INVESTIGATION OF GRANITE-CHIPPINGS AS A SUBSTITUTE FOR RIVER SAND IN CONCRETE PRODUCTION

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Abstract

Granite chippings are being deposited in large quantities in many quarry sites located in Ogun State of Nigeria as wastes. They constitutes environmental nuisance in the various quarries. On the other hand, the cost of river sand that is used in concrete production is on the high side due to increasing transportation cost. The aim of this study is to explore the possibility of using granite chippings to replace river sand in concrete production. The physical properties of both materials were tested in the laboratory. The consistency of the wet concrete mix as well as the water absorption and compressive strength of hardened concrete cubes were determined. Results shows that water absorption (WA), specific gravity (SG), percentage silt content (SC), and moisture content (MC) of river sand are 1.61%, 2.54, 4.14%, 5.14% and 5.12% respectively. While that of granite chippings are 4.31%, 2.46, 14.3%, 1.3%, and 4.65% respectively. Furthermore, the slump value, water absorption and compressive strength of hardened concrete for river sand are 8mm, 2.75% and 25.67N/mm^2 respectively. While that of granite chippings are 10mm, 2.61% and 21.34N/mm^2. The conclusion from the study is that granite chippings can be substituted for river sand as fine aggregate material in producing concrete.
Key Words: Exploration, River – sand, Granite – chippings, Concrete, Production.

Introduction

Nigeria as a developing nation is witnessing a lot of infrastructural development. The trend is becoming more pronounced as a result of governments' effort at the attainment of the objective ten (10) of the sustainable development goals. This undoubtedly implies that there will be increase in the demand for the production of concrete. Consequently, the demand for the materials of which concrete is made up of such as water, cement fine and coarse aggregates will equally increase. Fine aggregate is a major constituent of concrete contributing about 26 - % by volume (Omopariola 2020). It can be classified as natural or manufactured. Natural fine aggregates are sand which can be obtained from different sources such as pit, river, or sea (pit sand, river sand and sea/marine sand respectively. Manufactured sand are fine aggregates which manufactured by crushing either granite or basalt rock using 3 stage crushing process among which is granite chippings.

Granite chippings is a waste product of in the process of crushing of rock to produce granite stones as hard core materials in building construction as base course in road construction. These can further be broken down to produce granite stones that are used as coarse aggregates. These wastes are generated from quarries. It is available as a non-biodegradable fine powder. Its utilization in the production of concrete will reduce environmental degradation in the various quarry sites and ensure sustainable and greener development.
Singh · 2016, stated that published literature indicates that the potential of the use of granite chippings to replace natural fine aggregate is huge. It was further stated that the need to substitute natural sand is due to the depletion of reserves of sand. According to Singh 2016, the particle size of granite chippings to that of river sand hence it is considered suitable for use in place of sand. Furthermore, it was stated that as a result of its angular rough textured and porous property it has significant effect on the workability of concrete. This is further enhanced by the higher percentage of particles that are finer than 75μm. Previous research carried out on granite chippings includes the use of granite chippings as a filter material (Chairanjeevi 2015), its use as an additive I concrete production (Divakar 2012), it was used as replacement of sand and partial replacement of cement with fly ash fumes and slag in concrete (Felixkaka 2010).

This study focuses on the use of granite chippings in replacement of sand wholly without any other additional material.

Materials and methods

The materials used in the study are river sand, granite chippings, cement granite and water. All the materials except water were purchased from local dealers in Ilaro, Ogun State, Nigeria.

Test on Properties of Material

Grading test on both materials were carried out using sieve analysis which was carried out as stated in BS EN 933 – 1: 1997 so as to evaluate the particle size distribution of both materials. Furthermore, the gradations of both materials were determined from the values of coefficient of uniformity and coefficient of curvature obtained from the sieve analysis curve. The Specific Gravity and Water Absorption of both materials were also determined in accordance with BS EN 1097 – 6: 2000. In the same vein, the Moisture Content, Percentage Silt Content, Bulking were determined for both materials in accordance with BS 812-109:1990.

Concrete production

The procedure employed in producing the concrete used for both fresh and hardened state test on concrete includes concrete mix proportioning, dry mixing and wet mixing. The mix proportion used in the study was 1:2:4. Manual method was used in both the dry and wet mixing process. The water cement ratio used was 0.5. The methodology was in linne with the specifications in B.S. 1881 – 1:1975

Test on Fresh and hardened Concrete

After the mixing process, the workability of the two materials in its wet state were determined through slump test in accordance with BS EN 12390-2:2009. A total of 25 cubes were cast to determine both the Water absorption and Compressive strength of the hardened concrete cubes. Both tests were carried out in accordance with BS EN 12390-3:2009.

Results and discussions

Test on Fine Agregates

Gradation of River Sand and Granite Chippings

The result of the sieve analysis test of the two materials is presented in Figure 1. From the figure, the value of the percentage passing all the sieve sizes is within the lower and upper limits specified in BS 882:1992. The fineness modulus of river sand and granite chippings are 3.67 and 3.37 respectively as presented in Table 1. This according to IS 383:2016 implies that river sand fall into zone l while granite chippings falls into zone ll. By the British standard equivalent, river sand fall into Class C (coarse sand) while granite chippings is in Class M (medium sand) BS 882:1992. The values of the coefficient of uniformity (Cu) for the two materials as presented in Table 1 are 3.78, while the values of the coefficient of curvature (Cc) for the two materials are 0.94 and 0.95 respectively. Considering this result, it can be inferred that the two materials are poorly graded since they fall short of the requirement of Cu greater than and Cc between 1 and 3 as stated in .

Table 1: Values of the Properties/ Parameters of River Sand and Granite Chippings

S/N	Properties/ Parameters	River sand	Granite Chippings
1.	CC	0.94	0.95
2	CU	3.78	3.78
3.	FINESS MODULUS	3.67	3.37
4.	WATER ABSORPTION	1.61	4.31
5.	SPECIFIC GRAVITY	2.54	2.46
6.	% SILT CONTENT	4.14	14.30
7.	MOISTURE CONTENT	5.74	1.3
8.	BULKING	5.12	4.65

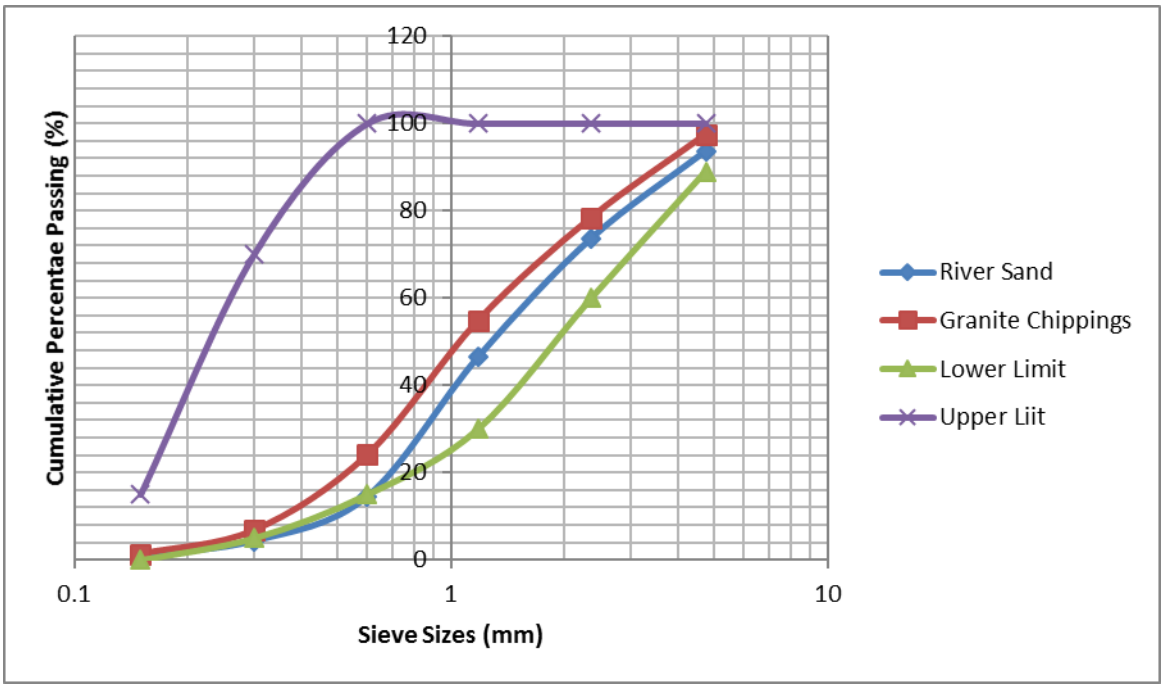

Figure 1: Sieve analysis of River Sand and Granite Chippings

Specific Gravity

According to BS EN 1097 – 6: 2020 the specific gravity of aggregates is related to its strength. The result of the specific gravity of the two materials presented in Table 1shows that river sand has a value of 2.54 while that of granite chippings has a value of 2.6. This implies that river sand is stronger than granite chippings. However, the specific gravity of both materials is within the range of values of 2.4 – 3. 0 stated in literature (Neville 2010, Shetty 2010, Arumugam 2013 ad Nemati 2015).

Water Absorption

From Table 1, the values of the water absorption of the two materials are 1.61%and 4.31%. This shows that river sand has a considerable lower value than granite chippings. It also reveals that the value for river sand is lower than the value 3% contained in BS 8007:1987 while that of granite chippings is above the specified value. This implies that granite chippings are susceptible to absorb water and as such should not be used in structures liable to absorb water.

Moisture Content

The moisture content of fine aggregate is an essential requirement in concrete mi design in determining the quantity of water to be applied in the wet mixing process of concrete production. The values of the moisture content of both materials are 5.74% and 1.3% respectively. This shows that granite chippings have considerably lower moisture content than river sand. However, this does not have any adverse effect on the concrete provided it is considered in the wet mixing state of concrete production.

Bulking

The values of the bulking of both materials as seen in Figure 1 are 5.12% and 4.65% respectively. This shows that river sand has greater tendency to bulk than granite chippings. Bulking effect of fine aggregate is realty reduced when weight batching is used instead of volume batching.

Percentage Silt Content

The percentage silt content of fine aggregate is very important factor in the overall performance of hardened concrete. The presence of silt in fie aggregate reduces the strength of concrete. The specified amount of silt required in fine aggregate for concrete is 8% (Is 383:2016). Results presented in Table 1 indicate that river sand has a value of 4.14%, this is lower than the specified value and as such is okay. However, that of granite chippings is 14.30%. This is far higher than that specified. It therefore follows that the concrete produced with granite chippings will not be able to attain to itr full potential of strength.

Test on Fresh Concrete

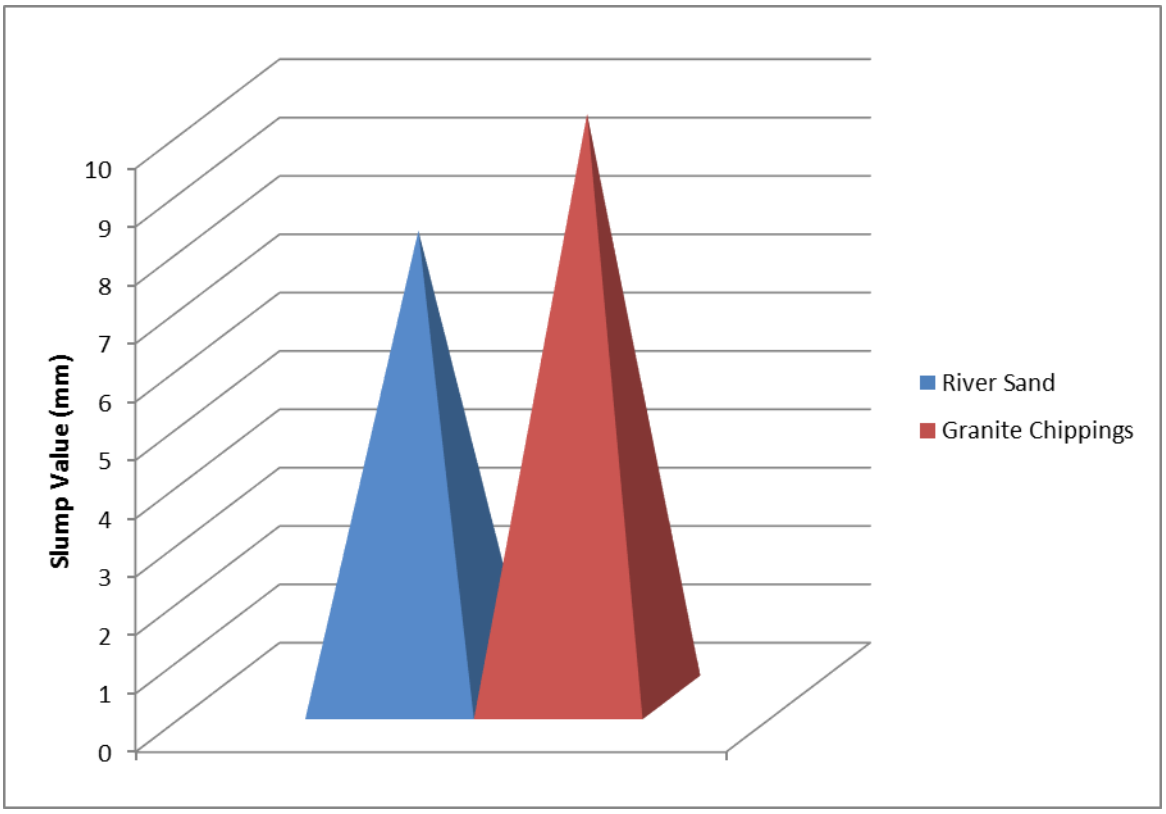

Figure 2: Slump Values of River Sand and Granite Chippings

Slump Test:

The Slump values of fresh concrete made both river sand and granite chippings are 8mm and 10mm respectively as seen in Figure 2. Both materials exhibit true slump. However, the result shows that concrete made with granite chippings is more workable than that made with river sand. This can be as a result of the presence of higher percentage of silt content.

Test On Hardened Concrete

Water Absorption Of Hardened Concrete

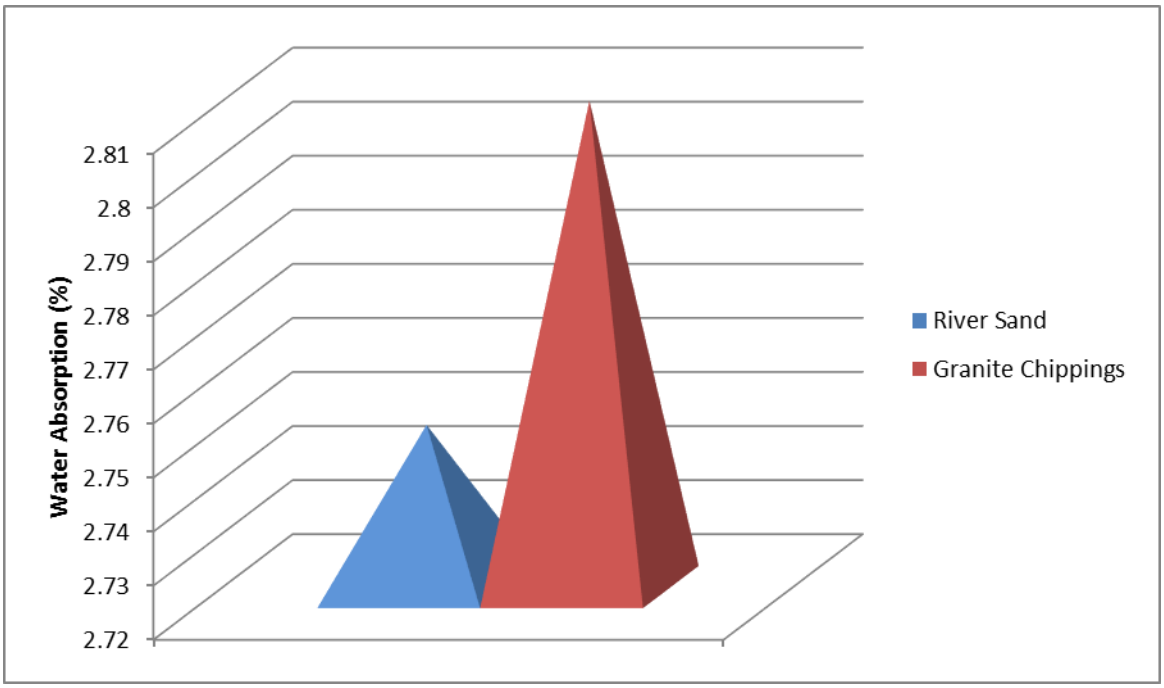

Figure 3: Water absorption Values of Hardened Concrete for River Sand and Granite Chippings

The water absorption of the hardened concrete made with river sand and granite chippings at 28 days are 2.75% and 2.81% respectively as presented in Figure 3. From this, it can be deduced that concrete made with granite chippings has the tendency to absorb water than river sand. Notwithstanding, concrete made with both materials have satisfactory water absorption value of less than the 3% specified in BS 6349:19

Compressive strength

The compressive strength of concrete made with the two materials are presented inn Figures 4 and 5. While Figure 4 presents the 7,14,21 and 28 days compressive strength, Figure 5 presents the 28days compressive strength of the two materials. From Figure 4 there is progressive increase in the strength of concrete made with the two materials with age. The compressive strength of river sand increase from 17.21 at 7days to 17.58 at 14 days, 24.09 at 21days and 25.67 at 28days, that of granite chippings increased from 13.65 at 7days to 14.85 at 14 days, 20.71 at 21days and 21.34 at 28days. Notwithstanding, the compressive strength of concrete made with granite chippings is consistently lower than that off river sand at 7, 14, 21, and 28 days. The 28days compressive strength of river sand falls within the class of grade M25 while that of granite chippings falls within the class of grade M20. Judging from these results, both materials are suitable for the production of concrete.

The difference in the compressive strength o the two materials can be attributed to the difference in their characteristic properties especially the Specific gravity, and percentage silt content. The strength of concrete is related to the specific gravity of the constituent materials of which it is made of. Hence granite chippings having lower specific gravity are expected to have lower strength. In a similar vein, higher percentage of silt content reduces the strength of concrete and as such the higher percentage of silt content of granite chippings can be responsible for the lower strength of the concrete made with the material. While river sand can be used in producing concrete that requires grade M25 concrete, concrete made with granite chippings are only suitable for concrete requiring grade M20 concrete.

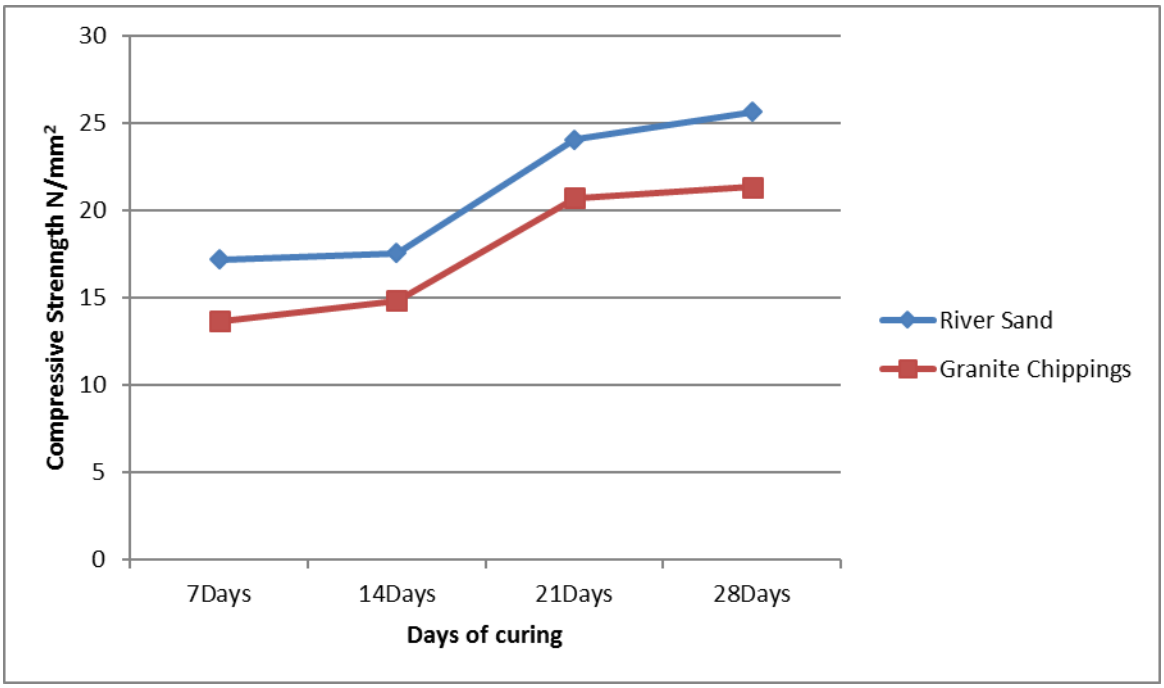

Figure 4: Compressive Strength of Concrete Cubes for River Sand and Granite Chippings at 7, 14, 21 and 28 Days

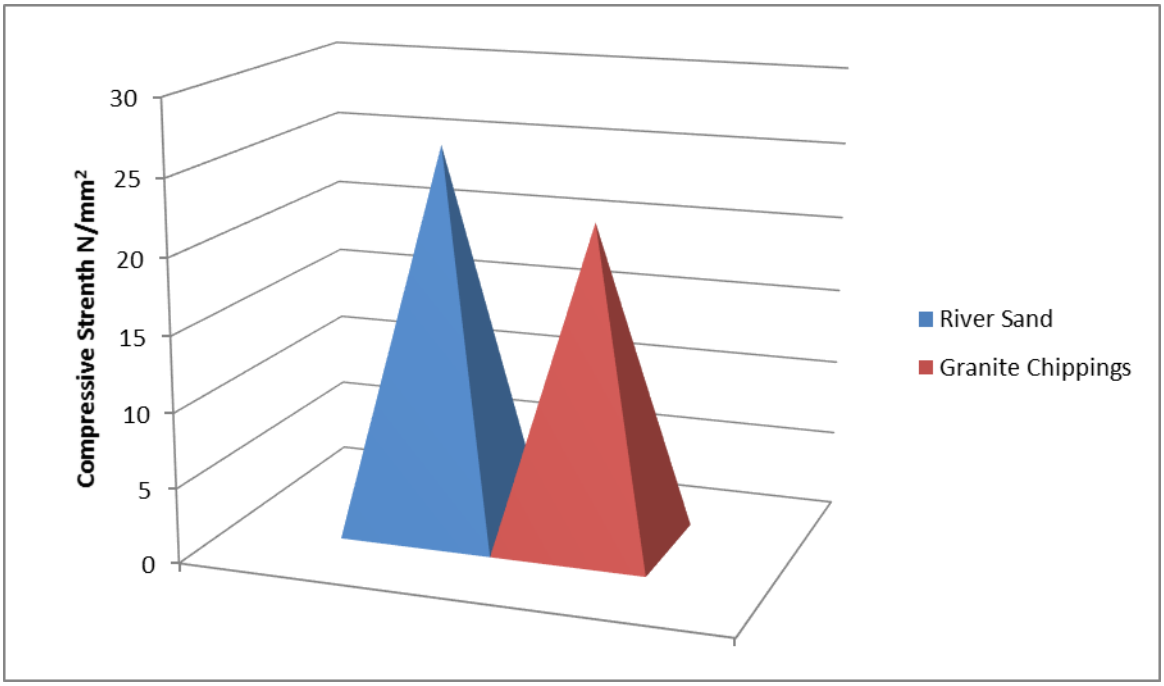

Figure 5: 28 Days Compressive Strength of Concrete Cubes for River Sand and Granite Chippings

CONCLUSION: Conclusively, from the result of the grading test, both materials are poorly graded. The specific gravity of both materials are within the range of specified value of 2.2 – 3.0 as stated in the related standards, the percentage silt content and water absorption of granite chippings are higher than what is specified in related standards. The concrete produced with granite chippings has lower strength than that of river sand.

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