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Assessment of The Properties of Concrete Produced with A Blend of Two Brands of Portland Cement

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Abstract: This research work studied the properties of concrete made with a blend of two brands of Portland cement. A grade 25 concrete was designed using BRE method and the water/cement ratio of 0.6 was used. The brands of cements used were Sokoto and Dangote cement at different percentage replacement to produce a concrete specimen. Cement mortar was tested for setting time which indicate that the final setting time of sample A_1, sample A_2, sample B, sample C, sample D were 201min, 187min, 204min, 191min, 187min respectively which fall within the range for total setting time of Portland cement. The fresh concrete was mixed manually and cast in 150mmx150mmx150mm steel moulds. The concrete specimens were cured by submersion in a water tank and were tested for compressive strength at the end of 3, 7 and 28 days. The research reveals that percentage blending of the two brands in respect to 75% SOK - 25% DNG as sample B, 25% SOK - 75% DNG as sample C, and 50% SOK – 50% DNG as sample D, sample B have the highest compressive strength of 27.85kN/mm at 28 days curing, followed by sample D specimen 23.30kN/mm at 28 days and sample C with the least compressive strength of 21.78kN/mm. It is recommended that sample B, C and D Blended brands of Portland cement used in this research can be used in structural construction.

IndexTerms- **Concrete, Blend of Portland Cement, Percentage Replacement, Setting Time, Compressive Strength**

1.0 INTRODUCTION

1.1 Background of the Study

Concrete is the world most commonly used construction material. In addition to this, concrete structures are the most common type of structure which keeps developing and improving day after day to meet our environmental needs and requirements (Salahaldein, 2016). According to Venu and Neelakanteswara (2012) concrete is a building material composed of cement, sand and crushed rock as fine and coarse aggregate respectively and water. Despite, concrete being a major structural material widely consumed in the world after water (Salahaldein, 2016). The properties of a good concrete should comprise of adequate compressive strength, adequate modulus of elasticity, adequate workability, adequate impermeability, etc. on the other hand, the strength, durability, and other characteristics of concrete depends upon the properties of its ingredients, which is the proportion of its mix design, the method of compaction and other controls during placing, compaction and curing (Gambhir, 2005). However, among the various properties of the concrete, its compressive strength is considered to be of great concern which takes into account the index of its overall quality. According to Yahaya *et al*. (2014) Portland cement is the most common type of cement used as a binder in general construction purpose; it is the basic ingredient of concrete, mortar and plaster.

According to Onwuka and Omerekpe (2003) cement are hydraulic binders (consisting of chemical compositions such as calcium silicate and calcium aluminates) which react exothermically with water to form hard strong masses that are extremely low in solubility.

Portland cement (PC) is the brand of cement used for most building construction which provides an adequate binding medium for aggregate in concrete and mortar (Arimanwa *et al*., 2016). Cement is extensively used in all type of construction works like in structures, especially where high strength is required and in a situation whereby the structure is to be exposed to the action of water (Duggal, 2008). However, cement to be used in construction is required to satisfy a range of properties as specified by BS 12(BSI, 1996). Is indeed noted as it is now a common practice as different brands of cement are mixed without caution on many construction sites in Nigeria either out of negligence or when a particular brand is out of stock and what is on ground won't be enough to carry out the work at hand.

Studies shows that the strength of concrete produced depends on the chemical composition of PC used as seen in Yahaya *et al.* (2014) when they studied the compressive strength of concrete made with different brands of PC, and as reported by Amimanwa *et al.* (2016) in their work on the effect of chemical composition of ordinary Portland cement on the compressive strength of concrete, Umar (2016) studied the influence of super plasticizer on concretes made with different brands of Portland cement, and the effect of different mineral admixtures on characteristics of concrete was studied by Salahaldin (2016) among others. However, none of these researchers conducted a research on properties of concrete produced by a blend of two different brands of PC. To this effect, this research therefore studies the properties of concrete produced by a mixture or blend of two brand of PC.

1.2 Statement of Research Problem

Research reports on the assessment of the effect of chemical composition of PC on the compressive strength of concrete by Arimanwa *et al.* (2016) indicates that the chemical composition of cement as well as the mix proportion of the combining element has an effect on the strength of concrete produced, and a research on the comparison of the compressive strength of concrete made with different brands of PC by Yahaya *et al.* (2014) reports that cement varying chemical properties and physical characteristics exhibit different properties on hydration. Despite many research carried out on the strength of concrete with relation to the brand of PC used, it is a common practice on some construction site to mix or blend two PC to form mortar or concrete because of impromptu action due to shortage of one, lack of awareness, lack of supervision, assumptions that the brands are the same amongst others. To this effect, an attempt will be made in order to determine the properties of concrete made with a blend of two brands of PC.

1.3 Need of the Research

Many researchers have argued on the issue of using two different cement in the same concrete mixture, though it is technically feasible, it is strongly advisable to avoid it. Owing to the fact that the blend ratio needs to be adhered to throughout the project, another school of thought is that since there is wide range of cement available, why then blend two cements. Many research results show that the strength of concrete generally depends on the constituents of the cement. This research intends to ascertain if there will be any significant change in strength either positively or negatively when the two brands of PC are blended and used for concrete production.

1.4 Aim and Objectives

1.4.1 Aim

The aim of this research is to assess the properties of concrete made with a blend of two brands of Portland Cement (PC) with a view to ascertaining it suitability in the production of concrete.

1.4.2 Objectives

This research will be achieved through the following objectives;

i. To determine the effect of blending on the properties of the fresh concrete specimens
ii. To determine the effect of blending on the properties of the hardened concrete specimens
iii. To compare the properties of the concrete specimen produced with that of control.

1.5 Scope

1.5.1 Scope

This research will focus on the physical and mechanical properties such as specific gravity, bulk density, compressive strength and water absorption of the concrete specimens produced with a blend of Sokoto and Dangote cement

2.0 LITERATURE REVIEW

2.1 Cement

Cement in the general sense of the work can be described as a material with adhesive properties which make it capable of holding mineral fragment into compact whole. This definition embraces a large variety of cementing materials. However, the definition could be restricted to bonding materials used with stones, sand bricks, building block etc. The cement of interest in making of concrete have property of setting and hardening in the presence of water by virtue of chemical reaction with it and are, therefore called hydraulic cement (Neville, 1995).

Cement in general termed as Ordinary Portland Cement (OPC), and is used as a perfect binding material across the world. It will also commonly available for material for general use around the globe, an ingredient to mortar, stucco and grout (Neville and Brooks, 2010). Cement is produced from limestone by grinding, calcining then grinding to produce a fine powder, which intern is mixed with gypsum to retard setting time. According to Neville and Brooke (2010) the basic cement clinker is a hydraulic mass composes two third mass of calcium silicate ($CaO.SiO_2$), and the rest consists of aluminium and iron associates and other materials with the ratio of CaO to SiO_2 to be not less than 2, and magnesium oxide to be not more than 5% by mass. The reacted mass (calcined mass) basically forms nodules like materials of approximately one-inch diameter, which acquires the properties of binding, and in order to increase the rate of reaction of binding, surface area is increased by grinding in a ball mill.

During the advent of technological developments cement has been considered to be the best material to be used in construction (Duggal, 2008). The basic cement clinker is produced by heating calcined limestone to an approximate temperature of 1300^oC. Iron oxide and aluminium oxide appear as flume and are responsible for strength of cement.

The so called Portland cement was developed first from natural cements of Great Britain during early period of nineteenth century and its anonymous nature of Portland stone, which is in general a type of rock which was excavated beside Portland in the desert of England (Kosmatka *et al*., 2002). He further stated that a brick layer Aspidin invented production of Portland cement in the year 1811, and was patented in the year 1822, and was called 'British Cement'. The entitled name of Portland cement was also published in the year 1823, as was associated with William Lockwood, Date Stewart, and others (Lea, 1970). The production of Portland cement was patented in the year 1824 (Kosmatka *et al*., 2002).

Cement has the ability of quick setting upon addition of water, and in order to retard the setting time a quantity of 2-8% of calcium sulphate is added to clinker and then grounded in a ball mill to produce final cement. The ball mill grinding is controlled to produce a particle size distribution as 15-18% of total mass to contain 5 micro meters, and 57% of particles above 45 micro meters (Neville and Brooke, 2010). Fineness is measured by 'specific surface area' which gives surface area of cement. The initial reactions of cement upon addition of water is faster and depends on fineness, general values of cement surface area is about 320-380 m^2/kg and 450-650 m^2/kg for fast hardening cements (Neville and Brooke, 1970). Transportation of cement is done by pneumatic mechanism for shorter distance and for longer distance specially designed containers are used, which manages the compactions of vibration during transportation. Cement plants have the silos to store the production of 1-20 weeks, and is delivered to customers by bags and containers.

2.1.1 Constituents of Portland cement

Tricalcium silicate $(CaO)_3.SiO_2$	C3S	45-75%
Dicalcium silicate $(CaO)_2.SiO_2$	C2S	7-32%
Tricalcium aluminate $(CaO)_3.Al_2O_3$	C3A	0-13%
Tetracalciumalumino ferrite $(CaO)_4.Al_2O_3.Fe_2O_3$	C4AF	0-18%
Gypsum $CaSO_4.2H_2O$ 2-10%		

Where, C3S, C2S, C3A, C4AF are the notations of cement chemists

2.1.2 Setting and Hardening of Cement

Cement when mixed with proper proportion of water starts setting hard due to series of complex reactions and so far the reactions are partly understood. The constituents present in cement causes slow interactions and interlinking yielding crystalinity and intern strength. During initial reactions carbon dioxide is slowly released and converted to Portlandite ($Ca(OH)_2$) into insoluble calcium carbonate, after the initial setting, the material is subjected to curing in warm or normal water where the reactions speeds up intern accelerating hardening. Gypsum is mixed in clinker to inhibit rate of reaction (Neville and Brooke, 2010). In conventional practice cement is extensively used to prepare concrete which in turn used in construction. For production of concrete which consists of gravel, water, sand and cement (Gupta and Gupta, 2012). The material to be constructed can be casted to any desired shape and upon hardening becomes a structural product, which withstands loads. Taylor made structures are also produced in the cement plant based on the requirement by the customer. When water is mixed with Portland cement, the mass sets in few hours and hardens over a period of about few weeks. This processes varies widely with the parameters like curing temperature, humidity but in general concrete sets within 6 hours and builds a compressive strength of about 9-15 Mpa in a day, then develops to 20-24 Mpa in 3 days, then develops to 30-35 Mpa in 7 days and then develops to 40-60 Mpa in 28 days (Neville and Brooke, 2010).

2.1.3. Portland cement

Portland cement is the most commonly utilized cement in almost every part of the world. The understanding of the embodiment of Portland cement could lead to a more sustainable concrete and mortar design. It chemically reacts with water to attain setting and hardening properties when used in the construction of buildings, roads, bridges, and other structures. The production of Portland cement is made by the calcination of a mixture of a calcareous and an argillaceous material at a temperature around 1450^oC (Lea, 1970). Calcareous substances are of calcium oxide origin usually found in limestone, chalk, or oyster shells whereas argillaceous sub-stances are of silicate and aluminate origin predominantly found in clays, shale, and slags (Mamlouk and Zaniewski, 2006). The calcination process between well-proportioned argillaceous and calcareous sub-stances leads to the production of clinker. According to Punmatharith *et al.* (2010) Portland cement is obtained when the produced clinker is mixed together with a predefined ratio of gypsum and milled together in a ball mill. The chemical composition of Portland cement involves both major and minor oxides. The major oxides include CaO, SiO_2, Al_2O_3, and Fe_2O_3 whereas the minor oxides also include MgO, SO_3, and some alkali oxides (K_2O and Na_2O) and sometimes the inclusion of other compounds, P_2O_5, Cl, TiO_2, MnO_3, and so forth (Punmatharith *et al*., 2010). Each of the oxides performs unique work during cement hydration; however, each content of the oxide must be in the right quantity during proportioning of raw materials (Huntzinger and Eatmon, 2009). Lea (1970) provided the required oxide composition of Portland cement (seeTable2.1).

Table 2.1: Required Oxide Composition of Portland cement

Component	Minimum	Average	Maximum
SiO_2	18.40	21.02	24.50
Fe_2O_3	0.16	2.85	5.78
Al_2O_3	3.10	5.04	7.56
CaO	58.10	64.18	68.00
MgO	0.02	1.67	7.10
SO_3	0.00	2.58	5.35
Na_2O	0.00	0.24	0.74
K_2O	0.04	0.70	1.66
Equivalent alkalis	0.03	0.68	1.24
Free lime	0.03	1.24	3.68

Source: (Lea, 1970).

A deviation from standard specifications of the oxide composition may lead to unsoundness and sometimes failure of concrete structures. Many experienced authors have shown that cement oxides which fall very close to the average values are more suitable to maintain concrete integrity (Young *et al*., 1998; Taylor 1997). During cement hydration CaO in conjunction with SiO_2,Al_2O_3, and Fe_2O_3 leads to hardening of Portland cement due to the formation of calcium aluminosilicates and aluminofer-rite hydrate. With Portland cement, an increased presence of MgO (greater than 2%) may be detrimental to the soundness of cement, especially at late ages. High percentage of SO_3 tends to cause unsoundness of cement. For the Americans in their standard, ASTM C618 limits SO_3 to 4% and 5% whilst the Indian standard limits SO_3 to 2.75%. Alkalis at higher levels and in the presence of moisture gives rise to reactions with certain types of aggregates to produce gel which expands and gives rise to cracking in mortars and concretes. Sometimes Loss on Ignition (LOI) is classified as a component of chemical composition. LOI indicates the amount of unburnt carbon in the material. However, in some instances it may not necessarily be a measure or indication of carbon content. It may be burning away of residual calcite, bound water molecules, and clay materials (Kosmatka and Wilson, 2011). High LOI content may be detrimental to concrete and mortar. It is also known that a high value of LOI results in increased water requirement and dosage of super plasticizer usage in mortar and concrete (Sata*et al*., 2007). Maximum LOI values for both American and Indian standards for common pozzolanic material are 10% and 12%, respectively.

2.1.4 Chemical Composition of Dangote and Sokoto Cement

Table 2.2 show the chemical constituents of the brands of cement used for the research work, which indicate that the both cement have the chemical composition which fall within the range of the required oxide composition for Portland cement as specified by Lea (1970).

Table 2.2 Chemical constituents of Dangote and Sokoto cement

Constituents	Brands of Cement	
	Sokoto	Dangote
Aluminum Oxide (Al_2O_3)	5.0	3.5
Silicon Oxide (SiO_2)	15.1	11.3
Iron Oxide (FeO_3)	5.05	4.50
Sulphur Oxide (SO_3)	3.48	2.53
Potassium Oxide (K_2O)	0.100	0.079
Calcium Oxide (CaO)	67.91	75.57
Titanium Oxide (TiO_2)	0.30	0.18
Chromium Oxide (Cr_2O_3)	0.027	0.010
Manganese Oxide (MnO)	0.140	0.032

Source: (Aminu, 2016).

2.3.3 Properties of Concrete

2.3.3.1 Properties of Fresh Concrete

Fresh concrete is a transient material with continuously changing properties. It is however, essential that these are such that the concrete can be handled, transported, placed, compacted and finished to form a homogenous, usually void-free, solid mass that realizes the full- potential hardened properties. A wide range of techniques and systems are available for these processes, and the concrete technologist, producer and user must ensure that the concrete is suitable for those proposed or favoured. Fresh concrete technology has advanced at a pace similar to many other aspects of concrete technology over the past three decades, and indeed many of these advances have been inter-dependent. For example, the availability of super plasticizers has enabled workable concrete to be produced at lower water/binder ratios thus increasing the in-situ strength (Garba, 2014).

i. Slump Test

The test is used extensively at the site of work all over the world. Actually this test does not measure the workability of concrete but is useful for finding the variations in the uniformity of a mix given nominal proportions and specifies procedures for determining the consistency of concrete where the nominal maximum size of the aggregate does not exceed 38.0mm

Table 2.6: Workability, Slump and Compacting factor of concretes with 19 or 38mm maximum size of aggregate

Degree of workability	Slump		Compacting factor	Use for which concrete is suitable
	mm	in.		
Very low	0–25	0–1	0.78	Roads vibrated by power-operated machines. At the more workable end of this group, concrete may be compacted in certain cases with hand-operated machines.
Low	25–50	1–2	0.85	Roads vibrated by hand-operated machines. At the more workable end of this group, concrete may be manually compacted in roads using aggregate of rounded or irregular shape. Mass concrete foundations without vibration or lightly reinforced sections with vibration.
Medium	25–100	2–4	0.92	At the less workable end of this group, manually compacted flat slabs using crushed aggregates. Normal reinforced concrete manually compacted and heavily reinforced sections with vibration.
High	100–175	4–7	0.95	For sections with congested reinforcement. Not normally suitable for vibration.

(Building Research Establishment, Crown copyright)

2.3.3.2 Properties of Hardened Concrete

i. Compressive Strength:

The strength of concrete is commonly considered as its most valuable properties. Although, in many practical cases other characteristics, such as durability and impermeability may in fact be more important. Nevertheless, strength usually gives an overall picture of the quality of concrete because strength is directly related to structure of the hardened cement paste. There are two classical theories of hardening or gain of strength of cement that put forward by it. In engineering, practice the strength of concrete at a given age and cured at a prescribed temperature is assumed to depend primarily on two factors only. The water/cement ratio and degree of compaction, when concrete is fully compacted its strength is taken to be inversely proportional to the water cement ratio according to the law established by Neville in 2000.

3.0 METHODOLOGY

3.1 Research Material

3.1.1 Coarse Aggregate

Coarse aggregate used was crushed granite (20mm maximum size and retained on a 10mm sieve) obtained from a single quarry site along Yauri-Sokoto road, it was sieved in accordance to BS 933 part 1 (1997).

3.1.2 Fine Aggregate

Clean and air-dried river sand sourced from Zauro the range of sizes of sand or fine aggregate was from 600micron – 4.75mm on the BS test sieve. A 5mm BS 112, sieve was used to remove larger aggregate size and impurity.

3.1.3 Portland cement (PC)

Two brands of PC mostly used within the study area were used, which are Sokoto and Dangote cements. The cement brands are assumed to comply with the requirement of BS 12 (1996) and were obtained from local dealers in Birnin Kebbi, Kebbi State.

3.1.4 Water

Water pumped from the Waziri Umaru Federal Polytechnic water works was used throughout the research. The quality of water is assumed to conform to the specification of BS 3148, (1980) which specifies that water to be used for concrete production must be safe for drinking, free from odor, color, taste and impurities.

3.2 Laboratory work

The research was carried out through the following processes; Relevant literatures were reviewed from text books, journals, conference proceeding, seminars published and unpublished research, lecture note, etc., so as to articulate existing knowledge on the topic of research.

The research also entails an experimental investigation. Details of the materials and method employed in the study are as follows:

3.2.1 A Preliminary Investigations

Test on the individual constituent of the concrete were carried out such as, specific gravity, bulk density, sieve analysis and setting time.

b. Setting Time

Determination of Initial and Final Setting Times was done in accordance to IS: 4031 (Part 5) 1988.

Initial Setting Time

i. Immediately place the test block with the non-porous resting plate, under the rod bearing the initial setting needle.
ii. Lower the needle and quickly release allowing it to penetrate in to the mould.
iii. In the beginning the needle will completely pierce the mould
iv. Repeat this procedure until the needle fails to pierce the mould for 5 + 0.5mm. Record the period elapsed between the times of adding water to the cement to the time when needle fails to pierce the mould by 5 + 0.5mm as the initial setting time.

Final Setting Time

i. Replace the needle of the vicat apparatus by the needle with an annular ring
ii. Lower the needle and quickly release.
iii. Repeat the process until the annular ring makes an impression on the mould.
iv. Record the period elapsed between the times of adding water to the cement to the time when the annular ring fails to make the impression on the mould as the final setting time.

REPORT: Report the initial setting time and final setting time in minutes.

PRECAUTION: The time of gauging in any case shall not be less than 3 minutes and not more than 5minutes.

c. Production and Testing of Concrete Specimens

The concrete specimens were cast in well-oiled 150mm x 150mm x 150mm metal cubes after manual mixing, the fresh concrete paste was placed in 3layers and 25blows were given to each layer. It was then allowed to rest and hardened for 24hours before demoulding. All concrete samples were cured at different periods (3, 7 and 28 days) in water, and tested for 3, 7 and 28 hydration periods only. Details of the type of concrete specimens and curing days are as presented in table 3.1

Table 3.1: Production of Concrete Cubes Using Two brands of PC

Types of test		Percentage Replacement		Control specimen	
	25/75 SOK/DNG	50/50 SOK/DNG	75/25 SOK/DNG	100% SOKOTO	100% DANGOTE
Curing period (days)	3 7 28	3 7 28	3 7 28	3 7 28	3 7 28
Compressive strength	3 3 3	3 3 3	3 3 3	3 3 3	3 3 3

Where DNG is Dangote Cement and SOK is Sokoto Cement.

Thus a total of 75 concrete specimens were produced out of which 30 were the control specimens i.e. 15 specimens (100% DNG) and 15 specimens (100%SOK). 45 number of specimen were produced using Dangote cement and Sokoto cement in varying percentage replacement (25% DNG &75% SOK, 50% DNG & 50% SOK, and 75% SOK & 25% DNG). The concrete cube specimens were subjected to compressive strength test at the end of 3, 7 and 28 curing period.

3.4 Production and Testing of Concrete Specimens

3.4.1 Mix Design

Grade C25 Concrete was designed using BRE method for the production of the concrete specimens. The quantity of water obtained from the design was reduced by 20%. The reduced water was maintained throughout this research work in order to study the influence of the percentage replacement on various properties of concrete at a constant water/cement ratio.

3.4.2 Test on Fresh Properties of Concrete

The fresh concrete was tested for workability using slump method. The tests were carried out in accordance with BS 1881 part 102 (1983).

3.4.2.1 Slump test

Slump test was carried out immediately after thoroughly mixing of the concrete paste. The apparatus used for carrying out the slump test includes steel tamping rod, base plate, hand scoop, trowel and metal cone. The internal surface of the mould was thoroughly cleaned and greased. Then this mould is placed on a smooth; horizontal, rigid and non-absorbent surface, such as a carefully levelled metal plate with the same smaller opening at the top. The mould should be held firmly in place while filling it with concrete. It is filled in four layers, each approximately 7.5cm in thickness and each layers is tamped with 25 strokes of the rounded end of the tamping rod. The strokes should be distributed uniformly over the whole area of the cross-section of the mould and for the subsequent layers should be penetrate into the underlying layer. The bottom layer should be tamped throughout its depth. After tamping the top layer, the surface is struck off level with a trowel or rolling motion of tamping rod such that the mould is exactly filled. Any mortar leaked out between the mould and its base should be wiped immediately. Now the mould should be lifted up vertically, slowly and carefully. This will allow the unsupported concrete to subside or slump, hence the name of the test. The decrease in the height of the centre of the slumped concrete is called slump and is measured to the nearest of 5mm. Thus slump is the difference between the original height of concrete in the mould and the highest part of concrete in subsided position.

3.3 Testing of Hardened Concrete

The concrete cubes produced were subjected to compressive strength test at the end of 3, 7 and 28 days of curing. The details of various test and results are presented as follows:

3.4.3.1 Compressive Strength Test

Compressive test is the common test conducted on hardened concrete, partly because it is an easy test to perform, and partly because most of the desirable characteristics properties of concrete are qualitatively related to it compressive strength. Cube samples were crushed at 3, 7 and 28 days, curing periods in ambient temperature. Compressive strength was determined in the laboratory with the aid of crushing machine. This was carried out in accordance to BS 1881, part 116 (1986).

3.5 Method of Data Analysis

The results of the conducted tests were analysed using percentage and mean to determine the relationship between the percentage replacement of concrete test results made with different brands of PC and the conventional concrete. The arithmetical mean is the central tendency of collection of numbers taken as the sum of numbers divided by the size of the collection. The mean was used to analyse the result of the compressive and water absorption at different curing period by summing the strength of the cubes for sample concrete and control specimen for a particular day and divided it by the numbers of cubes. Percentage was also used to analyse the results of water absorption test by calculating the percentage of water absorption for the entire concrete specimen and the percentage of weight loss. Graph and tables were also used to present some results. The result of above the tests are presented and analysed below,

4.0 DATA PRESENTATION, ANALYSIS AND CONCLUSION

4.1 Presentation and Results

4.1.1 Setting Time

Table 4.4Shows the setting time of the two brands of cement with view to their control mix as sample A_1 (100% SOK control) and A_2 (100% DNG control) and percentage blending of the two brands in respect to 75% SOK - 25% DNG as sample B, 50% SOK – 50% DNG as sample D, and 25% SOK - 75% DNG as sample C. which indicate that the final setting time of sample A_1, sample A_2, sample B, sample C, sample D were 201min, 187min, 204min, 191min, 187min respectively which fall within the range of time for total setting time of Portland cement as reported by Neville and Brooke (2010).

Table 4.4 Setting Time

	Sample A_2	Sample A_1	Sample B	Sample D	Sample C
Cement Powder (g)	400	400	400	400	400
Mixing Water (m/s)	150	142	148	150	154
Plunger Penetration(mm)	7	6	5	6	6
Initial Setting Time	120min	152min	162min	144min	133min
Final Setting Time	67min	49min	42min	47min	54min
Total Time	187min	201mins	204mins	191mins	187mins

Source: Research Laboratory Work, 2017

4.2.4 Quantities of Materials

Table 4.5 shows the quantities of materials used in producing 1 cube of concrete specimen.

Table 4.5 Quantities of material used for 1cube of concrete specimen

Water	Coarse Agg.(kg)	Fine Agg.(kg)	Concrete sample B (kg)		Concrete sample C (kg)		Concrete sample D (kg)	
			75% SOK	25% DNG	25% SOK	75% DNG	50% SOK	50% DNG
210	1391	489	236.25	78.75	78.75	236.25	157.5	157.5

Source: Research Laboratory Work, 2017

4.3 Mechanical Properties of Concrete

4.3.1 Fresh Concrete

4.3.1.1 Slump Test:

Table 4.4 shows the relationship between slump of the concrete made with percentage replacement and the control specimen. Sample A_1, sample A_2, sample B, sample C, sample D have slump values of 60mm, 45mm, 50mm, 50mm, 25mm respectively which falls within the range (25-100) as described by Building Research Establishment: Neville and Brooks (2000) which represents a medium slump and True slump.

Table 4.6 Slump Test

Workability	Concrete Specimen	Values (mm)
Slump (mm)	Sample A_1	60
	Sample A_2	45
	Sample B	50
	Sample C	50
	Sample D	25

4.3.2 Hardened Concrete

4.3.2.2 Compressive Strength

Fig. 4.2 shows the relationship between compressive strength of concrete produced with a blend of two brands of Portland cement. The compressive strength of sample A_1 and sample A_2 at 3days curing period was 7.93N/mm² and 11.85N/mm² respectively. Compressive strength of sample B, sample C, sample D were 13.48N/mm², 13.78N/mm², 12.59N/mm² respectively. Likewise, the compressive strength of sample

A_1 and sample A_2 at 7days curing period was 10.82N/mm² and 16.96N/mm² respectively. Compressive strength of sample B, sample C, sample D were 18.07N/mm², 17.63N/mm², 13.78N/mm² respectively. Sequentially, the compressive strength of sample A_1 and sample A_2 at 28days curing period was 15.78N/mm² and 18.15N/mm² respectively. Compressive strength of sample B, sample C, sample D were 27.82N/mm², 20N/mm², 23.30N/mm² respectively. Increasing the percentage replacement ratio in sample C, the compressive strength of concrete is reduced. Sample B has a percentage increase in strength of 51.60% while sample C and sample D were 31.11% and 45.86% increase in strength at 28days respectively. This is perhaps as a result of the improvement in the constituent's chemical oxides. The control specimen however has a percentage increase in strength at 28days to be 49.77% for sample A_1 and 34.96% for sample A_2 concrete. The concrete sample B has a higher percentage increase when compared to sample A_1, sample A_2, sample C and sample D concrete. All the concrete specimens produced had higher compressive strength when compared to the control specimens, this is perhaps as a result of improvement in the constituent oxides as a result of the replacement of the cements.

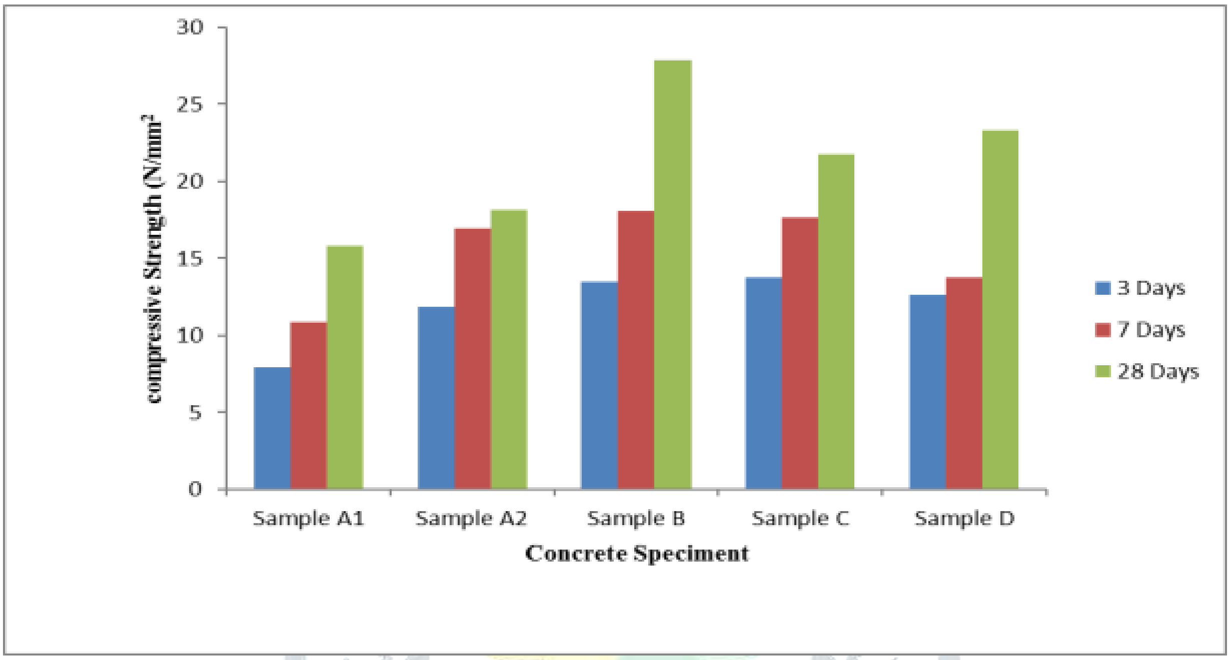

Fig.4.2 Relationship between compressive strength of percentage replacement of Portland cement used and control specimen.

NOTE: Sample A_1 (100% SOK control) and Sample A_2 (100% DNG control) and percentage blending of the two brands in respect to 75% SOK - 25% DNG as sample B, 25% SOK - 75% DNG as sample C and 50% SOK – 50% DNG as sample D.

5.0 SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 Summary of Findings

1. Sample B (75% SOK - 25% DNG) has the highest compressive strength value of 27.82 N/mm²when compared to sample C (25% SOK - 75% DNG) and sample D (50% SOK – 50%DNG) with the compressive strength value of 20 N/mm² and 23.30 N/mm² respectively.
2. The slump value of sample A_1 (100% SOK control) and A_2 (100% DNG control) and percentage blending of the two brands in respect to 75% SOK - 25% DNG as sample B, 25% SOK - 75% DNG as sample C, and 50% SOK – 50% DNG as sample D specimen which are 60, 45, 50, 50 and 25 all fall within the values of medium workability (25 – 100) as reported by Building Research Establishment.
3. The sample B, sample C and sample D specimens produced had a percentage increase in strength of 51.60%, 31.11% and 45.86% at 28 days respectively.
4. Compressive strength of concrete specimens (blend) is higher than the control specimen.

5.2 Conclusions

The following conclusions can be drawn based on the results and discussion of the study made;

1. From the Grade 25 concrete designed, the mix ratio was $1{:}^{8}/_{5}{:}4^{1}/_{2}$ with water cement ratio of 0.60. The compressive strength for the percentage replacement as sample B, sample C and sample D concrete specimens at 28days of curing was 27.85N/mm^2, 20.0N/mm² and 23.26N/mm² respectively.

2. Based on the results obtained sample B concrete specimen has higher compressive strength if compared to that of sample C and sample D specimens.

5.3 Recommendations

1. It is recommended that the strength development of the concrete should be determined at later age of the concrete from 90 days and above.

2. Further study should be carried out on the chemical composition of concrete produced with a blend of two brands of Portland cement.

3. The concrete could be used for structural work because of it high strength.

4. Research could be done on fire resistance, acid resistance and flexural strength of concrete made with a blend of two different brands of Portland cement.

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