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Properties of Some Natural Fine Aggregates in Minna, Nigeria and Environs

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Abstract

This paper investigates the properties of some natural fine aggregates in Minna and its environs. Nine soil samples were obtained from different locations and transported to Civil Engineering Laboratory, Federal University of Technology, Minna, Nigeria. Tests conducted on the soil samples include: specific gravity, sieve analysis, bulk density and silt content. Test result revealed the specific gravities of the soils to be between 2.60 to 2.84, compacted bulk densities to be between 1470 Kg/m^3 to 1867 Kg/m^3, loose bulk densities to be between 940 Kg/m^3 to 1013 Kg/m^3 and silt contents to be between 0.97 to 5.50 natural fine aggregates are suitable for construction purposes. Most of the soils satisfy the overall grading limits for natural fine aggregates and they are mainly fine grading except samples 6 and 9 which are medium grading and sample 2 which is coarse grading. These soils can be used for construction purposes but a good knowledge of mix design is essential and soils should be tested before use to obtain durable product.

Keywords

Natural fine aggregates, Soil samples tests

Introduction

Aggregates are generally divided into two groups: Fine and Coarse. Fine aggregate consists of natural or manufactured sand with particles sizes up to 5mm. It consists of inert natural sand conforming to [1]. It does not contain more than a total of 5% by weight of the followings: shale, silt and structurally weak particles [2].

Aggregates make up or occupy 60% to 80% of concrete volume making its selection highly important [3]. Aggregate should consist of particles with adequate strength and resistance to exposure condition and should not contain materials that will cause deterioration of concrete. All natural aggregate particles originally formed a part of a larger parent mass. This may have been fragmented by natural processes of weathering and abrasion or artificially by crushing. Thus, many properties of the aggregate depend entirely on the properties of the parent rock, for example, chemical and mineral composition, petrologic character, specific gravity, hardness, strength, physical and chemical stability, pore structure and colour [4]. Fine aggregates provide support function to the finer solids by producing voids of a size which do no contain or support the finer particles. Particle shape affects the behaviour of the water, harsh angular aggregates not packing well and resulting in high void content [5]. Such aggregates may have a high surface area, but because of a lack of contact between the particles, it does not effectively control the finer particles. Smooth rounded aggregates have the disadvantage that, although theoretically it should pack together and produce low voids, this situation does not necessarily occur in a graded material of this type.

Aggregates for mortar must be clean, sharp and free from salt and organic contamination. Most natural aggregates contain a small quantity of silt or clay. A small quantity of silt improves workability. Marine or estuarine aggregate should not be used unless washed completely to remove the magnesium and sodium chloride salts which are deliquescent and attract moisture [6]. The most suitable aggregate would appear to be one that is well graded with a balance between rounded and angular particles and a surface texture that is not too smooth. In practice it has been found that a natural river aggregate with a grading complying with [1] is the most suitable. Sea-dredged and crushed aggregates produce more extreme types, either all smooth and rounded or harsh and angular and generally requiring greater care in design.

The realization of the usefulness and effect of fine aggregate on the strength of concrete and sandcrete in the building and construction industry has put into the minds of Engineers and researchers to lay more emphasis into the study of the Civil Engineering properties and its usefulness. Emphasis is made on such properties like bulk density, specific gravity, silt content and particle size distribution. The aggregates used in construction works in Minna, being the case study, are obtained from rives, borrow pits and eroded materials.

Methodology

For the purpose of this work nine natural fine aggregates samples were obtained from areas currently in use for construction purposes in Minna, Nigeria. The nine locations used in this study are shown in Table 1.

Table 1. Sample Location

Sample	1	2	3	4	5	6	7	8	9
Location	Rafintofao	Tagwai dam	Dogo	Kodo	Gwada	Pyata	Shata	Paiko	Takuti
Area	Maikunkele	Chanchanga	Garatu (Bida road)	Along Beji	Kuta road	Along cais Road	Maikunkele	Paiko	Along Lapai

These soil samples were transported to Civil Engineering laboratory, Federal University of Technology, Minna, Nigeria. The tests carried out were: specific gravity and sieve analysis in accordance to [7] and bulk density and silt content in accordance to [8].

Results and Discussion

Specific Gravity of Soil Samples

The results for the specific gravities of soil samples are shown in Table 2.

Table 2. Specific Gravity of Soil Samples

Samples	1	2	3	4	5	6	7	8	9
Test 1	2.79	2.55	2.72	2.81	2.72	2.81	2.73	2.83	2.77
Test 2	2.79	2.65	2.74	2.79	2.72	2.75	2.73	2.85	2.79
Average	2.79	2.60	2.73	2.80	2.72	2.78	2.73	2.84	2.78

The values of the specific gravities range between 2.60 to 2.84. The average specific gravities for various rock groups ranges between 2.54 for flint to 2.80 for basalt and the range of specific gravities reported were between 2.4 to 2.6 (flint) to 2.7 to 3.0 (hornfels) [9]. The experimental results are in line with these standards. This implies that these aggregates have not been contaminated with other materials from the environment.

Bulk Density of Soil Samples

The results for the bulk densities of soil samples are shown in Table 3. The compacted bulk densities of the aggregates are between 1407 Kg/m^3 to 1867 Kg/m^3.

Table 3. Bulk Density of Soil Samples

Compacted									
Sample	1	2	3	4	5	6	7	8	9
Test 1	1539	1586	1614	1488	1889	1435	1634	1640	1629
Test 2	1569	1590	1594	1504	1845	1379	1638	1634	1625
Average Kg/m^3	1554	1588	1604	1496	1867	1407	1636	1637	1627
Loose									
Test 1	941	1012	934	942	941	739	934	943	809
Test 2	939	1014	934	940	955	735	936	941	797
Average Kg/m^3	940	1013	934	941	948	737	935	942	803

The uncompacted bulk densities of the aggregates are between 940 Kg/m^3 to 1013 Kg/m^3. The bulk density for sand and sandy soils before excavation ranges from 1650 Kg/m^3 to 1850 Kg/m^3 as reported in [10]. The experimental values are relatively low as the soil sample used for the experiment was a disturbed one. This increases the void spaces between the soil particles and thereby reduces the weight of material required to fill a unit volume and consequently reducing the bulk density of the soil.

Silt Contents of Soil Samples

The result for the silt content is presented in Table 4. The [8] permits silt contents to be within the range of 3 to 8 %. Silt is a material between 2µm and 60µm.

Table 4. Silt Content of Soil Samples

Samples	1	2	3	4	5	6	7	8	9
Height of Soil Sample (ml)	112.38	103.70	109.60	107.31	109.30	104.90	103.00	109.40	103.15
Height of Silt Layer (ml)	6.18	1.60	4.55	3.46	4.10	2.40	1.00	5.45	1.10
Silt Content (%)	5.50	1.54	4.15	3.22	3.75	2.29	0.97	4.98	1.07

Soil samples 2, 6, 7 and 9 have silt content less than 3 % while soil samples 1, 3, 4, 5 and 8 have silt contents between 3 to 8 %. Soil samples with silt content less than 3 % have insufficient fines and will require a considerable amount of cement for a reasonable workability. If such soils are to be used for construction work they have to be blended with suitable finer aggregates from other sources. Soil samples with silt content between 3 to 8 % are quite suitable for construction purposes. This will require optimum water and cement content for a reasonable workability. Silt content of over 8 % is unsuitable as it increases the amount of water needed to wet the particles in the mix [3]. This results in mix with high slump, high dry shrinkage and consequently weak and non-durable concrete.

Sieve Analysis of Soil Samples

The result for sieve analysis is shown in Table 5.

Table 5. Sieve Analysis of Soil Samples

Sieve Size (mm)	5.00	3.35	2.36	1.18	0.60	0.30	0.15	0.075	PAN
Samples	Percentage Finer (%)								
1	99.19	98.90	98.51	94.15	74.94	42.30	31.28	24.27	0.00
2	96.20	77.46	72.48	49.21	19.50	3.29	3.02	1.54	0.00
3	98.02	95.73	92.24	85.73	79.18	66.66	59.92	46.25	0.00
4	98.31	97.41	95.56	86.56	66.05	33.03	21.24	10.95	0.00
5	98.76	97.94	96.58	91.34	76.28	50.14	39.44	22.30	0.00
6	98.44	97.23	94.83	80.94	50.49	19.20	15.86	7.30	0.00
7	99.12	98.44	96.73	88.23	66.03	15.68	13.37	7.37	0.00
8	98.76	96.95	94.41	84.44	72.20	56.15	46.42	29.35	0.00
9	98.62	97.11	93.62	72.53	44.82	8.91	8.65	6.64	0.00

Soil sample 1 satisfy the overall grading limit except the percentage finer than 150μm sieve size which was 31.28 % falling outside the range (0-15 %). The soil is also fine grading. Soil sample 2 satisfy the overall grading limit except the percentage finer than 300μm sieve size which was 3.29 % falling outside the range (5-70 %). The soil is also coarse grading with percentage passing 300μm sieve size of 3.29 % falling outside the range (5-40 %). Soil sample 3 is fine grading and satisfy the overall grading limit except the percentage finer than 150μm sieve size which was 59.92 % falling outside the range (0-15 %). Soil sample 4 is fine grading and satisfy the overall grading limit except the percentage finer than 150μm sieve size which was 21.24 % falling outside the range (0-15 %). Soil sample 5 is fine grading and satisfy the overall grading limit except the percentage finer than 150μm sieve size which was 39.44 % falling outside the range (0-15 %). Soil sample 6 is medium grading and satisfies the overall grading. Soil sample 7 is fine grading and satisfies the overall grading limit. Soil sample 8 is fine grading and satisfy the overall grading limit except the percentage finer than 150μm sieve size which was 46.42 % falling outside the range (0-15 %). Soil sample 9 is medium grading and satisfies the overall grading limit. The soil samples agree reasonably well with [1] and are recommended for construction purposes. It does not mean that any grading is recommended; a wide range of grading may be acceptable through a trial and error approach [3].

Conclusions

The specific gravities of the soil samples were found to be between 2.60 to 2.84. The bulk compacted densities of aggregates are between 1470 Kg/m^3 to 1867 Kg/m^3 and the un-compacted (loose) bulk densities are between 940 Kg/m^3 to 1013 Kg/m^3. The deviations from standard are due to sample disturbance. Four of the nine soil samples have silt content less than 3 %. Five of the other soil samples have silt content in the range of 3 to 8 %. The nine soil samples satisfy the overall grading limit with greater value for percentage finer than sieve size 150μm for soil samples 1, 3, 5 and 8. This indicates excess finesse greater than normal. Such soils will produce poor mix with insufficient cement content if they are not mix with other aggregates. The soil samples 1, 3, 4, 5, 7 and 8 are fine grading, soil samples 6 and 9 are medium grading and soil sample 2 is coarse grading. Soils for construction works should be analysed before they are used. This will enable the users to prepare accurate mix to ensure workability, minimum dry shrinkage, durability and high strength.

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