

## PAPER 136 – CHARACTERIZATION OF PIT SAND OBTAINED FROM SELECTED LOCATIONS IN THE SOUTH WESTERN ZONE OF NIGERIA

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### **ABSTRACT**

Sand is about the commonest fine aggregate available in South Western Nigeria. Of the various types of natural sand, pit sand is the most readily available and most widely used. However, not all available Pit – sand is fit for concreting works. This study focusses on the characterization of Pit sand obtained from selected locations across the South Western zone of the Country. From the values obtained the conformity with relevant standards and the suitability for concreting works was determined. Samples of Pit – sand were collected from three different locations from each of the five states in the zone. Sieve analysis test were carried out on all the samples and the values of fineness modulus (FM), coefficient of uniformity (Cu) and coefficient of curvature (Cc) were determined. Other properties considered are specific gravity (SG), water absorption (WA), and percentage silt content (SC). These values were compared with values stipulated in British standards and other relevant literatures. The range of the values of FM, Cu and Cc SG, WA, and SC are 4.16 – 4.68, 2.63 – 10, and 0.53 – 2.56 2.67 – 2.86, 0.67 – 2.04 and 5.4 – 18.18 respectively. Conclusively, while some of the samples are suitable, some are not.

**KEYWORDS:** Characterization, Pit – Sand, Selected, Locations

### **1. INTRODUCTION**

Building construction is a major component of the sustainable cities and communities which is one of the seventeen goals of Envision 2030 sustainable development goals. However, the incessant report of building collapse constitutes an impediment to the achievement of this goal if not addressed. Alsadey and Omran (2021) opined that various studies have been carried out that shows that the use of poor-quality material is one of the major factors responsible for the collapse of buildings. Concrete is the most widely used building materials. It consists of water, cement, fine and coarse aggregate. Its failure in service is one of the major factors responsible for building collapse. This is as a result of the use of poor quality constituent materials for its production. Hannah et. al. (2014) stated that the physical and strength properties of concrete are highly dependent on the quality of constituent materials used in its production. Savitha, 2012 affirms that it is necessary to confirm the quality of building materials before their use so as to build strong, durable and cost-effective structures.

Sand is about the commonest fine aggregate available in South – western Nigeria. Orchard, et. al. (1979) described sand as a natural fine aggregate that is used in production of concrete. Of the various types of natural sand, pit sand is the most readily available and most widely used in this part of the country. However, not all available Pit – sand is fit for concreting works. According to Omopariola and Jimoh (2023), the durability and structural performance of concrete is greatly influenced by the properties of sand that is one of its major constituent materials. It should be noted that sand constitutes between 27 to 30 percent of the constituent materials of concrete by volume. Hence it was advocated that good quality sand of known properties should be used in the production for concrete production. Olanitori (2006) opined that the use of sand with high proportion of clay and silt content results in the production of concrete with low compressive strength. Hence it was therefore recommended that relevant tests should be carried out to check the effect of impurities in building sands on performance of concrete.

This study therefore focusses on the characterization of pit sand obtained from selected locations across the South – Western zone of the Country so as to assess its conformity with relevant standard. Laboratory tests were carried out on the various properties of sand that can influence the properties, durability and structural performance of concrete. This will assist in determining its suitability for concreting works.

### **2. THEORETICAL ANALYSIS**

The mathematical principles used in the determination of the various properties of the samples collected from all the locations are stated below.

#### **2.1. Fineness Modulus**

The fineness modulus was obtained by divide the cumulative percentage passing the recommended sieve sizes by 100.

### 2.2. Coefficient of uniformity and Coefficient of Curvature

These were determined by obtaining the values of D10, D30 and D60 from the sieve analysis curve and applying equations (1) and (2) respectively.

$$Cu = \frac{D60}{D30} \quad (1)$$

$$Cc = \frac{(D30)^2}{(D60)(D10)} \quad (2)$$

### 2.3. Specific gravity

The specific gravity of the samples was determined using Equation (3)

$$Gs = \frac{M2 - M1}{(M4 - M1) - (M3 - M2)} \quad (3)$$

Where: M1 is the weight of pycnometer, M2 is the weight of pycnometer and oven dried sample of sand, M3 is the weight of pycnometer, sand and water and M4 is the weight of pycnometer and water

### 2.4. Water Absorption

Water Absorption value was obtained using Equation (4)

$$A(\%) = \frac{W_{sat} - W_{dry}}{W_{sat} - W_{wet}} * 100 \quad (4)$$

Where: A – Water absorption (%), W<sub>sat</sub> - weigh of the saturated sample, W<sub>dry</sub>- weigh of the dry sample and W<sub>wat</sub>- weigh of the saturated sample immersed in water.

### 2.5. Moisture Content

The value of moisture content for all the samples was determine from Equation (5)

$$M = \frac{M1}{M2} * 100 \quad (5)$$

Where: M is the moisture content (%), M1 is the weight of water from the samples the weight of water from the sample and M2 is the weight of oven dried sample.

### 2.6 Percentage silt content

[Percentage silt content was carried out according to \[4\] and the result was obtained from the expression](#)

$$V = \frac{V1}{V2} * 100 \quad (6)$$

Where: V is the percentage Silt content, V1 is the volume of the silt layer and V2 is the sand level below the silt

## 3. MATERIALS AND METHODS

Samples of pit sand were collected from three locations in each of the five states of the South Western States. The states are Ekiti, Ogun, Ondo, Osun ad Oyo States. The locations and their GPS are presented in Table 1

Table 1: Locations, Location codes and GPS of Locations of collection of Sand

STATE	LOCATION CODE	LOCATION	GPS
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EKITI	FA 01	Ayedun	7.86°N, 5.52°E
	FA 02	Efon	7.66°N, 4.92°E
	FA 03	Ijan	7.61°N, 5.50°E
OGUN	FA 01	Abeokuta	7.16°N, 3.34°E
	FA 02	Ishara	6.98°N, 3.68°E
	FA 03	Ogbere	6.96°N, 3.20°E
ONDO	FA 01	Akure	7.25°N, 5.21°E
	FA 02	Ondo	7.10°N, 4.84°E
	FA 03	Owo	7.20°N, 5.59°E
OSUN	FA 01	Ede	7.73°N, 4.43°E
	FA 02	Ikire	7.37°N, 4.19°E
	FA 03	Ipetu	7.82°N, 4.74°E
OYO	FA 01	Ibadan	7.40°N, 3.92°E
	FA 02	Igboora	7.43°N, 3.29°E
	FA 03	Iseyin	7.97°N, 3.60°E

### 3.1. Sieve Analysis of Fine Aggregate

Samples of sand obtained from all the locations were oven dried to constant weight at about  $110 \pm 5^\circ\text{C}$  in accordance with BS EN 933 – 1: 1997. The oven dried samples were then placed a set of standard 8-inch sieve were arranged in descending order of sizes from top down and the lid of the sieve was closed. The set of sieves and then placed in a mechanical shaker which was made to run for about 10 minutes. Separate weighing of materials retained on any one screen was done for each of the sieve sizes and recorded. Cumulative weight retained each of the sieves were converted into percentages of the total weight. Finally, the cumulative percentage of samples passing each sieve size was obtained and the result was plotted in the sieve analysis graph.

### 3.2. Specific Gravity and Water Absorption of Fine Aggregate

The test was carried out in accordance with BS EN 1097 – 6: 2000. 500g of the sample was placed in a pycnometer was partially filled with water. The pycnometer was then filled to approximately 90% of capacity and placed in a vacuum flask to eliminate air bubbles. The pycnometer was then filled with water to full capacity. The total weight of water introduced into the glass graduate was determined and the sample was then removed from the pycnometer and dried in the oven to a constant weight at  $110 \pm 5^\circ\text{C}$ . It was allowed to cool in air at room temperature for 1-2 hours and then weighed to the nearest 0.1g. The weight of the pycnometer filled to its calibration capacity with water was determined and the specific gravity and absorption was then calculated using equation and 3 and 4 respectively.

### 3.4 Moisture Content

The container was first dried and weighed to the nearest 0.1g and the weight was recorded as M1. The samples then scooped into the container and the weight of the container with the sample were obtained to the nearest 0.1g and recorded as M2. The container and the samples were placed in an oven and dried to constant weight at a temperature of  $105 \pm 5^\circ\text{C}$  for a period of 24 hours as stipulated in BS 812:109 1990. The container and the oven dried sample were then removed from the oven and allowed to cool for about 1 hour. The container and the oven dried sample were weighed again to the nearest 0.1 and the weight was recorded as M3. The moisture content of the samples were the calculated using equation

### 4.4 Percentage Silt Content

1% solution of salt was prepared and poured into the 250ml measuring cylinder up to the 50ml as stipulated in B.S. 1881 – 1:1975. This was followed by the addition of the sample of sand to the solution up to the 100ml line of the cylinder in the first instance and then increased to the 150ml line. The cylinder was shaken thoroughly and left to settle for 3 hours. Measurement of the silt layer was obtained and recorded as V1, while the sand level below the silt was recorded as V2.

## 4 RESULTS AND DISCUSSION

From the sieve analysis carried out on all the samples, the following discoveries were made:

1. The percentage passing the 4.75mm sieve for the samples from all the three locations (Ayedun, Efon and Ijan) in Ekiti State falls below the stipulated lower limit of 89% (see Table 2). Furthermore, the percentage passing the 2.36mm sieve for Efon and Ijan also falls below the lower limit of 60%. However, the percentage

passing the other sieve sizes are within the lower and upper limits and falls into class C as stated in Table 4 of BS 882:1992 (see Table 2).

2. In the case of samples from Ogun State, only the sample from Abeokuta falls short of the grading limit of 60% in sieve size of 2.36. Samples from the two other locations Ishara and Ogbere are within the stipulated lower and upper limits in all the sieve sizes. Additionally, they satisfy the grading limits for class C.
3. Samples from all the three locations in Ondo State (Akure, Ondo and Owo) had lower percentage passing the 4.75mm sieve, additionally, samples from Akure and Ondo also had lower percentages in 2.36mm sieve.
4. Result of the sieve analysis of samples from Osun State indicates that the percentage passing the 4.75 and 2.36mm sieve sizes are lower than 89% stated in BS 882:1990. However, they all conform to the overall grading limits in the rest of the sieve sizes.
5. The sample from Ibadan in Oyo State has a lower value of percentage passing the 4.75mm sieve size. It however conforms to the required specification and falls within the limit of class C in the rest of the sieve sizes. Samples from the remaining 2 locations are within the overall limits in all the sieve sizes. Additionally, they both are within the limits of class C in all the sieve sizes.

From all of the above, it can be inferred that the lower values of percentage passing any of the sieve sizes implies that they are coarser materials. This does not prevent their use in concreting works. Moreover, the footnote of Table 4 BS 882:1990 states that where sands do not comply with values in the Table, an agreed grading envelope may also be used provided that the supplier can satisfy the purchaser that such materials can produce concrete of the required quality.

Table 2: Grading Limits for Fine Aggregates

Sieve Size	Percentage by mass passing BS sieves			
	Overall Limits	Additional Limits for grading		
		C	M	F
10.00mm	100	—	—	—
5.0mm	89 to 100	—	—	—
2.36mm	60 to 100	60 to 100	65 to 100	80 to 100
1.18mm	30 to 100	30 to 90	45 to 100	70 to 100
600 µm	15 to 100	15 to 54	25 to 80	55 to 100
300 µm	5 to 70	5 to 40	5 to 48	5 to 70
150 µm	0 to 15	—	—	—

NOTE Individual sands may comply with the requirements of more than one grading. Alternatively, some sands may satisfy the overall limits but may not fall within any one of the additional limits C, M or F. In this case and where sands do not comply with Table 4 an agreed grading envelope may also be used provided that the supplier can satisfy the purchaser that such materials can produce concrete of the required quality. an Increased to 20 % for crushed rock fines, except when they are used for heavy duty floors.

Source Table 4 BS 882:1992

Table 3: Table of values of Sieve Analysis of Samples of Sand from Ekiti State

Sieve Sizes	Lower limit	EKS01	EKS02	EKS03	Upper Limit
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9.5	100	100	100	100	100
4.75	89	82	84	84	100
2.36	60	66	42	54	100
1.18	30	63	38	52	100
0.6	15	20	17	16	100
0.3	5	19	16	14	70
0.15	1	7	6	5	15

Table 4: Table of values of Sieve Analysis of Samples of Sand from Ogun State

Sieve Sizes	Lower limit	OGS01	OGS02	OGS03	Upper Limit
9.5	100	100	100	100	100
4.75	89	91	90	97	100
2.36	60	54	69	96	100
1.18	30	51	49	87	100
0.6	15	17	20	51	100
0.3	5	16	18	46	70
0.15	1	5	6	3	15

Table 5: Table of values of Sieve Analysis of Samples of Sand from Ondo State

Sieve Sizes	Lower limit	ODS01	ODS02	ODS03	Upper Limit
9.5	100	100	100	100	100
4.75	89	60	87	88	100
2.36	60	50	51	73	100
1.18	30	48	49	33	100
0.6	15	33	21	18	100
0.3	5	31	20	12	70
0.15	1	8	6	1	15

Table 6: Table of values of Sieve Analysis of Samples of Sand from Osun State

Sieve Sizes	Lower limit	OSS01	OSS02	OSS3	Upper Limit
9.5	100	100	100	100	100
4.75	89	66	82	75	100
2.36	60	54	53	49	100
1.18	30	51	52	46	100
0.6	15	17	17	22	100
0.3	5	15	16	7	70
0.15	1	8	5	1	15

Table 7: Table of values of Sieve Analysis of Samples of Sand from Oyo State

Sieve Sizes	Lower limit	OYS01	OYS02	OYS3	Upper Limit
9.5	100	100	100	100	100
4.75	89	85	93	90	100
2.36	60	79	88	65	100
1.18	30	77	85	60	100
0.6	15	22	22	36	100
0.3	5	21	21	17	70
0.15	1	6	8	14	15

#### 4.2. Fineness Modulus

The fineness modulus is a representative of the mean size of particles of sand. The range of values according to Anupolu (2016) is 2.2 – 3.2. From 2.2 to 2.6 is classified as fine sand, 2.6 – 2.9 as medium and 2.9 – 3.2 as coarse sand. From the results presented in Table 8, it follows that only the sample from Ogbere in Ogun State is slightly lower than the code's requirement. All others are okay and can be classified as coarse sand.

#### 4.3. Coefficient of Uniformity and Coefficient of Curvature

According to Nenu (2019), the Coefficient of Uniformity (Cu) and Coefficient of Curvature (Cc) are parameters used to determine the grading characteristics of sand. Cu values between 4 and 6 are classified as well graded, while less than 4 are regarded as uniformly graded or poorly graded. Higher values are indications of materials with different size ranges. From the result presented in Table 8, samples from Owo in Ondo State, Ipetu in Osun State, Ibadan and Igboora in Oyo State are poorly graded while all others are well graded. It was also stated that Cc values of 1 – 3 implies a well graded sand. From the results in Table 8, samples from Akure in Ondo state, Ibadan, Igboora and Iseyin all in Oyo State have Cc values of less than 1, hence they can be classified as poorly graded. However all other samples have their values within the range of 1 and 3 and can thus be classified as well graded.

Table 8: Table of Value of Fineness Modulus, Coefficient of Uniformity and Coefficient of Curvature of Pit Sand from all locations.

PROPERTIES	FINENESS MODULUS			COEFFICIENT OF UNIFORMITY			COEFFICIENT OF CURVATURE		
	FA01	FA02	FA03	FA01	FA02	FA03	FA01	FA02	FA03
LOCATION	FA01	FA02	FA03	FA01	FA02	FA03	FA01	FA02	FA03
EKITI	4.19	4.46	4.37	5	5	5.6	1.8	1.25	1.21
OGUN	4.23	3.23	2.16	6.5	5.5	4.67	2.16	2.56	1.52
ONDO	4.53	4.28	3.34	10	4.83	2.63	0.32	1.13	2.38
OSUN	4.68	4.4	4.11	5	4.67	3.33	0.8	0.86	0.53
OYO	3.98	3.72	3.77	3.6	3.6	6.67	1.6	1.6	1.67

#### 4.4 Specific Gravity

The values of the specific gravity of the samples from all the locations as indicated in Table 9 are between 2.67 and 2.86. This is within the range of values specified in BS 882:1990 and some other literatures. This implies that the specific gravity of all the samples are okay and fit for use as concreting materials. The value of specific gravity of aggregates is of paramount importance and very useful in concrete mix design (Bahabri, 2016). It is also an indication of the strength as well as the quality of the material.

#### 4.5 Water Absorption

The water absorption values of all the samples presented in Table 9 are from 0.67 – 2.04 %. The specification in BS 8007 is 3%, while BS 6349 specifies maximum of 2% in case of critical conditions. It implies that the values of water absorption for all the samples are ok even for critical conditions.

#### 4.6 Moisture Content

The recommended value of moisture content of fine aggregate according to ASTM C 128 – 15 is 0.2 – 2% with proviso that sand can contribute up to 6% free moisture. The range of values of moisture content for all the samples in the study are between 0.45 and 5%. This implies that the moisture content of all the samples are okay for concreting. It should be noted that the need for the determination of moisture content in sand is so as to make provision for the quantity of water required to maintain the water cement ratio.

#### 4.7 Percentage Silt Content

The presence of high percentage of silt in sand results in the reduction of concrete strength. The maximum amount of silt require in sand for concreting work is 8%. Results from the study shows that only the samples from Ijan in Ekiti State, Obere in Ogun State and Ibadan in Oyo state meet this conditions. Samples from all other locations possess higher values.

TABLE 9: Table of Values of Specific Gravity, Water Absorption, Moisture Content and Percentage Silt Content of Pit Sand from all the locations.

PROPERTIES	SPECIFIC GRAVITY			WATER ABSORPTION			MOISTURE CONTENT			PERCENTAGE SILT CONNTENT		
	FA01	FA02	FA03	FA01	FA02	FA03	FA01	FA02	FA03	FA01	FA02	FA03
EKITI	2.81	2.78	2.84	0.67	1.01	1.01	1.12	5	1.06	11.11	8.89	5.35
OGUN	2.67	2.86	2.71	0.67	1.26	0.98	5	0.75	2.5	8.89	18.18	5.4
ONDO	2.86	2.83	2.81	2.04	1.35	2.04	1.32	1.12	1.35	11.32	9.62	10.91
OSUN	2.75	2.69	2.72	1.35	0.67	1.69	1.44	1.12	0.3	10.42	10	12
OYO	2.85	2.73	2.77	0.67	1.01	1.01	3.17	0.45	1.44	8	16	8.33

#### 5. CONCLUSION

In conclusion, the result of the sieve analysis from which grading parameters such as the coefficient of uniformity and coefficient of curvature indicates that samples from some locations are poorly graded. Sands from such locations by combining samples from different locations at appropriate proportions to obtain desired gradation. The values of specific gravity, water absorption and moisture content for all the samples indicate that all of them are suitable for concrete production. However, the major set – back to the use of these samples is the presence of high percentage of silt.

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