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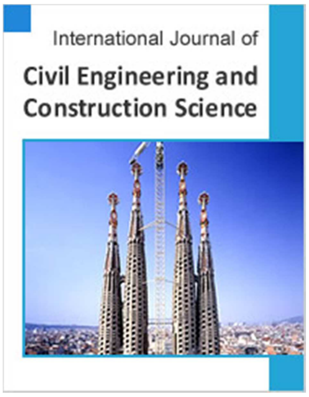

Partial Replacement of River Gravel with Crushed Granite to Determine the Optimum Compressive Strength of Concrete

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Abstract

This study investigates the effect of partial replacement of river gravel with crushed granite in concrete production. River gravel was replaced from 0% to 100% in the interval of 10% of crushed granite. Sieve analysis of river sand, river gravel and crushed granite was carried out. Concrete mix design was carried out and the mix ratio obtained was 1:1.78:3.98. Slump and compacting factor test was performed on the fresh concrete. Compressive strength test was also carried out on the concrete specimen cured for 7, 14 and 28 days respectively. The crushed granite sample was found to be uniformly graded and the concrete mixes had true slumps with decreasing consistency as the quantity of crushed granite increased. The compressive strength result shows that concrete made with river gravel replaced with crushed granite increases with age of curing. Optimum result was obtained when river gravel was partially replaced with 50% crushed granite which was 37.1N/mm^2 at 28 days on compressive strength.

1. Introduction

The vast bulk of our build environment is formed from raw materials obtained from the earth by the extractive industries. Without the raw materials with which to build houses, hospitals, school etc. life would certainly be basic and less comfortable than we presently experience. Concrete is a composite inert material comprising of a binder course (e.g. cement), mineral filler (body) or aggregates and water. The production of concrete is quite easy but however this must be done in such a manner as to allow the necessary processes that will lead to desire concrete properties to take place. One of these processes is the hydration of cement to produce chemical reaction that lead to bonding of the constituent materials together and harden to give the concrete its desirable property [1].

Aggregate used in concrete production are of two category, fine (sand) and coarse (gravel or crushed stone) aggregate. The first consideration in the design of concrete structures is that they should be strong enough to support the loads that they will carry. Strength of concrete is commonly considered as its most valuable property, 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 the structure of the hardened cement paste [2]. Many factors therefore have great influence on the properties of concrete. These factors include the properties of the aggregate used in the concrete, their sizes and their texture, whether angular or sub angular, other factors include the type of cement used, the water-cement ratio used the method of mixing and curing, relative humidity, temperature, etc. These factors must be adequately controlled to ensure that the desired properties of the concrete are obtained [3].

Aggregates, one of the constituents of concrete, play an important role in the strength properties of concrete their shapes and texture is important since they affect the workability of concrete. For low and medium strength concretes, smooth round gravels an usually to be preferred but for high crushing strength or flexural strength, concretes made with angular and rough or crystalline crushed rock e.g. granite, carboniferous limestone may demonstrate a benefit [4]. The preparation of crushed stone aggregates is not easy as that of gravel. The overburden must first be removed, the method depending on the formation of the top surface of the rock. The rock is next blasted and conveyed in lump in trucks. A primary crusher of the studded roll, jaw reduces most of the material to less than 75mm diameter. The material is separated above and below 75mm site and that passing the primary screen is conveyed to the final screens [5]. Gravel is composed of unconsolidated rock fragments that have a general particle size range and include size classes from granule to boulder sized fragments. Gravel can be sub- categorized into granule (>2mm to 4mm). Large gravel deposits are a common geological feature being formed as a result of the weathering and erosion of rocks. The action of rivers and waves tends to pile up gravel in large accumulations. This can sometimes result in gravel becoming compacted and concreted into the sedimentary rock called conglomerate. Where natural gravel deposits are insufficient for human purposes, gravel is often produced by quarrying and crushing hard wearing rocks such as sandstone, limestone or basalt [6]. The shape and texture of aggregate affects the properties of fresh concrete more than hardened concrete. Concrete is more workable when smooth and rounded aggregate is used instead of rough angular or elongated aggregate. Most natural sands and gravel from river beds or seashores are smooth and rounded and are excellent aggregates. Crashed stone produces much more angular and elongated aggregates, which have a higher surface to volume ratio, better bond characteristic but require more cement paste to produce a workable mixture [7]. A graded material is one that has some particles of all sizes from the coarsest permitted to the finest, without excess of any size. It should be appreciated that the void in sand are considerable as a percentage [8]. When fine particles are made to fill the spaces between the coarse the voids are reduced. In considering the void between dense particles, it should be remembered that scale of size large or small makes no difference to void percentage [9]. Aggregate gradation determines the void content within the structure of aggregate and consequently the amount of cement paste that is required to fill the void space and ensure a workable concrete [10]. Concrete mixture with well-graded or optimized gradations have a less likely chance to segregate and will minimize finishing labour [11]. For all concretes natural rounded sands and preferable to crashed stone fines flaky particles in coarse or fine aggregate are less satisfactory than rounded or cubical shaped particle [12]. For effective performance, they must be clean, hard, tough, strong, durable, inert, free from dust and well graded [13]. Test is carried out on concrete to determine its properties. The most common of all tests on hardened concrete is the compressive strength test. Tests can be made for different purposes but the main two objectives of tests are control of quality and compliance with specifications. Additional tests can be made for specific purposes; example, compressive strength test to determine the strength of concrete at transfer of pre-stress or at the time of striking the form work be due to the fact that cement is more expensive than aggregate, in concrete production and aggregate shape, texture and grading significantly affect concrete workability and strength [14]. To achieve the same workability, poorly shaped and poorly graded aggregates usually require more paste (cement and water). The additional paste is needed to compensate for the low packing density of those aggregates and for the higher inter-particle friction between them [15]. River gravel is partially replaced with granite to get the mixing proportion of river gravel and granite that will give the required workability and strength of concrete which in essence will minimize the amount of cement paste used in concrete production [16].

1.1. Aim and Objectives

The aim of this study is to unveil the effect of coarse aggregate type on the compressive strength of concrete.

The objective of this project is to determine the optimum strength of concrete when river gravel is partially replaced with granite.

1.2. Scope and Limitation

The scope to this research covers the partial replacement of Granite with river gravel in the production of concrete. This study is restricted to the use of granite obtained from Gboko, sand and gravel obtained from River Benue in makurdi. The granite is Located in Ahua of Mkar near Gboko where PW Construction Company blasted rocks for construction purpose

Figure 1. *Site Location of Crushed Granite in Mkar Gboko, Benue State.*

2. Methodology

2.1. Source of Materials

The materials used in this research work include water, ordinary Portland cement, river sand, river gravel and crushed granite. The portable water used for the experiments was taken from the concrete laboratory water tank. The crashed granite sample used was obtained from Gboko in Benue State where PW Construction Company blasted rocks for construction purpose. Ordinary Portland cement used was dengote cement obtained from cement dealer in makurdi. River sand and river gravel were obtained from river Benue in Benue state.

2.2. Test Carried out

The Specific Gravity and the Particle Size Distribution Analysis for the samples were carried out in accordance to BS1377. The workability test (slump test and compacting factor test), casting, and crushing of the cubes were carried out in accordance to BS1881 part 3 (1992). The cubes were cured in accordance with BS8110, Part 1 (1985). The concrete mix design was carried out and the method used was the British method for normal weight concrete, developed for department of environment in 1975 and revised in 1988. Concrete mix design of 1:1.78:3.98 was used and batching was done manually. cubes of 150mm × 150mm × 150mm in size were used for the casting. The proportion of the river gravel was replaced by crushed granite at 0%, 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% and 100% replacement levels. Two cubes were cast at each and average was taken. The load at failure divided by the effective area of the cubes in mm^2 was taken as the compressive strength of the cubes cured for 7, 14 and 28 days respectively. The curing of the concrete was by complete immersion in water. Table 1 below shows the batching of the materials at different replacement levels

Table 1. *Batching of the Materials at Different Replacement Levels.*

% Replacement	Sand (Kg)	Cement (Kg)	River Gravel (Kg)	Granite (Kg)
100% P 0% G	18.95	10.98	40.26	0
90% P 10% G	18.95	10.98	36.23	4.03
80% P 20% G	18.95	10.98	32.21	8.05
70% P 30% G	18.95	10.98	28.18	12.08
60% P 40% G	18.95	10.98	24.16	16.1
50% P 50% G	18.95	10.98	20.13	20.13
40% P 60% G	18.95	10.98	16.1	24.16
30% P 70% G	18.95	10.98	12.08	28.18
20% P 80% G	18.95	10.98	8.05	32.21
10% P 90% G	18.95	10.98	4.03	36.23
0% P 100% G	18.95	10.98	0	40.26

P=River Gravel, G=granite Mix Ratio= 1:1.78:3.98

3. Result

3.1. Physical Property of Sample

Table 2 below shows the summary of the physical properties of the sample (River Sand, River Gravel and Crushed Granite) used for the experiment. From the particle size distribution curves in figure 2 and 3, the uniformity coefficient of river sand, river gravel and crushed granite were calculated to be 0.24, 1.08 and 1.35 respectively.

Table 2. *Physical Property of Sample.*

Property	Sample		
	Sand	River Gravel	Crushed Granite
Specific Gravity	2.59	2.63	2.67
% Gravel (> 4.75mm)	0	98.87	99.9
% Sand (< 4.75 to 0.075mm)	99.7	1.13	0.11
% Fines < 0.075mm	0.27	0	0
Coefficient of Uniformity	0.24	1.08	1.35
Cc	0.13	0.93	0.96

The specific gravity of river sand, river gravel and crushed granite were 2.59, 2.63 and 2.67 respectively. This show how dense and suitable the material is in concrete production.

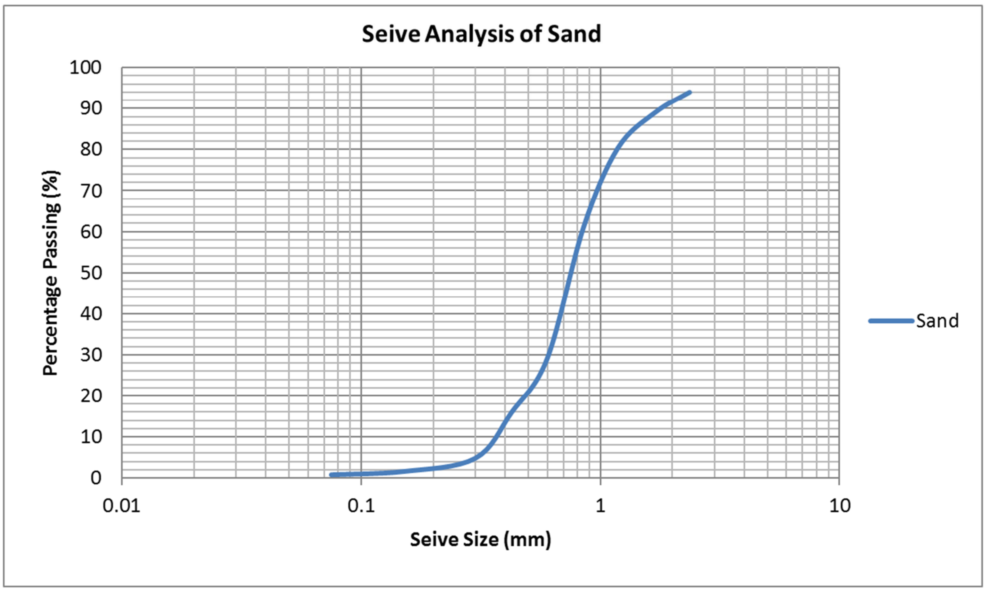

Figure 2. *Particle Size Distribution of Sand.*

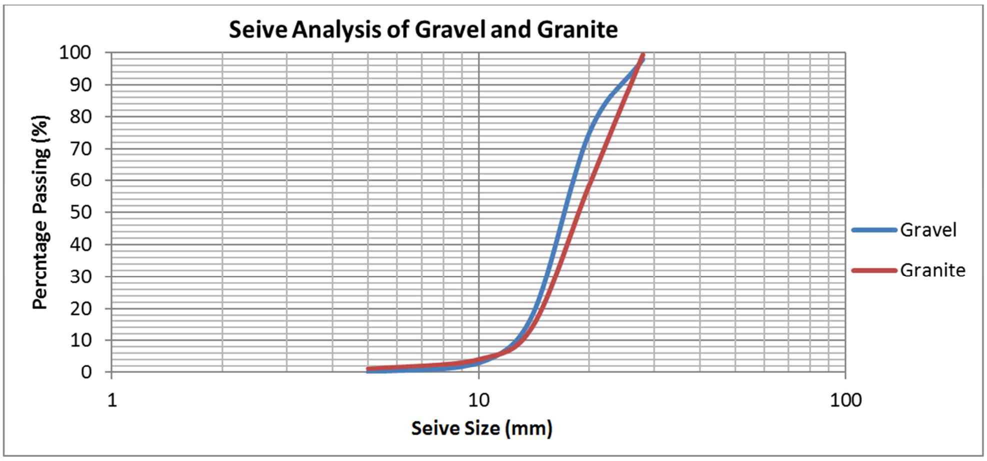

Figure 3. *Particle Size Distribution of River Gravel and Crushed Granite.*

3.2. Slump Test and Actual Water/Cement Ratio

The slump test result shown in table 3 below gave medium workability in all mixes, ranging from 0% to 100% of river gravel replaced with crushed granite.

Table 3. *Slump and actual Water/cement Ratio.*

Replacement of Gravel with Granite	Actual Water/Cement Ratio	Slump (mm)
100% P 0% G	0.50	51.00
90% P 10% G	0.50	49.50
80% P 20% G	0.52	53.00
70% P 30% G	0.52	50.00
60% P 40% G	0.53	52.50
50% P 50% G	0.53	50.00
40% P 60% G	0.55	53.50
30% P 70% G	0.55	51.50
20% P 80% G	0.57	52.50
10% P 90% G	0.57	48.50
0% P 100% G	0.58	52.50

3.3. Compacting Factor Test

Table 4 below shows the compacting factor of the fresh concrete

Table 4. *Compacting Factor Test Result.*

Replacement of River Gravel with Granite %	Compacting Factor
100% P 0% G	0.9282
90% P 10% G	0.9160
80% P 20% G	0.9125
70% P 30% G	0.9096
60% P 40% G	0.9345
50% P 50% G	0.9150
40% P 60% G	0.9360
30% P 70% G	0.9160
20% P 80% G	0.9250
10% P 90% G	0.9019
0% P 100% G	0.9250

3.4. Compressive Strength

Table 5 below shows the compressive test result. The compressive strength of the concrete increases with age at each replacement of river gravel with crushed granite.

Table 5. *Summary of Compressive Test result.*

Mix Ratio	7 Days	14 Days	28 Days
100% P 0% G	25.3	28.2	31.6
90% P 10% G	27.3	31.1	32.7
80% P 20% G	24.8	31.2	34.2
70% P 30% G	31.2	31.6	35.3
60% P 40% G	27.1	31.6	36
50% P 50% G	29.6	34.2	37.1
40% P 60% G	28.4	31.6	36.4
30% P 70% G	27.3	31.1	34.8
20% P 80% G	26.7	32	34.3
10% P 90% G	27.30	29.80	33.70
0% P 100% G	25.60	30.40	33.30

Figure 4 below shows the graph of 7, 14 and 28 days compressive strengths achieved at different replacement level of river gravel and crushed granite.

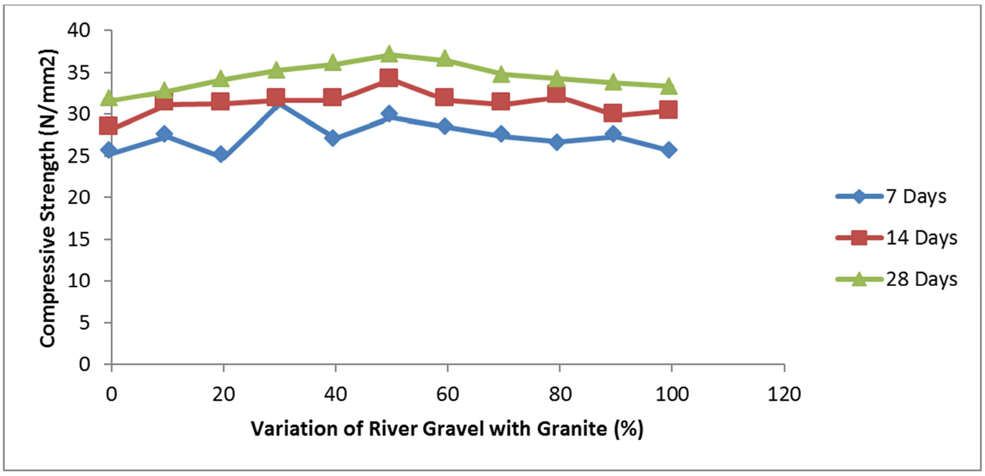

Figure 4. *Compressive Strength Achieved at Different Replacement Level.*

4. Discussion

4.1. Particle Size Distribution

The study gives a picture of the effects of coarse aggregate type on the compressive strength of concrete. The particle size distribution curve of the three materials in figure 2 and 3 shows that the materials are uniformly graded (poorly graded) aggregate according to the Unified Soil Classification System USCS. The value of coefficient of uniformity Cu < 4 and coefficient of gradation is not between 1 and 3 as shown in table 2. The gradation contains most of the particles in a very narrow size rage. With this grading, the aggregates are not effectively packed, and more paste was added to avoid porosity of the concrete.

4.2. Slump Test

The slump test result gave medium workability in all mixes, ranging from 0% to 100% of river gravel replaced with crushed granite. This was because as the percentage of crushed granite increases, the slump value degree. The water/cement ratio was increase by 0.01 to make the concrete mix workable

4.3. Compacting Factor

The compacting factor test result shows that as the percentage of crushed granite increase, the compacting factor decreases. The water/cement ratio has to be increase to make the concrete mix workable. This was because river gravel is smooth rounded in shape and it has greater workability on fresh concrete. The way river gravel was packed made compaction easier than crushed granite

4.4. Compressive Strength

The maximum strength was achieved at 50% replacement of river gravel with crushed granite which gave a value of 37.1N/m^2 at 28 days. The reduction in strength could be attributed to the amount of void filled with water in the concrete. The compressive strength increases from 0% to 50%, because foe water/cement ratio was not all that altered, from 0.5 to 0.52. As the water/cement ratio increases from 0.52 to 0.58, the porosity of the cement paste in the concrete also increases and also as the porosity increases, the compressive strength of the concrete decreases.

5. Conclusion

Based on the analysis conducted on concrete made of river gravel partially replaced with crushed granite, the following conclusion can be drawn:

1. River gravel can be partially be replaced with crushed granite in concrete production.
2. In partial or fully replacement of river sand with crushed granite, the compressive strength increases with the age of concrete at curing for every percentage of river gravel replaced with crushed granite.
3. Maximum strength attained was at 50% replacement of river sand with crushed granite which gave a compressive strength of 37.1N/m^2 at 28 days of curing.

Recommendation

From the research work, the following recommendations are put forward: River gravel in concrete production has greater workability, less compressive strength and economical in cost compared to crushed granite which have high strength, less workable in fresh concrete and high cost. Therefore 50% replacement of river gravel with crushed granite which gave a compressive strength of 37.1N/m^2 will be recommended in concrete production.

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