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Study of the Concrete Properties of Granite Pit and River Sand Concrete Properties

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Abstract
This study developed the study of the concrete properties of granite pit and river sand concrete properties. Sand and gravel represent the most widely consumed raw material on earth after water, and between 64-75% of aggregate mined each year is used for making concrete. The construction projects in Ethiopia mainly use river basin fine aggregate for concrete mix. The increment in demand and rapid extraction of river sand cause deepening of the river beds, loss of vegetation on the bank of rivers, and disturbance to aquatic life and agriculture. Therefore, a total of 43 mix designs by using the American Concrete Institute mix design method and the concrete 264 cubes specimen with 150 x 150 x 150 mm sizes were prepared at 0%, 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% and 100% replacement with NWWGPS and WWGPS for C-20, C-25 and C-30 at 7th and 28th curing days. Finally, some of their results show the compressive strength of concrete enhanced by the replacement of river sand with washed granite pit sand.
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1. Introduction

Sand and gravel represent the most widely consumed raw material on earth after water, and between 64-75% of aggregate mined each year is used for making concrete. Natural sand has been conventionally used as fine aggregate in concrete. Natural sand possesses rounded or cubical particles with smooth surface texture which provide good workability in concrete. Sand occupies around 35% volume in a concrete mix. Therefore, the quality of concrete produced is much influenced by the properties of aggregate (1-6).

The sources of natural fine aggregates are of three types those are pit sand (coarse sand) which is procured from deep pits of abundant supply. It has a property of being coarse-grained which is sharp, angular, and free from salts, mostly has a reddish-yellow color, and is mostly employed in concreting. River sand has the property of being fine and consists of fine rounded grains, almost white and grayish, usually available in clean condition, and is used for plastering (7-10).

The construction projects in Ethiopia mainly use river basin fine aggregate for concrete mix. The rapid extraction of sand from the river bed causes problems like deepening the river beds, loss of vegetation on the bank of rivers, disturbance to aquatic life, and agriculture due to the water table being lowered in the well, etc. Therefore, construction industries of developing countries are under stress to identify alternative materials to replace the demand for river sand (11-13).

The main natural and cheapest sources of sand are riverbeds and these natural resources are depleting very fast and increasing in cost rapidly due to transportation. Transportation is a major factor in the delivered price of construction sand. Based on this investigation, even there are some available sources of river sand to Mekelle and its surroundings such as Hwane River sand and Gereb Giba. But when a shortage of river sand is happening, the drivers tend to supply poor quality sand and bring from other remote area river sand sources such as Shiket afar region, Temben, etc. (14-17).

Due to over flow of rivers and inaccessibility to the site, natural sand obtained from river sands is difficult to produce during the wet season. Denamo stated that the sand production sites found in Ethiopia are not mechanized but rather make use of the traditional method where the local people of the area are the producers and transportation is done by donkeys that have a maximum carrying capacity of 70kg or 0.05m3 per trip. The donkeys transport it to a place where vehicles have access. Sand is then loaded to vehicles manually and transported to the actual site or to construction material suppliers which is then directly used for the intended purpose. Besides, Based on the observation done in the Hwane River, there is a shortage of river sand before the summer season begins, bank slides during the mining of river sand an accident of dump truck caused by heavy flood during the rainy season. According to W. O. Ajagbe's (December 13/ 2017) investigation, From the geotechnical properties of the different sample sources one borrowed pit sand was only well graded, but it was not free from clay lumps and friable particles and the pit sand derived from different sources had different properties. Generally, fine aggregates from river sources fell within the ASTM limit of standard specifications while those from burrow pits were found to deviate from limits in certain respects (18-21).

As described in the background of the problem, sand is one of the major content of concrete components; therefore, sand properties have a great impact on concrete properties. And also Transportation is a major factor in the delivered price of construction sand. Besides, based on the observation done in Hwane River, there is a shortage of sand in the summer season, Poor accessibility of roads to bring sand from the river, and Poor quality of river sand at the end of the winter season before summer begins, Bank slides of the farming land area leads to disagreement among farmers and drivers and water pollution and there is Shortage or unavailability of compressive strength machine. Also due to the shortage of river sand especially at the end of the winter season, the drivers tend to supply poor quality sand or bring it from remote river sand areas / i.e. Shiket, afar region, Temben, etc. /, which leads to an increase transportation cost and due to poor accessibility of road, accident of dump truck happened. The general advantage of studying this title will be to solve the shortage and supply of poor quality sand and its consequences, transportation costs, and poor road accessibility/ i.e. Accident of dump trucks by flood in rivers/, bank slides, and their consequences. Furthermore, the objective of this research is focused on the study of the concrete properties of granite pit and river sand concrete properties (22-30)

2. Materials and Methods

The main aim of this research is to study the effect of river sand replacement by wukro granite pit sand on the workability and compressive strength of concrete by the amount of 0, 10, 20, 30, 40, 50, 60, 70, 80, 90 and 100% replacement levels. Identify material types, sample location, and the experimental investigation and analysis methods of material property test /i.e. sieve analysis, silt content, specific gravity, and water absorption test, unit weight and moisture content/, on fresh concrete slump test, and hardened concrete compressive strength test and mix design methods for each percentage of replacement was included in this section to achieve the object of this research.

2.1 Materials

This study presented the study of the concrete properties of granite pit and river sand concrete properties. Ordinary Portland cement (simply called ordinary cement) refers to the hydraulic binding material ground by mixing Portland cement clinker, 6% ~ 15% blended materials, and the appropriate amount of gypsum, code-named. The maximum amount of active blended materials mixed in cement should not exceed 15% of the total mass. They are allowed to be replaced by kiln ash and inactive blended materials which should be no more than 5% and 10% of the cement mass respectively. The maximum amount of inactive blended materials mixed in cement should not exceed 10% of the total mass. Ordinary Portland cement class 42.5R is one of the products of the Mesebo cement factory and it was used for this experimental work. The drinkable water from the Mekelle University School of Civil Engineering Construction Laboratory was used for the study of this research. The nominal maximum Crushed coarse aggregate size of 25mm from the available source of around Quiha aggregate crushing plant was used as coarse aggregate for this research. The two types of natural sand/i.e. river sand and granite pit sand/were used for this experimental work which is mostly passed through the sieve size of 5mm. River sand was bought from Hwane River sand and pit sand from Wukro. The sample of Wukro granite pit sand was taken from around Wukro/Negash/ which is located 59.4 km in the east of Mekelle, the capital of Tigray region, and 10 km north of Wukro and to the west direction from Negash the main road of Mekelle to Adigrat. Its Geographical coordinates are 13°52′ north and 39°51′East.

2.2 Methodology

The following methodologies were carried out to achieve the objectives of this research as follows. First identification of the statement problem and research objectives. Second identification of sampling technique – nonprobability or purposive method, and data collection method- both primary data (i.e. laboratory, interviews, and observations) and secondary data (literature review, books, and internet) sources were used. Third, the experimental work like Sample preparation, Physical material test, Mix design, Fresh concrete test, and Hardened concrete (Compressive strength test) as shown in Figure 5, Figure 6, Figure 7, Figure 8, and Figure 9.

Figure 5 Sieving and washing of coarse aggregate

Figure 6 Silt content of NWWGPS, RS, and WWGPS sample

Figure 7 Batching and Mixing of ingredients of concrete

Figure 8 Measure slump test sample at different positions

Figure 9 Casting, compacting, curing, weighting, and breaking of cubes

Generally, a total of 264 cub samples with 150 x 150 x 150 mm sizes for C-20, C-25, and C-30 of 7th and 28 curing days were prepared and material property, workability, and compressive strength test methods for each river sand replacement level were described.

3. Results and Discussions

In this section, discuss the obtained results of material properties, workability, and compressive strengths from experimental works for C-20, C-25, and C-30 grades of concrete at different replacement levels of Tshwane river sand with washed Wukro granite pit sand and C-20 replaced with not washed wukro granite pit sand.

3.1 Material Property Test

The physical properties of coarse aggregate and river sand at each percent of replacement levels with granite pit sand (washed and not washed) such as sieve analysis, specific gravity, silt content, unit weight, absorption capacity, and moisture content were conducted and then a mix design was made. Generally, the gradation curve of RS at each percent of replacement levels with NWGPS and WGPS was described in the following Figure 10 and Figure 11.

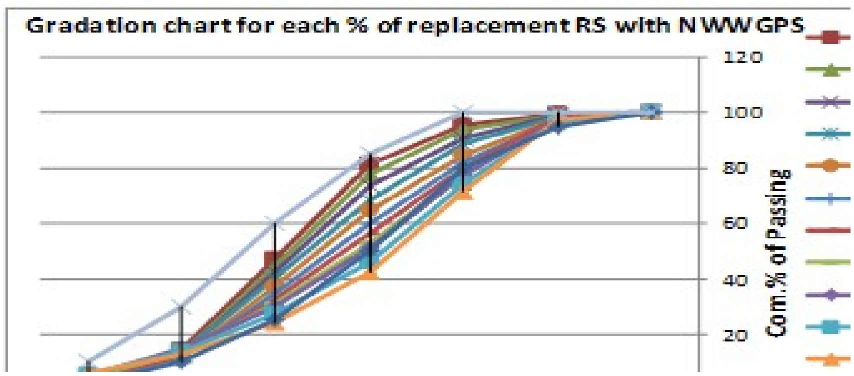

Figure 10 Gradation curve for each replacement level of RS with NWGPS

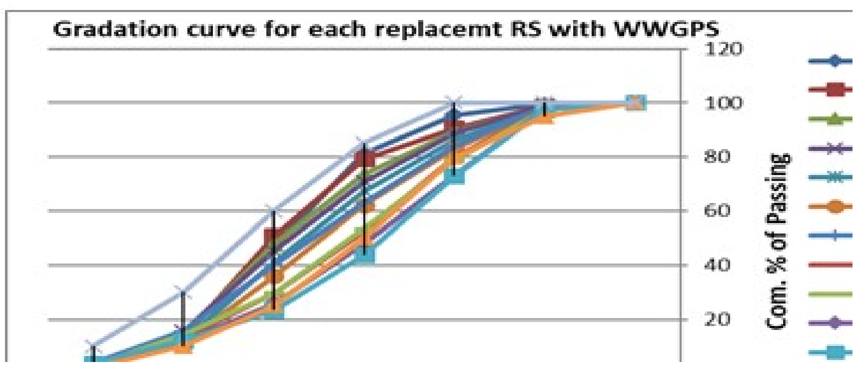

Figure 11 Gradation curve for each replacement level of RS with WWGPS

According to BS882:1992 Standards and as shown in the above Figure 10 and Figure 11 the gradation curve of all percentage replacement of river sand with NWWGPS and WWGPS was between the ranges of overall limitations and met ASTM 33-03 maximum and minimum limitation until 70% of replacement but failed above 70% of replacement in 2.36, 1.18 and 0.6 mm sieve sizes.

3.2 Fresh Concrete Property

In this section, the workability/consistency/ of the fresh concrete was measured by using a slump test for each replacement level of the fresh concrete mix. The procedures of slump tests for all fresh concrete mixes were made based on the ASTM C143 standard test method after the mixing process finished before casting. The observed slump value for C-20, C-25, and C-30 at each replacement level of river sand with not washed and washed wukro granite pit sand is determined as shown in Figure 12.

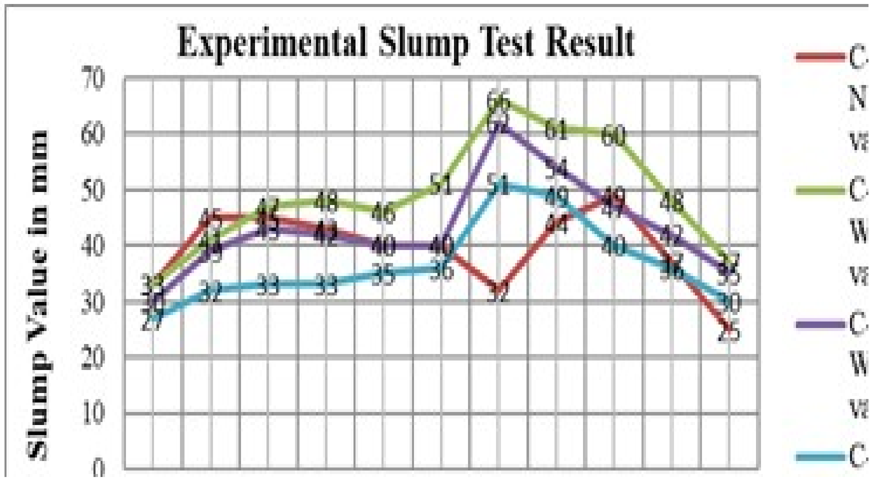

Figure 12 Slump test result for each replacement of RS

As shown in the above Figure 12 the obtained slump test result was relatively increased with increased percent of replacement because of decreased the surface area of the sand but finally after 80% of replacement the slump values decreased because of the increased fineness content.

3.3 Hardened Concrete Property

Compressive strength tests for C- 20, 25, and 30 Mpa were performed for each replacement level of river sand with not washed and washed wukro granite pit sand and plotted as the following Figure 13, Figure 14, Figure 15, and Figure 16

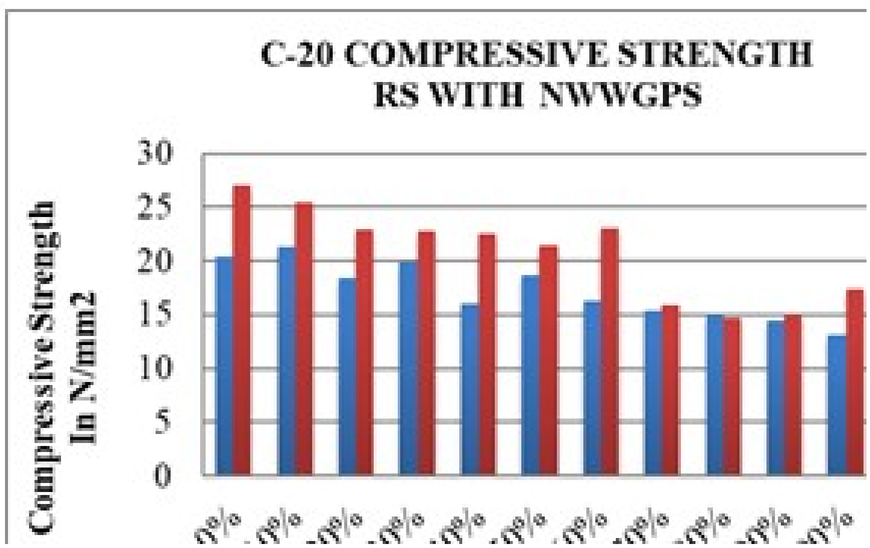

Figure 13 Compressive strength results for replacement of RS with NWWGPS for C-20

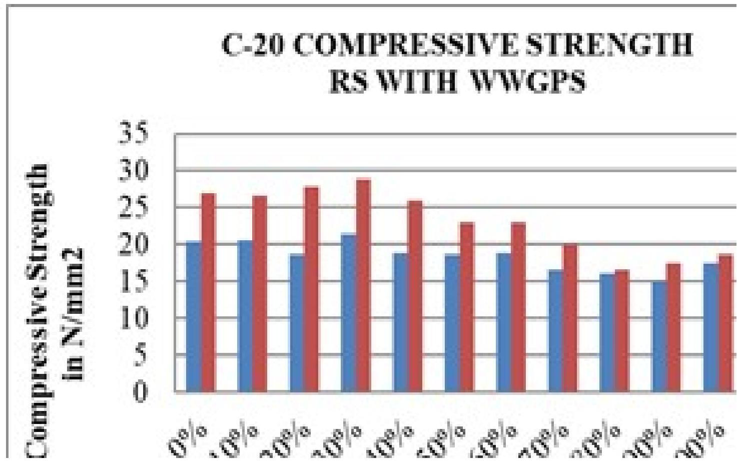

Figure 14 Compressive strength results for replacement of RS with WWGPS for C-20

As determined in above Figure 13 the compressive strength decreased but was acceptable until 60 % and 90 % after 28 and 7th curing days respectively as the percent replacement of RS with NWWGPS increased but according to Figure 14 compressive strength relatively increased with the minimum amount until 30% but still, 70% replacement of RS with WWGPS is acceptable at 28 days. However, the obtained early compressive strength test result at all replacement levels was above ACI 209 minimum expected compressive strength result of 14.07 at 7 days. The obtained compressive strength results at different replacement levels of RS with WWGPS for C-25 and C-30 are determined as shown in Figure 15 and Figure 16.

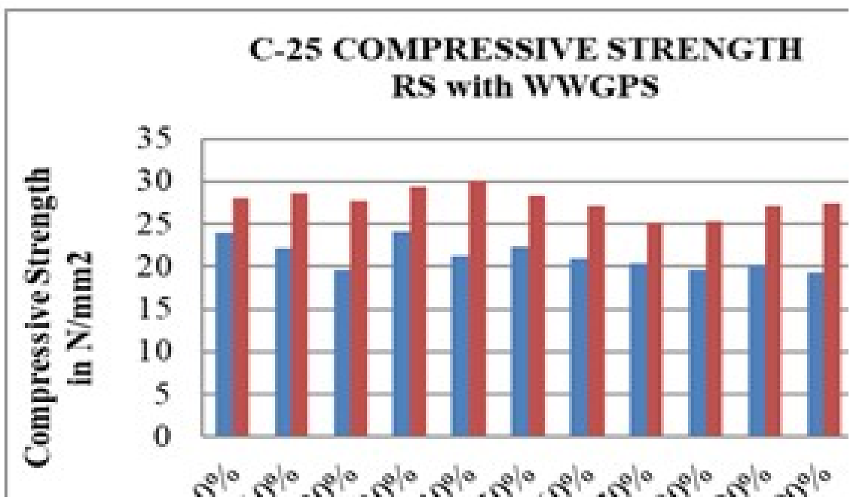

Figure 15 Compressive strength results for replacement of RS with WWGPS for C-25

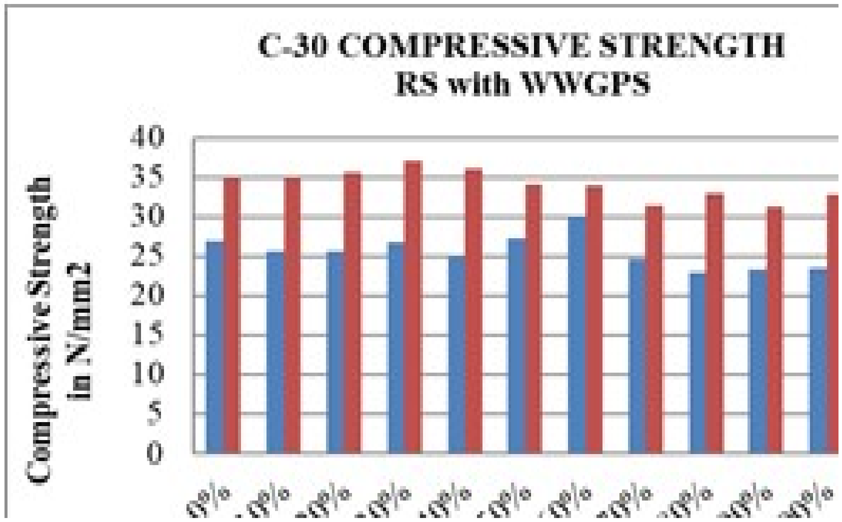

Figure 16 Compressive strength results for replacement of RS with WWGPS for C-30

As determined in Figure 15 compressive strength of C-25 concrete obtained a maximum value at 40 % of replacement but the obtained result of all replacement levels was above 17.588 Mpa according to ACI 209 criteria and the specified strength of 25 Mpa at 7 and 28 days respectively. But as shown in the above Figure 16 the compressive strength result was increased until 30 % of replacement and then decreased but the obtained result of all replacement levels was above 21.106Mpa according to ACI 209 criteria and the specified strength of 30 Mpa at 7 and 28 days respectively.

4. Conclusions

This study developed the study of the concrete properties of granite pits and river sand concrete properties. Based on the obtained study of RS replacement with NWWGPS and WWGPS on material properties, workability, and compressive strength the following conclusions are made.

1. Material properties – the gradation chart before blending and after 80% of replacement levels became out of ASTM C33-03 limitation.
2. Workability- The workability of the fresh concrete relatively increased as increase replacement levels.
3. Compressive strength- relatively the compressive strength decreased to 60 % was above the specified strength by replacement of RS with NWWGPS but increased still 40% but still 70 % of replacement RS with WWGPS is acceptable in C-20. For C-25 and C-30, 40 and 30% of replacement RS with WWGPS increased respectively and acceptable up to 100%.

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