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EFFECT OF CEREAL FLOURS ON THE PROPERTIES OF CONCRETE

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In hot weather in order to overcome accelerating effect of high temperature retarding admixture are added to concrete to slow down the initial hydration so that concrete remain plastic and workable for longer period of time which will gives room to high volume placements. The research is aim at investigating the effect of cereal flours made from maize and sorghum on the properties of concrete; this is with a view to establishing the results of the selected cereals as retarder in concrete. The mix used for the research was calculated using the BRE method and the water cement ratio of 0.6 was used. The mix ratio of 1:1.13:3.40 was used. Trial test was conducted with maize, sorghum, wheat and millet. The cereal was ground, sieved and added in various percentages by weight to the cement, mix and cast in a cube of 100 by 100 by100mm mould left in the mould for 24 hours then demould and immersed in water for seven days. After seven days it was tested for compressive strength, the sorghum and maize gave the highest and higher values of compressive strength respectively and therefore used for the main work. The same procedure was used for the main work the samples used were produced in three different batches. The first sets of batches were the control samples which also served as source of comparison. The second and the third batches had various percentages of maize and sorghum flour added respectively. The curing was done by complete immersion for 1, 3, 7, 28 and 56 days for all the samples. It was observed that the maize flour has higher starch content, PH and solubility than the sorghum flour. The cyanide content of sorghum flour was higher than the maize flour. The compressive strength increase as the age of curing increases. Sorghum flour had higher values of compression strength than maize flour. The optimum compressive strength of the test specimen is achieved at 3% dosage of maize and sorghum flour added to the cement. Maize and Sorghum flour improved the workability of concrete; it was observed that as the dosage of cereal flour increases, the slump increased. Maize and sorghum flour also delay the setting time of cement, for sorghum flour added to cement the setting time is achieved at 410 minutes while for maize is 248 minutes. Sorghum and maize flour are good sources of retarding admixture to concrete.

Keywords: cereal flours, compressive strength, concrete, retarding admixture, setting time

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INTRODUCTION

Concrete is a construction material made by mixing cement paste (Portland cement and water) and aggregate (sand and stone). The cement-paste is the "glue" which binds the particles in the aggregate together (Malhotra, 2000). (Shetty, 2005) stated that the strength of cement-paste depends on the relative proportion of water and cement, a more dilute paste been weaker. They further stated that concrete hardens through chemical reaction between water and cement without the need for air. The relative proportion of cement-paste and aggregates affects the strength, a high proportion of the paste making stronger concrete.

Due to high temperature when concrete is mixed freshly the water demand for adequate workability is high, other problems associated with this high temperature are increase in concrete shrink loss, difficulties in placing concrete as a result of high rate of setting, increased tendency of plastic shrinkage cracking (Khan and Muhammad, 2004). The hot weather also has tendencies of increasing the temperature of fresh concrete resulting in lower ultimate strength and thermal cracking (Otoko, 2014). As a result of the above mentioned problems associated with fresh concrete due to hot weather retarders are introduced in producing concrete in hot climate so that concrete remain plastic during mixing, transporting, placing, compacting and finishing. These conventional retarding admixtures are rare to find and expensive (Alibaba, 2017) thereby making search for alternative materials to be necessary. The importance of the use of retarder for producing concrete in hot climate cannot be over emphasis as set retarding concrete admixtures delay the chemical reaction that takes place when concrete starts the setting process (Mihai and Rosca, 2008). Retarders as admixture in concrete a lot of initial setting problem could be solved.

According to Okafor (2008), several compounds have been found to exhibit retarding action in concrete and their performance is covered in the British standard BS 5075: Part 1 (1982). Some of these compounds include soluble zinc, salt, borates, sugar and carbohydrate derivatives. Cereal flours are carbohydrate derivatives; they are good source of retarding admixture. Cereal flours are relatively cheap, produced locally in very large quantities and the production of flour from their grains does not require any complicated technology. Using cereal flour will avail more opportunities for the farmers in terms of increase in income from the sale or yield from their farms, this will also create more job opportunities that will increase the standards of living.

Okafor (2008), observed that cassava flour considerably improved the workability of the fresh concrete and delayed the setting time of cement by up to 6 hours. Cassava reduced the early strength of concrete but the long term strength will be improved. According to Otoko (2014), a small quantity of cassava powder (0.05% by weight of cement) has the potential of increasing the workability as well as the long term strength of concrete. Also Abalaka (2011) observed that the compressive strength of sugar as admixture is at peak at 0.05% of sugar concentration. He also ascertained that the maximum strength of cassava powder as admixture is at 0.05% of cassava starch concentration. For the purpose of this research, the researcher intends to investigate the effect of two cereal flours namely maize and sorghum on the properties of concrete.

LITERATURE REVIEW

Retarding admixtures

Retarding admixtures slow down the initial hydration of cement, lengthening set time. According to the European Federation of Concrete Admixture Associations (2005), retarding admixture make up of 1.5% of admixtures sold in Europe. Retarders are beneficially used in hot weather condition in order to overcome accelerating effects of higher temperature and large masses of concrete on concrete setting time (American Concrete Institute, 1999). It functions by coating the surface of C3S (Tricalcium Silicate) components, thus, delaying the reaction with water. Reaction products are slow to form as such the setting and hardening of concrete are delayed reducing early compressive strength (Rixom et al., 1999). According to the European Federation of Concrete Admixture Associations (2005) Retarders can be used in hot weather to prevent early stiffening and;

- To increase working life, especially when used in conjunction with superplasticisers.
- To allow the placing of a large pour of concrete over several hours.
- To place concrete in layers without cold joints.
- To extend the time between mixing and placing (e.g., for long transport time).
- Prevent setting of the concrete in the truck in case of delay.

According to the National Ready Mixed Concrete Association (2001), for large jobs, or in hot weather, retarding admixture should be added to concrete to allow more time for placing and finishing. Most retarders also function as water reducers. Retarders should meet the requirements for type B or D in ASTM C 494 – 12 (2002). Retarding admixture are used to offset unwanted effect of high temperature such as acceleration of set and reduction of 28 day compressive strength and to keep concrete workable during the entire placing and consolidation period (ACI Education Committee, 2013).

Types of retarding admixture

According to ASTM C494 – 12 (2002), there are three (3) kinds of retarders namely

- Type C (Retarding Admixtures) this simply retards the hydration of Portland cement
- Type D (water reducing and Retarding Admixtures) this does not only retards the hydration but also acts to disperse the cement particle and thereby provides water reduction. According to Dias, Dewapriya, Edirisooriya and Jayathunga (2010) the most commonly used chemical retarder is the type D. The main differences between type C and D are the water – reducing characteristic in type D that gives higher compressive strengths by lowering water – cement ration (Dias et al., 2010).
- Type G (High range water reducing and retarding admixture)

Chemical Composition of retarding admixture

Retarding Admixtures consists of both organic and inorganic agents. The main ingredients of organic retarders are as follows:

- Lignosulphonic acids and their salts. Example sodium (Na), Calcium (Ca) or Ammonium (NH4).

- Hydro-carboxylic acids and their salts.
- Carbohydrates including sugar.

The main ingredients of inorganic retarder are oxides of

- Lead and zinc
- Phosphates
- Magnesium
- Fluorates and borates

Advantages of retarding admixtures

- In large scale construction, retarding admixtures permits greater flexibility in extending the time of set and prevention of cold joint.
- Retarding Admixtures improves workability, cohesion and extends setting time, provide protection against delays and stoppages and facilitates keeping workable concrete for extended period.
- Facilitates finishing in hot weather, improves pumpability, cohesion and workability of concrete.
- Reduces bleeding and segregation where poor sand grading are unavoidable.
- Reduces adverse environmental effects of various nature on concrete and embedded steel by consideration of reduction in permeability.

Where retarding admixture are used

Retarding admixture are used in concrete to offset the accelerating effects of high temperature which decrease setting time to avoid compilation when unavoidable delays between mixing and placing occur (United State Department of Transportation (FHWA, 2015). Retarding concrete admixtures are used to delay the chemical reaction that take place when the concrete starts the setting process. Retarding admixture are used in concrete pavement construction, allowing more time for finishing concrete pavements reducing additional costs to place a new concrete batch plant on the job site and helps eliminate cold joints in concrete, retarders can also be used to resist cracking due to form deflection that can occur when horizontal slabs are placed in sections. Most retarder also functions as water reducers and may entrain some air in concrete, (Khan et al.,2004).

According to Mihai et al., (2008), retarder serve best to compensate for unwanted accelerations of working times due to changes in temperature of cement or due to other admixture side effects. They also are used to extend the working time required for complicated or high – volume placements and for retarding the set of concrete at a surface where an exposed aggregate finish is desired. Retarding admixtures are used

- Where long transportation of ready mixed concrete is required then premature setting can be usefully avoided by this type of admixture.
- When concrete is being placed or transported under conditions of high ambient temperature.
- In case of large concrete pours.
- Concrete construction involving sliding formwork.

Retarders are used in varying proportions, often in combination with other admixtures, so that, as working temperatures increase, higher doses of the

admixture may be used to obtain a uniform setting time (Mihai et al.,2008). Simple retarders typically consist of one of four relatively inexpensive materials: lignin, borax, sugars, or tartaric acids or salts (Khan et al., 2004). Retarding admixtures are widely appreciated as these can improve both mixing water efficiency and delay initial set of concrete mixes. This improvement in water is used to provide increased strength, density and workability without rise in cement, while retardation of setting times permits ignorance of cold joint where delay in transporting and placing concrete take place. Retarding admixtures are used on towers, chimneys, high building, tunnels/shaft lining and offshore construction.

Problems associated with the use of retarding admixtures

The prime function of retarding admixture is to delay the setting of concrete. Over usage of retarding admixture on concrete can result to the following side effect

- Excessive dosage may excessively delay hardening of concrete
- A decrease of early strength within the first 24 hours
- Increase bleedings
- An increase in slump
- A slight increase of the plastic shrinkage
- Creep, drying shrinkage
- Durability are not significantly affected by the inclusion of retarding admixture.

Possible Cost of Retarder Admixture

The production cost of concrete we use in construction is very high so we use different methodology to bring down the high price for example different types of admixtures are used to enhance the properties of concrete. Retarders are used to enhance the properties of concrete in hot weather (Kumar, 2015). Producers uses admixture to bring special properties to the fresh or hardened concrete; these special properties are related to the reduction of water consumption, increased resistance to compression or extension of the setting time, and others, they also can improve the durability, workability and strength of a concrete mixture and also is used to overcome difficult situations in construction such as casts in hot or cold weather, pumping requirements, early strength requirements or specifications of a water/cement ratio very low.

Retarding admixture are usually not manufactures in Nigeria, not really available and expensive. According to Alibaba (2017) the available retarding concrete admixtures in Nigeria market are:

- Sodium Gluconate set retarding concrete admixture
- Retarding concrete admixture
- Sodium Naphthalene set retarder concrete admixture
- Lignin Sulfonate water retarder

According to Alibaba (2017) one ton of sodium gluconate retarding concrete admixture cost range from 140,000 naira to 150,500 naira, one metric ton of sodium gluconate retarding concrete admixture cost range from 192,500 naira to 210,000 naira, one ton of retarding concrete admixture cost range from 140,000 naira to 525,000 naira, one ton of sodium Naphthalene set retarder cost range from

150,000 naira to 200,000 naira, and one metric ton of Lignin Sulfonate water retarder calcium cost range from 4,000 naira and above.

Effect of retarders on cement paste

When water is first added to cement there is a rapid initial hydration reaction, after which there is little formation of further hydrates for typically 2–3 hours (Ballieu, 2013) The exact time depends mainly on the cement type and the temperature (Portland Cement Association, 2015). This is called the dormant period when the concrete is plastic and can be placed (Baradan, 1998). At the end of the dormant period, the hydration rate increases and a lot of calcium silicate hydrate and calcium hydroxide is formed relatively quickly (Portland Cement Association, 2015). This corresponds to the setting time of the concrete. Cement paste/concrete set gradually under the standard laboratory condition (temperature 230C and relative humidity not less than 90%) ASTM C 191 – 77, (2013). Outside the laboratory concreting is done under harsh or mild weather. In Northern part of Nigeria concreting is usually subjected to hot weather which is defined as any combination of high air temperature low relative humidity wind velocity and intensities of solar radiation (Khan et al., 2004) tending to adversely affect the quality of fresh and hardened concrete.

Cereal flour as retarding admixtures

According to Ioannis and Persefoni (2008) Cereal crops are mostly grasses cultivated for their edible seeds (actually a fruit called Caryopsis). Cereal grains are grown in greater quantities worldwide than any other type of crop and provide more food energy to the human race than any other crops. The seven principal cereals grown in the world are wheat, maize, rice, barley, oats, rye and sorghum (FAOSat, 2014). Their mature dry kernels (seeds) are often called cereal grains. All cereals crops belong to the grass family Gramineae that accounts for the major portion of the monocot (monocotyledonae) division of flowering (seed – producing) plants (Lantican, 2001).

Cereal flours are carbohydrate derivatives; they are good source of retarding admixture. ASTM C494 – 12 (2002), defined retarding admixture as admixture that are used to slow down the speed of the reaction between cement and water by affecting the growth of the hydration products and/or reducing the rate of water penetration to the cement particles.

According to the European Federation of Concrete Admixture Association (2005), Retarding admixture are used for the following purpose

i. In hot weather to prevent early stiffening;
ii. To increase working life, that is increase workability;
iii. To allow the placing of a large pour of concrete over several hours;
iv. To place concrete in layers without cold joints;
v. To extend the time between mixing and placing (e.g., for long transport time);
vi. Prevent setting of the concrete in the truck in case of delay.

Soluble carbohydrate derivative admixtures like sugar, water soluble carbohydrate such as soluble starch (cassava and cereal flours) and dextrins are effective retarding admixtures. Very small dosage of the order of 0.05 to 0.1 percent of mass

of cement is enough. 0.05 percent sugar can delay initial setting time by about four hours (Gambhir, 2004).

MATERIALS AND METHOD

Materials

The materials used in the research include cement, sand, crushed granite, water, sorghum flour and maize flour.

Cement

The cement used for this research work was ordinary Portland cement OPC, grade 42 conforming to BS 12:1996 manufactured by Dangote Cement Company obtained from Samaru Zaria.

Coarse aggregate

The coarse aggregates used were crushed granite with maximum nominal size of 20mm and was then sieved by using sieves conforming to BS 812 – 103.1:1985

Fine aggregate

The fine aggregate used in this research work was sieved conforming to BS 812 - 103.1:1985. The fine aggregate used was sourced from a river in Zaria and having nominal maximum size of 5mm.

Water

Clean tap water deemed for drinking was used for the production and curing of concrete samples for this research. The water conforms to BS EN 1008.2:2002.

Cereal flours

The cereal was obtained from Seed Production unit of Institute for Agricultural Research (IAR), Ahamdu Bello University, Zaria. The maize used is Sammaz 15 and the sorghum used is Samsara 17. The cereals were grinded in the milling centre of the same Institute. The milling machine was thoroughly washed, allowed to dry and used to ground the cereal seeds to powdered texture. The cereal flour was taken to the laboratory of Department of Building, Ahamdu Bello University Zaria and sieved in accordance with BS sieve number 85 (standard sieves and mesh size) to remove any chaff present in the flour.

Proximate analysis of sorghum flour

The samples of the sieved cereal flours were taken to Faculty of Agriculture, Department of Animal Sciences (Biochemical Laboratory Unit), Ahamdu Bello University, Zaria to determine the starch content, PH value, solubility and cyanide content.

Preparation of specimen

Trail mix

A trail mix was designed using BRE method from which the quantities of the various constituents of concrete was derived using concrete mix of 1:1.13: 3.40 (1 part of cement, 1.13 parts of fine aggregate and 3.40 parts of coarse aggregate) and water cement ratio of 0.6.

The various constituents of the concrete mix were batched as obtained from the design, the batching was done by weight using an electronic scale, after which the portion of the cereal flour was thoroughly mixed with the cement and added to the aggregates mixed dry until an homogenous mixture was achieved. Water was then added and the mixing continued for few minutes after which the concrete was placed in a 100 x 100 x 100 mm mould in three layers, each layer was compacted 25 times with a tamping rod to exclude all voids in the concrete, the cast concrete was allowed to set for 24 hours after which it was demoulded and put in a curing tank; the curing method used was complete immersion.

This process was repeated for concrete mixes containing four different cereal flours namely maize, sorghum, millet and wheat and percentages of cereal flours added to the cement were 1% to 5% respectively. After 7 days of curing the cast samples were removed from the curing tank and sun dried for 2 hours and then tested for compressive strengths by placing them in crushing machine and the crushing load of each specimen was recorded.

After the tests were carried out and the results compared with the control mix (that is mix without any cereal flour). It was observed that the samples containing maize and sorghum had the higher and highest values of compression respectively; hence they were used to conduct this research.

Final mix

The proportioning of the mix was carried out by batching the various quantities of the constituents as derived from the concrete mix design using the BRE method. The mixing was done using mixing machine, but each cast sample was cured for different period of 1, 3, 7, 28 and 56 days. For the control mix (that is no cereal flour added) and the specimen with maize and sorghum in the various percentages of 1% to 5% respectively. The mould were clamped together to prevent leakage of cement paste and it was ensured that every batch of mix was placed in mould to produce cube samples with regular surfaces. The samples were demoulded after 24 hours and then transferred into the curing tank for curing until the desired age for testing (1, 3, 7, 28 and 56 days) was attained. The properties of the hardened concrete samples tested were compressive strength.

RESULTS AND DISCUSSION

Proximate analysis of cereal flour

Table 1 presents results of the proximate analysis test of cereal flour used for the research, Maize (Sammaz 15) and sorghum (Samsara 17). It was observed that the maize has higher starch content, PH and solubility than the sorghum. The starch content of the maize was 85.62%, PH was 7.94%, and solubility was 4.78% while the starch content of sorghum was 83.57%, PH was 7.31% and solubility was 4.19%. The cyanide content of sorghum was higher than maize, the cyanide content of sorghum was 2.22% and maize was 0.8%. The maize flour is more alkaline than the sorghum flour this means that the maize flour may have lower compressive strength of the test sample (Sharma and Sood, 2015). From Table 1, the P value shows that there is significant difference between the starch content, PH, solubility, cyanide content of maize flour and sorghum flour.

Table 1: Proximate analysis of maize and sorghum flour

Parameters	Maize flour added to concrete	Sorghumflour added to concrete	P Value
	Mean ± S.E	Mean ± S.E	
STARCH (%)	85.62 ± 0.00	83.57 ± 0.00	0.00
PH(%)	7.94 ± 0.00	7.31 ± 0.00	0.00
SOLUBILITY(%)	4.78 ± 0.00	4.19 ± 0.00	0.00
CYANIDE(%)	0.80 ± 0.00	2.22 ± 0.00	0.00

Results for tests on fresh concrete specimens

Workability test of concrete

Table 2 presents the Slump test results of the fresh concrete made with maize and sorghum flours as admixture. It was observed as the dosage of the cereal flour increases, the slump increased for both maize and sorghum. The maize flour increased from 49mm to 120mm while the sorghum increased from 38mm to 98mm.the P value shows that there are significant differences between the slump test result of maize flour added to concrete and sorghum flour added to concrete.

Table 2: Slump test result of maize and sorghum flour added to concrete

Percentage dosage of cereal flour added to concrete	Maize (mm)	Sorghum (mm)	P Values
	Mean ± S.E	Mean ± S.E	
0 %	30.00 ± 0.32	30.00 ± 0.32	1.00
1 %	49.00 ± 0.32	38.00 ± 0.32	0.00
2 %	55.00 ± 0.32	51.00 ± 0.32	0.00
3 %	60.00 ± 0.32	57.00 ± 0.32	0.00
4 %	80.00 ± 0.32	74.00 ±0.32	0.00
5 %	120.00 ± 0.32	98.00 ± 0.32	0.00

Setting time test

Table 3 presents the setting time of cement produced with different dosage of cereal flour. The results and P value show a significant delay in both the initial and final setting time of cement added with cereal flour. For the maize flour added to cement both the initial and final setting time increases as the dosage level of maize flour increases. For sorghum flour added to cement the initial setting time increase from 1% to 4% and falls at 5% this might probably be due to the fact that the cyanide content of sorghum is higher than that of maize while the final setting time of sorghum increases as the dosage level of sorghum flour increases.

As the accumulation of cyanide content increase the initial setting time increase. This is attributed to the increased cyanide content of the cement due to the increased quantity of the admixture, the cyanide probably alter the alkalinity of the cement environment. However, this condition appears to cease as cyanide becomes exhausted and the retarding action of the carbohydrate restored hence, the final setting time remains unaffected (Okafor, 2008).

Table 3: Setting time of cement with cereal flour as admixtures

Dosage of admixture (%)	Initial setting time maize flour added to cement (mins)	Initial setting time sorghum flour added to cement (mins)	P	Final setting time maize flour added to cement (mins)	Final setting time sorghum flour added to cement (mins)	P
	Mean ± S.E	Mean ± S.E		Mean± S.E	Mean ± S.E	
0	111.02±0.31	111.02 ± 0.32	1.00	201.2±0.34	201.20 ± 0.34	1.00
1	150.04±0.32	221.10 ± 0.33	0.00	248.0±0.32	242.10 ± 0.33	0.00
2	178.06±0.32	338.00 ± 0.31	0.00	317.3±0.20	379.00 ± 0.31	0.00
3	353.22±0.32	381.00 ±0.32	0.00	353.0±0.16	399.10 ± 0.33	0.00
4	210.04±0.35	410.10 ± 0.33	0.00	402.2±0.34	446.1 ± 0.31	0.00
5	248.00±0.32	212.50 ± 0.44	0.00	437.9±0.19	492.00 ± 0.27	0.00

Results for tests on hardened concrete

Density

Table 4 shows the average density of concrete test samples at different ages of curing. It was observed that there is no uniform change in the density of the sample as the dosage of cereal flour increases with increase in time of storage in water tank. This may be due to the shape of the mold, mixing and compaction. It was also observed that the density of the test concrete samples with cereal flour is higher than that of the control samples. This might be due to the increase in consistency achieved when cereal flour was introduced to the concrete.

Table 4: Densities of concrete with cereal flour admixtures

Cereal flour Dosage (%)	1day (Kg/m^3)	3days (Kg/m^3)	7days (Kg/m^3)	28days (Kg/m^3)	56days (Kg/m^3)
0%(control)	2300	2421	2486	2440	2526
1% maize	2335	2485	2493	2534	2547
2% maize	2417	2490	2498	2562	2546
3% maize	2380	2483	2497	2450	2547
4% maize	2368	2448	2312	2537	2549
5% maize	2370	2370	2480	2543	2546
1% sorghum	2360	2510	2479	2480	2540
2% sorghum	2375	2490	2460	2486	2544
3% sorghum	2349	2477	2425	2510	2500
4% sorghum	2342	2486	2450	2523	2511
5% sorghum	2344	2480	2400	2480	2440

Compressive strength

Compressive strength of concrete with cereal flour as admixture

Table 5 shows the compressive strength of concrete containing cereal flour as admixture, it was observed that the compressive strength increases as the dosage of the cereal flour increases. There was increase in strength from 1% to 3% dosage of the maize flour and drop at 4% and 5%. The trends of strength development in sorghum flour added to concrete is similar to that of maize flour added to concrete

except that the sorghum flour has higher results due to the effect of dispersion of cement particle and formation of denser gel due to delayed setting (Okafor, 2008). Other factor may include improved degree of compaction, increase in consistency and enhanced workability (Neville et al., 2010). It can also be observed that at 28 and 56 days the 4% and 5% dosage level of maize flour admixture added to concrete has a lower compressive strength compared to the control concrete. From 1% to 3% dosage of maize flour admixture added to the concrete the strength increases more than the control concrete.

Table 5: Compressive Strength of Concrete Containing Cereal Flour

Percentage (%)	Day	Control(N/mm^2)	Maize(N/mm^2)	Sorghum(N/mm^2)	F - factor	P - value
		Mean ± S.E	Mean ± S.E	Mean ± S.E		
1	1	7.92 ± 0.18^a	8.30 ±0.37^a	11.80 ± 1.20^b	8.51	0.05
	3	11.00 ± 0.55^a	13.40 ± 0.29^a	17.80 ± 1.24^b	18.53	0.00
	7	16.60 ± 0.73	17.00 ± 0.27	19.50 ± 1.56	2.42	0.131
	28	25.30 ± 0.37	25.50 ± 0.39	25.20 ± 1.30	0.035	0.965
	56	30.20 ± 0.58^b	25.80 ± 0.37^a	25.20 ± 1.30^a	20.76	0.00
2	1	7.92 ± 0.18^a	10.20 ± 0.26^b	12.10 ± 0.33^c	63.66	0.00
	3	11.00 ± 0.55^a	14.60 ± 0.73^b	19.40 ± 0.48^c	49.79	0.00
	7	16.60 ± 0.73^a	17.20 ± 0.56^a	21.52 ± 0.72^b	15.65	0.00
	28	25.30 ± 0.37	25.60 ± 0.67	25.20 ± 1.30	0.057	0.94
	56	30.20 ± 0.58	27.90 ± 2.00	30.80 ± 0.34	1.57	0.25
3	1	7.92 ± 0.18^a	13.60 ±0.45^b	13.60 ± 0.67^b	45.99	0.00
	3	11.00 ± 0.55^a	17.20 ± 0.64^b	20.50 ± 0.75^c	54.10	0.00
	7	16.60 ± 0.73^a	19.40 ± 0.81^a	23.90 ± 0.71^b	23.86	0.00
	28	25.30 ± 0.37	26.10 ± 0.74	28.02 ± 1.17	2.80	0.10
	56	30.20 ± 0.58	30.80 ± 0.59	32.80 ± 1.14	2.78	0.10
4	1	7.92 ± 0.18^a	11.80 ± 0.37^b	11.10 ± 0.18^b	62.15	0.00
	3	11.00 ± 0.55^a	14.10 ±0.60^{ab}	15.60 ± 1.19^b	7.88	0.007
	7	16.60 ± 0.73	18.40 ± 0.50	18.32 ± 0.99	1.74	0.216
	28	25.30 ± 0.37^b	20.04 ± 0.56^a	24.80 ± 1.39^b	10.54	0.002
	56	30.20 ± 0.58^b	24.90 ± 0.64^a	23.42 ± 2.26^a	6.51	0.01
5	1	7.92 ± 0.18^a	8.80 ± 0.46^a	11.60 ± 0.29^b	33.43	0.00
	3	11.00 ± 0.55^a	11.40 ± 0.66^a	14.50 ± 0.50^b	11.18	0.002
	7	16.60 ± 0.73	18.00 ± 0.57	18.00 ± 0.44	1.85	0.20
	28	25.30 ± 0.37^c	20.40 ± 0.43^a	23.42 ± 0.55^b	29.13	0.00
	56	30.20 ± 0.58^b	23.60 ±1.12^a	28.28 ± 1.91^{ab}	6.57	0.01

Source: Laboratory Research Work (2016)

n = 5; data analyzed using one –way ANOVA followed by turkey multiple comparison post hoc test. Values along the same rows with different superscripts a, b, are significantly different ($p \leq 0.05$).

From Table 5, 1% to 3% dosage of sorghum flour added to concrete the compressive strength increases as the ages of curing increases, at 4% and 5% dosage of sorghum flour added to concrete there is a negative effect on the compressive strength at 28 and 56days, the test sample is lower in strength compared to the control concrete. This is attributed to the prolonged retarding action of the sorghum flour due to the high dosage level of the sorghum flour (Okafor, 2008). The optimum dosage is 3%, the compressive strength increases as the age of curing increases. From Table 4.13 the F – factor and P – values are significant where the superscripts a and b are different. For instance at 1% dosage of sorghum flour added to concrete as admixture the F – factor and P – value are significant at day 1, 3 and 56.

CONCLUSION

After carrying out the experiments, observation, analysis and discussion on the effects of cereal flour on the properties of concrete the following conclusion were drawn

1. Proximate analysis showed that maize flour has higher starch content, PH and solubility than sorghum flour. The cyanide content of sorghum flour is higher than maize.
2. Maize flour and sorghum flour delays the setting time of cement, for sorghum the setting time is achieved at 410 minutes while maize is 248 minutes. Maize flour as admixture in concrete did not adversely affect the compressive strength of concrete. At 56 days the maximum compressive strength is 30.8 N/mm2while that of sorghum at 56 days is 32.5 N/mm2. The control is 30.2 N/mm2.
3. 3% dosage of maize and sorghum flour appeared to be the approximate dosage for the concrete mix. The optimum compressive strength of the test specimen is achieved at 3% dosage of maize and sorghum flour.
4. The use of sorghum flour as admixture in concrete gives better result in the compressive strength than maize flour.

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