



Effect of Activated Lime and Kaolin as Partial Replacement for Cement in Concrete Structure

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ABSTRACT: This research presents the effect of activated lime and activated kaolin as a cement replacement on the properties of concrete. A natural clay sample known as kaolin and lime was activated through thermal activation and used to partially replaced cement. $\frac{3}{4}$ size aggregate was used in the casting of concrete cubes using 150mm x 150mm x 150mm for grades 20 and 25, and 150mm x 150mm x 150mm mould using a mix ratio of 1:2:4 for grade 20 and 1:1 $\frac{1}{2}$: 3 for grade 25. The water-cement ratio adopted for the experiment was 0.55. A preliminary laboratory investigation was conducted include; sieve analysis, bulk density, specific gravity, aggregate impact value (AIV), aggregate crushing value (ACV), flakiness test, and elongation test. Also setting time of cement and standard consistency test was carried out. A Different replacement was cast and cured for 7, 14, and 28 days, and crushed. The compressive strength was gotten and conclusion a drawn.

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Limestone is a sedimentary rock composed largely of the mineral calcite and aragonite, which are different crystals form of calcium carbonates (CaCO_3). It has been used in concrete production for the last 30 years, not only for the main purpose of lowering the cost and environmental impact of cement production but also to increase concrete durability (Ahmed et al., 2009). More recently, they are used as filler materials to improve the workability and stability of fresh concrete and for high-flowable concrete. Limestone is a low-cost, readily available material that is easier to grind than clinker and it leads to improved packing and hydration (Hawkins et al., 2003). Kaolin is a naturally occurring material with wide abundance, the unique quality of kaolin is that it is neither the by-product of an industrial process nor it is not entirely natural. The uniqueness and the availability of the material as a

sustainable alternative for cement arouses the review. Kaolin is supplementary mineral material used in concrete production, majorly as a partial replacement for cement because of its Pozzolanic properties. This reflects in the physical properties of the material. (Haile et al., 1998). Activated lime can be used as a cement replacement in concrete. There are, as there have always been, two critical issues with this type of cement replacement: the change in physical properties with respect to compressive strength and the cost analysis of the alternatives. The first stage of this research looks at the change in compressive strength of a standard concrete mix when activated lime is substituted for cement. The results from this research show a linear decline in strength with a linear increase in the relative percentage of activated lime replacement of cement. A cost analysis will be

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addressed at a later date as the research progresses. (Fatoye and Gideon, 2013). The world is gradually dying, and one day, the construction industry will also be held responsible. The production of cement contributes highly to the emission of CO₂ which is affecting the atmosphere. This greenhouse gas is depleting the ozone layer thereby resulting in Global warming. The cement industry has attracted considerable international attention, and sizeable resources are expected to be deployed for reducing CO₂ emissions from cement production.

In Nigeria, there has been re-awakened awareness of the need to relate research to production, especially in the use of local materials as alternatives for the construction of functional, but low-cost dwellings, both in the urban and rural areas (Joshua and Lawal, 2011). These alternative materials are capable of meeting structural needs with lower energy and material consumption (Oyemogum et al., 2013). Efforts have been made to use recycled, cheaper, environmental-friendly materials worldwide to produce durable, high-strength, life cycle cost-effective long-lasting concrete. Therefore, it is always encouraged that we can find new technologies for the concrete industry. Clays have been and continue to be one of the most important industrial minerals. Clays and clay minerals are widely utilized in our society. They are important in geology, agriculture, construction, engineering, process industries, and environmental applications. Traditional applications of clay include ceramics, paper, paint, plastics, drilling fluids, chemical carriers, liquid barriers, and catalysis. Research and development activities by researchers in higher education and industry are continually resulting in new and innovative products (Patil et al., 2014). Different mix designs with various materials and technologies have been used to alter strength as well as save cost. Portland cement, coarse aggregate, fine aggregate, and water are the basic building components of the PCC. Every year, there are huge demands on the component's raw materials for the production of the PCC, turning into an extensive exploration of natural resources. Efforts have been made to use recycled, cheaper, environmental-friendly materials worldwide to produce durable, high-strength, life cycle cost-effective long-lasting concrete. Therefore, this research evaluates the effect of activated lime and activated kaolin as partial replacement on properties of concrete.

MATERIAL AND METHOD

Activated Lime and Activated Kaolin

Kaolin: A natural clay material known as kaolin was used for the replacement of this research. It was gotten from the southern part of Kaduna. Zonkwa to be precise.

Activated Lime: Lime is natural Clay; it is abundant in Kogi State. It is a major component in the production of cement.

Method: Limestone-forming environments (i.e. shallow coastal marine conditions), appear to have occurred several times in the geological history of the basins. However, the limestone deposits of the Benue Trough appear to contain the largest and most economically viable limestone resources in the country. Extensive deposits of limestone exist throughout the country. They provide the necessary raw material for the country's cement industry. A few of them are currently being exploited. For activation, 50kg materials used (12xx, BS 410) were digested with 250cm of concentrated sulphuric acid for 3hour in a mixer apparatus. After cooling, the solid was washed with distilled water several times until the washings were neutral (pH 7.0). The washing water was decanted and the solids dried at 100°C for 1 hour and then heated between 350 - 500°C in an aching furnace for about 2 hours. The solids obtained after heat activation were sieved to obtain particle size passing through mesh size 250um used for subsequent work. The two samples were mixed together at equal percentages to achieve a significant quantity to be used in carrying out this research. Ordinary Portland cement (Dangote 3X), fine aggregate (sand), and coarse aggregate (gravel) were used for casting the concrete.

Compressive strength test: The compressive strength of the concrete cube test provides an idea about all the characteristics of concrete. By this single test, one judges whether Concreting has been done properly or not. The compressive strength of concrete depends on many factors such as water-cement ratio, cement strength, quality of concrete material, and quality control during the production of concrete, etc. For cube test, casting was done using 150mm X 150mm X 150mm concrete mould. The concrete is poured in the mould and tempered 35 times in three (3) layers properly so as not to have any voids. After 24 hours these moulds are removed and test specimens are put in water for curing. The top surface of these specimens is made even and smooth. These specimens are tested by a compression testing machine (digital display) after 7 days 14 days and 28 days of curing. Load is applied gradually until the Specimens fail. Load at the failure divided by the area of the specimen gives the compressive strength of concrete.

RESULTS AND DISCUSSION

The results obtained from the entire test carried out on the sample of concrete are presented in Table 1 and Figure 1. The result of Compressive Strength for

Control, 5% 10%, and 15 % replacement in Grades 20 and 25 are as follows: For Grade 20 at 7, 14, and 28 days are, Control mix: 14.20 N/mm², 17.25 N/mm², and 22.51 N/mm², 5% replacement: 14.14 N/mm², 17.00 N/mm², and 20.63 N/mm², 10% replacement: 13.86 N/mm², 16.54 N/mm², and 20.04 N/mm², 15% replacement: 13.21 N/mm², 16.02 N/mm², and 18.97 N/mm². For Grade 25 at 7, 14, and 28 days. Control mix: 18.67 N/mm², 22.10 N/mm², and 27.86 N/mm², 5% replacement: 16.84 N/mm², 19.98 N/mm², and 25.27 N/mm², 10% replacement: 14.26 N/mm², 17.55 N/mm², and 23.46 N/mm², 15% replacement: 13.87 N/mm², 17.11 N/mm², and 22.48 N/mm² respectively.

Table 1: Compressive Strength of Control, 5%, 10%, and 15% (Grade 20)

Age (Days)	Crushing strength (N/mm ²)			
	Control	5% Repl.	10% Repl.	15% Repl.
7	14.20	14.14	13.86	13.21
14	17.25	17.00	16.54	16.02
28	22.51	20.63	20.04	18.97

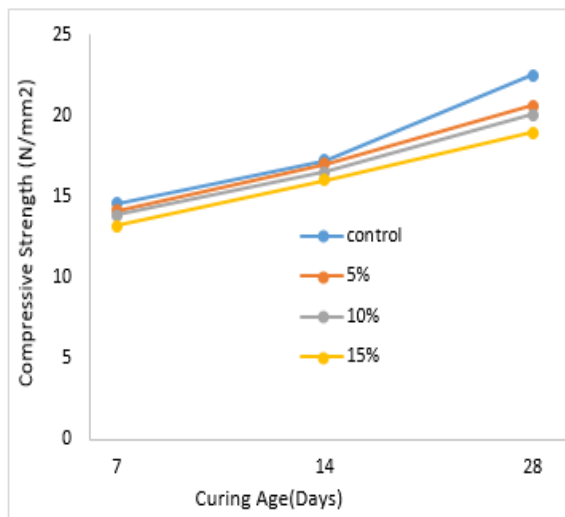


Fig. 1: A graph of compressive strength (N/mm²) against Age (Days) for Grade 30

Table 2: Compressive Strength of Control, 5%, 10% and 15% (Grade 25)

Age (Days)	Crushing strength (N/mm ²)			
	Control	5% Repl.	10% Repl.	15% Repl.
7	18.67	16.84	14.26	13.87
14	22.10	19.98	17.55	17.11
28	27.86	25.27	23.46	22.48

the percentage of replacement decreases the strength of concrete for both grades 20 and 25 and increases in strength with an increase in curing days. The results of this trend may be due to a drop in workability with an increase in the additive. Test to assess the workability of fresh concrete indicates that the incorporation of activated lime and activated kaolin in concrete leads to a drastic decrease in slump value, which depends on the mixture content. This reduction in a slump was due

to the absorption of some quantity of mixing water by particles of the lime and kaolin. Because of the large surface area the mixture exhibited, more water molecules were attracted toward the surface of these particles.

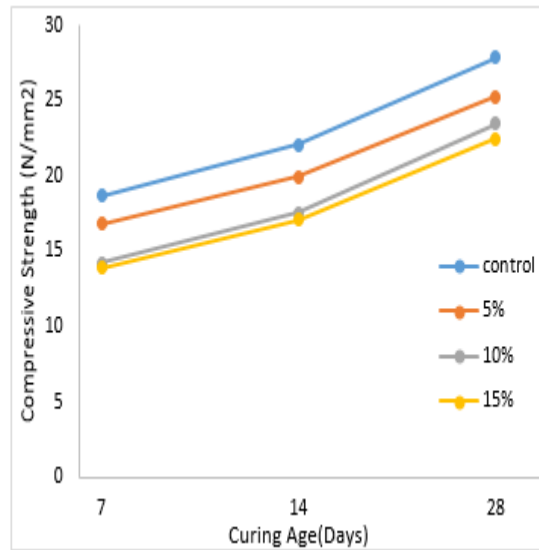


Fig. 2: A graph of compressive strength (N/mm²) against Age (Days) for Grade 25

Therefore, the result above shows that an increase in Thus, the quantity of the free water available for the concrete mix which helps in improving the fluidity of the mixture was decreased and there was an increase in the viscosity of the concrete mix. This in turn reduces the workability of the concrete and the effect was the same for the other two tests also. If density were to be considered according to BS877, the concrete using the mixtures would have been considered lightweight concrete.

Conclusion: From the result obtained in this study, it can be concluded that the suitability of Activated kaolin and activated lime as partial replacement of cement in the concrete mix of Grade 20, and Grade 25 can be used as potential material for replacing cement. 5, 10, and 15 percent of Activated kaolin and activated lime were partially replaced with cement and the best proportion that gives the maximum strength was obtained. The experiment result revealed that the most appropriate strength was obtained for a replacement rate of kaolin and lime binder ranging between 5% and 15%.

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