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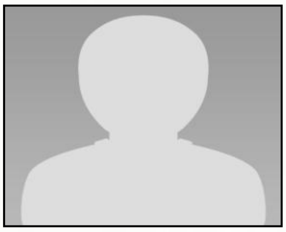
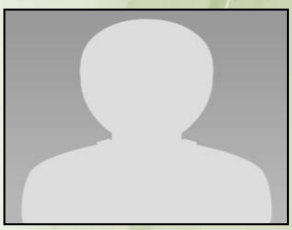
"Investigation and Comparative Analysis of Clay Content, Grain Size and Grain Size Distribution of Foundry Moulding Sands"





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Abstract

The chemical composition, clay content, grain size and grain size distribution (sieve analysis) of silica sands in six locations in Lagos area (South West, Nigeria) used in most foundry industries in Lagos and its environments as moulding sand for casting were investigated. The aim was to carry out comparative analysis of the sands and determine their suitability for casting both ferrous and non ferrous metals. Silica sand samples were collected at random from six major deposit of silica sand used by a leading Foundry industry based in Lagos, namely: Ajido, Araromi, Badagry, Epe, Gbelejo and Oworonsoki areas in Lagos beaches. The corresponding values of active clay contents for Ajido, Araromi, Badagry, Gbelejo and Oworonsoki are 0.3%, 0.76%, 0.85%, 0.55%, 0.60% and 0.84% respectively. These results showed that Ajido silica sand with lowest active clay contents would require highest binders while Badagry silica sand with highest active clay content would require least binders. However, these active clay contents fall within acceptable limit for moulding sand. Average Grain fineness number of 74.92, 76.22, 68.67, 80.64, 31.98 and 62.37 were obtained for Ajido, Araromi, Badagry, Epe, Gbelejo and Oworonsoki respectively. The results were presented in tabular and graphical forms to further analyse the grain size distribution. Effects of clay content on amount of binders and A.F.S grain fineness number on grain size and grain size distribution of each sample on green compressive strength, compactability and permeability were discussed.

Keywords: Silica sand, casting, active clay content, grain size distribution, A.F.S grain fineness number.

Introduction

Silica sand is evaluated for industrial use on the basis of its composition and physical properties (Mclaws 1971). Silica sand is commonly used in green sand system because of its low cost and availability. Green sand allows the steam from the sand to escape when the molten metal comes into contact with mould (The navy foundry manual 2002). According to shape, moulding sands can be classified as rounded, sub-angular and compound. Moulding sands composed of angular grains need higher amounts of binder, and moisture because of their greater specific surface area. Compound grains also require higher amount of binder and moisture. Compound grains are least desirable to sand mixtures because they have a tendency to disintegrate at high temperature (Sinha & Goel 1991).

Sand moulds are designed to have a good collapsibility and accommodate shrinkage of cast metal during solidification to avoid defects in the cast metal. Casting sand should have good flowability to pack well during moulding to produce good surface finish as well as exhibition of lower permeability to give a better as-cast finish (Higginbs 1983). The quality of sand cast products are high (Rzydon 2008) as the sand mould can withstand high melting temperature of the cast metal. As casting size increases, more gas is produced in the mould, implying that the permeability of the sand must be higher. Burns 1986 reported that green sand is mostly used for large casting (450kg) while dry sand is usually for smaller casting (25kg).

Silica sand (SiO_2) is found as natural deposits in many beaches in Lagos area. Although pure silica is not suitable in itself for moulding and it has to be mixed with clay or carbon since it lacks binding qualities. Aweda et al 2009 reported in their paper that Abolarin et al 2007 once produced some samples of brake disc without any additives and found that the cast yield was high with minimal surface defect and that knowledge of the heating rates of sand moulds would help reduce the occurrence of defects generated by internal stresses due to high operating temperature (Solenik et al 2009).

As expected of any natural silica sand, the Ajido, Araromi, Badagry, Epe, Gbelejo and Oworonsoki silica sand deposit in Lagos area would not be adequately bonded with clay and therefore need some binders to cast ferrous and non ferrous metals. For Alumino-silicate sand to be suitable for non-ferrous alloy casting, 2.5% bentonite clay, 1.0% kaolin clay with about 2% moisture content are requited (Ademoh, 2008).

A grain size distribution plot is a special purpose graph generally used to depict the results of a sieve analysis, commonly known as a "gradation test". The sieve analysis determines the gradation (the distribution of aggregate particles, by size, within a given sample) in order to determine compliance with design, production control requirements, and verification specifications.

A sieve analysis (or a gradation test) is a practice or procedure used to assess the particle size distribution of a granular material (Wikipedia).

Statement of the Problem

Moulding sand is the most common material in casting process because of its certain inherent properties e.g. refractoriness, chemical and thermal stability at higher temperature, high permeability, and workability along with good strength. Moreover it is also cheap and easily available. Foundry Industries in Lagos rely on supply of moulding sands from various beaches in Lagos. However, these moulding sands are of varying chemical compositions, grain sizes and active clay content. The ever increasing demand for higher degree of accuracy and good surface finish of castings necessitates certainty in the quality of foundry sands. Therefore the needs to examine the clay content and carry out sieve analysis become necessary.

Aims of the Study

The aim of this study is to control the moulding sand preparation to impart consistent sand properties to the sand being delivered to the moulding unit. This is to be achieved by collecting samples from major deposit in the following areas in Lagos: Ajido, Araromi, Badagry, Epe, Gbelejo, and Oworonsoki. Chemical composition, active clay content, grain size and grain size distribution tests are to be carried out on each sample and the results compared from which the best sample is chosen and recommendations are made on the best use by the foundry industries.

Significance of The Study

Close examination, clay content and sieve analysis of moulding sand ensure the following:

Lower cost of materials: These tests would allow the use of less expensive local sands. It also ensures reliable sand mixing and enables a fuller utilization of the inherent properties of moulding sands.

Less number of rejects: The tests would help to detect any variation from standard quality, and adjustment of the sand mixture to specific requirement can be made.

Improved surface finish: Such tests allow the choice of sand to give a desired surface finish.

Scope and Limitation of the Study

The scope of this study is limited to the determination of chemical composition, investigation and comparative analysis of active clay content and grain size distribution. However, it is important to know that isolated sand tests give insufficient information on the consistency of foundry sand, and it is necessary to determine a full range of tests including ignition figures and grading before sand can be confirmed as having suitable properties for the particular plant and size of casting. Further studies on this subject would involve determination of moisture content, permeability, green strength, shatter index etc.

Literature Review

Chemical composition of moulding sand

Silica is the main constituent but along with silica small amounts of iron oxide, alumina, limestone, magnesia, manganese oxide, soda and potash are present as impurities.
The chemical compositions of a moulding sand give an idea of the impurities like lime, magnesia, alkalis etc, present, and thereby of the refractoriness of the sand. The present of excessive amounts of iron oxide, alkalis oxides and lime can lower the fusion point to a considerable extent which is not desired (Sinha & Goel 1991).

Grain size of moulding sand

The grain size influences the properties of sands as follows:

Compactability: Finer the sand, the lower is the compactability and vice versa. This results from the fact that the specific surface increases as the grain size decreases. As a result, the number of points of contact per unit volume increases and this in turn raises the resistance to compacting.

Green strength: The green strength has a certain tendency, admittedly not very pronounced, towards a maximum with a grain size which corresponds approximately to the medium grain size. As the grains become finner, the film of bentonite becomes thinner, although the percentage of bentonite remains the same. Due to the thinning of bentonite film, the green strength is reduced. With very coarse grains, however, the number of grains and, therefore, the number of points of contact per unit of volume decreases so sharply that the green strength is again reduced.

Permeability: The sands with grains equal but coarse in size have greater void space and have therefore, greater permeability than the finer sands. This is more pronounced if the sand grains are equal in size (Sinha & Goel 1991).

Grain size distribution of moulding sand

The grain size distribution influences the properties of the sand as follows:

Compactability: Sand with wide range of particle size has higher compactability than sand with narrow distribution. The broadening of the size distribution may be done either to the fine or coarse side of the distribution or in both directions simultaneously and a sand of higher density will result. Broadening to the coarse side has a great effect on density than broadening the distribution to the fine side.
Green strength: A wide range distribution favours the green strength while narrow grain distributions reduce it.

Permeability: The grain size distribution has a pronounced effect on permeability. A sand containing many fines and a wide range of particle size (i.e. wide distribution) will have low permeability as compared to that containing grains of average fineness but of the same size (i.e. narrow distribution) (Sinha & Goel 1991).

Particle Size & Sand Sieve Analysis

□□□Particle Size Analysis: % Sand, % Silt, % Clay, and Textural Class

□□□Sand Sieve Analysis: Seven separations will be reported in percent according to the following table:

Table 1: Particle size and sieve analysis

SOIL SEPARATE	DIAMETER RANGE (MM)	US STANDARD SIEVE NO
GRAVEL	2.0 and larger	10
VERY COARSE SAND	2.0-1.0	18
COARSE SAND	1.0-0.5	35
MEDIUM SAND	0.5-0.25	60
FINE SAND	0.25-0.10	140
VERY FINE SAND	0.10-0.05	270
FINES	Less than 0.05	-

Source: Agricultural Analytical Services Laboratory. The Pennsylvania State University

Foundry sands usually fall into the range of 150-400μm, with 220-250μm being the most commonly used. Direct conversion between average grain size and AFS grain fineness number is not possible, bur an approximate relation is shown below:

Table 2: Relation between AFS grain fineness number and Average grain size

AFS grain fineness no	35	40	45	50	55	60	65	70	80	90
Average grain size (μm)	390	340	300	280	240	220	210	195	170	150

Source: Foseco Ferrous Foundryman's Handbook.

While average grain size and AFS grain fineness number are useful parameters. Choice of sand should be based on particle size distribution

Limitations of Sieve Analysis

Sieve analysis has, in general, been used for decades to monitor material quality based on particle size. For coarse material, sizes that range down to #100 mesh (150μm), a sieve analysis and particle size distribution is accurate and consistent.

However, for material that is finer than 100 mesh, dry sieving can be significantly less accurate. This is because the mechanical energy required to make particles pass through an opening and the surface attraction effects between the particles themselves and between particles and the screen increase as the particle size decreases. Wet sieve analysis can be utilized where the material analyzed is not affected by the liquid - except to disperse it. Suspending the particles in a suitable liquid transports fine material through the sieve much more efficiently than shaking the dry material (British Standard Institute, 1976).

Sieve analysis assumes that all particles will be round (spherical) or nearly so and will pass through the square openings when the particle diameter is less than the size of the square opening in the screen. For elongated and flat particles a sieve analysis will not yield reliable mass-based results, as the particle size reported will assume that the particles are spherical, where in fact an elongated particle might pass through the screen end-on, but would be prevented from doing so if it presented itself side-on. (Wikipedia, the free encyclopedia 2011).

Research Methodolgy

This study was experimental and involves determination of clay content and mechanical sieve analysis to determine the average grain size and grain size distribution of sand specimens.

Clay grade and sieve analysis are two separate tests, but as it is necessary to do a clay grade determination on sand before the sieve analysis is done, both are considered as sections of one test. It is important to know the clay grade, as this gives an indication of the binder content present. According to Sinha & Goel 1991, if a sieve analysis is carried out on the sand without removal of the clay, a false result will be obtained.

Grain size distribution gives an indication of suitability of moulding sand to withstand various mechanical properties like compactability, shatter index, green strength, permeability etc.

Materials And Methods

Sand samples were taken from six different supplies of silica sand in Nigerian Foundries Lagos where the tests were carried out. Other materials include Oven, Weighing scale, Variable-Speed test sieve shaker and water.

Table 3: Chemical composition of silica sand samples

CHEMICAL COMPOSITION	AJIDO %	ARAROMI %	BADAGRY %	EPE %	GBELEJO %	OWORONSOKI %
SiO_2	89.50	87.05	90.20	88.70	88.10	89.06
Al_2O_3	3.62	4.75	5.26	4.17	6.65	6.22
Fe_3O_2	2.04	2.64	0.68	1.21	0.91	0.67
TiO_2	0.19	0.10	0.17	0.08	0.12	0.11
CaO	0.63	0.52	0.58	0.73	0.68	0.61
MgO	0.28	0.46	0.32	0.31	0.62	0.82
Na_2O	0.17	0.36	0.27	0.31	0.52	0.33
K_2O	1.23	1.32	1.02	1.82	1.12	0.88
MnO	-	0.01	-	0.03	-	-
Loss on Ignition	1.13	1.34	1.11	0.83	0.77	1.03

Source: Research data, 2013

Determination of Clay Contents and Sieve Grading

200g of each sand sample was weighed out and dried completely at about 150^{0}C. It was allowed to cool and weighed. The clay content was washed away by adding water to the dried sample. The clay free sample was dried completely again and allowed to cool and weighed.
Sieve analysis is conducted by weighing out 100g of sand from the sand sample now free of clay. The clay-free sample is placed in the top sieve of variable-speed test sieve shaker for about 3 minutes. The sieves are removed from the shaker, and then separated, and the sand retained on each sieve weighed. The grain size and grain size distribution influence the properties of the sand such as shatter index, compactability, permeability and green strength while the clay content is used to determine the extent of binder required in moulding sand.

Results

Table 4 presents the results obtained from clay content determination of the six sand samples. While tables 5a, b, c, d, e, f present grain distribution and calculation of A.F.S grain fineness number from mechanical sieve analysis of the silica sand samples. The results from mechanical sieve analysis are further presented in tables 6a, b, c, d, e, and f to show the variation of mesh diameter with cumulative percent retained. The amount and type of clay have a great influence on the strength and other properties of moulding sand. The permeability decreases with increasing clay content. The green compressive strength first increases with the increase in clay content. But after a certain value, it is expected to start decreasing (Sinha & Goel 1991). The determination of grain fineness number provides a rapid method for expressing the average grain size and is of value in comparing various grades of sands from a given deposit having similar grain distribution. It enables the control of system or heap sand in foundry. The limitation of this number is that this number is in no way an index of the distribution of the sand grains. Sands having the same grain fineness number need not be of the same grade.

Hence, a more reliable method for assessing the suitability of a sand sample from the view point of size distribution is to plot % values (by weight of sand retained in sieves of different mesh sizes as cumulative grading curves. The nature of the cumulative grading curve is independent of the type of standard sieves used.

The results from table 5a-f are presented in graphical plots as shown in figure 1a-g while figure 2a-g represents the results in table 6a-f.

For control purposes it is essential that test results are recorded graphically on a chart to indicate whether sand properties are being kept within the prescribed limit, but more important, whether there are any tendencies towards poor conditions in the sand.

Grain size distribution plot is a special purpose graph generally used to depict the results of a sieve analysis, commonly known as a "gradation test". The sieve analysis determines the gradation (the distribution of aggregate particles, by size, within a given sample) in order to determine compliance with design, production control requirements, and verification specifications.

Table 4: Clay Content of samples

SAMPLE	SAMPLE WEIGHT DRY (g)	SAMPLE WEIGHT WASHED (g)	CLAY CONTENTS (g)	CLAY CONTENT (%)
Ajido	188.6	188.0	0.6	0.30
Araromi	182.4	181.0	1.4	0.76
Badagry	189.0	187.3	1.7	0.85
Epe	189.2	188.1	1.1	0.55
Gbelejo	181.6	180.4	1.2	0.60
Oworonsoki	188.6	187.0	1.6	0.84

Source: Research data, 2013

Table 5a: A.F.S Grain fineness number of Ajido Silica Sand

Mesh Diameter in mm	Amount retained on sieve in g	Amount retained on sieve in %	Multiplier	Product
1.400	0.00	0.00	6	0.00
1.000	0.00	0.00	9	0.00
0.710	0.30	0.30	15	4.50
0.500	0.80	0.80	25	20.00
0.355	1.50	1.50	35	52.00
0.250	7.70	7.70	45	346.50
0.180	37.00	37.00	60	2220.00
0.125	49.60	39.60	81	3207.60
0.090	10.60	10.60	118	1250.80
0.063	1.60	1.60	164	262.40
Sieve Pan	0.30	0.30	275	82.50
Total		99.40		7446.80

Source: Research data, 2013

A.F.S grain fineness number = $\frac{744.68}{99.40}$ = 74.92

Table 5b: A.F.S Grain fineness number of Araromi Silica Sand

Mesh Diameter in mm	Amount retained on sieve in g	Amount retained on sieve in %	Multiplier	Product
1.400	0.00	0.00	6	0.00
1.000	0.10	0.10	9	0.90
0.710	0.60	0.60	15	9.00
0.500	2.80	2.80	25	70.00
0.355	3.30	3.30	35	115.50
0.250	8.40	8.40	45	1378.00
0.180	27.60	27.60	60	1656.00
0.125	37.80	37.80	81	3061.80
0.090	12.60	12.60	118	1486.80
0.063	2.10	2.10	164	344.40
Sieve Pan	0.70	0.70	275	195.50
Total		96.00		7317.10

Source: Research data, 2013

A.F.S grain fineness number = $\frac{7317.10}{96.00}$ = 76.22

Table 5c: A.F.S Grain fineness number of Badagry silica sand

Mesh Diameter in mm	Amount retained on sieve in g	Amount retained on sieve in %	Multiplier	Product
1.400	0.00	0.00	6	0.00
1.000	0.00	0.00	9	0.00
0.710	0.30	0.30	15	4.50
0.500	1.10	1.10	25	27.50
0.355	2.30	2.30	35	80.50
0.250	20.00	20.00	45	900.00
0.180	36.60	36.60	60	2196.00
0.125	29.60	29.60	81	2397.60
0.090	7.90	7.90	118	932.20
0.063	1.10	1.10	164	164.00
Sieve Pan	0.40	0.40	275	110.0
Total		99.20		6812.10

Source: Research data, 2013

A.F.S grain fineness number = $\frac{6812.10}{99.2}$ = 68.67

Table 5d: A.F.S Grain fineness number of Epe silica sand

Mesh Diameter in mm	Amount retained on sieve in g	Amount retained on sieve in %	Multiplier	Product
1.400	0.00	0.00	6	0.00
1.000	0.00	0.00	9	0.00
0.710	0.00	0.00	15	0.00
0.500	0.40	0.40	25	10.00
0.355	0.90	0.90	35	31.50
0.250	6.90	6.90	45	310.50
0.180	31.40	31.40	60	1884.00
0.125	37.40	37.40	81	3029.40
0.090	16.80	16.80	118	1982.40
0.063	2.40	2.40	164	393.60
Sieve Pan	0.60	0.60	275	165.00
Total		96.80		7806.40

Source: Research data, 2013

A.F.S grain fineness number = $\frac{7806.40}{96.8}$ = 80.64

Table 5e: A.F.S Grain fineness number of Gbelejo Silica Sand

Mesh Diameter in mm	Amount retained on sieve in g	Amount retained on sieve in %	Multiplier	Product
1.400	5.00	5.00	6	48.00
1.000	9.50	9.50	9	85.50
0.710	12.20	12.20	15	183.00
0.500	18.50	18.50	25	462.50

0.355	19.70	19.70	35	689.50
0.250	22.40	22.40	45	1008.00
0.180	7.50	7.50	60	450.00
0.125	1.80	1.80	81	145.80
0.090	0.20	0.20	118	23.60
0.063	0.00	0.00	164	0.00
Sieve Pan	0.00	0.00	275	0.00
Total		96.80		3095.90

Source: Research data, 2013

A.F.S grain fineness number = $\frac{3095.90}{96.8}$ = 31.98

Table 5f: A.F.S Grain fineness table of Oworonsoki silica sand

Mesh Diameter in mm	Amount retained on sieve in g	Amount retained on sieve in %	Multiplier	Product
1.400	0.00	0.00	6	0.00
1.000	0.00	0.00	9	0.00
0.710	0.00	0.00	15	0.00
0.500	0.50	0.50	25	12.50
0.355	0.90	0.90	35	31.50
0.250	5.80	5.80	45	261.00
0.180	28.80	28.80	60	1296.00
0.125	36.10	36.10	81	2166.00
0.090	21.60	21.60	118	1749.60
0.063	1.80	1.80	164	212.40
Sieve Pan	0.60	0.60	275	165.00
Total		96.1		5994.00

Source: Research data, 2013

A.F.S grain fineness number = $\frac{5994.00}{96.1}$ = 62.37

Table 6a: Cumulative grading table of Ajido Silica Sand

Mesh Diameter in mm	Amount retained on sieve in g	Amount retained on sieve in %	Cumulative % retained
1.400	0.00	0.00	0.00
1.000	0.00	0.00	0.00
0.710	0.30	0.30	0.30
0.500	0.80	0.80	1.10
0.355	1.50	1.50	2.60
0.250	7.70	7.70	10.30
0.180	37.00	37.00	47.30
0.125	39.60	39.60	86.90
0.090	10.60	10.60	97.50
0.063	1.60	1.60	99.10
Sieve Pan	0.30	0.30	99.40
Total		99.40	

Source: Research data, 2013

Table 6b: Cumulative grading table of Araromi Silica Sand

Mesh Diameter in mm	Amount retained on sieve in g	Amount retained on sieve in %	Cumulative % retained
1.400	0.00	0.00	0.00
1.000	0.10	0.10	0.10
0.710	0.60	0.60	0.70
0.500	2.80	2.80	3.50
0.355	3.30	3.30	6.80
0.250	8.40	8.40	15.2
0.180	27.60	27.60	42.8
0.125	37.80	37.80	80.60
0.090	12.60	12.60	93.20
0.063	2.10	2.10	95.30
Sieve Pan	0.70	0.70	96.00
Total		96.00	

Source: Research data, 2013

Table 6c: Cumulative grading table of Badagry silica sand

Mesh Diameter in mm	Amount retained on sieve in g	Amount retained on sieve in %	Cumulative % retained
1.400	0.00	0.00	0.00
1.000	0.00	0.00	0.00
0.710	0.30	0.30	0.30
0.500	1.10	1.10	1.40
0.355	2.30	2.30	3.70
0.250	20.00	20.00	23.70
0.180	36.60	36.60	60.30
0.125	29.60	29.60	89.90
0.090	7.90	7.90	97.80
0.063	1.10	1.00	98.80
Sieve Pan	0.40	0.40	99.20
Total		99.20	

Source: Research data, 2013

Table 6d: Cumulative grading table of Epe silica sand

Mesh Diameter in mm	Amount retained on sieve in g	Amount retained on sieve in %	Cumulative % retained
1.400	0.00	0.00	0.00
1.000	0.00	0.00	0.00
0.710	0.00	0.00	0.00
0.500	0.40	0.40	0.40
0.355	0.90	0.90	1.30
0.250	6.90	6.90	8.20
0.180	31.40	31.40	39.60
0.125	37.40	37.40	77.00
0.090	16.80	16.80	93.80
0.063	2.40	2.40	96.20

Sieve Pan	0.60	0.60	96.80
Total		96.80	

Source: Research data, 2013

Table 6e: Cumulative grading table of Gbelejo Silica Sand

Mesh Diameter in mm	Amount retained on sieve in g	Amount retained on sieve in %	Cumulative % retained
1.400	5.00	5.00	5.00
1.000	9.50	9.50	14.50
0.710	12.20	12.20	26.70
0.500	18.50	18.50	45.20
0.355	19.70	19.70	64.90
0.250	22.40	22.40	87.30
0.180	7.50	7.50	94.80
0.125	1.80	1.80	96.60
0.090	0.20	0.20	96.80
0.063	0.00	0.00	96.80
Sieve Pan	0.00	0.00	96.80
Total		96.80	

Table 6f: Cumulative grading table of Oworonsoki silica sand

Mesh Diameter in mm	Amount retained on sieve in g	Amount retained on sieve in %	Cumulative % retained
1.400	0.00	0.00	0.00
1.000	0.00	0.00	0.00
0.710	0.00	0.00	0.00
0.500	0.50	0.50	0.50
0.355	0.90	0.90	1.40
0.250	5.80	5.80	7.20
0.180	28.80	28.80	36.00
0.125	36.10	36.10	72.10
0.090	21.60	21.60	93.70
0.063	1.80	1.80	95.50
Sieve Pan	0.60	0.60	96.10
Total		96.10	

Source: Research data, 2013

Discussion

Clay Content: Badagry and Araromi silica sands have the highest clay content of 0.85% and 0.84% respectively while Epe silica sand has the lowest of 0.3%. Since the higher the clay content the lower the binder content required and vice-versa. It can be deduced that Badagry and Araromi silica sands would require minimum amount of binders while Epe silica sand requires the highest amount of binders. However, Badagry and Araromo silica sand with high clay content will have low permeability and high compressive strength

Table 6: Clay content classification

SILICA SAND TYPE	COMPACTABILITY	GREEN STRENGTH	PERMEABILITY
AJIDO	Low	High	Average
ARAROMI	Low	High	Average
BADAGRY	Low	High	High
EPE	Very Low	Very High	Low
GBELEJO	Very High	Moderately Low	Very High
OWORONSOKI	Average	Average	High

Source: Research data, 2013

Sieve Analysis: Using results obtained of the A.F.S Grain fineness number for all samples and when compared with table 1 for particle size and sieve analysis and table 2 for. relation between A.F.S grain fineness number and average grain size as suggested by Foseco Ferrous Foundryman's Handbook 2000. Then tables 7 and 8 show the expectation in terms of the grain size and grain size distribution effects on compactability, permeability and strength of all the six samples.

Ajido, Araromi and Badagry silica sands have wide range of grain size distribution broadening to fine side, narrow to the coarse side and high percentage of fine sand giving sand which could have low compactibility, high green strength and average permeability. But Badagry silica sand has a high percentage of medium fine sand which may result in higher permeability.

Epe and Oworonsoki silica sand both have very narrow range of grain size distribution to the coarse side and wide range broadening to fine side. Both sands show tendency of low compactability but due to a remarkable difference in grain size with Oworonsoki silica sand having lower percentage of fine sands than Epe silica sand, it is expected that Oworonsoki silica sand has an average green strength and high permeability while Epe silica sand will have a high green strength and low permeability.

Gbelejo silica sand shows a clearly different grain distribution and grain size from other silica sands. The sand has a wide size distribution to the coarse side and fairly narrow size distribution to the fine side. The highest percent grain size is medium thus giving sand with high compactability, average green strength and very high permeability. The values of A.F.S grain fineness number for all samples also confirm these assertions.

Table 7: A.F.S Grain fineness number versus Average grain size, Compactability, Strength and permeability.

	AJIDO	ARAROMI	BADAGRY	EPE	GBELEJO	OWORONSOKI
AFS GRAIN FINESS NUMBER	74.92	76.22	68.67	80.64	31.98	62.37
GRAIN SIZE RANGE (μm)	195-170	195-170	210-150	170-150	>395	220-210
AVERAGE GRAIN SIZE REMARK	Fine	Fine	Moderately fine	Very fine	Very coarse	Average
COMPACTABILITY	Low	Low	Moderately	Very	Very high	Average

			low	low		
GREEN STRENGTH	High	High	Moderately high	Very high	Very low	Average
PERMEABILITY	Average	Average	High	Low	Very high	High

Source: Research data, 2013

The higher the average AFS grain fineness number the lower the grain size and vice-versa.

Table 8: Summary of Grain size distribution

SILICA SAND TYPE	COMPACTABILITY	GREEN STRENGTH	PERMEABILITY
AJIDO	Low	High	Average
ARAROMI	Low	High	Average
BADAGRY	Low	High	High
EPE	Very Low	Very High	Low
GBELEJO	Very High	Moderately Low	Very High
OWORONSOKI	Average	Average	High

Source: Research data, 2013

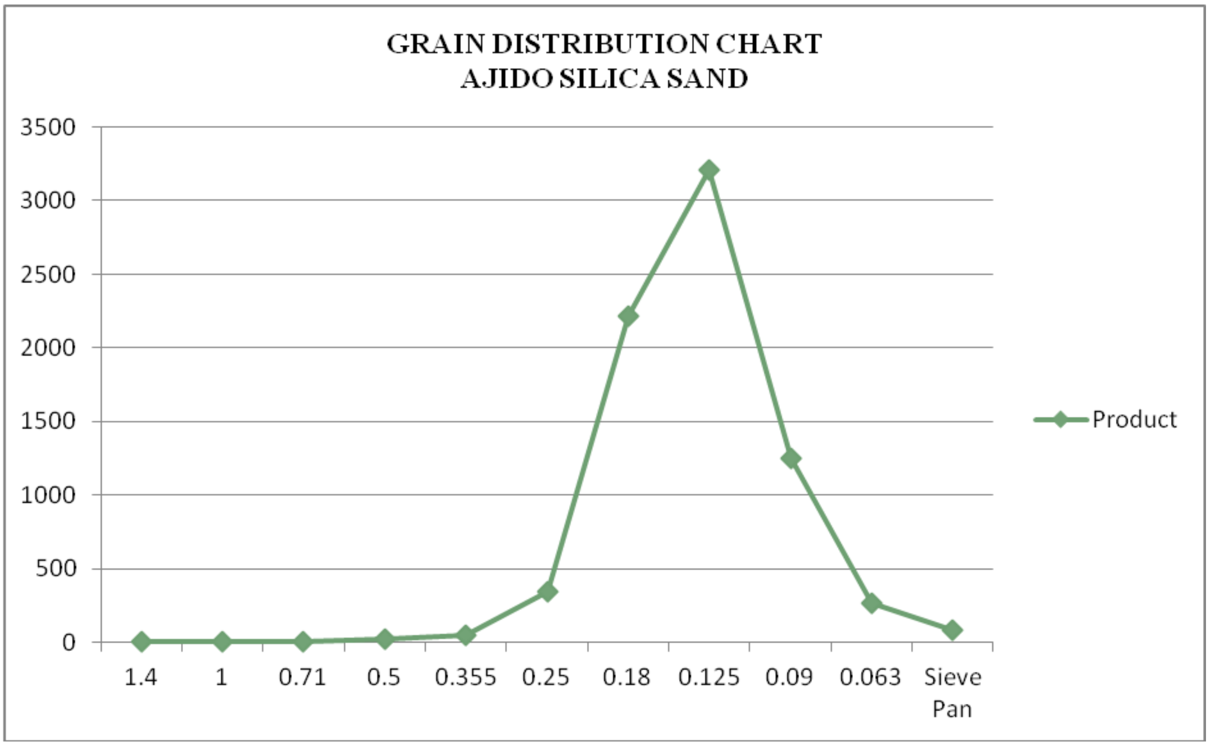

Figure 1a: Variation of mesh diameter in mm with product (i.e. Percent retained x multiplier) for Ajido silica sand

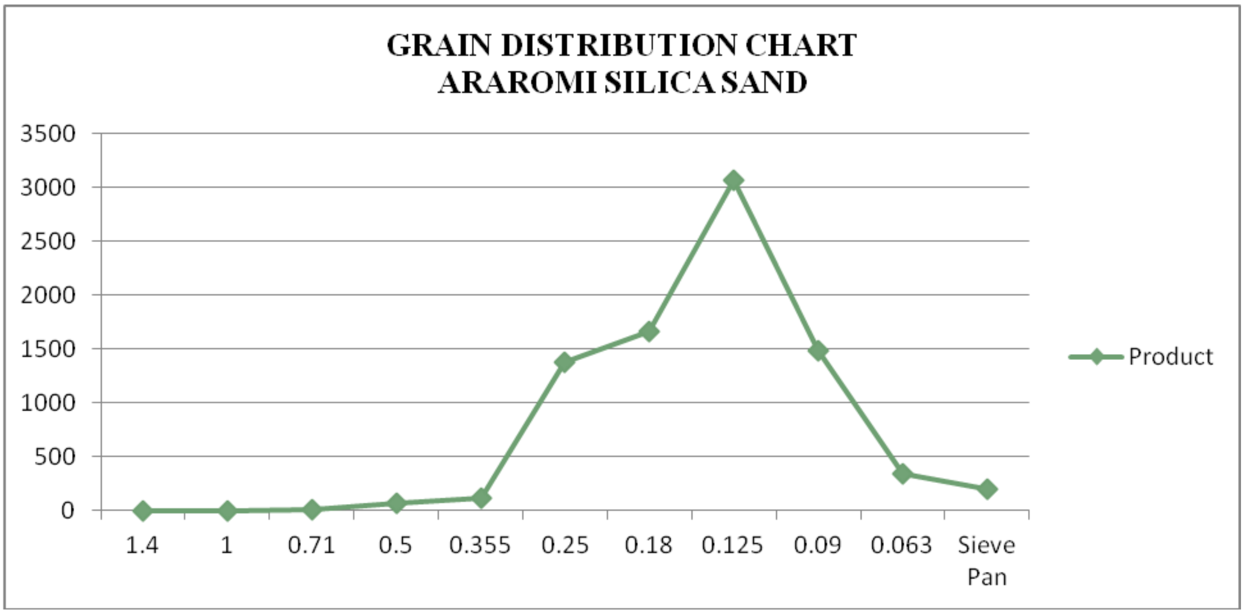

Figure 1b: Variation of mesh diameter in mm with product (i.e. Percent retained x multiplier) for Araromi silica sand

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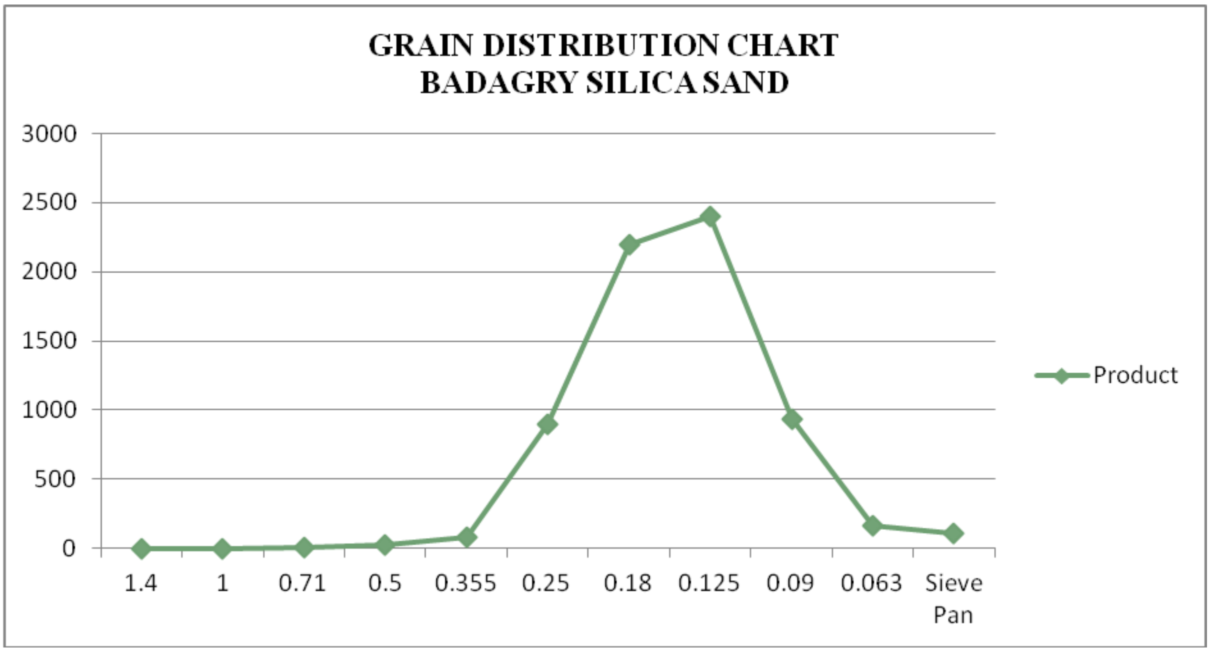

Figure 1c: Variation of mesh diameter in mm with product (i.e. Percent retained x multiplier) for Badagry silica sand

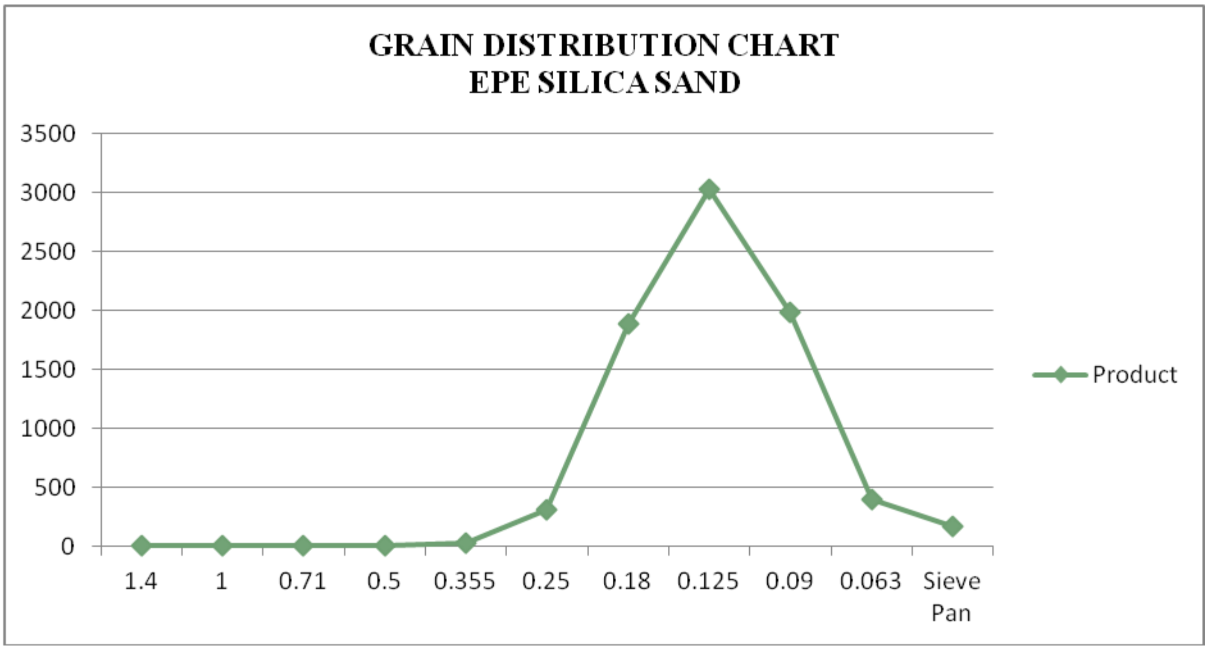

Figure 1d: Variation of mesh diameter in mm with product (i.e. Percent retained x multiplier) for Epe silica sand

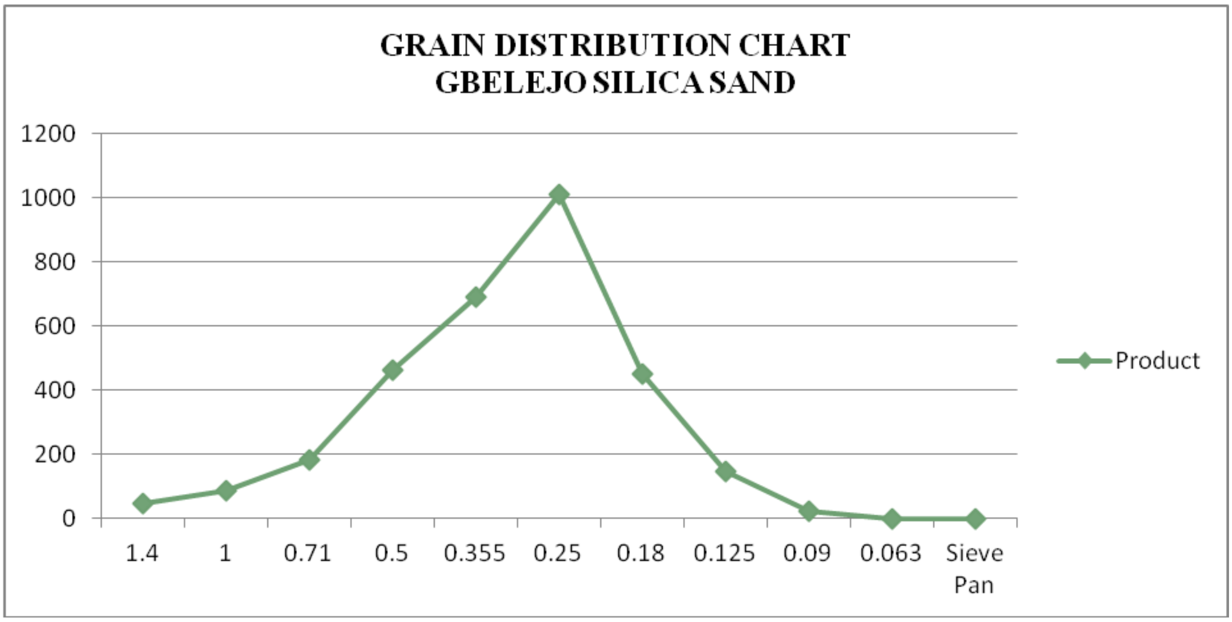

Figure 1e: Variation of mesh diameter in mm with product (i.e. Percent retained x multiplier) for Gbelejo silica sand

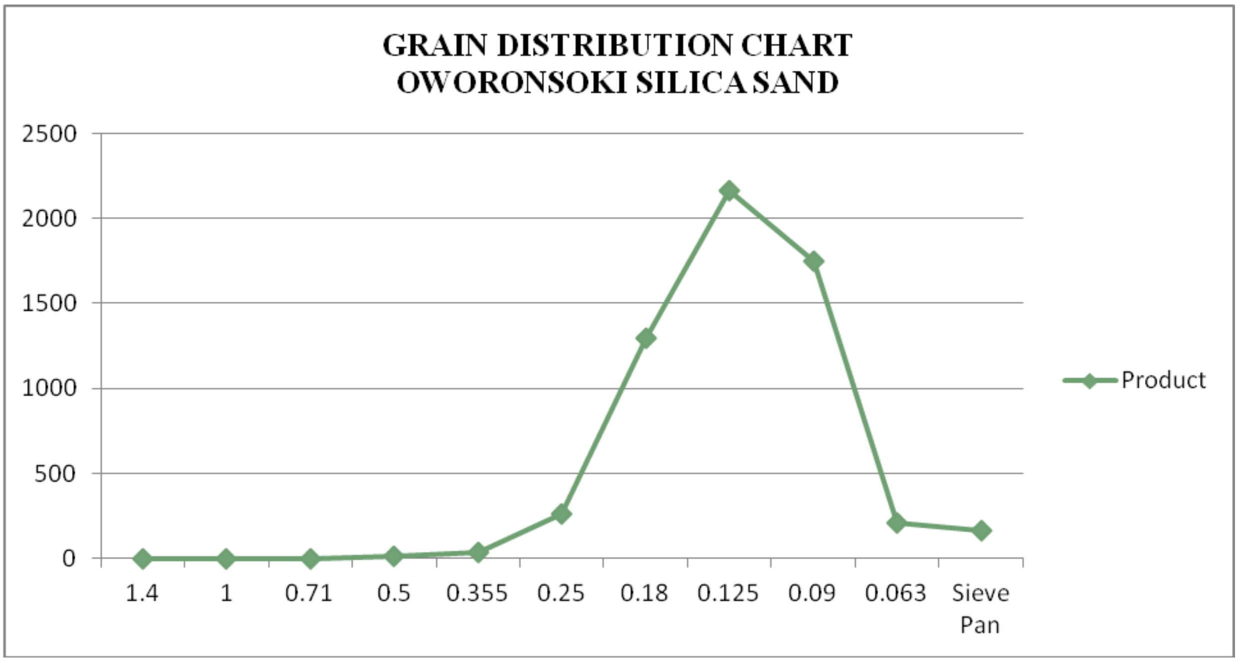

Figure 1f: Variation of mesh diameter in mm with product (i.e. Percent retained x multiplier) for Oworonsoki silica sand.

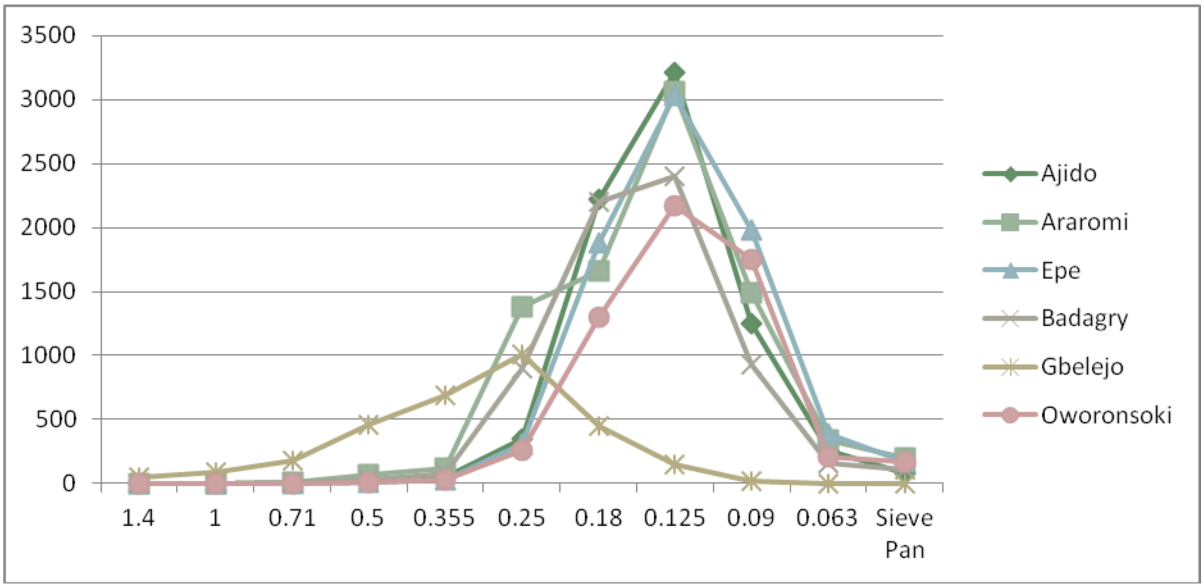

Figure 1g: Variation of mesh diameter in mm with product (i.e. Percent retained x multiplier) for all silica sand samples

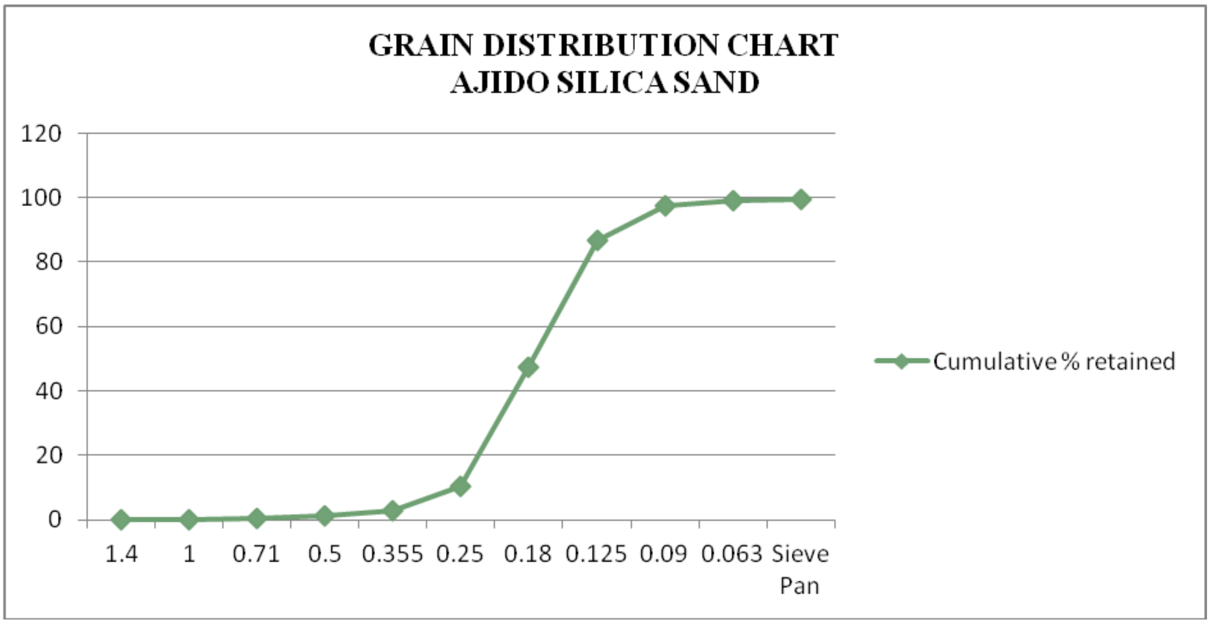

Figure 2a: Variation of mesh diameter in mm with cumulative % retained for Ajido silica sand

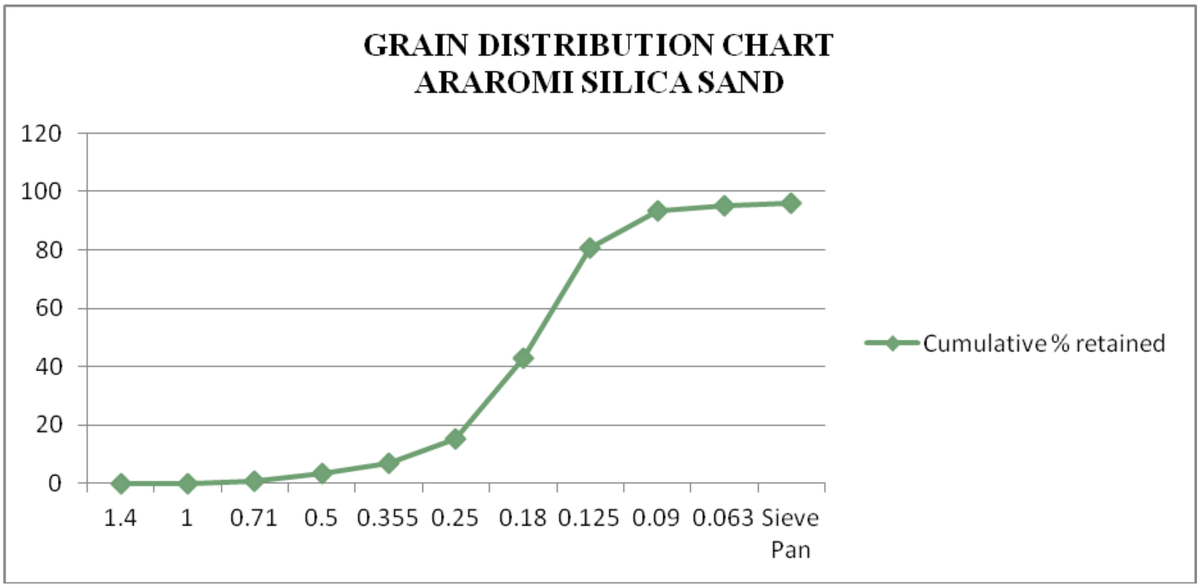

Figure 2b: Variation of mesh diameter in mm with cumulative % retained for Araromi silica sand

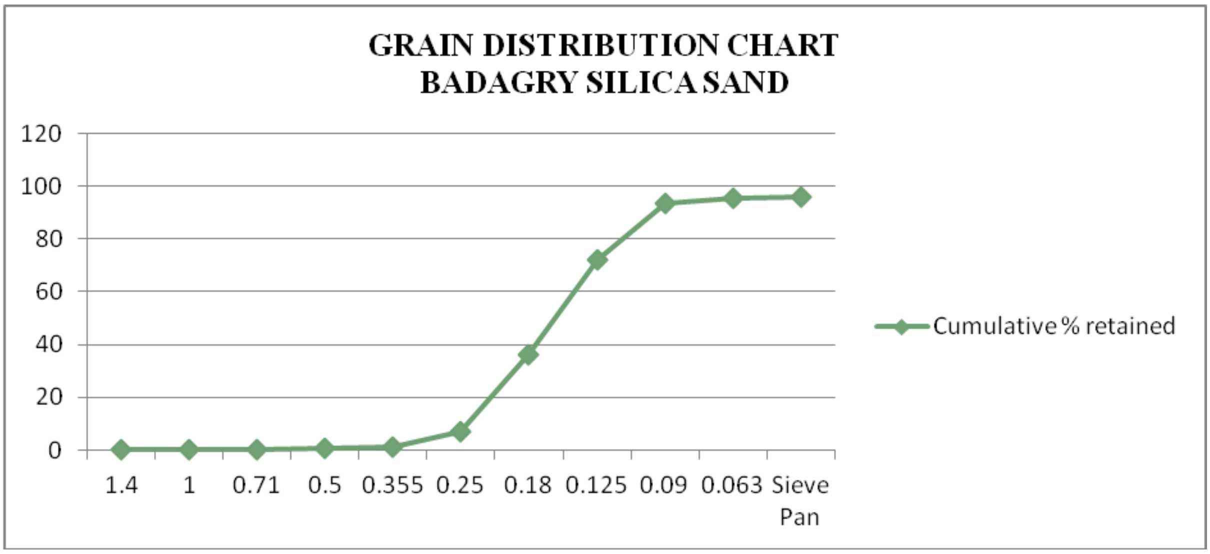

Figure 2c: Variation of mesh diameter in mm with cumulative % retained for Badagry silica sand

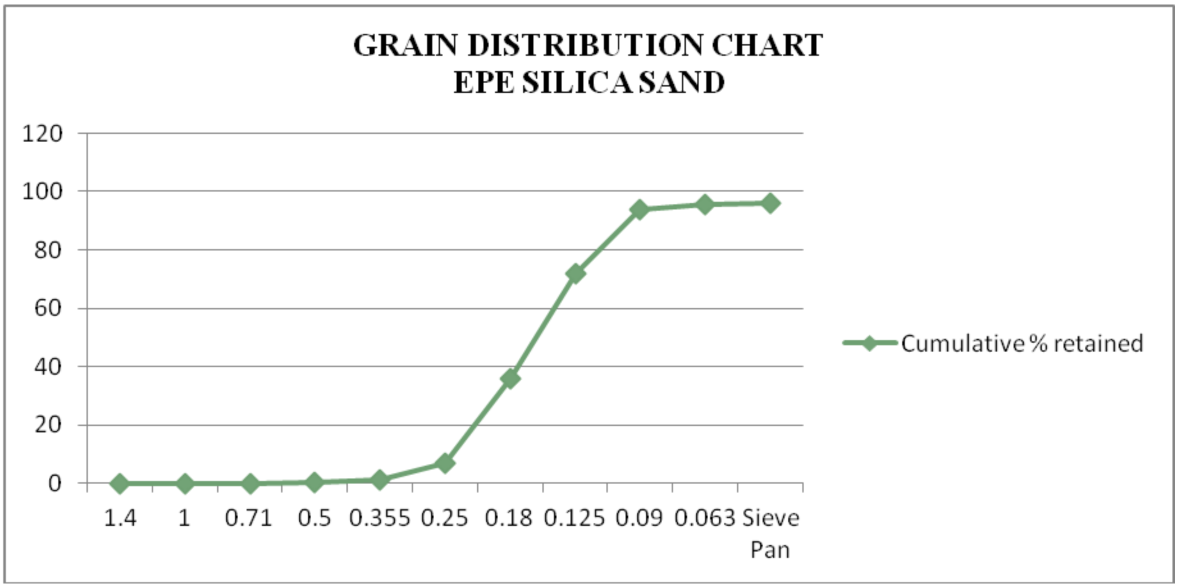

Figure 2d: Variation of mesh diameter in mm with cumulative % retained for Epe silica sand

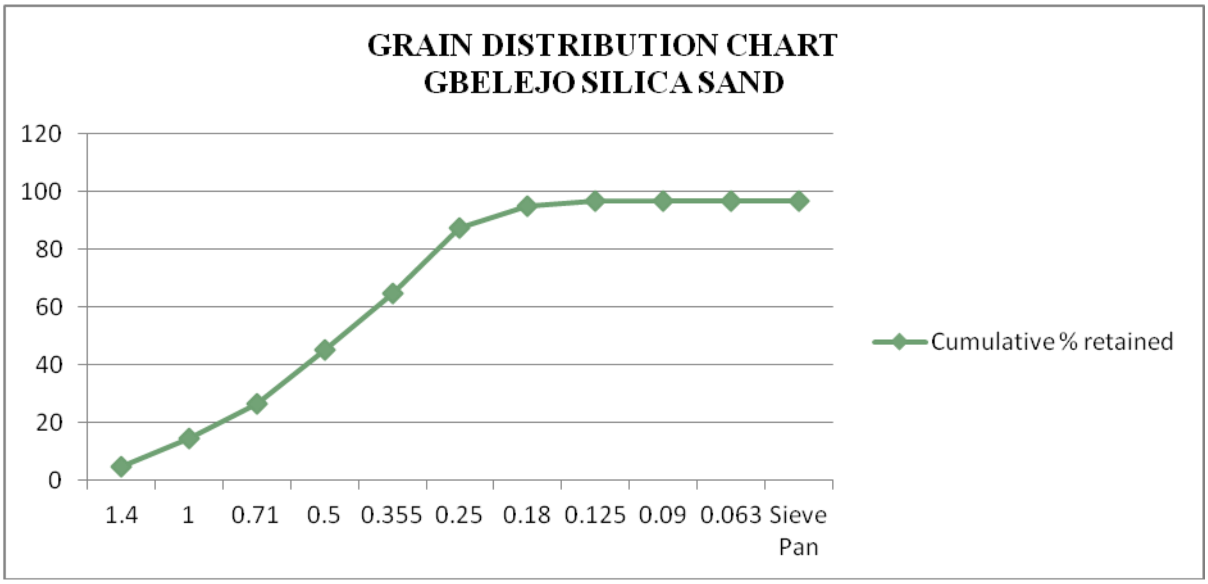

Figure 2e: Variation of mesh diameter in mm with cumulative % retained for Gbelejo silica sand

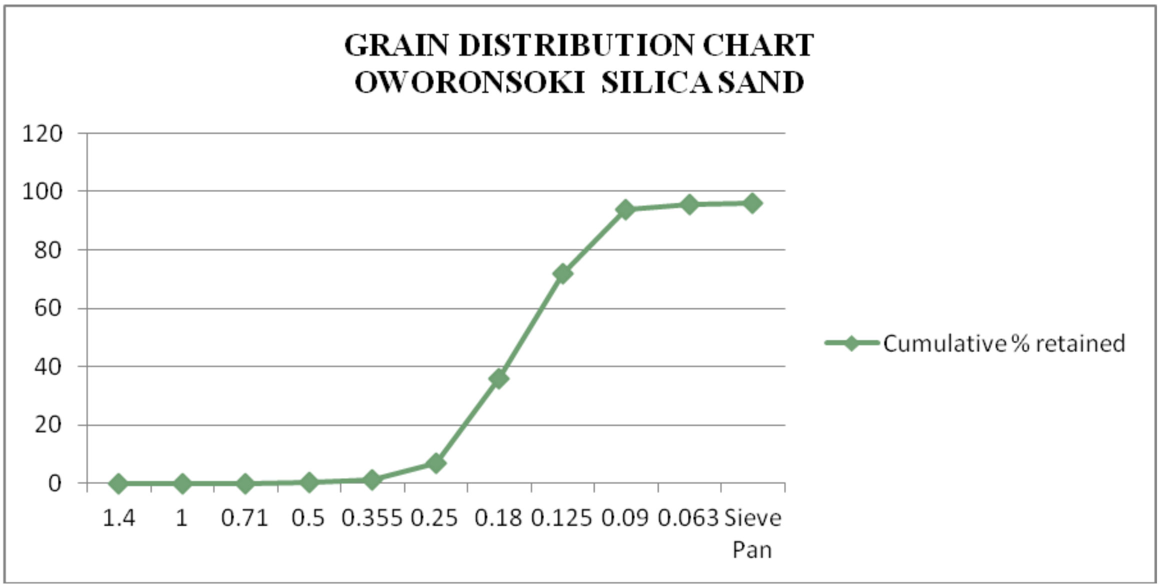

Figure 2f: Variation of mesh diameter in mm with cumulative % retained for Oworonsoki silica sand

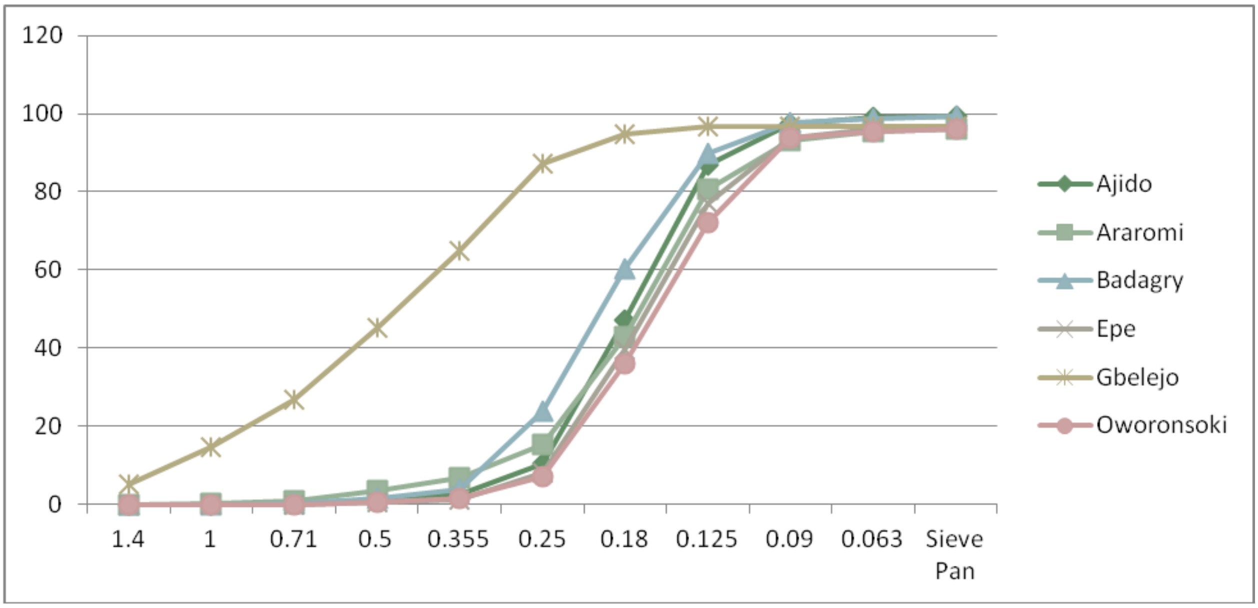

Figure 2g: Variation of mesh diameter in mm with cumulative % retained for all silica sand samples silica sand.

Conclusion

The study revealed that Gbelejo silica sand has the best compactability, green strength and permeability properties. The amount of active clay content of 0.6% and grain size distribution pattern makes its use suitable for both ferrous and non ferrous metals. Ajido, Araromi, Badagry, Epe and Oworonsoki silica sands all have compactablity, green strength and permeability properties which make their use suitable for casting non ferrous and ferrous metals, but with careful selection of binders, moisture content and size of casting if a sound casting is to be obtained.

However, this conclusion will be compared to results obtained in our further studies on determination of other properties like shatter index, permeability, moisture content, green strength and compactability on the same silica sand samples.

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