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EFFECTS OF DIFFERENT DISPERSING SOLUTION ON THE PROPERTIES OF SOIL PARTICLE DURING HYDROMETER TEST

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Abstract

Soil particle less than 75 microns can be analyzed for the distribution of various grains sizes of silt and clay. This is achieved through hydrometer test. In this study the effect of different dispersing agents on the hydrometer test were studied. Four different solutions of dispersing agent and soil samples were prepared. The first solution was prepared using 35g of sodium hexametaphosphate with 7g of sodium carbonate (solution I). Second solution is prepared using only 40g of sodium hexametaphosphate per 1 litre of solution (solution II). Third solution is prepared using 40g of sodium carbonate (solution III) and the fourth is prepared without using any dispersing agent rather, the two soil samples used were dissolved in distilled water (solution IV). After comparative analysis, solutions I and II were recommended as the best method for preparation of soil solution for hydrometer test. Percentage passing obtained for solution I differs from solutions II, III, IV by 3.20, 6.88 and 24.07 respectively; for sample A and 3.22, 11.1 and 19.52 respectively; for sample B. Solution I and II are consistent for both samples whereas solution III is not consistent showing that it depends on the nature of soil being dispersed. Therefore, sodium carbonate is added to solution I to reduce its hardness. The results obtained showed that solution I and II are recommended only as prescribed by BS and ASTM respectively.

Key word: Dispersing agent effect, mechanical analysis, hydrometer test.

1.0 INTROUDCTION

The common laboratory method used to determine size distribution of fine-grained soil is called hydrometer test. In hydrometer test a small amount of soil is mixed into a suspension and its settlement is observed over time. Larger particles will settle quickly followed by smaller particles. When hydrometer is lowered into suspensions, it will sink into the suspension until buoyancy force is sufficient to balance the weight of the hydrometer. The length of the hydrometer projecting above the suspension is a function of the density, so it is possible to calibrate the hydrometer to read the density of the suspension at different intervals of time (Budhu, 2011).

Typically, a hydrometer test is conducted by taking a small quantity of a dry and fine grained soil and thoroughly mixing it with distilled water to form a paste. The British standard recommends 35g of sodium hexametaphosphate with 7g of sodium carbonate along with distilled water to make 1 litre standard solution. Whereas ASTM standard method of particle size analysis (D422-ASTM 1965) suggest that 125ml of solution of sodium hexametaphosphate shall be used in distilled water at the rate of 40g of sodium hexametaphosphate per litre of solution (Bindu & Ramabhadran, 2010; bindhu, 2011).

A hydrometer is placed in the glass cylinder and a clock is simultaneously started at intervals of 1min, 2min, 4min, 8min, 15min, 30min, 1hr, 2hrs, 4hrs, 8hrs, 16hrs, 24hrs. The hydrometer is read, the diameter D(cm) of the particle at time t(second) is calculated from Stoke's law as

$$D = \sqrt{\frac{18\mu z}{(Gs-1)\rho_w g t}}$$

Where is the viscosity of water (0.01gram/cms at 20^0C), z is the depth (cm), is the density of water (1gram/cm^3), g is the acceleration due to gravity (981cm/s^2) and Gs is the specific gravity of the soil particles (≅2.7) (Budhu, 2011; Bindu & Ramabhadran, 2010). Stoke's Law can also be expressed in terms of unit weight of soil as follows

$$V = \frac{\gamma_s - \gamma_w}{18\mu} D^2$$

Where V is the terminal velocity, γ_w is the unit weight of water, γ_s is the unit weight of the soil (Murthy, 2008).

In application of Stoke's Law, the particles are assumed to be free-falling spheres with no collision. But the mineral particles of clays are plate like, and collision of particles during sedimentation is unavoidable. Also Stokes law is valid only for laminar flow with Reynolds number smaller than 1 (Budhu, 2011; Ye, Kuang & Li, 2014; Ye, Ye & tang, 2014).

This work studied the comparative effect of different dispersing agents on hydrometer test result.

2.0 MATERIALS AND METHOD

Two different soil samples were used for this test. The first sample (A) was collected from Ogun State, Nigeria. The AASHTO classification for this soil is A-7-5.

The second sample (B) classified as A-6 was collected from Kaduna State, Nigeria. For each of the samples, four different solution were prepared for hydrometer test.

Solution I: This was prepared using 35g of sodium hexametaphosphate with 7g of sodium carbonate in line with BS standard.

Solution II: This was prepared using only 140g of sodium hexametaphosphate per litre of solution according to ASTM standard.

Solution III: This was prepared using only 140g of sodium carbonate.

Solution IV: This was prepared to serve as control and contains no dispersing agent.

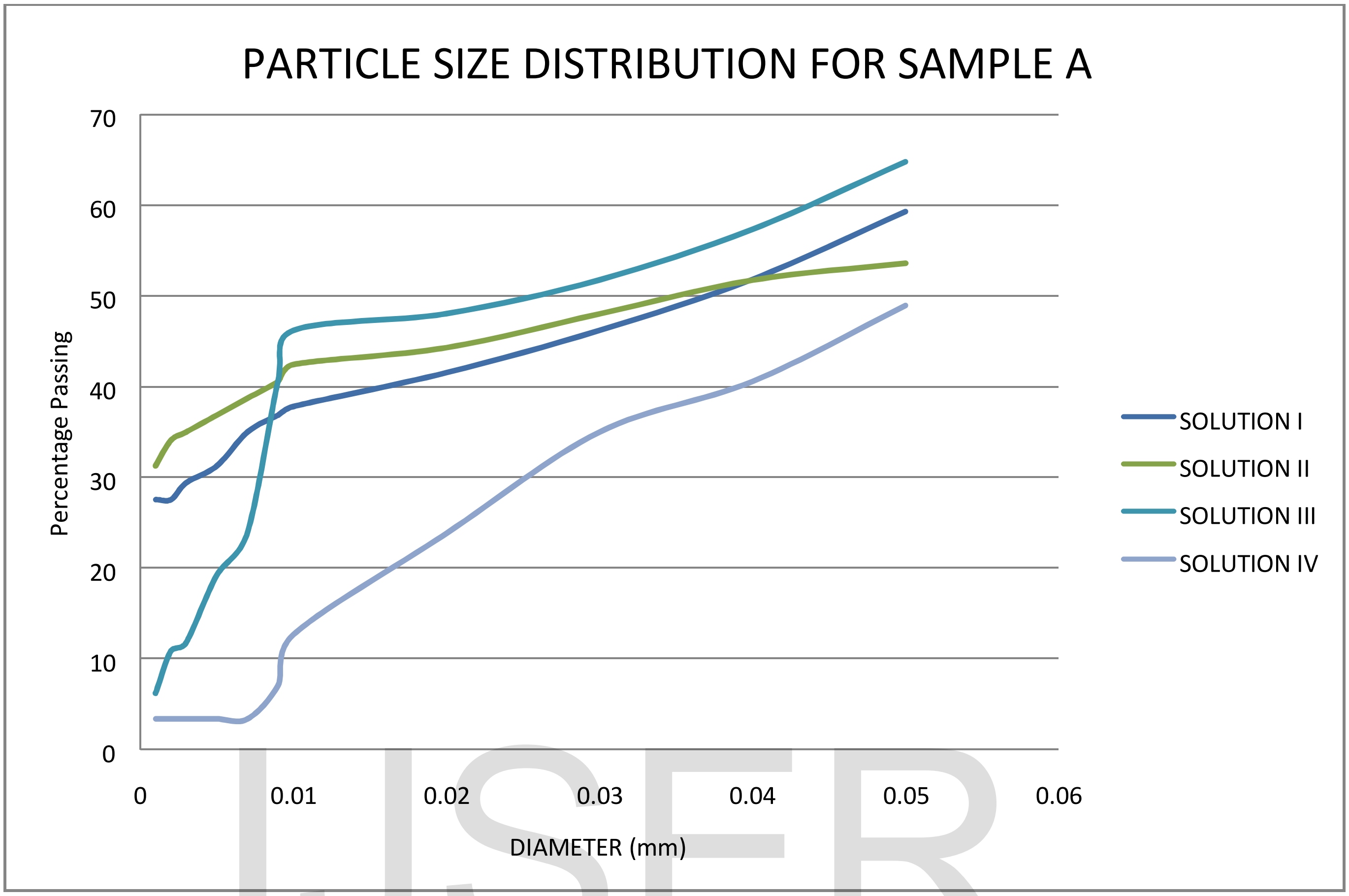
3.0 RESULTS AND DISCUSSION CURVE

The results for sample A for each of the solution (I-IV) are shown in table 2.1 below

Sample A:

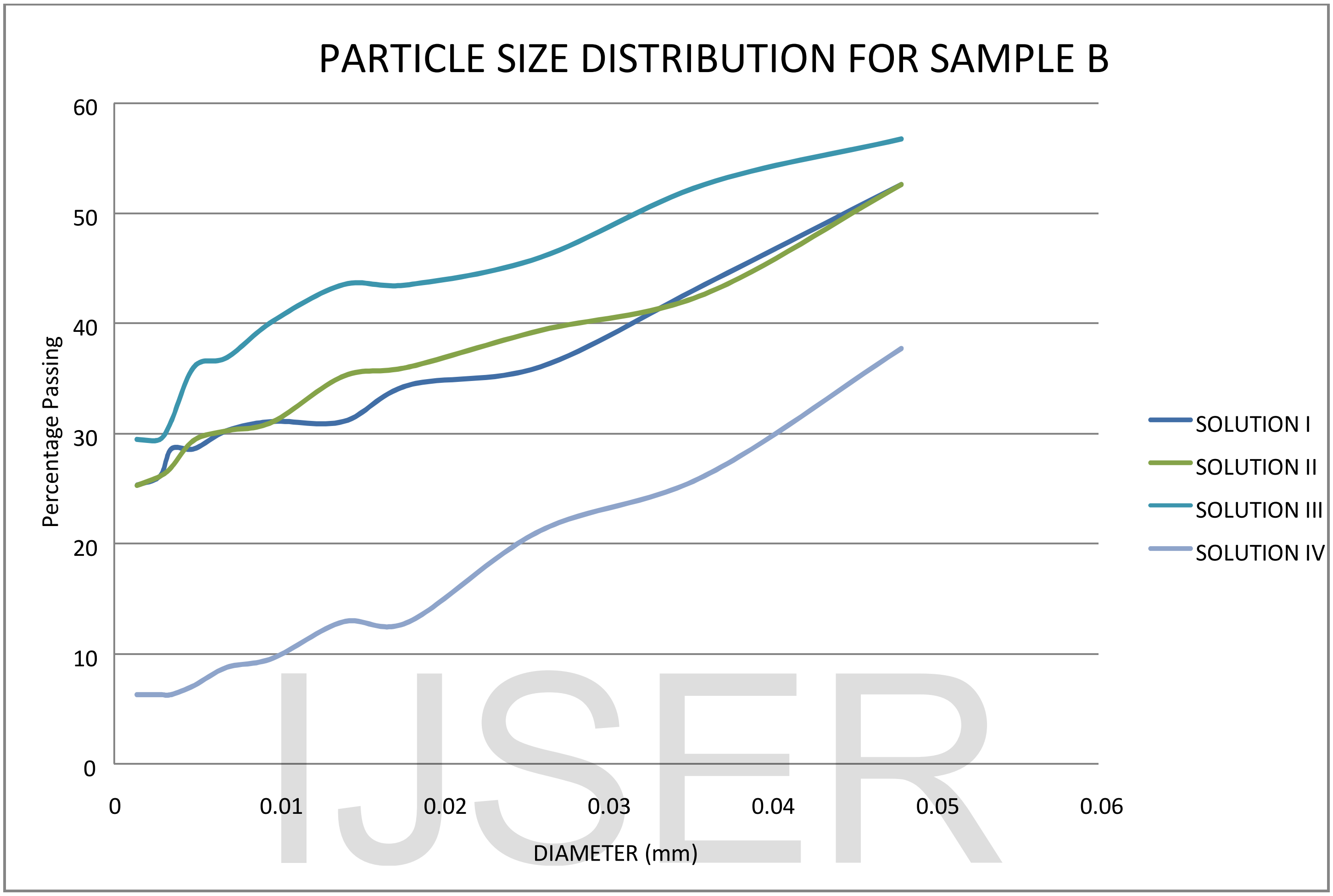
Elapsed time	Solution I		Solution II		Solution III		Solution IV	
	Diameter (mm)	% Passing	Diameter (mm)	% Passing	Diameter (mm)	% Passing	Diameter (mm)	% Passing
1min	0.050	59.24	0.049	53.57	0.047	64.73	0.050	48.92
2mins	0.040	51.78	0.035	51.71	0.035	57.29	0.037	40.55
4mins	0.030	46.17	0.025	47.99	0.025	51.71	0.026	34.97
8mins	0.020	41.52	0.018	44.27	0.018	47.99	0.019	23.8
15mins	0.010	37.80	0.013	42.41	0.013	46.13	0.015	12.65
30mins	0.009	36.86	0.0090	40.55	0.009	40.55	0.0010	7.07
1hr	0.007	35.00	0.0068	38.69	0.007	23.81	0.0075	3.35
2hrs	0.005	31.28	0.0048	36.83	0.005	19.16	0.0053	3.35
4hrs	0.003	29.42	0.0034	34.97	0.004	11.72	0.0037	3.35
6hrs	0.002	27.56	0.0028	34.04	0.0029	10.79	0.0030	3.35
24hrs	0.001	27.56	0.0014	31.25	0.0015	6.14	0.0015	3.35

Fig. 2.1: The particle distribution size for different solutions


PARTICLE SIZE DISTRIBUTION FOR SAMPLE A
Percentage Passing
70
60
50
40
30
20
10
0
0
0.01
0.02
0.03
0.04
0.05
0.06
DIAMETER (mm)
SOLUTION I
SOLUTION II
SOLUTION III
SOLUTION IV

The Results for sample B for each of the solutions are shown in Table 2.2 below

Elapsed time	Solution I		Solution II		Solution III		Solution IV	
	Diameter (mm)	% Passing	Diameter (mm)	% Passing	Diameter (mm)	% Passing	Diameter (mm)	% Passing
1min	0.048	52.63	0.048	52.63	0.048	56.77	0.051	37.73
2mins	0.036	43.53	0.035	42.69	0.014	52.63	0.038	26.15
4mins	0.026	36.08	0.026	39.39	0.025	46.01	0.027	21.18
8mins	0.018	34.42	0.018	36.08	0.018	43.53	0.019	12.91
15mins	0.014	31.11	0.013	35.25	0.013	43.53	0.011	12.91
30mins	0.0097	31.11	0.0097	31.11	0.0093	40.22	0.010	9.60
1hr	0.0069	30.29	0.0069	30.29	0.0067	36.91	0.0074	8.77
2hrs	0.0049	28.63	0.0049	29.46	0.0047	36.08	0.0052	7.12
4hrs	0.0035	28.63	0.0035	26.98	0.0034	31.11	0.0037	6.29
6hrs	0.0028	26.15	0.0028	26.15	0.0028	29.46	0.0030	6.29
24hrs	0.0014	25.32	0.0014	25.32	0.0014	29.46	0.0015	6.29


PARTICLE SIZE DISTRIBUTION FOR SAMPLE B
60
50
40
30
20
10
0
Percentage Passing
0
0.01
0.02
0.03
0.04
0.05
0.06
DIAMETER (mm)
SOLUTION I
SOLUTION II
SOLUTION III
SOLUTION IV

Individual soil particles must be dispersed in an aqueous solution and remain dispersed to enable determination of particle size distributed. However, soil naturally exists as aggregates and not a dispersed mixture of particles; sand, silt and clay. Cementing agents include organic matter; mineral oxides or polyvalent cations. That is the reason why solution IV without dispersion agent was not well dispersed. The percentage finer is the same, from 1hr to 24hrs for Sample A and also the same for Sample B from 4hrs to the 24hrs.

The average particle diameter for each solution was calculated. The corresponding percentage finer was calculated using mathematical interpolation. This average particle diameter is shown in table 2.3 and 2.4 below for each of the sample.

Solution type	Average particle (mm) diameter	% Finer
I	0.0161	40.07
II	0.0153	43.27
III	0.0152	46.95
IV	0.0162	16.00

Table 2.3: Average particle size and corresponding percentage passing for sample A.

Solution Type	Average particle (mm) diameter	% Finer
I	0.0156	32.43
II	0.0154	35.65
III	0.0133	43.53
IV	0.0160	12.91

Table 2.4: Average particle size and corresponding percentage weight passing for sample B.

The sodium monovalent cation (Na^+) replaces polyvalent cations adsorbed on clays, breaking the interparticle linkage. The displaced polyvalent cations form insoluble complexes with phosphorus which prevents reestablishment of floccules. This explains the reason why solutions I and II that contains sodium hexametaphosphates are well dispersed, giving a consistent result. Solution III does not disperse well in both samples probably because of strong bond between sodium and trioxocarbonate IV ions in sodium carbonate.

Secondly, it does not contain phosphorus or any element that can do what phosphorus does in the solutions containing sodium hexametaphosphate.

According to Andreola et al (2004), sodium carbonate is sometimes added to sodium hexametaphosphate to raise the pH to 8.0-8.6, which produces a number of sodium hexametaphohate products used for water softening.

CONCLUSION

Percentage passing obtained for solution I differs from solutions II, III, IV by 3.20, 6.88 and 24.07 respectively; for sample A and 3.22, 11.1 and 19.52 respectively; for sample B.

Solution I and II are consistent for both samples whereas solution III is not consistent showing that it depends on the nature of soil being dispersed.

Therefore, sodium carbonate is added to solution I to reduce its hardness. The results obtained showed that solution I and II are recommended only as prescribed by BS and ASTM respectively.

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