strength test

The test was carried out after the bricks had attained the curing ages of 7-day, 14-day and 28 – days using a compressive strength testing machine. Each literate brick was crushed and the compressive strength of the brick was recorded. The compressive strength was computed as:

N/mm3 …………………………………… (4)

Thus:

P = crushing load in (kN), and A = cross-sectional area (mm3)

Figure 5. Compressive Strength Testing Machine

3.0 Results and Discussion

3.1 Sieve analysis

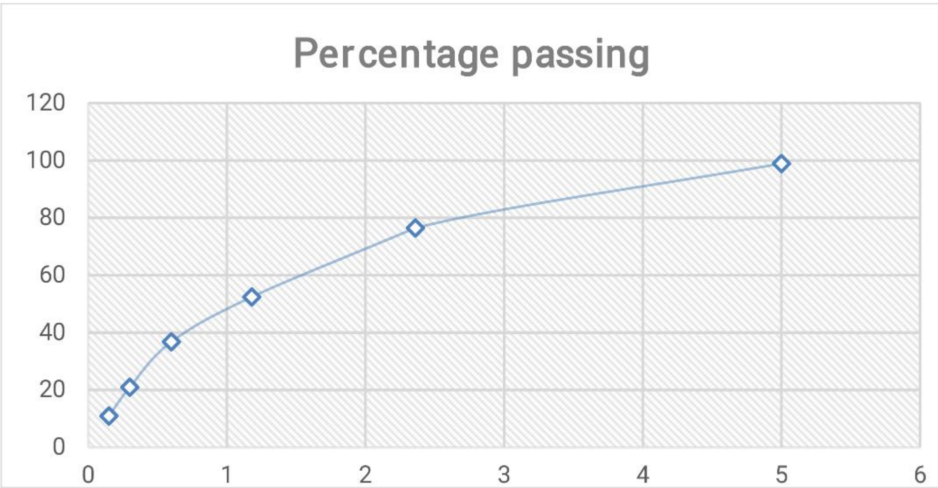

Figure 6. Result of sieve analysis

The particle size distribution of literate used in brick production is presented in Figure 6. Literate used in the work was classified as A-2-6 soil using the AASHTO system of soil classification implying that the soil has gravel, sand and silt fines

Table 1: Physical properties of literate soil used

Properties	Value
Colour	Reddish Brown
Specific Gravity	2.59
Liquid Limit (%)	46
Plastic Limit(%)	30
Plasticity Index(%)	16
Conditions of sample	Air Dried
Bulk Density (kg/m^3)	1388

3.2 Bulk density test

The average bulk density of bricks cured under the different conditions for 7, 14 and 28 curing days are presented in Figure 7. The study observed the highest Average bulk density in samples cured using Condition “C”: Using water and air-tight polythene bags with an average bulk density of 1785Kg/m3 at 28 days curing age. This is closely followed by Condition “A”: Using tarpaulin and covering bricks and sprinkling water morning and evening twice a day. , Condition “D”: Using wet hessian and polythene sheet to cover the bricks, condition “B”: wet curing throughout (by complete immersion in portable water and covering with tarpaulin), “G”: keeping in the open air under shed and condition “E” keeping under dry laboratory Condition “E”: By keeping the bricks under dry laboratory conditions with average bulk density with 1779Kg/m3, 1974Kg/m3,1720Kg/m3, 1668Kg/m3 and 1654Kg/m3 respectively. Bricks cured using Condition “F”: By curing the bricks in the open air under direct sunshine with average compressive strength of 1642Kg/m3 had recorded the lowest average bulk density. The findings show that curing bricks using water and air-tight polythene bags the bricks produced a better result, which approximately satisfied the minimum bulk density of 1810 kg/m3 at maximum cement content fixed at 5% as recommended by NBRRI.

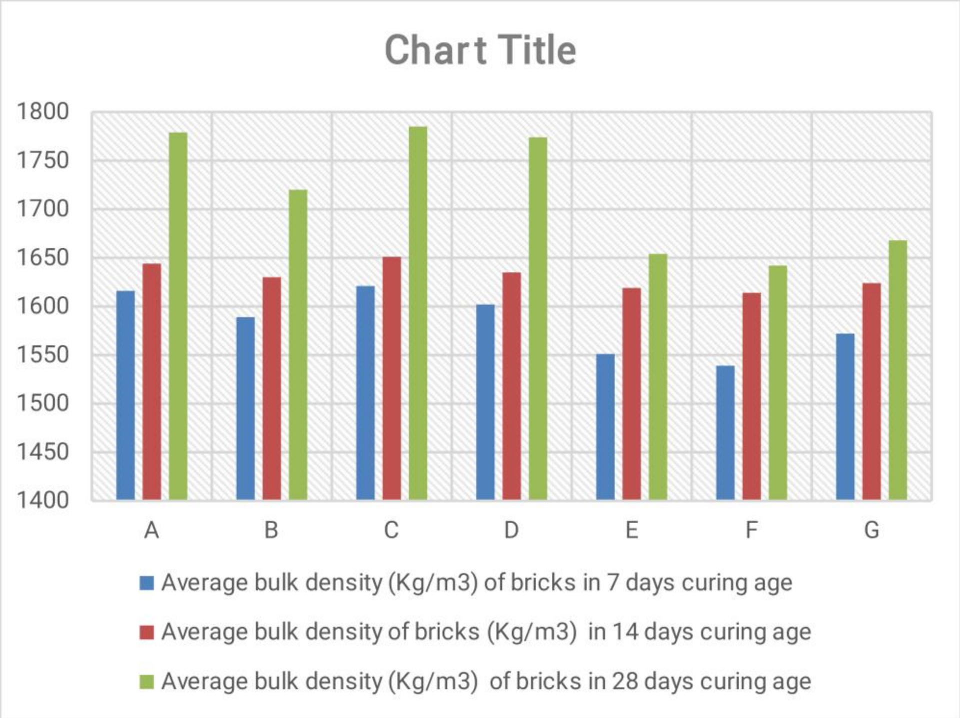

Figure 7: Bulk density test result

3.3 Durability test

The durability of bricks cured under the different conditions for 7, 14 and 28 curing days are presented in Fig 8. The study observed highest durability in samples cured by Condition “C”: Using water and air tight polythene bags, with average durability of 6.8% at 28 days curing age. Thus, closely followed by Condition “A”: Using tarpaulin and covering bricks and sprinkling water morning and evening twice a day Condition “D”: Using wet hessian and polythene sheet to cover the bricks, condition “B”: wet curing throughout (by complete immersion in portable water and covering with tarpaulin), “G”: keeping in open air under shed and Condition “E”: By keeping the bricks under dry laboratory conditions with average compressive strength of 6.5%, 6.2%, 6.0%, 5.7% and 5.5% respectively. Bricks cured using Condition “F”: By curing the bricks in open air under direct sunshine with average durability of 5.3%had recorded lowest average durability. The outcomes designated that curing the samples using water and air tight polythene bags yielded desired outcome, which approximately satisfied minimum durability of 6.9% at maximum cement content fixed at 5% recommended by NBRRI.

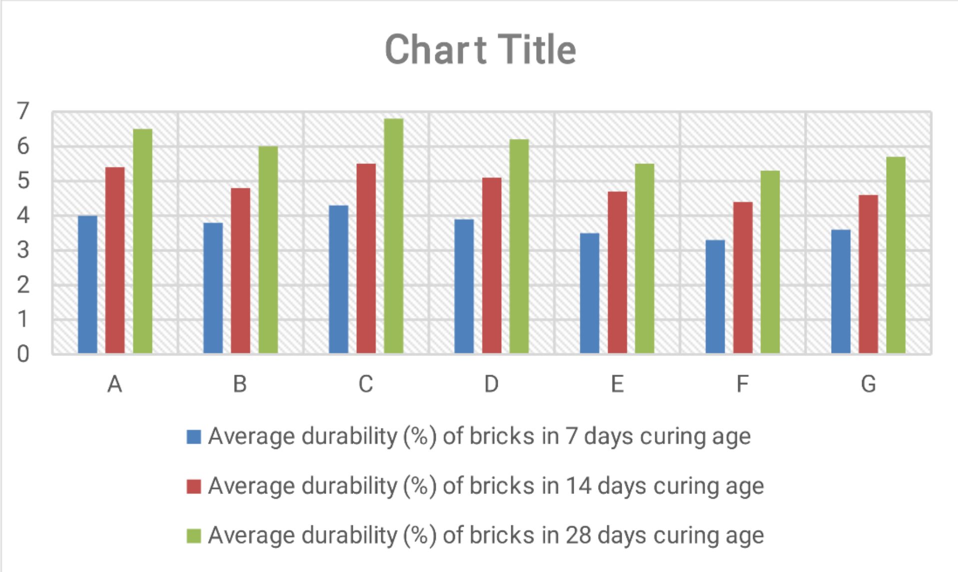

Figure 8. Durability test result

3.4 Water absorption test

Findings of the water absorption test using the different curing conditions at 7, 14 and 28 curing ages are presented in Figure, 9. The study observed the lowest water absorption in sample cured using Condition “C”: Using water and air-tight polythene bags. Average water absorption of 12.4% at 28 days of curing age was recorded. The findings showed that the curing of bricks using water and air-tight polythene bags, produced the required result, which approximately satisfied minimum durability of 12.5% at maximum cement content fixed at 5% recommended by NBRRI. The lowest water absorption value was recorded due to less water escaping from the bricks as compared with the other curing techniques. However, the study suggested that, among the curing regimes used in the study, using water and air-tight polythene bags, seems to have the highest attainable water absorption. Water absorption of bricks cured using regime “A”: Using tarpaulin and covering bricks and sprinkling water morning and evening twice a day, Condition “D”: Using wet hessian and polythene sheet to cover the bricks, condition “B”: wet curing throughout (by complete immersion in portable water and covering with tarpaulin), “G”: keeping in the open air under the shed, Condition “E”: By keeping the bricks under dry laboratory conditions and Condition “F”: By curing the bricks in the open air under direct sunshine observed the water absorption values of 12.4%, 12.6%,12.8%, 12.9%,13.1% and 13.2% respectively. The study also revealed that where water is scarce, covering bricks using tarpaulin and covering bricks and sprinkling water morning and evening twice a day and covering with wet hessian and polythene sheets are recommended for use. However, where water is available, complete immersion is recommended.

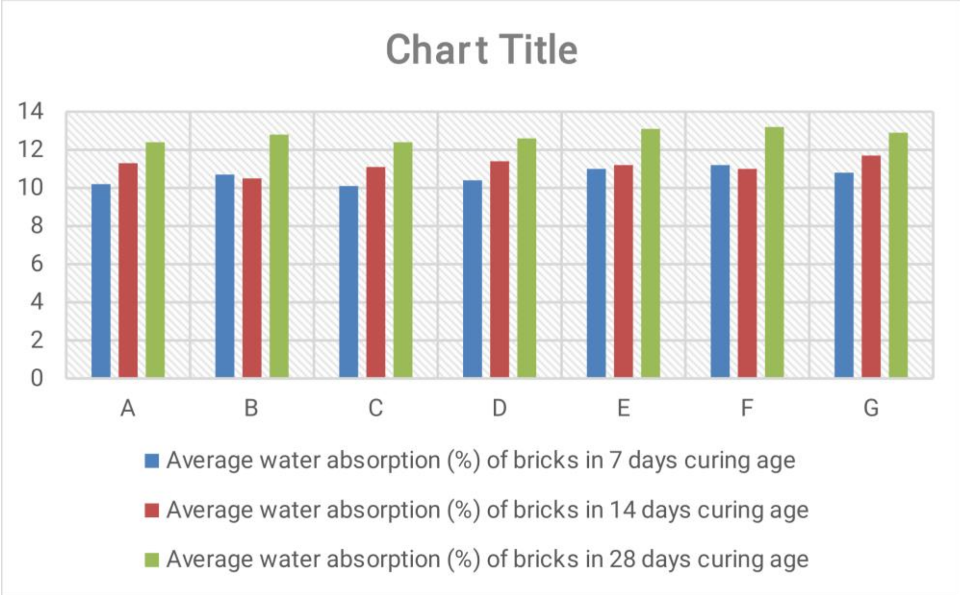

Figure 9. Water absorption test

3.5 Compressive Strength

The compressive strengths of bricks were cured under different conditions for 7, 14 and 28 curing days. The study observed the highest strength in bricks cured using Condition “C”: Using water and air-tight polythene bags with average compressive strength of 1.62N/mm3 at 28 days curing age, which approximately satisfied the minimum durability of 1.60N/mm3 with a maximum cement content fixed at 5% recommended by NBRRI. The highest compressive strength obtained with curing condition “C” can be attributed to the non-evaporation of moisture from bricks covered with air and water-tight polythene bags that provided approximately 100 % relative humidity, while at the same time ensuring relatively stable temperature, as reported by (18) which ensures effective hydration of cement as observed with moisture retained in the polythene bags during the removal of bricks for the test. This result is closely followed by “A”: Using tarpaulin and covering bricks and sprinkling water morning and evening twice a day, Condition “D”: Using wet hessian and polythene sheet to cover the bricks, condition “B”: wet curing throughout (by complete immersion in portable water and covering with tarpaulin), “E”: By keeping the bricks under dry laboratory conditions and “G”: keeping in the open air under shed and condition with average compressive strength of 1.60N/mm3, 1.58N/mm3N/mm3,1.54N/mm3, 1.50N/mm3 and 1.46N/mm3 respectively. Bricks cured using Condition “F”: By curing the bricks in the open air under the direct sunshine condition with average compressive strength of 1.40N/mm3 recorded lowest compressive strength. This might happen as a result of the sudden escape of moisture content of the bricks due to exposure to open air under direct sunshine on which the bricks were cured, the escape of moisture content may have consequences on the strength of the bricks due to cement hydration.

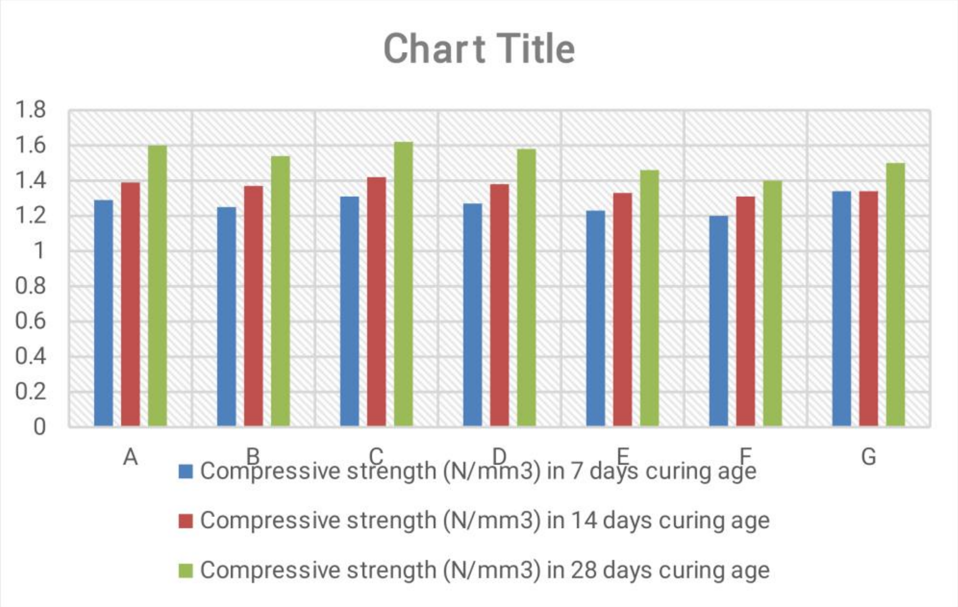

Figure 10. Compressive strength test result

4. Conclusion

From the findings of the study, the following conclusions were made:

1) Different curing systems have different influences on the bulk density, water absorption, durability and compressive strength of NBRRI interlocking bricks.
2) Curing bricks using water and air-tight polythene bags resulted in maximum bulk density, water absorption, durability and compressive strength.
3) Covering bricks completely with air and water-tight polythene bags, and curing the bricks in open air under direct sunshine produced lower bulk density, water absorption, durability and compressive strength.
4) Curing bricks using water and air-tight polythene bags is suggested for practice, especially in areas in which water is not freely accessible.

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