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Particle Size Analysis of Soil Obtainable in Maiduguri, Nigeria

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Abstracts: Soil is a substantial resource and displays adaptable physical, chemical, mineralogical, hydrological and geochemical properties. Particle size is a fundamental analysis procedure for soils, and pedological and paleopedological analysis. In view of this particle size distribution of soil samples were conducted and analysed for 10 locations in Maiduguri, Nigeria by sieving technique. Their sand, silt, and clay contents were determined. The distribution of particle size influences the moisture retention and transmission properties of soils. The overall result showed that the soil in Maiduguri is predominantly sand having low moisture retention and high permeability. This study at higher precision will be helpful for the textural management concerns all operations, practices and treatments used to protect soil and enhance its performance.

Keywords: Particle size, Soil samples, Moisture retention, Textural management

1.0 Introduction

Particle size is a fundamental analysis procedure for soils, and pedological and paleopedological analysis (Konen et al., 2003; Lindbo et al., 2008). Particle size distribution is one of the most important soil characteristics, which influences many soil properties (Ryzak and Bieganowski, 2011). Its distributions also provide fundamental information for rock characterization and geological process description in earth sciences, including sedimentology, stratigraphy, structural geology, pedology, and volcanology (Storti and Balsamo, 2010). The need for classification of soil particles according to their sizes granularity divided into intervals that are called grain size category. There are several classification systems based on differently defined thresholds granularity intervals. The basic division of fine soil particles and the skeleton (particles less than 2 mm) is the same in most systems (Skalová, 2003). The clay (0-2 µm), silt (2-50µm) and sand (50-2000 µm), are three texture fraction which are commonly used to characterize the soil particle distribution of fine soil (< 2 mm) by classifying it into a soil texture class according to a soil texture triangle (Vandecasteele, and De Vos, 2001).

Soil texture is one of the important properties of soil maps and is defined as relative proportions of clay, sand and silt contents. Soil texture has an extremely significant influence on the physical and mechanical behaviours of the soil and on all the properties related to water content and the movement of water (Marc and Jacques, 2011). Soil texture directly affects the porosity of soil, which in turn, determines its water-retention, flow characteristics, rate of water intake, nutrient-holding capacity and long-term soil fertility (Zhengyong et al, 2008). It also determines the soil erodibility and thus, affects the risk of soil erosion. The interaction of soil clay with nutrient ions, water and organic substances determines the soil fertility, which in turn largely controlled by the quality and nature of minerals (Thompson and Troen, 1973). Land use capability and soil management practices are also determined by the texture.

The most fundamental method of soil characterization is the measurement of particle size distribution (PSD). The PSD of a coarse-grained soil is usually found by sieving. Hence the objective of this study was to determine the PSD of the soil samples by sieving technique, also, to find out whether the sieving method is suitable for use on soils collected from Maiduguri and its environs in the North Eastern part of Nigeria.

2.0 Materials and Methods

Soil samples were collected from 10 locations in Maiduguri, Borno State, Nigeria lying on the geographical coordinates of 11° 51' N, 13° 9' E. The locations are namely; Bolori Ward, Shehuri North, Limanti Ward Gwange Ward, Gamburu Ward, Bulabulin Ward, Polo Ground, National Stadium and

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Teachers Village. From each sampling site, moist soil samples of about 500 g were collected at 0.5 m depth and bulked to form a composite air-dried, gently crushed to break the clods and passed through a 2-mm sieve to separate the fine-earth materials from coarse fragments with the aid of sieve shaker machine. The sieves were removed from the sieve machine and the contents retained, passed and percentages passed (mass) by each sieve were weighed and recorded using electronic balance. The process was repeated for the remaining samples of the remaining locations at different depths-1.0 m, 1.5 m and 2.0 m. A wet sieving method was used for Polo Ground, National Stadium and Teachers Village because of their high clay and silt contents.

3.0 Results and Discussion

3.1 Particle Size Analysis of Soil

Tables 1 – 10, are the sieve analysis test results for the locations where the samples were collected. The Tables show weight retained (g), commulative weight retained (g), percentage weight retained and percentage of the weight that passed from each sieve number. For the sake of completeness, Particle size distribution characteristics of these locations are presented in Figures 1 – 10.

The distribution of particle size influences the moisture retention and transmission properties of soils. From the result obtained, the soil at 7 locations are sand with the highest passentage content value of 99.28% obtained in Bulabulin ward followed by 99.06% obtained in Ramat Polytechnic area while the least passentage content value of 95.74% is obtained in Bolori ward. The soils have low moisture retention and high permeability. The soil at the National Stadium and Teachers Village have the silt and clay passentage content value of 41.66% and 41.92 % of respectively. Hence the soil is classified as loam. The soils in this area have high moisture retention and low permeability. The soil at Polo Ground is clay soil since it has 75.74% content value of clay and silt. This may be due to inadequate drainage. The clay fraction contains larger alumino –silicates and has higher content of humus. Therefore, the properties of soils are affected by clay content rather than silt and sand particle. The clay content is also characterized by a higher charge density per unit surface. The overall result showed that the soil in Maiduguri is predominantly sand.

The process of particle size analysis of soil textural characteristic helped for continuous textural information generation at precise level. The superimposing of soil samples over soil types clearly visualized the relationship between soil types and texture.

Table 1: Particle Size Analysis of the soils from Ramat Polytechnic

S/N0	*Sieve size (mm)*	*Weight Retained (g)*	*Cumulative Weight Retained(g)*	*%Weight Retained(g)*	*% Weight Passing*
1	4.750	7.2	7.2	1.44	98.56
2	3.750	8.3	15.5	1.66	96.90
3	2.360	21.0	36.5	4.20	92.70
4	1.180	38.2	74.7	7.64	85.06
5	0.600	70.3	145.0	14.04	71.02
6	0.425	56.0	201.0	11.20	59.82
7	0.300	40.6	241.6	8.12	51.70
8	0.150	230.0	471.6	46.0	5.70
9	0.075	23.7	495.3	4.74	0.96
	Pan	4.1	499.4	0.82	0.14
	Total	*499.4*			

Weight of dry sample before sieving = 500g
Percentage of sand content = 99.06%
Percentage of clay and silt content = 0.94%
The soil is sand soil.

Table 2: Particle Size Analysis of the soils from Bolori

S/N0	*Sieve size (mm)*	*Weight Retained (g*	*Cumulative Weigh Retained (g)*	*% Weight Retaine*	*% Weight Passing*
1	4.750	0.0	0.0	0.0	100
2	3.750	0.6	0.6	0.12	99.88
3	2.360	1.4	2.0	0.28	99.60
4	1.180	32.0	34.0	6.40	93.2
5	0.600	114.5	148.5	22.90	70.3
6	0.425	77.1	225.6	15.42	54.88
7	0.300	58.1	283.7	11.62	43.26
8	0.150	150.8	434.5	30.16	13.10
9	0.075	44.2	478.7	8.84	4.26
10	Pan	20.6	499.3	4.12	0.34
	Total	*499.3*			

Weight of dry sample before sieving = 500g
Percentage of sand = 95.74%
Percentage of silt and clay = 4.26
The soil is sand soil.

Table 3: Particle Size Analysis of the soils from Limanti Ward

S/N0	*Sieve size (mm)*	*Weight Retained (g*	*Cumulative Weight Retained (g)*	*% Weight Retained*	*% Weight passing*
1	4.750	2.4	2.4	0.48	99.52
2	3.750	2.5	4.9	0.50	99.02
3	2.360	5.3	10.2	1.06	97.96
4	1.180	32.8	43.0	6.40	91.56
5	0.600	123.2	116.2	24.64	66.92
6	0.425	92.0	258.2	18.40	48.52
7	0.300	68.4	326.6	13.68	34.84
8	0.150	126.4	453.0	24.48	10.36
9	0.075	36.4	489.4	7.28	3.08
10	Pan	10.5	499.9	2.10	0.98
	Total	*499.9*			

Weight of dry sample before sieving = 500g
Percentage of sand = 97.88%
Percentage of silt and clay = 2.12%
The soil is sand soil.

Table 4: Particle Size Analysis of the soils from Gamboru

S/N0	*Sieve size (mm)*	*Weight Retained (g)*	*Cummulative Weight Retained (g)*	*% Weight Retained*	*% Weight Passing*
1	4.750	9.1	9.1	1.82	98.18
2	3.750	10.2	19.3	2.04	96.14
3	2.360	27.9	47.2	5.58	90.56
4	1.180	87.5	134.7	17.50	73.06
5	0.600	127.6	262.3	25.52	47.81
6	0.425	79.7	342.0	15.94	31.87
7	0.300	54.9	396.9	10.98	20.89
8	0.150	95.3	492.2	19.06	1.83
9	0.075	3.2	495.4	0.64	1.19
10	Pan	1.8	497.2	0.36	0.83
	Total	*497.2*			

Weight of dry sample before sieving = 500g
Percentage of sand = 99.08%
Percentage of silt and clay = 0.92%
The soil is sand soil.

Table 5: Particle Size Analysis of the soils from Shehuri North

S/N0	*Sieve size (mm)*	*Material retained (g)*	*Cumulative Weight Retained (g)*	*% Weight Retaine*	*% Weight Passing*
1	4.750	7.8	7.8	1.56	98.44
2	3.750	8.1	15.9	1.62	96.82
3	2.360	22.1	38.0	4.42	92.4
4	1.180	69.6	107.6	13.92	78.48
5	0.600	104.3	211.9	20.86	57.62
6	0.425	73.0	284.9	14.60	43.02
7	0.300	59.9	344.8	11.90	31.12
8	0.150	123.6	468.4	24.72	6.40
9	0.075	25.0	493.4	5.00	1.40
10	Pan	6.1	499.5	1.22	0.18
	Total	*499.5*			

Weight of dry sample before sieving = 500g
Percentage of sand = 98.68%
Percentage of silt and clay = 1.32%
The soil is sand soil.

Table 6: Particle Size Analysis of the soils from Gwange

S/N0	*Sieve size (mm)*	*Weight Retained (g*	*Cumulative Weight Retaine (g)*	*% Weight Retained*	*% Wight Passing*
1	4.750	12.4	12.4	2.48	97.52
2	3.750	18.0	30.4	3.60	93.92
3	2.360	45.8	76.2	9.16	84.76
4	1.180	118.9	195.1	23.78	60.98
5	0.600	118.4	313.5	23.68	37.3
6	0.425	57.1	370.6	11.42	25.88
7	0.300	37.4	408.0	7.48	18.4
8	0.150	74.7	482.7	14.94	3.46
9	0.075	13.6	496.3	2.72	0.74
10	Pan	3.2	499.5	0.64	0.10
	Total	*499.5*			

Weight of dry sample before sieving = 500g
Percentage of sand = 99.26%
Percentage of silt and clay = 0.74%
The soil is sand soil.

Table 7: Particle Size Analysis of the soils from Bulabulin

S/N0	*Sieve size (mm)*	*Weight Retained (g*	*Cumulative Weight Retaine (g)*	*% Weight Retained*	*% Weight passing*
1	4.750	12.9	12.9	2.58	97.75
2	3.750	16.4	29.3	3.28	94.47
3	2.360	34.1	63.4	6.82	87.65
4	1.180	113.1	176.5	22.62	65.03
5	0.600	145.9	322.4	29.18	35.85
6	0.425	59.2	381.6	11.84	24.01
7	0.300	35.9	417.5	7.18	16.83
8	0.150	67.1	484.6	13.42	3.41
9	0.075	11.8	496.4	2,36	1.05
10	Pan	3.0	499.4	0.6	0.45
	Total	*499.4*			

Weight of dry sample before sieving = 500g
Percentage of sand = 99.28%
Percentage of silt and clay = 0.72%
The soil is sand soil.

Table 8: Particle Size Analysis of the soils from Polo Ground

S/N0	*Sieve size (mm)*	*Weight Retained (g*	*Cumulative Weight Retaine (g)*	*% Weight Retained*	*% Weight passin*
1	4.750	22.00	22.00	4.40	95.60
2	3.750	13.00	35.00	2.60	93.00
3	2.360	15.02	50.02	3.00	90.00
4	1.180	9.00	59.02	1.80	88.2
5	0.600	8.40	67.42	1.68	86.52
6	0.425	21.60	89.02	4.32	82.20
7	0.300	6.20	95.22	1.24	80.96
8	0.150	18.00	113.22	3.60	77.36
9	0.075	8.1	121.32	1.62	75.74
10	Pan	0.00			
	Total	*121.32*			

Weight of dry sample before sieving = 500g
Percentage of sand = 24.26%
Percentage of clay and silt content = 75.74%
The soil is clay soil.

Table 9: Particle Size Analysis of the soils from National Stadium

S/N0	*Sieve size (mm)*	*Weight Retained (g*	*Cumulative Weight Retaine (g)*	*% Weight Retained*	*% Weight Passin*
1	4.750	23.80	23.80	4.76	95.24
2	3.750	27.90	51.7	5.58	89.66
3	2.360	33.60	85.3	6.72	82.94
4	1.180	41.20	126.5	8.24	74.7
5	0.600	32.80	159.3	6.56	68.14
6	0.425	40.50	199.8	8.10	60.04
7	0.300	31.60	231.4	6.32	53.72
8	0.150	33.70	265.1	6.74	46.98
9	0.075	26.6	291.7	5.32	41.66
10	Pan	00.00			
	Total	*291.7*			

Weight of dry sample before sieving = 500g
Percentage of sand content = 58.34%
Percentage of clay and silt = 41.66%
The soil is loam soil.

Table10: Particle Size Analysis of the soils from Teachers Village

S/N0	*Sieve size (mm)*	*Weight Retained (g*	*Cumulative Weight Retained (g)*	*% Weight Retainec*	*%Weight passing*
1	4.750	25.4	25.4	5.08	94.92
2	3.750	30.2	55.6	6.04	88.88
3	2.360	35.2	90.8	7.00	81.88
4	1.180	40.9	131.7	8.18	73.70
5	0.600	30.4	162.1	6.08	67.62
6	0.425	38.5	2000.6	7.70	59.92
7	0.300	31.5	232.1	6.30	53.62
8	0.150	35.0	267.1	7.00	46.62
9	0.075	23.5	290.6	4.70	4192
10	Pan	00.00			
	Total	*290.6*			

Weight of dry sample before sieving = 500g
Percentage of sand content = 58.08%
Percentage of silt and clay = 41.92. %
The soil is loam soil.

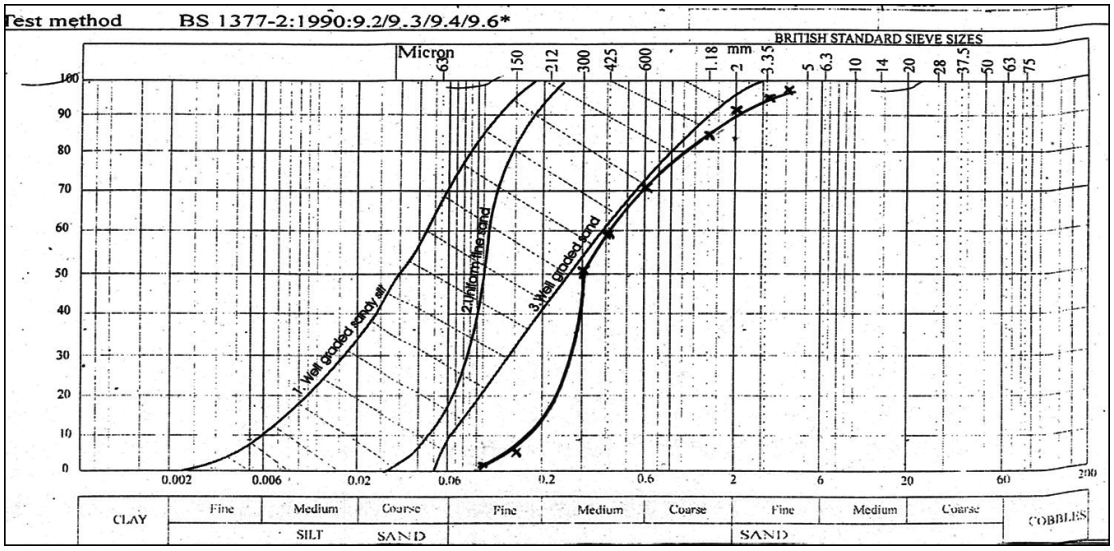

Fig. 1: Particle size distribution characteristics of various soils used in Ramat Polytechnic.

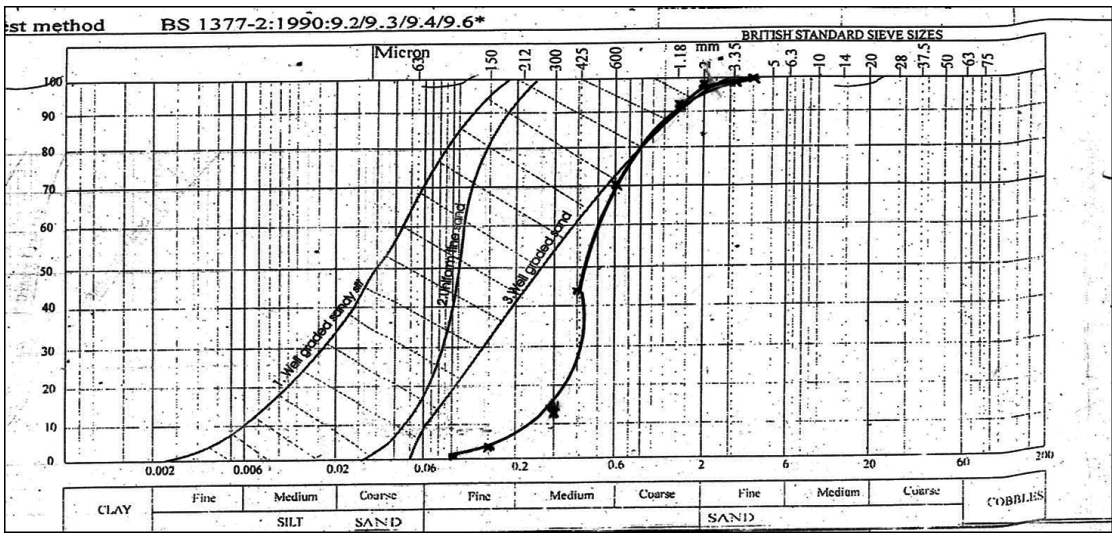

Fig. 2: Particle size distribution characteristics of various soils used in Bolori ward.

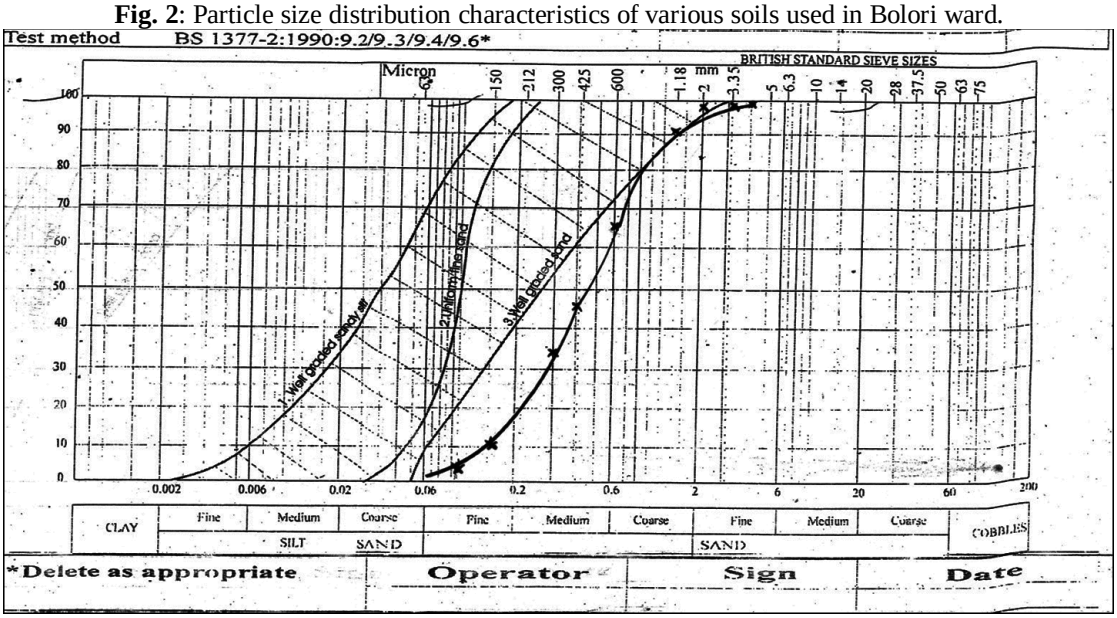

Fig. 3: Particle size distribution characteristics of various soils used in Limanti ward.

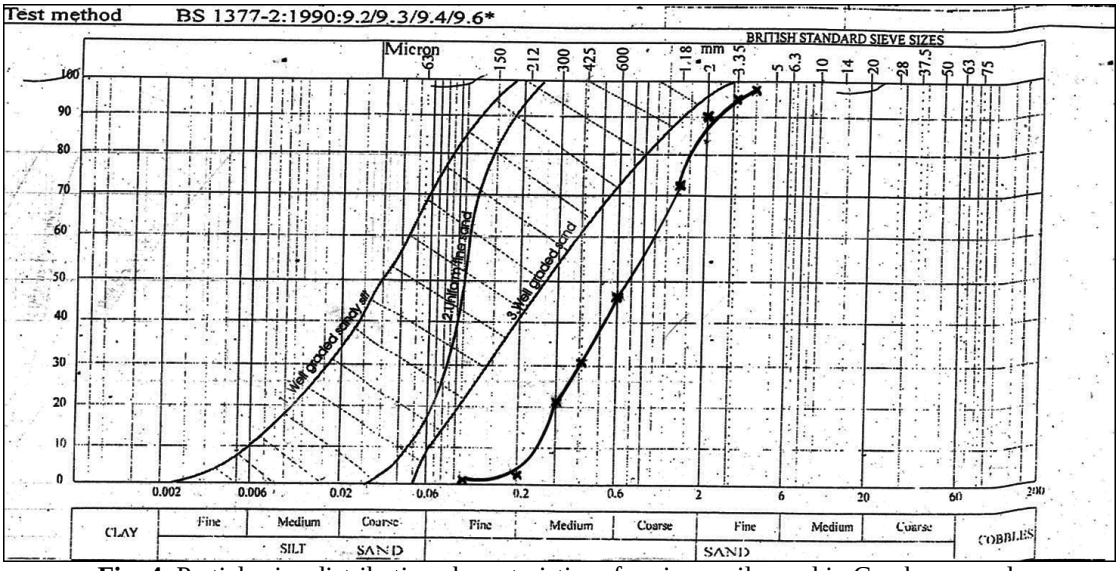

Fig. 4: Particle size distribution characteristics of various soils used in Gamboru ward.

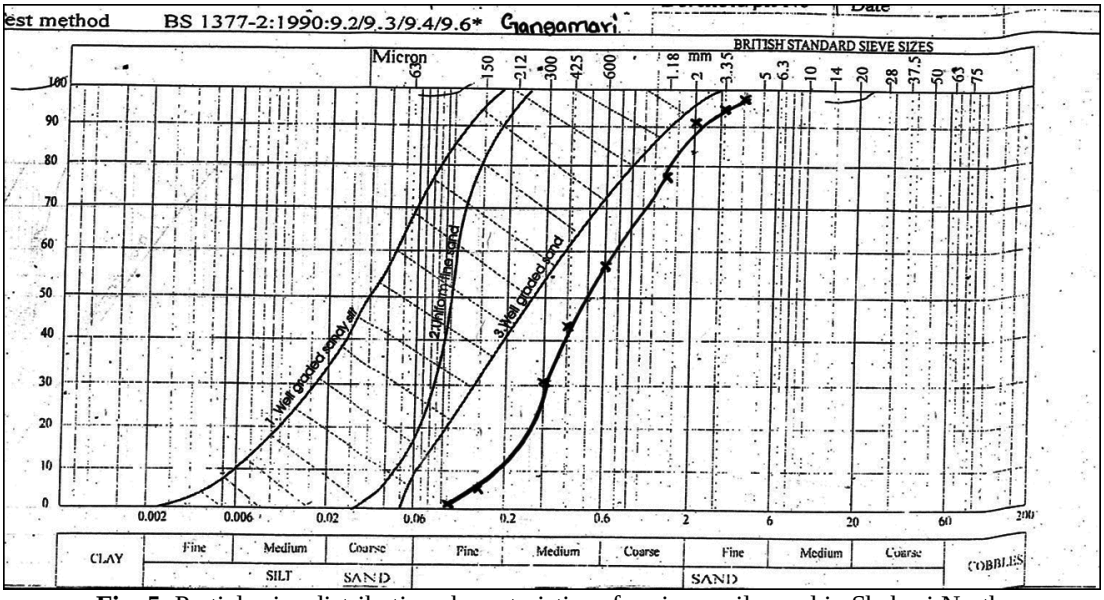

Fig. 5: Particle size distribution characteristics of various soils used in Shehuri North.

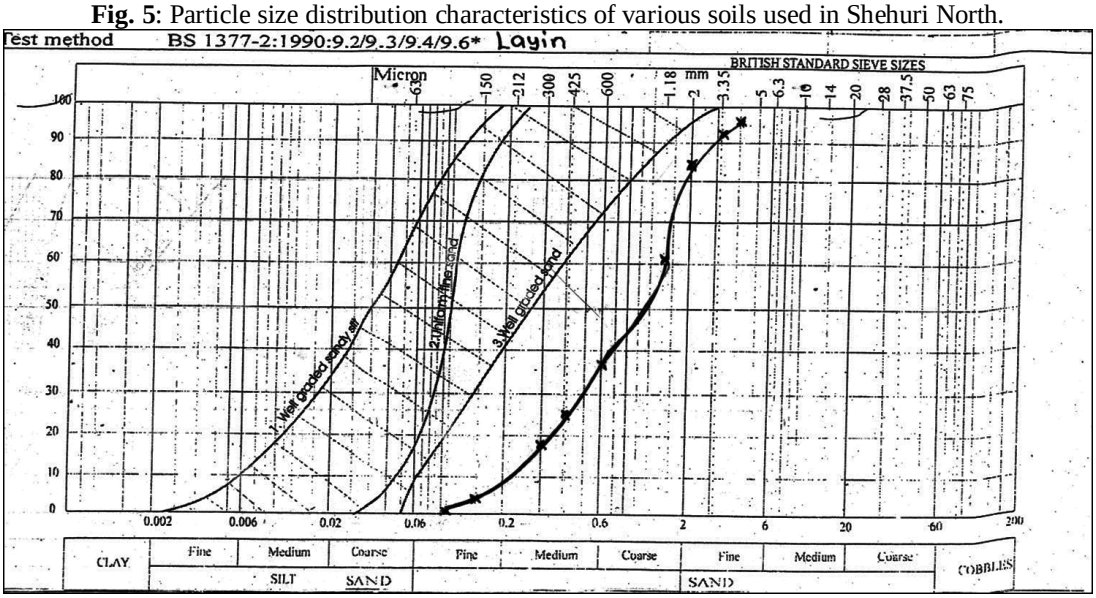

Fig. 6: Particle size distribution characteristics of various soils used in Gwange ward.

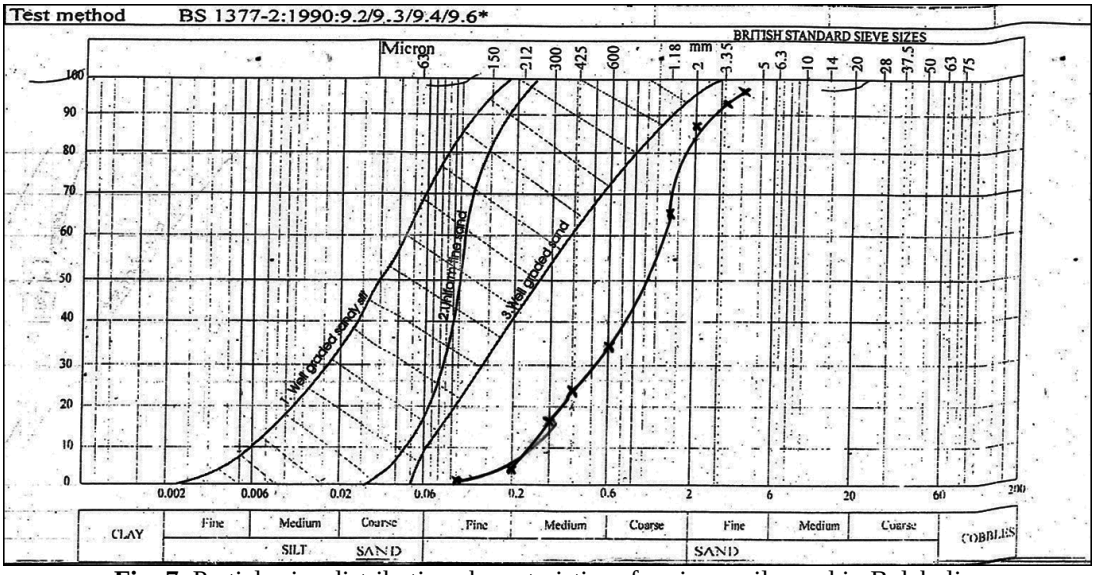

Fig. 7: Particle size distribution characteristics of various soils used in Bulabulin.

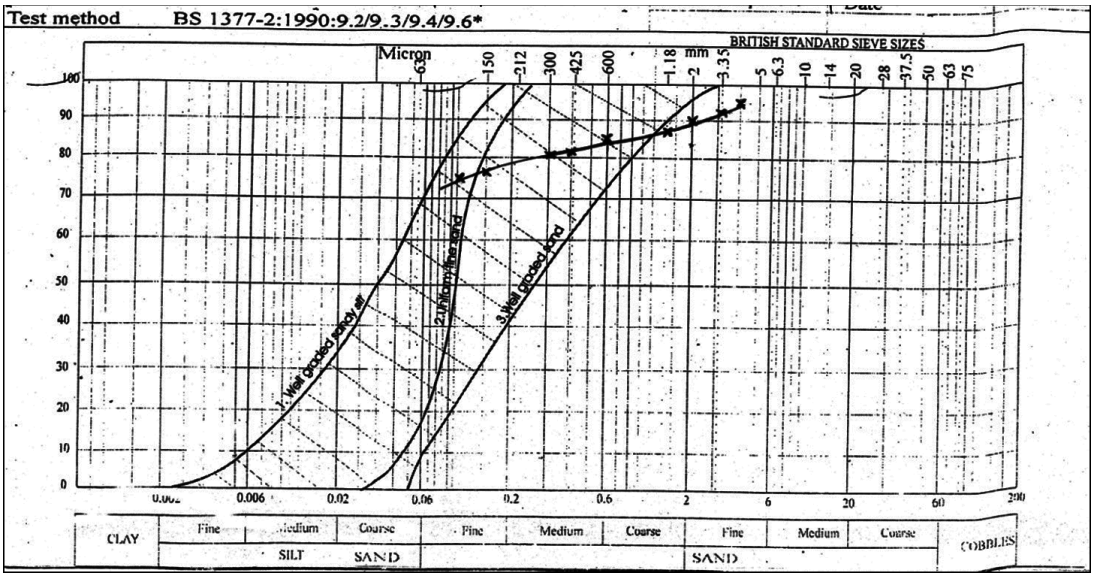

Fig. 8: Particle size distribution characteristics of various soils used in Polo Ground.

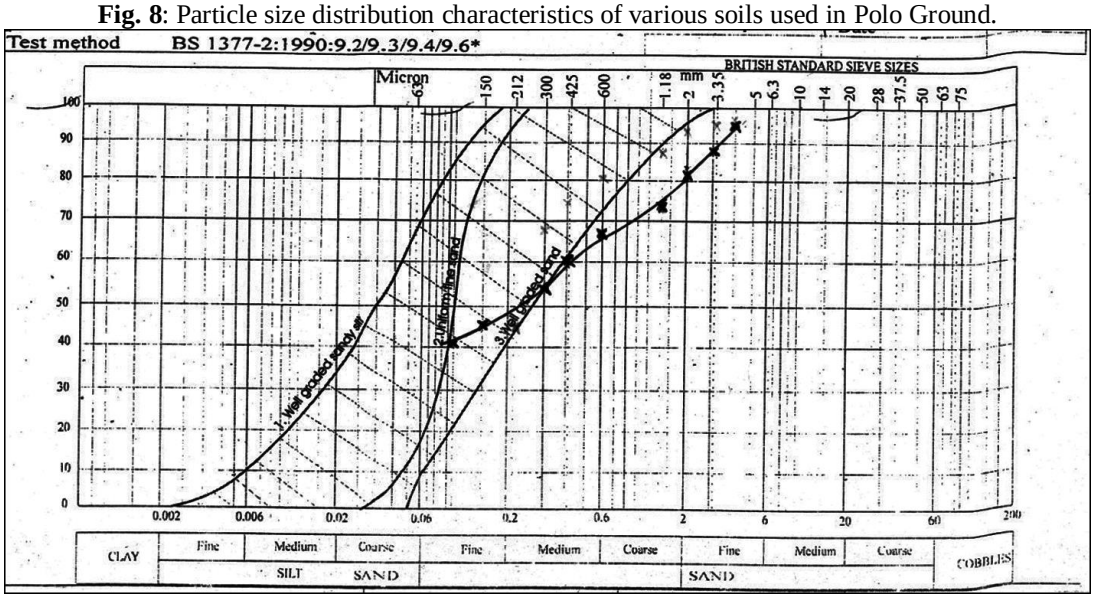

Fig. 9: Particle size distribution characteristics of various soils used in National Stadium.

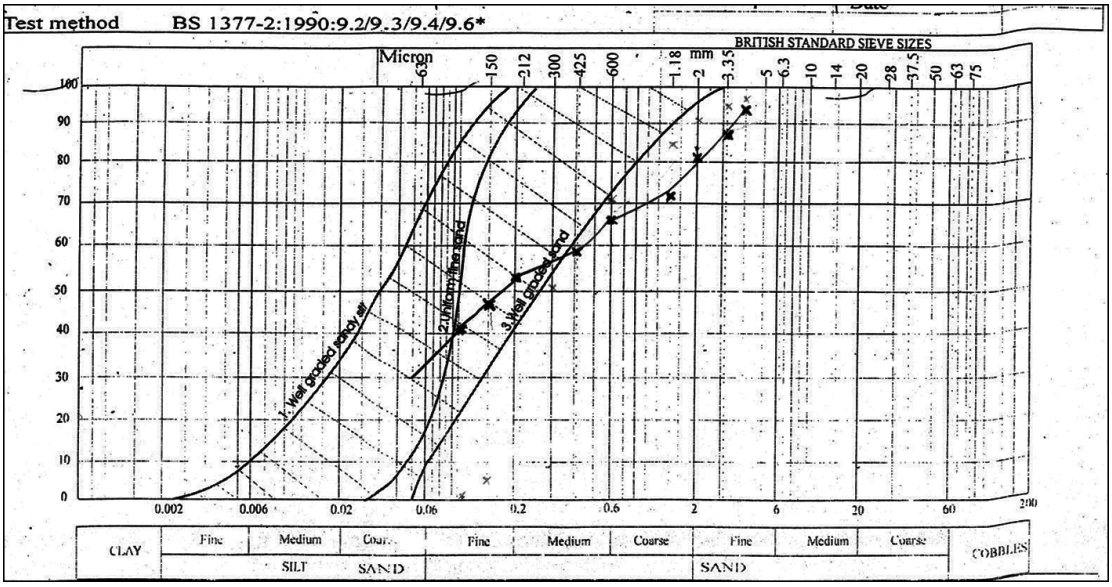

Fig. 10: Particle size distribution characteristics of various soils used in Teacher's Village.

4.0 Conclusion

The particle size distribution of soil samples were conducted for 10 locations in Maiduguri, Borno State, Nigeria by sieving technique. It is observed that this method is a fast, repeatable and accurate method of soil particle size determination. Three textural groups of soils viz. clay, loam and sand were identified in the areas. Out of these, majority of the samples represent sand which are located in 7 locations namely: Ramat Polytechnic, Bolori, Limanti, Gamboru, Shehuri North, Gwange and Bulabulin indicating that the soil in Maiduguri is predominantly sand. The soils have low moisture retention and high permeability. The study of soil textural characteristics at higher precision will be helpful for the textural management concerns all operations, practices and treatments used to protect soil and enhance its performance.

5.0 References

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