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ALKALINE ACTIVATED METAKAOLIN AND ALKALINE ACTIVATED SUGARCANE BAGASSEAS PARTIAL REPLACEMENT FOR CEMENT IN CONCRETE

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ABSTRACT

This study is aimed at investigating the compressive strength of concrete using metakaolin and sugarcane bagasse as a replacement for cement in concrete using three grades of concrete; grade 20, 25 and 30 respectively, the concrete cube cast was; control (0%) 5%, 10%, 15% and 20% respectively. the cube was cast, cured and tested at 7days and 28days. The compressive strength grade 20, 25 and 30 for 0%, 5%, 10%, 15%, and 20% were obtained as follows: Concrete grade 20 7 days =13.6 N/mm^2, 14.3 N/mm^2, 18.4 N/mm^2, 20.2 N/mm^2, and 18.8 N/mm^2, 28 days =21.4 N/mm^2, 21.8 N/mm^2, 23.6 N/mm^2, 24.7 N/mm^2, and 22.9 N/mm^2. Concrete grade 25 7 days =17.4 N/mm^2, 21.9 N/mm^2, 22.4 N/mm^2, 24.8 N/mm^2, and 23.6 N/mm^2, 28 days = 26.3 N/mm^2, 26.7 N/mm^2, 27.4 N/mm^2, 28.0 N/mm^2, and 25.3 N/mm^2. Concrete grade 30 7 days = 21.3 N/mm^2, 23.5 N/mm^2, 24.3 N/mm^2, 25.9 N/mm^2, and 25.0 N/mm^2, 28 days = 31.2 N/mm^2, 31.8 N/mm^2, 32.3 N/mm^2, 36.4 N/mm^2, and 31.7 N/mm^2. The results of this study have shown a significant increase in compressive strength of concrete utilizing metakaolin and sugarcane bagasse than normal concrete, it could be recommended that metakaolin incorporated with sugarcane bagasse (activated) of 5%, 10% & 15% replacement can be used for the different grades of concrete, while 20% replacement of metakaolin can be used in road kerbs, concrete blocks, non-bearing concrete walls, Light Weight Concrete, precast units (partition walls, concrete blocks for Architectural applications and some cases of slabs on soil, culverts, sidewalks, drive ways), foundation pads for machinery, etc.

Keywords: *Cementious Material, Compressive Strength, Metakaolin, Sugarcane Bagasse Pozzolana, filler*

INTRODUCTION

Clays have been and continue to be one of the most important industrial minerials. 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 including 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 new and innovative products (Patil S.N. et.al, 2014). Sugarcane Bagasse Ash (SCBA) which is a byproduct of sugar factories found after burning sugarcane bagasse is being produced from sugar manufacturing units as a waste material which will be grinded to the fineness less than cement for obtaining good bonding between cement and SCBA. Recently, sugarcane bagasse ash, has been tested in some parts of the world for its pozzolanic property and has been found to improve some of the properties of the concrete like compressive strength and water tightness in certain replacement percentages and fineness, Ranjith A. and Sanjith J. (2015). The use of sugarcane bagasse ash (SCBA) as cement replacement material is to improve quality and reduce the cost of construction material such as mortar and concrete pavers. Hence, several research groups, and even the Portland cement industry, are investigating alternatives to produce green binding materials. Moreover, these binding materials can reduce up to 80% of CO2 emissions when compared to that of Portland cement production. The release of dust, gases, noise and vibration when operating machinery and during blasting in quarries and consumption of large quantities of fuel during manufacture is a form of airborne pollution. Therefore, there is the need to search for local materials as alternatives for the construction of functional but low cost buildings in both the rural and urban areas.

Metakaolin is one of the innovative clay products developed in recent years. It is produced by controlled thermal treatment of kaolin. Metakaolin can be used as a concrete constituent, replacing part of the cement content since it has pozzolanic properties. The use of metakaolin as a partial replacement material in mortar and concrete has been studied widely in recent years. Despite of the recent studies, there are still many unknowns with the use of metakaolin. Study is needed to determine the contribution of metakaolin in the performance of hardened concrete. This research is therefore decided to study the effect of activated metakaolin and activated Sugarcane bagasse ash in concrete when both are replaced with cement content in minimal percentage of not more than 20%. It has been deducted in past studies that activated metakaolin when used to replaced cement in concrete gained more strength than normal concrete mix up to 15% before dropping after 15%, while sugarcane bagasse has no significant effect when replaced with cement upto 6%, it is due to this previous research that further study was necessitated to check what the effect of both materials will be when used together and activated.

The introduction of pozzolans as cement replacement materials in recent years seems to be successful. The use of Pozzolana has proven to be an effective solution in enhancing the properties of concrete in terms of strength and durability. The current pozzolans in use are such as fly ash, silica fume and slag. Development and investigation of other sources of Pozzolana such as kaolin and sugarcane bagasse ash will be able to provide more alternatives for the engineer to select the most suitable cement replacement material for different environments.

In addition, the use of by-products and non-by-product together to replace cement in concrete is not common in Nigeria, This study will be able to enhance its suitability in concrete.

MATERIAL AND METHOD

Metakaolin and Bagasse Ash

Metakaolin is the anhydrous calcined form of the clay mineral kaolinite. Minerals that are rich in kaolinite are known as china clay or kaolin, traditionally used in manufacture of porcelain. The particle size of Metakaolin is smaller than cement particles, but not as fine as silica fume.

Bagasse is a cellulose fiber remaining after the extraction of the sugar-bearing juice from sugarcane. Bagasse ash is one of the biomass sources and valuable byproducts in sugar milling that often uses bagasse as a primary fuel source to supply all the needs of energy to move the plants. The bagasse ash is about 8-10% of the bagasse and contains unburned matter, silica and alumina. Kanchan L. (2013).

Materials

The Samples under investigation were subjected to activation process. The method of activation was compounded from various methods described by Bradley & Grim (1951), Grim & Kulbicki (1961) and Joshi et al (1961). For activation, 50kg of local clay (Metakaolin) and Sugarcane Ash (Bagasse Ash) powder (12xx, BS 410) was digested with 250cm of concentrated sulphuric acid for 3hour in a mixer apparatus. After cooling, the solid 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^{o}C for 1hour and then heated between 350 - 500^{o}C in an aching furnace for about 2hour. The solids obtained after heat activation were sieved to obtain particle size passing through mesh size 250um used for subsequent work.

Compressive Strength Test

Compressive strength of concrete cube test provides an idea about all the characteristics of concrete. By this single test one judge that whether Concreting has been done properly or not. Compressive strength of concrete depends on many factors such as water-cement ratio, cement strength, quality of concrete material, quality control during 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 specimen is made even and smooth. These specimens are tested by compression testing machine (digital display) after 7 days and 28 days curing. Load are applied gradually until the Specimens fails. Load at the failure divided by area of specimen gives the compressive strength of concrete.

RESULTS AND DISCUSSION

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

Age (Days)	Crushing strength (N/mm²)				
	Control	5% Repl.	10% Repl.	15% Repl.	20% Repl.
7	13.6	14.3	18.4	20.2	18.8
28	21.4	21.8	23.6	24.7	22.9

Table 2: Compressive Strength of Control, 5%, 10%, 15% and 20% (Grade 25)

Age (Days)	Crushing strength (N/mm²)				
	Control	5% Repl.	10% Repl.	15% Repl.	20% Repl.
7	17.4	21.9	22.4	24.8	23.6
28	26.3	26.7	27.4	28.0	25.3

Table 3: Compressive Strength of Control, 5%, 10%, 15% and 20% (Grade 30)

Age (Days)	Crushing strength (N/mm²)				
	Control	5% Repl.	10% Repl.	15% Repl.	20% Repl.
7	21.3	23.5	24.3	25.9	25.0
28	31.2	31.8	32.3	36.4	31.7

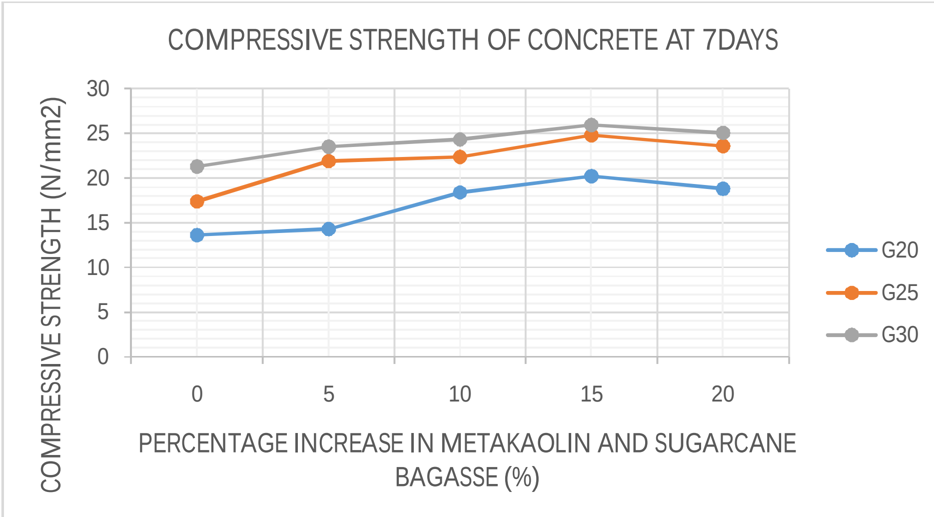

Fig. 1: A graph of compressive strength (N/mm^2) against % increase in metakaolin and Bagassee at 7days

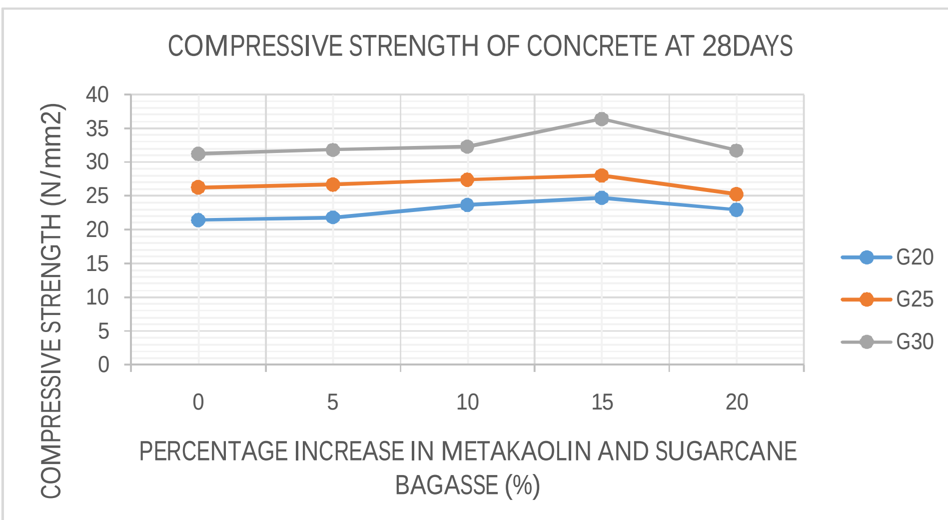

Fig. 2: A graph of compressive strength (N/mm^2) against % increase in metakaolin and Bagasse at 28days

DISCUSSION OF RESULT

The result obtained from the entire test carried out on the sample of concrete is as follows:

The compressive strength grade 20, 25 and 30 for 0%, 5%, 10%, 15%, and 20% were obtained as follows: Concrete grade 20 7 days =13.6 N/mm^2,14.3 N/mm^2,18.4 N/mm^2,20.2 N/mm^2, and 18.8 N/mm^2, 28 days =21.4 N/mm^2,21.8 N/mm^2,23.6 N/mm^2,24.7 N/mm^2, and 22.9 N/mm^2. Concrete grade 25 7 days =17.4 N/mm^2,21.9 N/mm^2, 22.4 N/mm^2,24.8 N/mm^2, and 23.6 N/mm^2, 28 days = 26.3 N/mm^2,26.7 N/mm^2, 27.4 N/mm^2,28.0 N/mm^2, and 25.3 N/mm^2. Concrete grade 30 7 days = 21.3 N/mm^2,23.5 N/mm^2,24.3 N/mm^2,25.9 N/mm^2, and 25.0 N/mm^2, 28 days = 31.2 N/mm^2,31.8 N/mm^2,32.3 N/mm^2,36.4 N/mm^2, and 31.7 N/mm^2. Therefore, the result above shows that increase in percentage of replacement up to 15% increases the strength of concrete for both grade 20, 25 and 30 and increases in strength with increase in curing days.

The results of this trend may be due to a increase in workability with increase metakaolin and bagasse up to 15%. Test to assess the workability of fresh concrete indicates that incorporation of metakaolin and bagasse in concrete leads to increase in slump value, which depends on the metakaolin and bagasse content. This increase in slump was due to the retention of some quantity of mixing water by metakaolin particles and bagasse.

From the compressive strength result, most of the cubes crushed were able to attain above 65% strength in 7days curing and maximum strength in 28days curing. Also all the grades of concrete were able to gain maximum strength at 15% addition of metakaolin and begin to lose its strength at 20% addition of metakaolin.

CONCLUSION

From the result obtained in this study, it can be concluded that metakaolin and bagasse ash can be used as a potential material for replacing cement. There is an increase in strength with increase in curing age, an increase in strength with an increase in percentage replacement up to 15% of the metakaolin and Bagasse Ash.

RECOMMENDATIONS

The results of this study have shown a significant increase in compressive strength of concrete utilizing metakaolin and Bagasse ash than normal concrete, it could be recommended that metakaolin and bagasse ash of 5%, 10% & 15% replacement can be used for the different grades of concrete, while from 20% replacement of metakaolin and bagasse can be used in road kerbs, concrete blocks, non-bearing concrete walls, Light Weight Concrete, precast units (partition walls, concrete blocks for Architectural applications and some cases of slabs on soil, culverts, sidewalks, drive ways), foundation pads for machinery, etc.

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