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Experimental Investigation of the Effect of High Fineness of River Sand on the Workability and Strength of Concrete

Ehichioya, Innocent, Okodugha,Dauda Aluya, Ibhafidon-Momodu Gladys Omisi & Omenaimen, Ikhide
Department of Civil Engineering
Auchi Polytechnic,
Auchi, Edo State, Nigeria
E-mail: ehichioyainnocent@auchipoly.edu.ng
Phone: +2347043582821

ABSTRACT

This research evaluates the experimental investigation of the effect of high fineness of river sand on the workability and strength of concrete. It was determine the impact of fines content of river sand and water/cement ratio on properties of concrete. Fines content in river obtained through sieve 2.36mm, 1.18mm, and 600µm as well as water/cement ratio of 0.45 was used. The concrete was prepared using the basic mix 1:1.5:3.5. Workability test on fresh concrete as well as compression strengths were conducted in accordance with BS 1881. The results show that, workability of concrete decreased as fineness content increases under the same water cement ratio. The study again revealed that with sieve 2.36mm fines content, compressive strength of 40.02N/mm2 was recorded, which indicate an increased in value. As the fines content increases with sieve 1.18mm and 600µm respectively, the compressive strength decreases. Also high degree fineness of river sand is uneconomical, as the cost for its preparation is high in concrete production.

Keywords: Concrete, Compressive Strength, Workability, Quarry Dust

Aims Research Journal Reference Format:
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1. INTRODUCTION

The quality and nature of materials used in the production of concrete plays a pivotal role in the development of both physical and strength properties of the resultant concrete. The constituents material used in the production of concrete should be free from harmful impurities that negatively impact on the properties of hardened concrete. Sand is one of the normal natural fine aggregates used in concrete production (Orchard, 1997). Past researches identify the major causes of buildings failure as dependent on the quality of building materials used (sand, cement, coarse aggregates, steel reinforcement, water), the workmanship employed in the concrete proportioning and construction methodology, defective designs and non-compliance with specifications (Oloyede et al,2010).

This paper aim at the quality of building sand (fine aggregate) in terms of having the silt and clay content and organic impurities within the allowable limit as stipulated in British Standard (BS) 882:1992. Quality assurance of building materials is significant in order to build strong, durable and cost effective structures (Savitha, 2012). The use of poor quality construction materials result in poor quality structures and may cause structures to fail leading to injuries, deaths and loss of investment for developers. Olanitori (2000) asserts that the higher the percentage of clay and silt content in sand used in concrete production, the lower the compressive strength of the hardened concrete.

Concrete is a very important material in the construction industry which is spearheading infrastructural development in Nigeria leading to the expected prosperity and growth of the nation. The quality of concrete constituent materials controls its strength (Chudley and Greeno, 1999) which has also been found to be one of the causes of building collapse all over the world (Ede, 2011). For this reason attention must be given to the factors which affect the strength of concrete (Desire and Leopold, 2013). Among these factors are sand fines which are materials that pass through the 75μm sieve. These fines are considered as an impurity in building sand in the BS882:1992. The presence of Sand fines in concrete is likely to affect the workability, strength and long-term performance of concrete (Gambhir, 2002). To this effect, the percentage limit of sand fines (clay/silt) is recommended by various building standards in other to check their effects on the strength of concrete. Some of which are the British Standards (BS), and the American Standard for Testing and Materials (ASTM) which recommends 4% and 10% of fines in building sand respectively.

Nonetheless, Nigeria is yet to specify the limit of fines (clay/silt) percentage in building sand for producing concrete. Moreover, it has been recommended by Danso and Boateng (2013) to investigate the quality of building sand used in construction industries. Another contributing factor affecting concrete strength is the water content used which in some are increased to improved workability (Cemex, 2013). When the fines content in sand are excessive, there is the need to add more water to the concrete mix in other to improve the workability. That is fine particles such as clay and cement interact with water in a physiochemical state which leads to more absorption of water than that of fine and coarse aggregates. Research has shown that higher amount of sand fines in concrete results in poor workability. This eventually leads to the addition of water to the concrete mix before or even during the unloading process to improve workability (Olusola, *et al* 2012).

Meanwhile, research have also shown that an increase in water/cement ratio result to a decrease in the compressive strength of concrete (Apebo and Shiwua, 2013). Additionally, the increase in sand fines content has also been found to decrease the compressive and tensile strengths of concrete (Cho, 2013). Inadequate sand fine content also has adverse effect of the strength of concrete due to poor adhesion. Researchers have therefore developed various models for predicting the effect of sand fines and water cement (W/C) on the strength of concrete. However, there is a gap in literature for the combined effect of sand fines and water/cement ratio's effect on the properties of concrete. This paper seeks to address this gap in the literature containing the various sand fines (clay/silt) replacement in the fine aggregate with three different water/cement ratios.

In order to achieve the aim of this study, the following objectives have been set:

a) To determine at what degree of fine aggregate is compressive strength maximum and how it affect the density of concrete.
b) To weigh the predetermine proportions of 1:1.5:3.5 by weight and corresponding weight of water that would give water /cement ratios of 0.45 to give optimum strength in the mix.
c) To crush the cubes produced in order to determine the failure load.

1.1 Statement of the problem

In concrete mix design, the strength properties of the constituent materials are paramount, that should be properly evaluated to ensure safety of a structure. In production of concrete, a vast number of aggregate are readily available with variable degree of fineness. The grading and maximum size of aggregates is important parameters in any concrete mix. They affect relative proportions in mix, workability, economy, porosity and shrinkage of concrete etc. Experience has shown that very fine sands or very coarse sands are objectionable the former is uneconomical; the latter gives harsh unworkable mixes. Thus the object in this work is to find the best fineness modulus of sand to get the optimum grading of combined aggregate (all-in-aggregate), which is most suitable, and for economy. In general, the grading of aggregates, which do not have a deficiency or excess of any size of aggregate and give a smooth grading curve, produce the most suitable concrete mix. In the present investigations, effect of the grading of river sand particles has been investigated for a good Concrete mix.

Relevance of the work

Concrete is a composite material. The relevance of this investigation had been to obtain a better understanding of the strength behaviour of concrete specimens produced from different fineness of river sand as fine aggregate at all stages of loading with one mix ratio of concrete design. The results under this mix ratio, with water cement ratio will help immensely in understanding the strength behaviour of concrete used in Nigeria construction industries at different fineness modulus in Nigeria.

2. METHODOLOGY

Preparations of Concrete Materials

The concrete materials used in this research were cement, aggregate (fine and coarse) and water.

Choice of Cement to BS 12:1989

The Bua brand of cement was used in this work. It is a grey finely grinded powder substance and it has a property of effective hydration in water. The Bua cement is manufactured in accordance with the requirement of BS12:1989.

Preparation of Coarse Aggregate (Granite To BS 812: Part 1. 1995)

Particle size distribution analysis was carried out on the coarse aggregate in the course of this work and it was in accordance with the recommendation of BS 812: part 1 1995. The coarse aggregate was crushed rock.

Preparation of Fine Aggregates. (quarry dust) To BS: 812: Part 1:1995

Fine aggregates are often considered as inert material. The fine aggregate used in this research was quarry dust obtained from a quarry site in Imeke. The aggregates were thoroughly washed (to remove unwanted materials) and dried; they were graded in accordance with BS 812 part 1: 2002.

Concrete Cylinder Dimension (Moulds)

The moulds used in this work are of cube size of 150mmx150mm (for compressive strength test). Before the experimental work, all the moulds were thoroughly cleaned, oil and dried, and were all placed on a wooden board.

Concrete Mix Design

Often concrete mix is designed to give the specified strength at minimum cost. The cost depends upon the value of the materials and labour required for batching, mixing, transporting, placing, compaction and toweling and the method of curing adopted.

Table 2.1 Mix Design for mix ratio 1:1.5:3.5 (MIX A) with water cement ratio 0.45

A-1	Stipulations for Proportioning	
1	Grade Designation	C35
2	Type of Cement	Grade confirming to BS12:1989.
3	Maximum Nominal Aggregate Size	20 mm
4	Minimum Cement Content	290 kg/m^3
5	Maximum Water Cement Ratio	0.45
6	Workability	50-75 mm (Slump)
7	Exposure Condition	Normal
8	Type of Aggregate	Crushed Angular Aggregate
9	Maximum Cement Content	380 kg/m^3
A-2	Mix Proportions for One Cum of Concrete (SSD Condition)	
1	Mass of Cement in kg/m^3	380
2	Mass of Water in kg/m^3	170
3	Mass of Fine Aggregate in kg/m^3	570
4	Mass of Coarse Aggregate in kg/m^3	1330

Preparation of the compressive strength Specimens

The batching of concrete was done by weighing the different constituent materials based on the adopted mix ratios of 1: 1.5: 3.5 with water cement ratio of 0.45. Fines (clay/silt) were initially extracted from sand using dry sieving 2.36mm, 1.18mm and 600µm. During this stage, the sand was first spread and dried in air for some days, Sand passing through the 2.36mm was further sieved with the 600µm sieve where the sand particles passing through this sieve were collected for replacement of the sand content in concrete. They were mixed together with the aid of a shove and in the course of mixing, and the corresponding quantity of water was added when the mixture had been mixed to a homogeneous state, the mixture was poured into a head pan.

150mm x 150mm cubes were cast. This was to test the average compressive strength of concrete for this study. Each mould was filled with concrete in three layers using a trowel. And each of this layer was compacted using a 20mm diameter tamping rod to tap 25 times in accordance with BS 1881(15) After demoulding, the specimens were then transferred into a curing tank that contains clean water where they were store till 7, 14, 21 and 28 days before compressive test was carried out. A total of forty-five (45 No.) numbers of concrete specimens were made for this operation. The concrete specimens were prepared in the concrete workshop of Civil Engineering Department, Auchi polytechnic, Auchi.

3.RESULTS

This chapter show in detailed discussions on the results obtained. The analysis is presented in tables 4.1 to 4.5 and graphs 4.1 to 4.2

Table 3.1 slump tests result

Sieve sizes (for various fineness)	Slump value(mm)	Compacting factor ratio
2.36mm	0	0.8
1.18mm	90	0.83
600µm	38	0.9

Table 3.2 Rate of compressive strength development at 7 days for the various fineness

Sieve sizes (for various fineness)	Compressive strength(N/mm2)
2.36mm	18.27
1.18mm	15.76
600µm	10.22

Table 3.3 Rate of compressive strength development at 14 days for the various fineness

Sieve sizes (for various fineness)	Compressive strength(N/mm2)
2.36mm	22.54
1.18mm	19.92
600µm	14.20

Table 3.4 Rate of compressive strength development at 21 days for the various fineness

Sieve sizes (for various fineness)	Compressive strength(N/mm2)
2.36mm	35.56
1.18mm	29.85
600µm	29.33

Table 3.5 Rate of compressive strength development at 28 days for the various fineness

Sieve sizes (for various fineness)	Compressive strength(N/mm2)
2.36mm	40.02
1.18mm	37.00
600µm	32.56

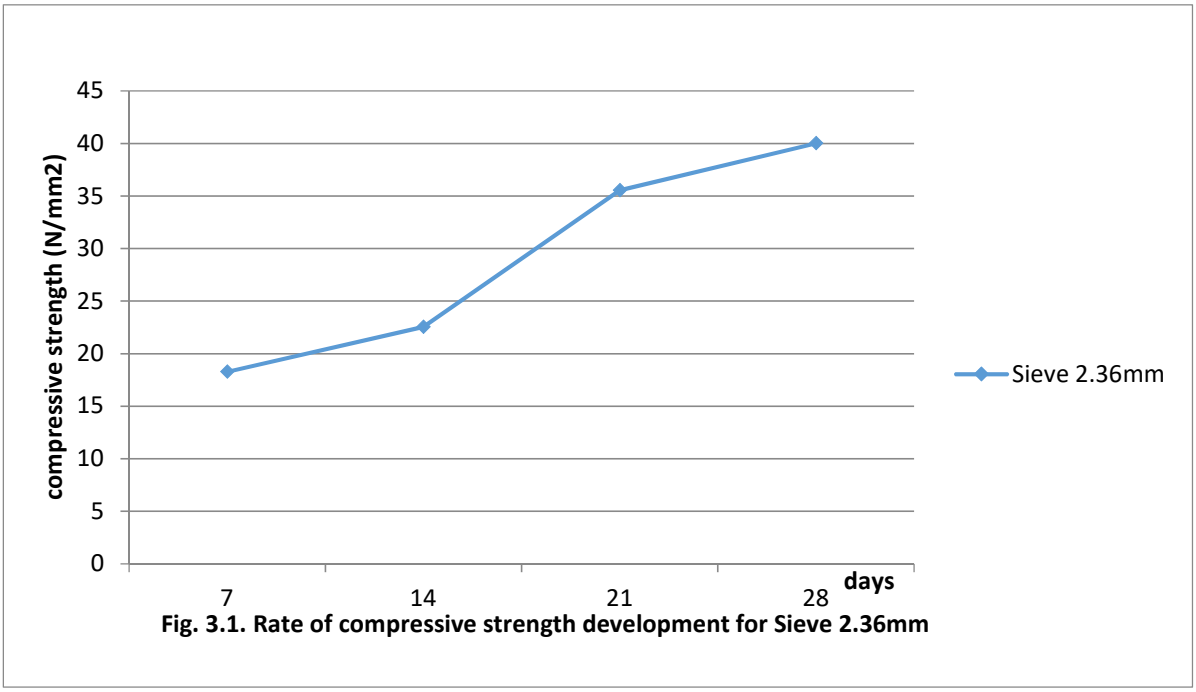

Fig. 3.1. Rate of compressive strength development for Sieve 2.36mm

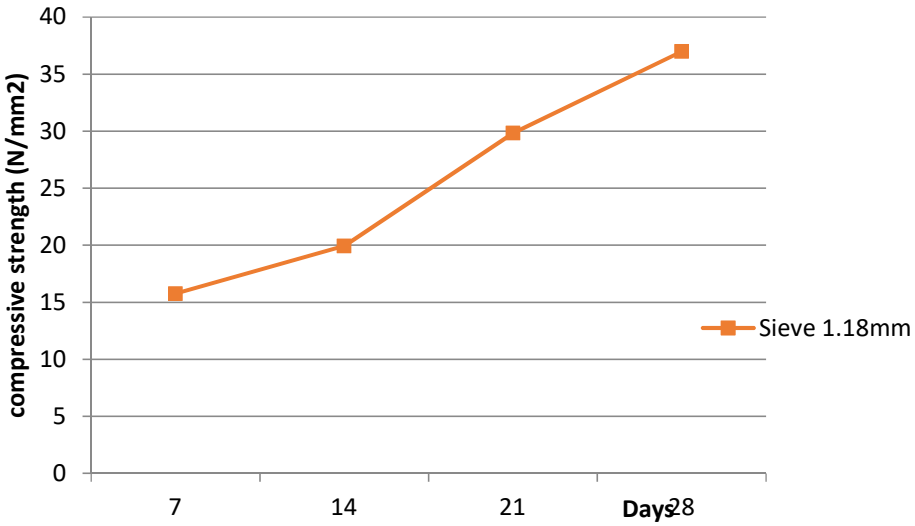

Fig. 3.2. Rate of compressive strength development for Sieve 1.18mm

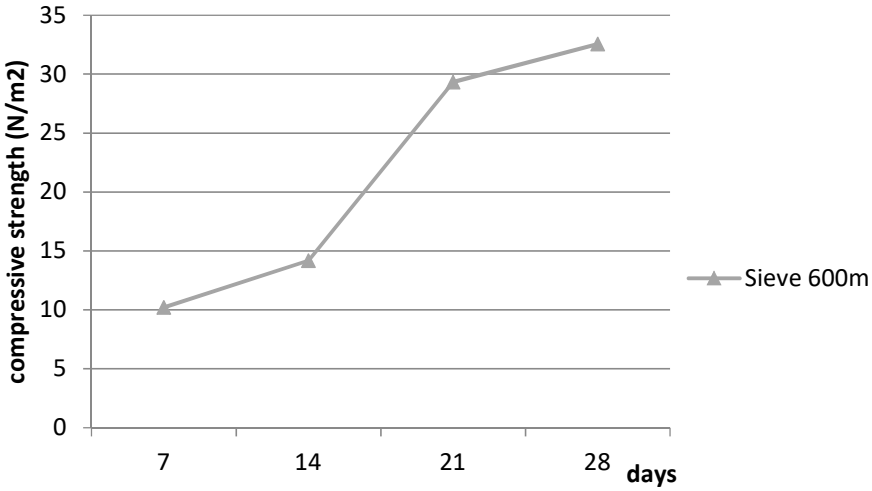

Fig. 3.3.Rate of compressive strength development for Sieve 600µm

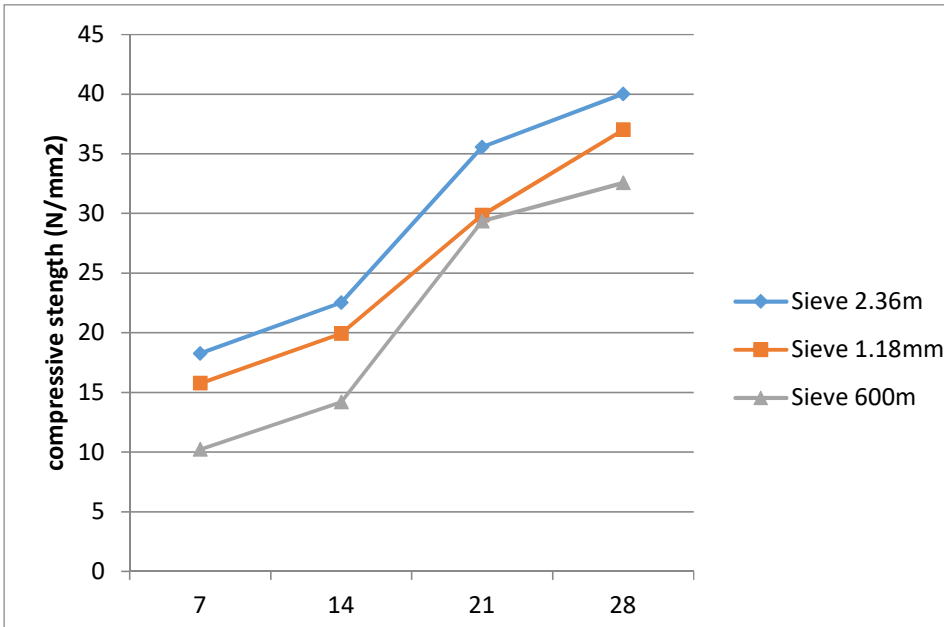

Fig. 3.4. Rate of compressive strength development for all Sieves

4. DISCUSSIONS

Table 4.1 to 4.5 showed the variation of compressive strength development with age for the various combinations of various sizes of sieve. This was to determine the fineness (Clay/silt) content of sand as it affects the properties and cost of concrete. The variation of compressive strength development for the different sieve sizes for the mix (1:1.5:3.5) with water/cement ratio of 0.45 are illustrated in figure 4.1 to 4.4Highest compressive strength of 40.02N/mm^2 was attained at 28 days with sieve 2.36mm. The strength was found to be inversely proportional to the water cement ration, this was as expected.

In general the compressive strength development in the other sieve 1.18mm and 600μm) indicated a decrease in strength as the percentage of fineness (clay/silt) of sand increases in the mix considered respectively. This may be due to the high water intake of (clay/silt) sand which brought insufficient water in the mix for total hydration of cement since the same water content was adopted throughout the work. Moreover, higher percentage of fines in sand will require higher amount of water to make

the concrete workable which intend result to lower strength of concrete. In term of cost implication and analysis, high degree fineness of sand is uneconomical, as the cost for its production is high.

5. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The following assertions were made:

(a) High degree of fineness (silt) and water/cement ratio have been reported to be one of the causes of weakness in concrete strength.

(b) The results of this work indicate that with the increase in fineness of sand, workability gets affected considerably.

(c) In general the compressive strength of concrete produced with various degree of fineness was inversely proportional to the water cement ratio used in this research program; that is 0.45 this was as expected in normal concrete.

Recommendations

(a) It is recommended that different kinds of water cement ratios and with different concrete mixes to evaluate the effect of fineness of river sand on the properties of concrete.

(b) Moreover, the chemical and biological compositions of fines are recommended to be investigated to determine their influence on concrete properties.

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