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Comparison of the Compressive Strength of Concrete Produced using Sand from Different Sources

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ABSTRACT
The research focused on comparing the compressive strength of concrete produced using sand from different sources/locations. To do this, various tests were performed to assess the suitability of these sand (i.e. from different locations) on the strength of strength of concrete. The results revealed that the concrete produced with badagry beach sand, gave the highest compressive strength followed by Gbogidi runoff sand and Mokoloki dredged river sand with compressive strength of 32.37N/mm2, 31.15N/mm2 and 27.75N/mm2 respectively. While the least compressive strength was achieved with concrete produced with badagry dredged river sand with compressive strength of 25.39N/mm2

Keywords: Sand, Concrete, Compressive strength

INTRODUCTION

Sand is a naturally occurring granular material composed of finely divided rock and mineral particles. It is defined by size, being finer than gravel and coarser than silt. Sand can also refer to a textural class of soil or soil type; i.e. a soil containing more than 85% sand-sized particles (by mass) Ottawa (1976)

The composition of sand varies, depending on the local rock sources and conditions, but the most common constituent of sand in inland continental settings and non-tropical coastal settings is silica (silicon dioxide, or SiO_2), usually in the form of quartz. The second most common type of sand is calcium carbonate, for example aragonite, which has mostly been created, over the past half billion years, by various forms of life, like coral and shellfish. It is, for example, the primary form of sand apparent in areas where reefs have dominated the ecosystem for millions of years like the Caribbean

Sand is formed by the weathering of rocks. Based on the natural sources from which sand is obtained, it is classified as follows:

- Pit sand
- River sand
- Sea sand
- Crushed stones (Artificial sand)

COMPOSITION AND CLASSIFICATION

The composition of sand varies, depending on the local rock sources and conditions, but the most common constituent of sand in inland continental settings and non-tropical coastal settings is silica (silicon dioxide, or SiO_2), usually in the form of quartz. The second most common type of sand is calcium carbonate, for example aragonite, which has mostly been created, over the past half billion years, by various forms of life, like coral and shellfish. It is, for example, the primary form of sand apparent in areas where reefs have dominated the ecosystem for millions of years like the Caribbean

In terms of particle size as used by geologists, sand particles range in diameter from 0.0625 mm (or $1/16$ mm) to 2 mm (Crag 2004). An individual particle in this range size is termed a sand grain. Sand grains are between gravel (with particles ranging from 2 mm up to 64 mm) and silt (particles smaller than 0.0625 mm down to 0.004 mm). The size specification between sand and gravel has remained constant for more than a century, but particle diameters as small as 0.02 mm were considered sand under the Albert Atterberg standard in use during the early 20th century. A 1953 engineering standard published by the American Association of State Highway and Transportation Officials set the minimum sand size at 0.074 mm. A 1938 specification of the United States Department of Agriculture was 0.05 mm (Urquhart 1959). Sand feels gritty when rubbed between the fingers (silt, by comparison, feels like flour).

ISO 14688 grades sands as fine, medium and coarse with ranges 0.063 mm to 0.2 mm to 0.63 mm to 2.0 mm. In the United States, sand is commonly divided into five sub-categories based on size: very fine sand ($1/16$– $1/8$ mm diameter), fine sand ($1/8$ mm –$1/4$ mm), medium sand ($1/4$ mm – $1/2$ mm), coarse sand ($1/2$ mm – 1 mm), and very coarse sand (1 mm – 2 mm). These sizes are based on the Krumbein phi scale, where size in $\Phi = -\log_2 D$; D being the particle size in mm. On this scale, for sand the value of Φ varies from −1 to +4, with the divisions between sub-categories at whole numbers.

SAND FOR CONSTRUCTION WORKS
Different construction works require different standards of sand for construction.

• Brick Works/ masonry work: finest modulus of fine sand should be 1.2 to 1.5, silt contents not more than 4% and must pass through a sieve of clear opening of 3.175mm. it is referred to as coarsesand

• Plastering Works: finest modulus of fine sand should not be more than 1.5, silt contents not more than 4% and must pass through a sieve with clear opening of 1.5875mm. it is refereed to as fine sand
• Concreting Works: coarse sand should be used with finest modulus 2.5 to 3.5, silt contents should not be more than 4% and must pass through a sieve of clear opening of 7.62mm. it is referred to as gravely sand
GRADING OF SAND
On the basis of particle size, fine aggregate is graded into four zones

IS SIEVES	PERCENTAGE PASSING FOR			
	Grading zone I	Grading zone II	Grading zone III	Grading zone IV
10mm	100	100	100	100
4.75mm	90-100	90-100	90-100	90-100
2.36mm	60-95	75-100	85-100	95-100
1.18mm	30-70	55-90	75-100	90-100
600microns	15-34	35-59	60-79	80-100
300microns	5-20	8-30	12-40	15-50
150microns	0-10	0-10	0-10	0-15

CONCRETE
Sand is the one of the main constituents of concrete making about 35% of volume of concrete of concrete used in concrete in construction industry. Natural sand can be got from various source, river, run off, sand deposit etc. and always contains high percentages of inorganic materials, chlorides, chlorides, sulphates, silt and clay that adversely affect the strength and durability of concrete ad reinforcing steel thereby by reducing the life of structure. Because of high percentages of sand and hardened concrete and have an impact on cost effectiveness of the concrete. That is why the materials for construction should be sampled, inspected, tested and acceptance for use or be given if they meet the established standards in all respects. A great number of researchers have studied the effect of sand either natural or artificial on the concrete strength and some of them and their findings are explained below.

B. Balapgol, S. Kulharn, K.Bajoria (2002), investigated the use of crushed sand as fine aggregates along with fly ash in concrete. They says that a combination of fly ash and crushed sand yield a far superior concrete mix than crushed sand alone.
Hadassa Baun and Amnon Katz (2009) studied the percentage of fines in crushed sand and its effects on the concrete mixes. They pointed out that the addition of fine filler (mesh 0.0075mm) has a positive potential on the properties of the concrete. But, at the same time, the fraction of less than 5 microns of the fine filler used for plastering may have a bad effect on the concrete.
Mannasseh (2010), the workability of crushed granite fine (CGF) and river sand in concrete production for use in rigid pavements was investigated by Manasseh. Fifteen different concrete mixes having five mix proportions for both natural and manufactured sand (i.e 100%NS+0%MS; 75%NS+25%; 50%NS+50%MS; 25%NS+75%%MS% and 0%NS+100%MS). The mix produced with only Makurdi river sand as fine aggregate, served as the control mix. And base on his findings the partial replacement of Makurdi river sand with 20% CGF is recommended for use in concrete production for use in rigid pavement (in low to moderately trafficked roads).
Sachin Balkrishna et al (2012) also reported on the strength of concrete containing difference types of fine aggregate. They came to know that Grit, which is quarry rock dust has proven to be highest compressible strength fine aggregate as compared to natural sand, artificial sand & combination of natural sand & artificial sand. In case of Beam the ultimate load for artificial.

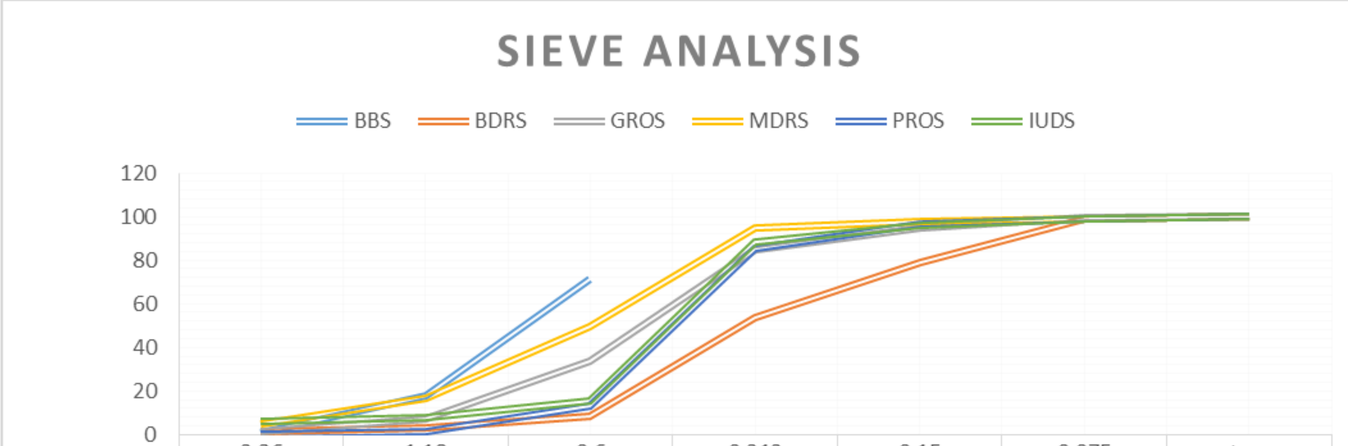
Methodology
All the experiment were conducted at both the civil engineering & science Laboratory technology (SLT) laboratories of the Federal polytechnic Ilaro. All the samples were brought from different locations within Ogun state Nigeria and the following tests were carried out: grading test analysis of which gave values for fineness modulus, coefficient of uniformity, coefficient of curvature and classification of these sand samples into zones, slump test, silt test, salt test & compressive strength test. To assess the compressive strength of concrete produced during the experiment, 36 cubes were cast in all, meaning six cubes for each location were cast, two each out of the six cubes were used to determine 7, 14 and 28 day strength of the cubes. The mix design was 1:2:4 with maximum aggregate size of 12.5mm with water cement ratio of 0.6, values obtained throughout the course of the experiments were compared with established standard and all the tests complied with the British standard.

RESULTS

Sample					Slump test (mm)	Silt content (mm)	Salt test value (salinity)	Density (kg/m^3) for 28 days	Compressive strength		
	F.M	Zone	C_u	C_c					7 days	14 days	28 days
Badagry beach sand	2.1	i	0.0	0.00	26	0.00	0.7	2436.6	26.98	27.33	32.37
Badagry dredge sand	3.56	iv	2.80	0.88	21	4.20	0.7	2419.3	21.09	24.53	25.39
Gbogidi run-off sand	2.79	iii	3.48	1.25	135	6.40	0.3	2375.6	22.81	27.47	31.15
Mokoloki river sand	2.37	ii	2.79	0.88	16	0.00	0.3	2268.9	24.53	26.25	27.75
Pahayi run-off sand	3.04	iv	2.61	1.22	67	8.70	0.4	2415.6	25.14	25.27	26.74
Iweke	2.88	iv	2.1	1.0	37	4.20	0.3	2451.9	25.26	25.51	26.98

TABLE I

ABBREVIATION	LOCATIONS
BBS	Badagry beach sand
BDRS	Badagry dredge sand
GROS	Gbogidi run-off sand
MDRS	Mokoloki river sand
PROS	Pahayi run-off sand
IUDS	Iweke uphill deposit sand



	2.36	1.18	0.6	0.212	0.15	0.075	tray
BBS	0.9	18	71.1				
BDRS	1.3	3.35	8.5	53.8	78.8	98.9	100
GROS	1.1	7.2	33.8	84.9	94.9	99.4	100
MDRS	4.6	16.8	49.56	94.8	98	99.05	100
PROS	0.4	1.6	13	85.5	96.5	99.1	100
IUDS	6.2	7.6	15.4	88.2	95.7	98.95	100

FIGURE 1

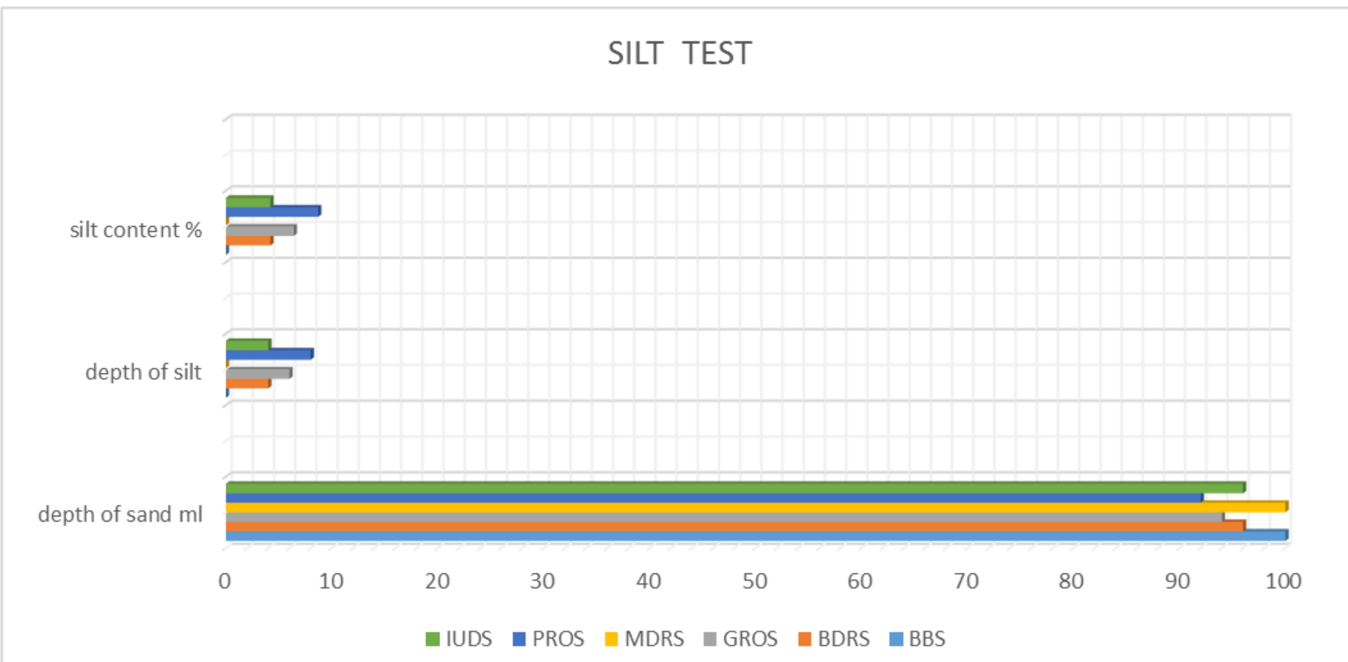


FIGURE II

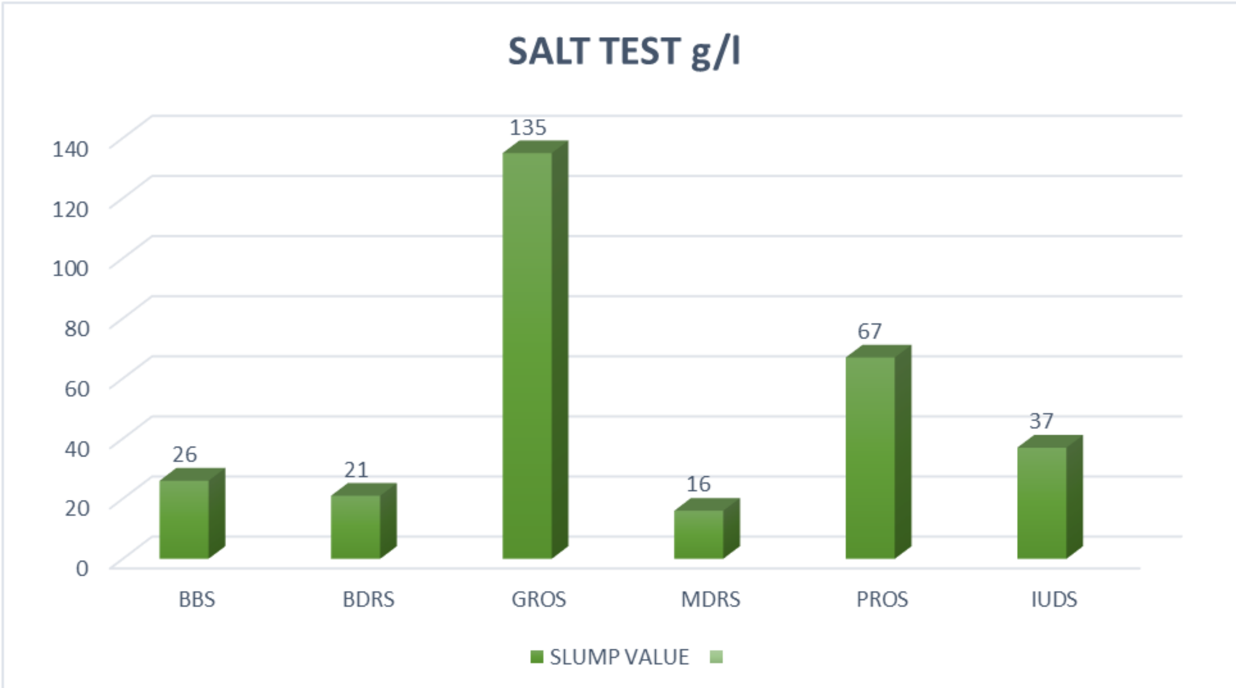


FIGURE III

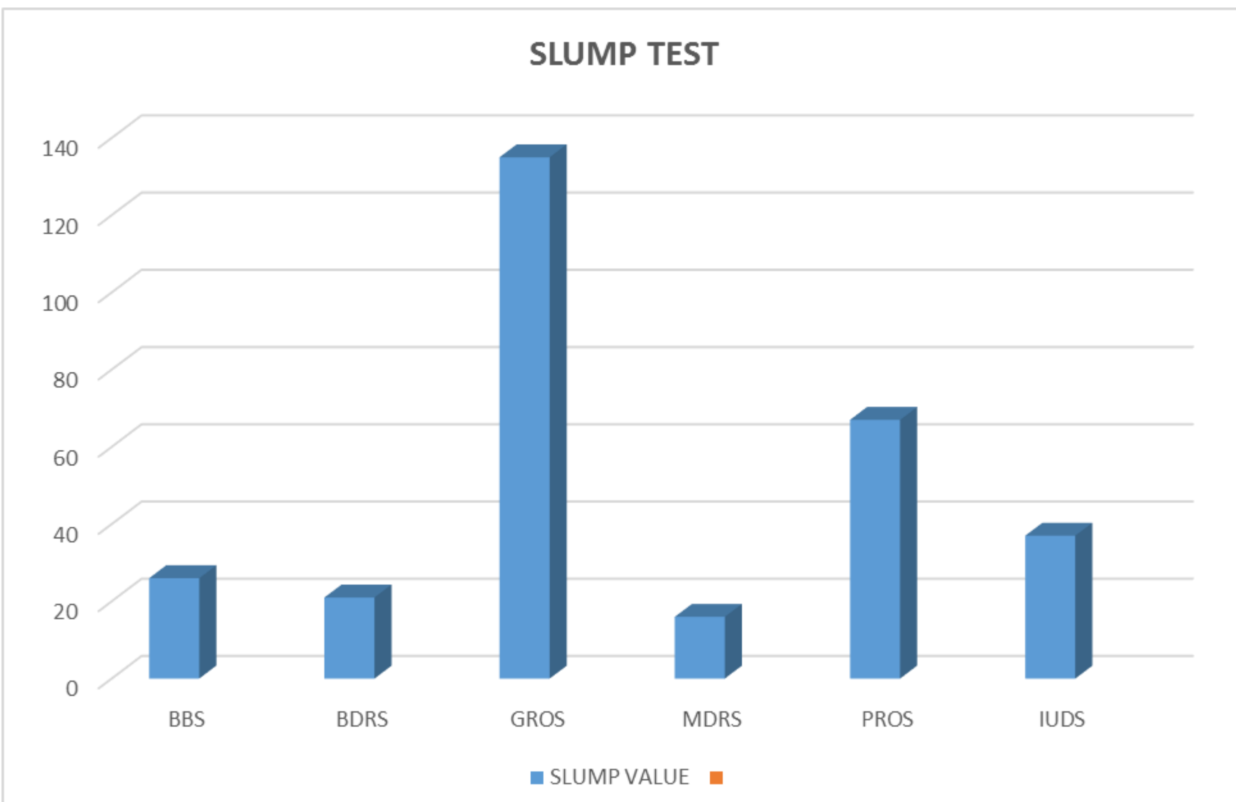


FIGURE IV

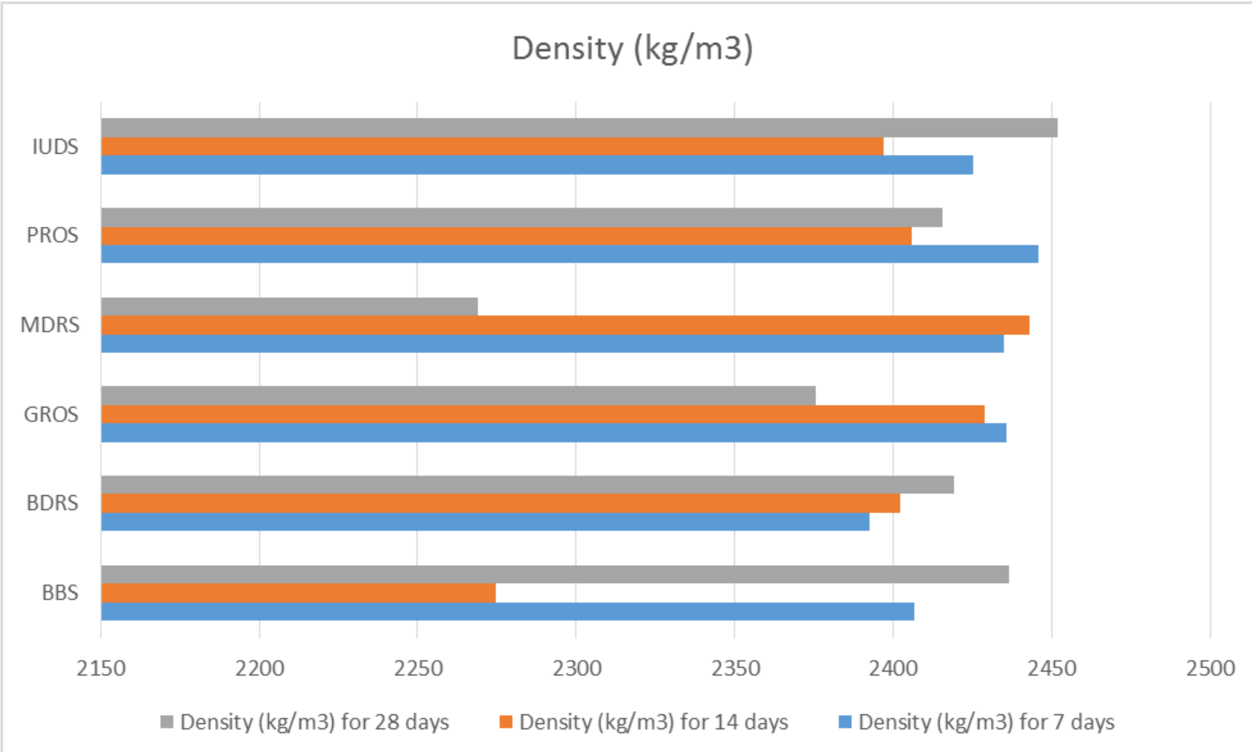


FIGURE V

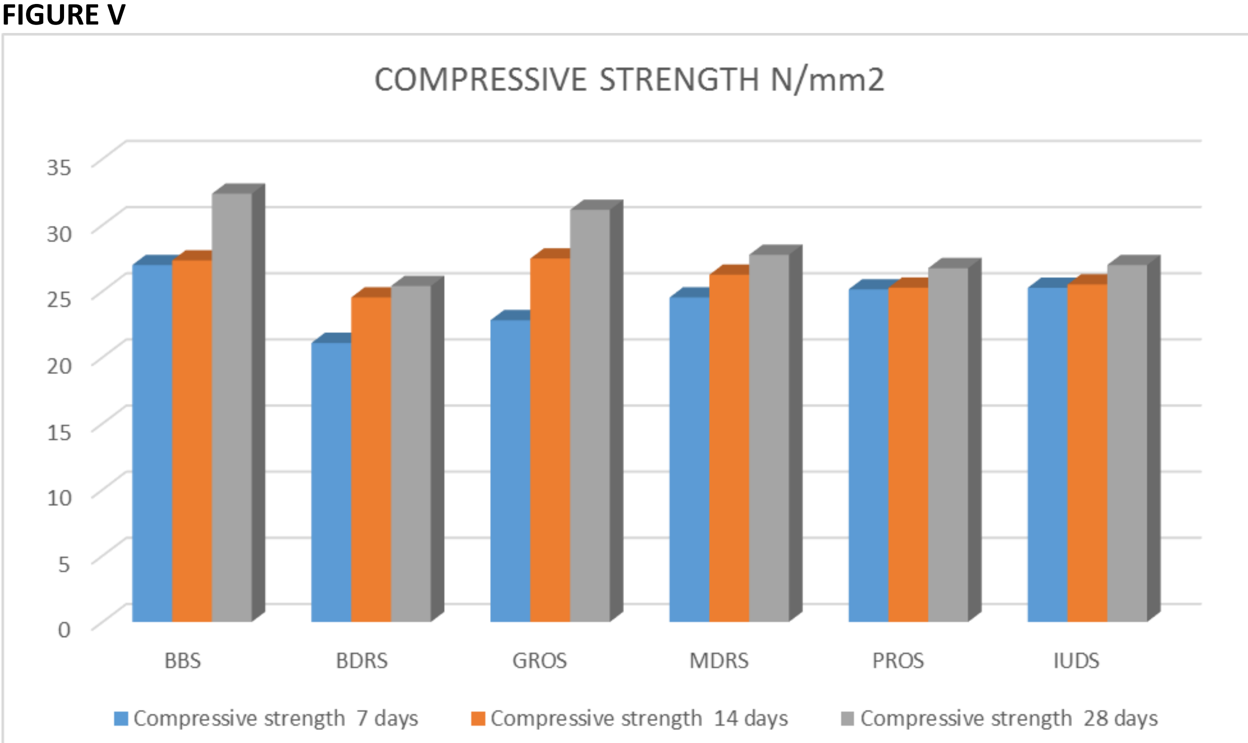


FIGURE VI

TABLE II (STANDARD VALUES)

Features of test	Interpretation	Range of value
Co effiecient of curvature (C_c)	Well graded	1 – 3
Co efficient of uniformity (C_u)	(a) Well graded (b) Uniformly graded (c) Poorly graded	›5 1 – 5 < 1
Zones using sieve of 0.600	 Zone i: coarse sand Zone ii: medium sand Zone iii: medium to fine sand Zone iv: Fine sand	%passing 0.600mm (15 – 34) % (35 – 50) % (60 – 79) % (80 – 100) %
Silt content (%)		≤ 5
Slump (degree of workability)	Very low Low Medium High	0 – 25mm 25 – 50mm 50 – 100mm 100 – 175mm
Salt content (g/l)	(a) Pre stressed concrete (b) Reinforced concrete in moist environment (c) Reinforced concrete in dry environment	0.5g/l 0.8 g/l 1.6 g/l
Compressive strength at 28 days using coarse aggregate with water/cement ratio of 0.6 and 1:2:4 mix		25 N/mm^2

SOURCE: BS 882; BS 1881; CP 114 (1970); R.F. CRAG (2004); SHETTY M.S. (2005); G.N. SMITH (1978)

ANALYSIS OF RESULTS

Table 1 provides the summary of results of all the tests carried out and was observed that badagry beach sand had the highest compressive strength having got a finest modulus value of 2.1 falling within zone I of sand classification, a slump value of 26 with no silt content and also salt content of 0.7g/l but adjudged to be poorly graded, because its C_c and C_u values are less than 1. Gbogidi run off sand produced concrete with second highest compressive strength. Although it had a high value of silt content of 6.4% which was higher than the maximum recommended ≤5%. It had all other factors in its favour. It was well graded (C_c 1.25), an FM value of 2.79, second lowest and a salt content of 0.3g/l.

Badagry dredged sand had the lowest compressive strength of 25.39N/mm^2. This was expected because it had the highest FM value (3.56), low slump test value, highest salt content value of 0.7g/l, poorly graded (C_c = 0.88 which is less than 1) and fell into zone iv in sand classification which meant it was too fine. Out of all the three sand samples that fell into zone iv Badagry dredge sand , Pahayi run off sand & Iweke uphill sands, Badagry dredged sand had the lowest compressive strength value but with the highest FM value followed by Pahayi run-off sand FM value of 3.04 and the least FM value of 2.88 recorded for Iweke uphill sand. It showed that the higher the FM value the lower the compressive strength. Badagry dredged sand had the lowest value of C_c (<1) which suggest it was poorly graded. It equally had the highest salt content. The content of table II were the standard values to which results of all tests were compared.

CONCLUSION

1. It was observed from table1 that the lower the FM the higher the strength, save for Mokoloki dredged river sand (the only one in zone II).
2. Badagry as beach sand gave the highest compressive strength value because it is in zone I, FM value of 2.1 with sharp particles (C_c= 0), no silt with tolerable salt content as against Badagry dredged sand with least value which is due to the fact that it falls within zone iv with C_c value less than 1, high silt content although tolerable and equally tolerable salt content. This showed that the strength of concrete is moderated by its FM (≤2.8), its zone, its silt content (≤5% and slightly higher value if it does not stick on the materials) and finally the salt content (≤0.8g/l).
3. That all the samples led to concrete production having compressive strength higher than the specified (table II). Mokoloki dredged river sand would have given higher strength if the C_c had been up to 1 because it is silt free and salt content very low.
4. The run-off sand sourced from gbogidi and Pahayi gave good compressive strength when compared with the standard. Gbogidi performed better because of lower silt content 6.40 as against 8.70 and salt content of 0.3 as against 0.4, the silt values are high (>5) but they do not stick onto the particles and as such did not portend any danger. The two run-off sand sourced from the two locations are well graded having C_c > 1.0.

RECOMMENDATION

That sand sourced from Badagry beach can be used for concrete production. The public must have had an enormous idea of the sand being salty and not favorable for construction work. This research work showed vividly that the salt content is 0.7g/l which is less than specified and as such very suitable for concrete production

Runoff sand could be used in the production of concrete contrary to the earlier held view.

Uphill sand, although finer than river sourced sharp sand can be used entirely in place of river sourced sharp sand in the production of concrete to achieve concrete of permissible strength.

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