THERMAL LAG PERFORMANCE OF A MOBILE DOUBLE WALLED SAWDUST INSULATED METALLIC SILO

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ABSTRACT

A 1000 kg double walled insulated mobile metallic silo was designed and constructed with two mild sheets of 1mm thickness using sawdust as an insulating material between the metal sheets. The silo has a total height of 1.2m above the ground level with an internal and external diameter of 0.64 m and 0.68 m respectively and resting on a platform which has four wheels attached to it for mobility. A preloading assessment was conducted on the silo to determine the possibility of using sawdust as an insulator in the silo. Comparison was also made between the single walled aluminium sheet silo placed on a platform and the double walled insulated mobile metallic silo to determine thermal performance. Temperature readings were taken 3 times for each time interval for 10 days using a therma waterproof K thermocouple model 232-101. The result showed that the temperature reading was usually low by 8:30am within the double walled silo having a least temperature of 23.9^{0}C, while the highest temperature for double walled silo was at 12:30pm with 33.6^{0}C and the result also showed that the temperature reading was usually low by 8:30am within the single walled silo having a least temperature of 25.2^{0}C while highest temperature for single walled silo was at 12:30pm having a range of 36.6^{0}C. The double walled mobile metallic silo moved smoothly on a flat untilled road by pushing without a jolting action and undulating movement. In conclusion, the double walled mobile metallic silo performed better than the single walled silo and has a good thermal property which is suitable for the storage of grains in tropical region for low income farmer.

Keywords: *Double walled, temperature, thermal time lag, metallic, silo, mobile and Nigeria*.

INTRODUCTION

It was predicted that the world's population will increase to about 9.1 billion people by the year 2050 and most of this increase will occur in developing countries (FAO, 2009). This increase translates into 33% more human mouths to feed, with the greatest demand growth in the developing communities of the world,
food supplies would need to increase by 60% in order to meet the food demand in 2050. Food availability and accessibility can be increased by increasing production, improving distribution, and reducing the losses. Thus, reduction of post-harvest food losses is a critical component of ensuring future global food security (Jaspreet and Anita, 2015). Hence, the need of investing much into the agricultural sector is necessary in order to produce more food to feed the world. Furthermore, increasing agricultural productivity must go hand-in-hand with improved storage in order to reduce post-harvest losses. Promoting small scale agriculture is the key to achieving food security in developing countries Metal silo technology for small and medium scale farming are developed for more comfortable and effective grains protection. The vast majority of silo structures in existence in Nigeria are made from single walled metal sheets which a lot of researchers have studied and reported that they are majorly affected by moisture build up within the silo wall as a result of high thermal conductivity between the ambient environment and the silo wall which then transfers heat to the stored grains in the silo thereby reducing the quality (Alonge *et al*, 2011 ; Alonge and Ayeni , 2014). The prospect of utilizing sawdust as an insulator in silo was investigated by Adejumo *et al*, (2010) when he developed a 350kg double-walled metallic silo using galvanized iron sheet with sawdust as insulating material between the walls. Temperature differences between the silo and the ambient as well as along the height were monitored for a period of thirty days. The result showed the double-walled sawdust insulated metallic silo demonstrated some prospects for use in grain storage especially in the reduction of temperature fluctuations within the silo. In a related research, Yusuf and He, (2011) developed a single walled mobile metallic silo that could be hitched to any class of vehicle with the aim of providing a mobile storage platform for grains in developing countries.

Sawdust is the main by product of wood timber processing. Types of sawdust depend on the varieties of wood from which it is obtained. Hence their thermal properties will differ from one to another. Ogunleye and Awogbemi, (2007) investigated the thermal and physical properties of eight varieties of sawdust and found that they had different thermal conductivity values. Although many outlets are available for the utilization of this waste, economical disposal of sawdust remains a problem of growing concern to the wood industry. Sawdust

particles have proven to be an effective thermal conductor over other alternative and non expensive insulators as reported by (Ogedengbe, *et al*, 2013; Tokan *et al*, 2014).
There is a need to find a suitable material of construction or a construction method that would mitigate against the rising temperature between the silo walls and the ambient environment by acting as a retardant which would slow down the flow of heat into the grains from the outside environment. In addition to this, there is a challenge of moving the grains from the harvest field to the farm house and eventually to the local market. Therefore it is imperative to construct a mobile silo for easy accessibility.

MATERIALS AND METHODS

The materials and methods were divided into three parts: design, construction and testing of the silo prototype.

Design of Deep Silo

For the purpose of this research, a double walled mobile silo made of mild metal sheet was designed and constructed with sawdust as an insulating material between walls of silo. The silo consists of four major sections which include the roof, the wall, conical hopper and the accessories. The accessories include the cover, inspection hole, the platform, wheels, handle, cover opening mechanism and the silo unloading outlet. Inspection hole were incorporated into the design to facilitate proper monitoring of the grains during storage.

Design Consideration

In the design of the silo, a number of factors aimed at ensuring effective utilization, ease of construction and management, considering the level of technology available in the rural communities and accessibility to the intended beneficiaries were taken into account. a cylindrical shape was chosen and for the estimated capacity of 1 tonnes using shelled corn of a density 720kg/m^3 and angle of repose of 27° , an internal and external diameter of 0.64m and 0.68m respectively and height of 1.2m were considered adequate for the silo.

Design Calculations for Silo

The following parameters were calculated and designed for before the silo was fabricated:

i. Plane of rupture method was used to obtain a deep silo because a silo is shallow, if its depth is less than the least lateral dimension while in a deep silo; the depth is greater than the maximum lateral dimension.

ii. Total lateral pressure per unit of wall perimeter

i. Lateral wall pressure L

ii. Vertical wall load, W_l

iii. Vertical floor pressure F_P

iv. Designs against wind load using the modified formula of Barret and Sammet (1966). The isometric view of the mobile double walled silo is shown in Figure 1.

Figure 1: Isometric view of silo

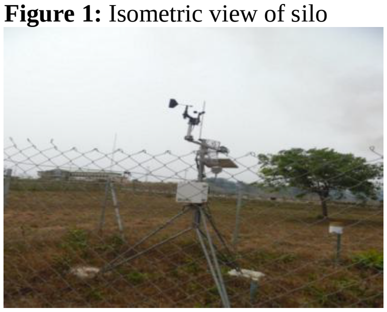

Figure 2: Automatic Weather Station

The materials used were obtained locally at various markets in Omuaran Town, Kwara State, the materials were critically considered based on strength, availability, durability and corrosiveness to prevent ease in construction work and maintenance. The materials used include 2 metal sheets of 1mm thickness, angle iron 50*50, 20mm ball bearing, 20mm shaft, flat bar, pipe, bolt and nut, sawdust, electrode, filler wire, cutting disc, filling disc, twisted rod, smoothing paper, paint, therma waterproof K thermocouple 232-101 model and Automatic Weather Station (Figure 2).

Construction Procedures

1. Marking-out, Cutting and Rolling: The silo comprised of two open cylinders, two complete cones, two frustum cones and a host of other small parts. The two cylinders (outer and inner) were marked out on two different galvanized sheets such that when rolled between two parallel cylinders rotating in opposite direction, it forms the cylindrical shape desired for the structure. All the members were cut-out using a manual shear cutter immediately after the marking out stage and they were rolled into their respective shapes (Figures 3 and 4 below).

Figure 3: Cutting out the frustum

Figure 4: Folded frustum

2 Assembling of Members: After the rolling stage, the inner and outer cylinders and the lower cones were joined by welding them one to another. The inner cylinder was centrally placed in the bigger/outer cylinder and supported by guides made of small metal chips to allow for a uniform spacing 5 cm along the circumference of the two cylinders. With the two lower cones attached to the two cylinders, the small cylinders that form the discharge outlet were fixed on the outer cone by drilling the cones to facilitate easy attachment and discharge of grains from the silo.

3. Incorporation of the Insulation Material: the choice of the insulating material was sawdust due to its low thermal conductivity of 0.06W/ (mK). The sawdust was placed in the spacing of 5 cm between the inner and outer cylinder and the lower and upper conical sections for the purpose of reducing temperature influx into the structure.

4. Incorporation of Accessories: the silo accessories include the inspection holes, the platform, wheels, the cover opening mechanism and the silo unloading outlet. Holes of diameter 20 mm were drilled from the external cylinder through the inner cylinder to serve as a means of inspecting the storage conditions in the structure. A hole was made at the top side of the silo in which the probe of the thermocouple was inserted to measure the temperature in the silo. The platform was constructed and a handle attached to it, the welded circular wheels were constructed and attached to the platform. To further improve the appearance of the structure, it was painted with green paint.

Figure 5: Temperature reading using therma probe for double walled insulated metallic silo

Figure 6: Temperature reading for single walled aluminium sheet silo

Testing of the silo

Pre-storage temperature measurements were carried out to establish the efficiency of the silo before grains are stored in the structure. Measurements were taken through each of the inspection hole located on the silo wall and outside the silo for a period of 10 days. Temperature readings were taken three times daily at 8:30 am, 12:30 pm and 3:30 pm. The inspection hole was opened slightly to avoid exchange of air with the ambient environment which might reduce the internal temperature readings, the k thermocouple was inserted and the lid closed for about 2 minutes (Figure 5). The readings were recorded and this step was repeated two more times at the pre-determined time of the day. The average of these readings were calculated and recorded as a single value in the final table. To assess the thermal performance of the double walled silo over the single walled silo, an already fabricated single walled silo made from aluinium sheet located in the Storage and Processing Laboratory, Landmark University was used for the test. The silo was transferred to the field, placed beside the double walled silo and the same procedure stated earlier was used for the measurement (Figure 6). The temperature difference between the ambient environment and both silos were also measured using the same procedure while the Automatic Weather Station measured the ambient climatic readings.

RESULTS AND DISCUSSION

The results show that there were differences between the temperature within the double walled and single walled silo. This is an indication that there is resistance to heat influx into the double walled silo from the ambient environment. The low temperature within the silo was also found to be dependent on the time of the day at which readings were taken. Naturally lower temperatures were recorded in the mornings than in the afternoon; this also has direct effect on the temperature within the silo. It could be observed that the thermal insulation property of the sawdust has reduced the heat transfer into the silo.

Double walled silo temperature reading

The Highest Temperature (H.T) of 28.2^{0}C for 8:30 am in the double walled silo (DWS) was obtained on Day 2, the H.T of 42.5^{0}C for 12:30 pm in the DWS was obtained on Day 7, the H.T. of40.9^{0}C for 3:30 pm in the DWS was obtained on Day10, the Lowest Temperature (L.T) of 21.2^{0}C for 8:30 am in the DWS was obtained on Day 6, The L.T of 32.6^{0}C for 12:30 pm in the DWS was obtained on Day 4, and the L.T of 24.9^{0}C for 3:30 pm in the DWS was obtained on Day 1. The analysis shows that the temperature increases with the time of the day, with the lowest at 8:30 am and the highest at 12:30 pm and 3:30 pm respectively (Figure 7)

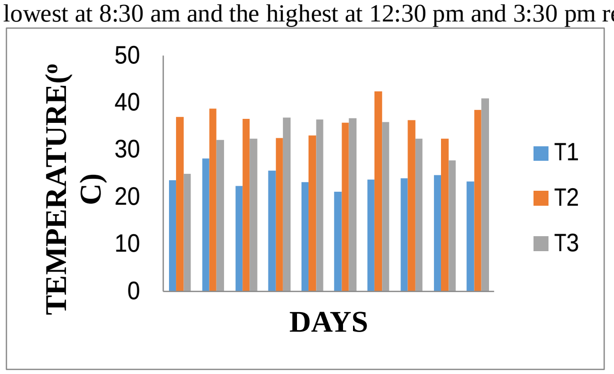

Figure 7: Average temperature variation within DW silo at different time of the day (15th to 24th May, 2015) where T1(blue) is 8:30 am, T2 (red) is 12:30pm and T3(green) is 3:30pm.

Single walled silo temperature readings

The H.T. of 29.4^{0}C for 8:30 am in the single walled silo (SWS) was obtained on Day 2, H.T. of 42.8^{0}C for 12:30 pm in the SWS was obtained on Day 7, The H.T. of 42.8^{0}C for 3:30 pm in the SW was obtained on Day10, The L.T. of 21.3^{0}C for 8:30 am in the SWS was obtained on Day 6, The L.T. of 30.4^{0}C for 12:30 pm in the SWS was obtained on Day 5, and the L.T. of 27.9^{0}C for 3:30 pm in the SWS was obtained on Day 9. The statistical analysis shows that the temperature increases with the time of the day, with the lowest at 8:30 am and gradually increased at 12:30 pm and highest at 3:30 pm (Figure 8).

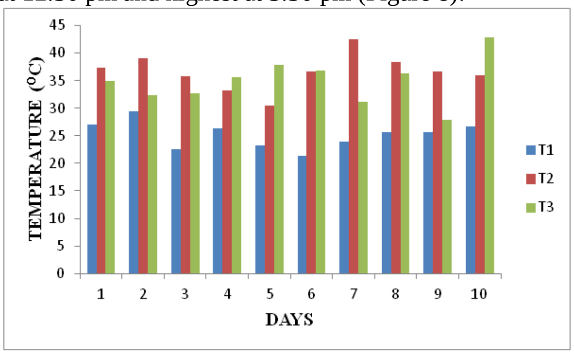

Figure 8: Average temperature variation within silo at different time of the day (15th to 24th May, 2015. Where T1(blue) is 8:30 am, T2 (red) is 12:30pm and T3(green) is 3:30pm.

Comparison between different silos at the same time.

Temperature differences at 8:30am between DWS and SWS

The H.T of 29.4^{0}C at 8:30 am in the SWS was obtained on Day 2, the H.T of 28.2^{0}C at 8:30 am in the DWS was obtained on Day 2.The L.T of 21.2^{0}C at 8:30 am in the SWS was obtained on Day 6, the L.T of 21.3^{0}C at 8:30 am in the DWS was obtained on Day 6.

The statistical analysis showed that temperature readings gotten at 8:30 am in the SWS increased but at the DWS, temperature readings gotten at 8:30 am decreased (Figure 9).

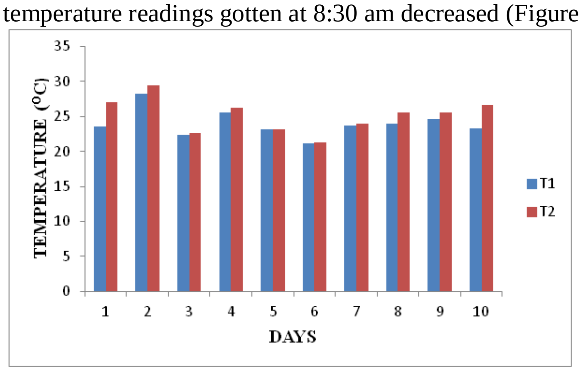

Figure 9: Average temperature variation within the two silos at 8:30am (15th to 24th May, 2015). Where T1(blue) represents DWS and T2(red) represents SWS.

Temperature differences at 12:30pm between DWS and SWS.

The H.T of 42.8^{0}C at 12:30 pm in the SWS was obtained on Day7; the H.T of 42.5^{0}C at 12:30 pm in the SWS was obtained on Day 7.The L.T of 30.4^{0}C at 12:30 pm in the SWS was obtained on Day 5, the L.T of 32.4^{0}C at 12:30 pm in the DWS was on Day 9. The statistical analysis showed that temperature reading gotten at 12:30 pm in the single walled silo; increased but at the DWS, temperature reading gotten at 12:30 pm decreased (Figure 10)

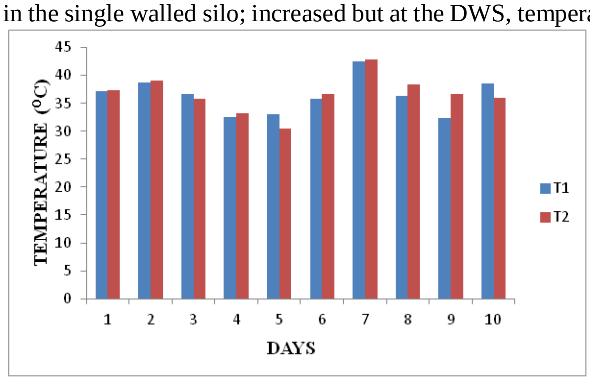

Figure 10: Average temperature variation within the two silos at 12:30pm (15th to 24th May, 2015). Where T1(blue) represents DWS and T2(red) represents SWS.

Temperature differences at 3:30pm between DWS and SWS.

The H.T. of 42.8^{0}C at 3:30 pm in the SWS was obtained on Day10, The H.T of 40.9^{0}C at 3:30 pm in the DWS was obtained on Day 10, The L.T of 27.9^{0}C at 3:30 pm in the SWS was obtained on Day 9, The L.T. of 24.9^{0}C at 3:30 pm in the DWS was obtained on Day 1.

The statistical analysis showed that temperature reading gotten at 3:30 pm in the SWS increased but at the DWS temperature readings gotten at 3:30 pm decreased (Figure 11).

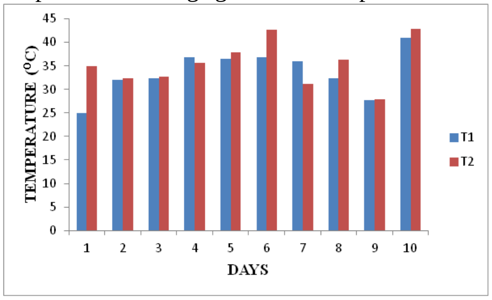

Figure 11: Average temperature variation within the two silos at 3:30pm (15th of 24th May, 2015). Where T1(blue) represents DWS and T2(red) represents SWS.

Comparison with environmental condition

Thermal time lag difference at 8:30am between DWS and ambient condition

The statistical analyses show that there are significant differences between the temperature within the DWS silo and the ambient environment (Figure 12).The H.T. of 28.2^{0}C in the DWS at 8:30 pm was obtained on Day 2 due to an heavy rainfall on the that day, the ambient temperature of 23.7^{0}C at 8:30 pm was obtained on Day 2, the temperature gotten from DWS was high due to the effect of rainfall when compared to the ambient temperature, this difference is largely due to the lagging effect of the sawdust in between the walls which did not allow heat flow from the interior into the ambient environment which had a lower temperature reading. This effect is termed the thermal time lag difference.

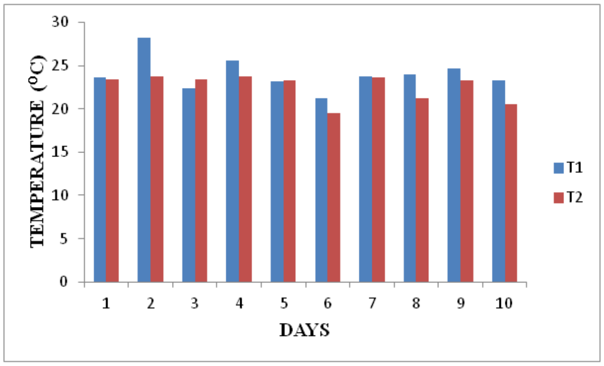

Figure 12: Average temperature within the Double walled silo and ambient condition at 8:30am (15th to 24th May, 2015). Where T1 represents DWS and T2 represents the ambient temperature.

Thermal time lag difference at 12:30pm between DWS and ambient condition

The statistical analyses showed that there were significant differences between the temperature within the double walled silo (DWS) and the ambient (Figure 13). The H.T of 42.5^{0}C in the DWS at 12:30 pm was obtained on Day 7; the ambient temperature (A.T) of 30.6^{0}C at 12:30 pm was obtained on Day 2.

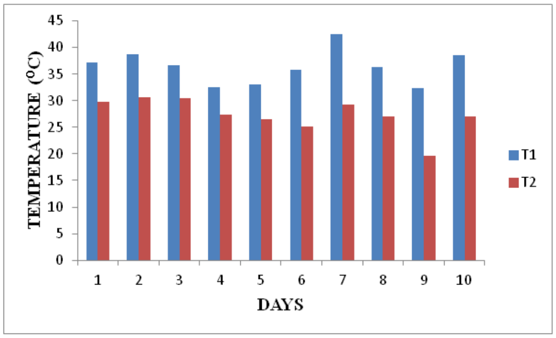

Figure 13: Average temperature within the Double walled silo and ambient condition at 12:30pm (15th to 24th May, 2015). Where T1 represents DWS and T2 represents the ambient environment temperature.

Thermal time lag difference at 3:30pm between DWS and ambient condition

The statistical analyses showed that there were significant time lag differences between the temperatures within the DW silo and the ambient (Figure 14). The H.T of 40.9^{0}C in the DWS at 3:30 pm was obtained on Day 10; the A.T. of 30.3^{0}C at 3:30 pm was obtained on Day 2.

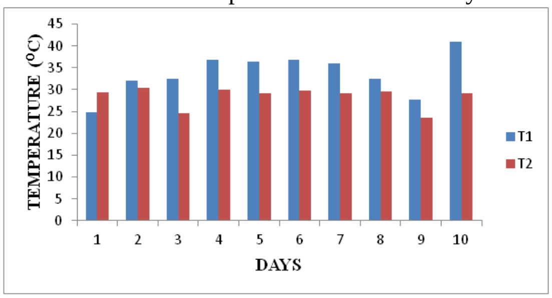

Figure 14: Average temperature within the Double walled silo and ambient condition at 3:30pm (15th to 24th May, 2015). Where T1 represents DWS and T2 represents the ambient environment temperature.

CONCLUSION

The sawdust insulated double-walled metallic silo demonstrated some prospects for use in grain storage; especially in the reduction of temperature fluctuations within the silo due to the low thermal conductivity of the sawdust. This is an indication that there is resistance to temperature influx into the silo from the ambient environment which shows that the low thermal conductivity of the sawdust has reduced the heat transfer into the silo. The silo was tested for ease of movement on a typical farm road by pushing and pulling and it easily moved from one place to another during evaluation period without jolting and undulating on the ground. The silo makes efficient use of space as compared to other locally constructed storage structures.

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EFFECT OF SEGREGATION ON THE STRENGTH OF CONCRETE USED IN FARM STORAGE STRUCTURES

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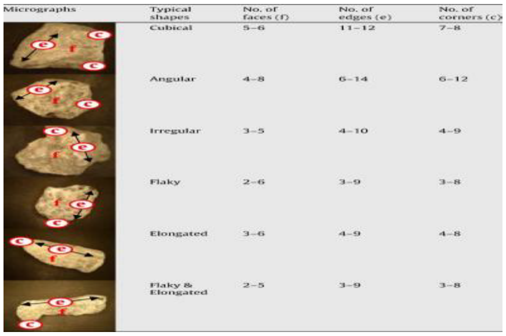
ABSTRACT
Segregation of solid module significantly affects the quality of concrete. Which can be measured through compressive quality test, to decide the limit of the heap that a solid can convey which is connected unswervingly and the devastating burden per unit surface region of the connected burden to the solid. The accompanying states of total was utilized; Angular, Elongated, Smooth rounded, Flaky total, Control total to cast 60 cubes of concrete. The trial blend proportion utilized was 1:3:6 with a water/concrete proportion of 0.5. The threw solid shapes were cured for7,14,21,and28 days and their normal compressive quality and normal thickness was ascertaine d,the compressive quality are for Angular(9.4818.28N/mm2), Elongated(9.08-16.36N/mm2),Smooth rounded(9.0-16.98N/mm2), Flaky(10.01-8.16N/mm2) and Control aggregate is (17.56-26.01N/mm2). Arrangement of this outcome shows that angular aggregate has the most elevated quality esteem; it is advisable to obtain angular aggregate even from the local quarry.

Keywords: Absorption, Aggregate, Durability, Mortar, Strength,

INTRODUCTION
Concrete and its cementations (volcanic) constituents, such as pozzolanic ash, have been used since the days of the Greeks, the Romans, and possibly earlier ancient civilizations. However, the early part of the Nineteenth Century marks the start of more intensive use of the material. Garber,(2006). Published his statement of principles of construction, recognizing the weakness of the material in tension. Also according to Nawy, (2005) a Plain concrete is formed from a hardened mixture of cement, water, fine aggregate, coarse aggregate (crushed stone or gravel), air, and often other admixtures. The plastic mix is placed and consolidated in the formwork and, then cured to facilitate the acceleration of the chemical hydration reaction of the cement-water mix, resulting in hardened concrete. Concrete is a stone like material obtained by permitting proportioned mixture of cement, sand and gravel or other aggregate, and water to harden in forms of the shape and dimensions of the desired structure (Arthur, H. N., David, D. and Charsles, W. D., 2004).Concrete is an assemblage of cement, aggregate and water. The most commonly used fine aggregate is Sand derived from river banks (Lohani, T.K., Padhi M., Dash, K.P. and Jena, S., 2012).
Concrete is one of the most widely manufactured materials in the world and over recent decades technical innovations, especially in the use of admixtures have improved not only the quality but also the range of potential applications for this versatile construction product. Today's concrete has to fulfil a wide range of requirements in both the fresh and hardened state. In most cases the properties of fresh concrete also affect the quality of the hardened concrete and ultimately its durability. This means that concrete has to be correctly proportioned and must remain homogeneous during placing and after compaction in order to avoid effects such as bleeding, segregation, honey combing, laitance, settlement and plastic cracking over the top bar. These effects would all lead to reduced quality and durability of the hardened concrete. European Federation for Specialist Construction Chemicals and Concrete Systems and European Federation of Concrete Admixture Associations, (2006). Concrete is widely used for making architectural structures, foundations, brick/block walls, pavements or roads, bridges/overpasses, motorways/roads, runways, parking structures, dams, pools/reservoirs, pipes, footings for gates, fences and poles and even boats. Famous concrete structures include the Burj Khalifa (World's Tallest Building), The Hoover Dam, The Panama Canal and The Roman Pantheon (Matthias, 2010).



Micrographs	Typical shapes	No. of faces (f)	No. of edges (e)	No. of corners (c)
	Cubical	5–6	11–12	7–8
	Angular	4–8	6–14	6–12
	Irregular	3–5	4–10	4–9
	Flaky	2–6	3–9	3–8
	Elongated	3–6	4–9	4–8
	Flaky & Elongated	2–5	3–9	3–8

Plate 1: Different Typical Shapes of Aggregate.
[www.sciencedirect.com/science/article/pii/s0301751609000428 (image Google search)]

As surface smoothness increases, contact area decreases, hence a highly polished particles will have less bonding area with the matrix than a rough particles of the same volume (Shetty, 2005).

Materials and Methods

The coarse aggregate material obtained from Tungan Mallam (Soject Quarry), Mai-Tunbi Minna and Rabah Sokoto South, was used in this research. Aggregate shapes considered during sorting of aggregate according to shapes in Plate 1, were as Follows Elongated, Flaky, Angular and Smooth Rounded. Elongated, and Flaky, were obtained from Soject Quarry at Tungan Mallam Niger State, angular was gotten from Mai-tunbi local quarry, Minna Niger state and Smooth rounded was obtained from Sokoto South at Sokoto State. Their physical property was determined and recorded. And their sizes range from 10 to 20mm.

Physical Properties

The physical properties of the aggregate were determined in accordance with BS 1377-9 (1990). These include; Moisture Content, Bulk Density (compacted and Un-Compacted), Porosity, Void Ratio, Specific Gravity, Impact value, Water Absorption, Sphericity, Roundness Ratio.

Sieve Analyses.

Some set of standard sieves was weighed and arranged in ascending order of the sizes from base to top. Some part of the samples was then taken and weigh by the use of a weighting balance, and the value obtained was recorded.

Weight of aggregate retained = (weight of sieve + aggregate sample) - (weight of sieve)

% Weight retained = $\frac{\text{Weight of aggregate retained}}{\text{Total weight of aggregate retained}}$ x 1OO

Fineness modulus (FM) = $\frac{total\ commulative\ \%retained}{100}$

Coefficient of uniformity (Cu) = $\frac{D60}{D10}$

Coefficient of curvature (Cc) = $\frac{D30}{D60 \times D10}$

Sorting coefficient (So) = $(\frac{D75}{D25})^{1/2} = \sqrt{(\frac{D75}{D25})}$

Coefficient of uniformity (Cu); - This indicate the range or spread of the sand grain size, also known as coefficient of concavity.

Coefficient of curvature (Cc); - This is the major of shape of the curve between diameter D60 and D10.

Compressive Strength Test of Concrete Cubes.

The cubes of concrete were removed from the curing tank, dried for 3 minute and weight immediately on a weighing balance to determine the weight of each cube. The cube was carefully placed in the compressive testing machine with it smooth side in contact with the plates of the machine. The machine power was switch on, the gear of the machine turn clockwise, and ready to crush the cube. At the loading the dial start reading clockwise, at failure, the dial stops and the gear turned anti-clockwise. The load at each failure was obtained and recorded. Three cubes were crushed for each shape of each sample on 7th, 14th, 21st, and 28th days of curing. The following equation was applied:

$$\text{strength} = \frac{\text{crushed load}}{\text{surface area of concrete cube}} \times 100$$

RESULTS AND DISCUSSIONS

Moisture Content (M.C)

The Moisture Content of experiment samples (Control, Flaky, Angular, Elongated, Smooth and Fine Aggregate) are given in table 1 as 0.19, 0.18, 0.19, 0.16, and 1.13 respectively. Since the Moisture content reveal the quantity of water present in each aggregates, the result shows that the aggregate contain certain amount of water which will result to low absorption capacity.

Bulk Density

The Bulk Density test result of the aggregates of different shapes are given in Table 1 for Compacted and Un-compacted respectively. The statistical analysis shows result there was significant difference in the samples for both Compacted and Un-compacted, the Elongated Aggregate as the leased compacted Bulk Density (1473.79±0.2 Kg/m^3) while Smooth Aggregate as the highest compacted Bulk Density (1605.40±0.13Kg/m^3) and Un-compacted Bulk Density shows no significant different between angular and Elongated Aggregate. These value are within the range of 1440kg/m^3 to 1850kg/m^3 as reported by Abdullahi (2005).

Specific Gravity

The results of specific gravity of the aggregates (Control, Flaky, Angular, Elongated, Smooth and Fine Aggregate) are given in Table 1 as 2.52, 2.67, 2.62, 2.55, 3.04, and 2.55 respectively. The results are within the specification of specific gravity of rock group that lies between 2.5 and 3.0 for natural aggregate. The Smooth Round aggregate have highest specific gravity. The mix design of a concrete is relative of specific gravity.

Porosity and Void ratio

Concrete durability is a subject to the level of porosity and void ratio of aggregates. Result of porosity given in Table 1 with the following value 6.68, 3.03, 6.17, 3.50, 5.96, 5.53% respectively and the void ratio obtained in the result lies between the (0-50%) percent specified

Table 1: Physical Properties result of Different Aggregates

	MC	Compacted bulk density	Un-compacted Bulk D	Porosity	Void Ratio	SG	Impact Value	Water ABS
Control Agg	0.19^c	1595.44^e	1488.9^c	6.68^f	0.94	2.52^a	9.92^e	0.65^b
Flaky Agg	0.18^b	1552.49^c	1505.4^d	3.03^a	0.94	2.67^d	5.18^a	0.63^a
Angular Agg	0.19^c	1515.63^b	1422.1^a	6.17^e	0.94	2.62^c	7.83^c	0.72^c
Elongated Agg	0.19^c	1473.79^a	1422.1^a	3.50^b	0.94	2.55^b	6.35^b	0.84^d
Smooth Agg	0.16^a	1606.40^f	1509.7^e	5.96^d	0.95	3.04^e	8.52^d	1.04^f
Fine Agg	1.13^d	1588.074^d	1487.4^b	5.53^c	0.94	2.55^b	7.94^c	0.94^e

*Value followed by same superscript alphabet are not significantly different at (P<0.05) along the column. Values are Mean of triplicate determination. (Agg)Aggregate.

Sieve Analysis

Table 2: Sieve Analysis of Aggregate.

	fineness modulus	Coefficient Uniformity	Coefficient of Curvature	Sorting Coefficient
Control Agg	6.366	1.642	1.006	1.212
Flaky Ags	5.869	1.5	1.041	1.164

Angular Agg	6.608	1.6	1.1	1.69
Elongated Agg	6.196	1.5	1.009	1.264
Smooth Rounded Agg	6.432	1.833	1.094	1.274
Fine Agg	4.213	2.714	1.371	1.618

Grading of Aggregate (Agg) was done by sieve analysis. The properties of aggregate used for the research are summarized in Table 1.0 while shows their particles size distribution.From the Table, it shows the sieve analysis of the sand used as fine aggregate in the experiment and it distribution into fine, medium, and coarse aggregate of tiny particle distributions. The sand fractions were more of medium fraction of the sieve analysis, than coarse and fine fractions. Followed by some coarse nature of the sand particles and some little fine fraction of its content the particle size distribution curve for the Elongated, Flaky, Angular, and Smooth Rounded and Control Coarse Aggregates. From the Table, it was observed that, there was more of coarse size gravel fraction in appearance than the medium and fine size gravel fraction. The Fineness modulus (FM) for fine Aggregate (sand), and Coarse Aggregate (Elongated Aggregate, Flaky Aggregate, Angular Aggregate, Smooth Rounded Aggregate, and Control Aggregate) are as follows; 4.2130 and (6.1965, 5.8696, 6.6086, 6.4328, and 6.3663).Comparing the fineness modulus calculated of all the aggregate used for this experiment, it was observed that the sand can be used as fine aggregate more than the order aggregates which were used as the coarse aggregates.

Comparing all the coarse aggregate, it was observed that Angular aggregate possess the highest fineness modulus which makes it to be the coarsest in nature, followed by the Smooth Rounded Aggregate, Control Aggregate, Elongated Aggregate, and lastly the Flaky Aggregate. Coefficient of uniformity (Cu) for Fine Aggregate (sand), and Coarse Aggregate (Elongated Aggregate, Flaky Aggregate, Angular Aggregate, Smooth Rounded Aggregate, and Control Aggregate) are as follows 2.7143, and (1.5000, 1.5000, 1.6000, 1.8333, and 1.6429).The fine aggregate which was the sand shows a great uniformity in nature; according to the value obtain from the calculated Coefficient of Uniformity of aggregate, and when it was compared with the rest of the coarse aggregate.

This result gives the blending nature of the fine and coarse aggregates use for this experiment in the nature. Coefficient of Curvature (Cc) for fine Aggregate (sand), and Coarse Aggregate (Elongated Aggregate, Flaky Aggregate, Angular Aggregate, Smooth Rounded Aggregate, and Control Aggregate) are as follows 1.3714, and (1.0099, 1.0417, 1.1000, 1.0947, and 1.0062).

The Angular aggregate shows the highest curving nature when it was compared with the order Coarse aggregate, this was because of its Angular nature. Smooth rounded was the second in terms of arrangement from highest to lowest, and this was because of it physical nature as smooth and roundness. Flaky aggregate was the third but has much greater curviness than the Elongated and Control. Sorting coefficient (So) for fine Aggregate (sand), and coarse Aggregate (Elongated Aggregate, Flaky Aggregate, Angular Aggregate, Smooth Rounded Aggregate, and Control Aggregate) are as follows 1.6183, and (1.2649, 1.1649, 1.1698, 1.2748, and 1.2127).

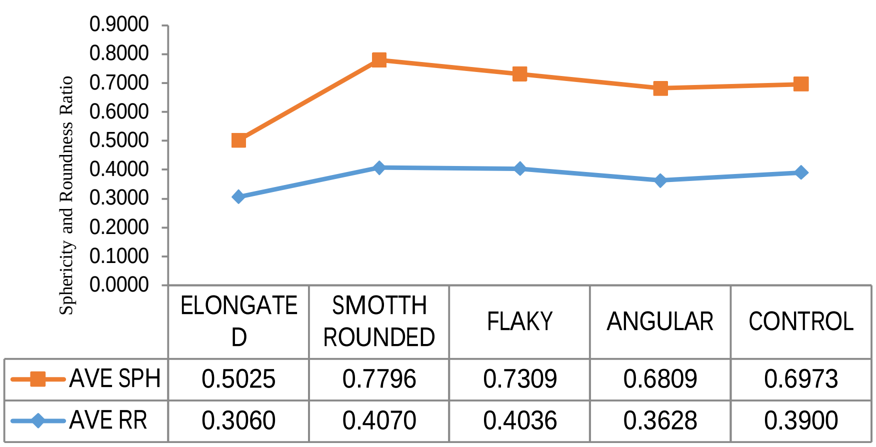
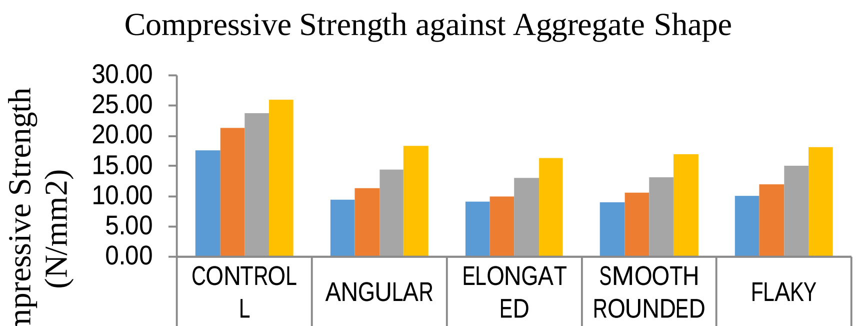


Figure 1: Sphericity and Roundness Ratio against Aggregate Shape

The Coarse Aggregate were arranged in according to their increase in strength from the lowest to the highest in terms of strength, and the graph in Figure 1 indicate that there was an increase in the sphericity and roundness ratio as the strength moves or increases from left to right which later decreases in terms of the Aggregate shape. This also shows the Sphericity and Roundness Ratio of the Coarse Aggregate Shapes. The Weight of Aggregate used was between 600g to 1000g of each sample of this experiment. At the highest compressive strength (control) the roundness ratio and sphericity was at an average when compared to the rest of the shapes, because it constitute of aggregate with different shapes, number of edges , faces, and corners. This result indicated that considering the arrangement of aggregate from left to right in terms of their increase in strength, in relation to concrete segregation to the effect of the concrete strength it was relies that the control aggregate has an average to high resistance of segregation to the strength of concrete casted with it as a sample.
Smooth Rounded Aggregate shows a high sphericity and roundness ratio, which contributed mostly to it failure due to the occurrences of segregation to the concrete casted



	CONTROL L	ANGULAR	ELONGAT ED	SMOOTH ROUNDED	FLAKY
7	17.56	9.48	9.08	9.01	10.01
14	21.30	11.36	10.00	10.61	12.00
21	23.82	14.50	13.01	13.21	15.11
28	26.01	18.28	16.36	16.98	18.16

Figure 2: Compressive strength (N/mm^2) versus Aggregate shapes (Control, Angular, Elongated, Smooth Rounded and Flaky Aggregate).

Compacting Factor Test are shown in Figure 2, for Aggregate such as Angular, Elongated, Smooth rounded, Flaky Aggregate, and Control aggregate it was 42.00mm, 39.00mm, 41.00mm, 37.00mm, and 41.00mm. For the compacting factor test aggregate such as Angular, Elongated, Smooth rounded, Flaky Aggregate, and Control aggregate it was 0.94, 0.97, 0.93, 0.88, and 0.91 The result of the average Compressive strength (N/mm^2) for 7, 14, 21, and 28 days for each aggregate such as Angular, Elongated, Smooth rounded, Flaky Aggregate, and Control aggregate. For Angular it has the following result 9.48 N/mm^2, 11.36 N/mm^2, 14.50 N/mm^2, and 18.28 N/mm^2, The result indicated that there was an increase in the compressive strength of the concrete with respect to the ageing of the concrete after curing for 7, 14, 21, and 28 days.

The result of the average density of cubes (kg/m^3) for 7, 14, 21, and 28 days for each Aggregate such as Angular, Elongated, Smooth Rounded, Flaky Aggregate, and Control aggregate. For Angular it has the following result 2202.47 kg/m^3, 2141.23 kg/m^3, 2307.16 kg/m^3, and 2322.96 kg/m^3, for Elongated it has the following result 2099.75 kg/m^3, 2105.68 kg/m^3, 2334.81 kg/m^3, and 2431.60 kg/m^3, for Smooth rounded it has the following result 2206.42 kg/m^3, 2202.47 kg/m^3, 2269.63 kg/m^3, and 2382.22 kg/m^3, The results of the average bulk density indicate that there was an increase in the average bulk density of the concrete cubes from 7 days to 28 days of curing for some of the coarse Aggregate shapes. However, the significant differences of the average compressive strength of the different aggregate used during the experiment indicates how the concrete strength varies with respect to time or days of curing.

CONCLUSION

The experimental work carried out on the effect of concrete segregation on the strength of concrete used in farm storage structures was successfully carried out, and the result shows that the theory behind effective segregation is dependent on the specific gravity, bulk density, shapes (i.e. Angular, Flaky, Elongated, and Smooth Rounded), and number of edges (e), faces (f), & corners (c) and also sphericity and roundness ratio of some aggregate which make up the shapes of the aggregate.

The mean compressive strength of the concrete which was produce using the different shapes but the same trial mixture, and which under goes 28 days curing period (hydration with water) are as follows for the following shapes Angular, Elongated, Smooth rounded, Flaky aggregate, and Control aggregate are 18.28 N/mm^2, 16.36 N/mm^2, 16.98 N/mm^2, 18.16 N/mm^2, and 26.01 N/mm^2, From this result, it can be concluded that Angular aggregate has the highest strength there by showing a good resistance to segregation during the time of settling of the concrete fresh mixture i.e after the concrete have been placed in kit formwork or mould, and before the cement hydration is completed to bind both the fine and coarse aggregate together in the presence of water for curing, however the control aggregate shows the highest strength when compared with the rest of the shape.

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