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Soft Clay Treatment Using Geo-Foam Beads and Bypass Cement Dust

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Abstract

Soft clays are usually classified according to their undrained shear strength, Cu. Values of Cu less than 12.5kPa are associated with very soft clays, whereas, soft clays possess undrained shear strength ranging between 12.5kPa and 25kPa. In addition to the low shear strength of soft clays, they experience high compressibility upon loading. This is why soft clays are considered as problematic for foundation purposes. Also, Geo-foam is an industrial material, characterized by a very low unit weight (average of 20kg/m3) compared to that of the soil. Having a density ranging from 1.0% to 2.5% of that of soil EPS possesses a compressive strength ranging between 70kPa and 140kPa and an elastic modulus ranging between 5MPa and 12MPa, According to Horvath (1997). EPS Geo-foam blocks are used in a wide range of geotechnical applications as a light weight fill.

So, the main objective of this study is to investigate the geotechnical properties of soft clay with Geo-foam beads and bypass cement dust. Also, investigate the possibility of preparing low strength excavatable fill mixtures. For studying the effect of (Geo-foam beads + CBPD) / soft clay on fluid-state and hardened properties of new fill, experimental work was carried out on two groups of mixture (A&B). Different ratios of (Geo-foam beads + CBPD) were added to the mixture to study its effect on flow consistency, dry unit weight, unconfined compressive strength, and shear strength. The results of test conducted on the materials illustrated that, cement bypass dust and excess foundry sand can be successfully used to procedure self-compaction, self-leveling excavatable flowable fill material. The unconfined compressive strength of the studied mixtures without Geo-foam ranged between 271.8kPa and 1405.14kPa at CBPD between 3.88% and 18.63%. The Cohesion values for group with Geo-foam with ranged between 50kPa and 20kPa at Geo-foam between 0.32% and 1.35%. The friction angle of group with Geo-foam with ranged between 10 and 22kPa at CBPD between 0.32% and 1.35%.

Keywords: Geo-foam Beads; Bypass Cement Dust; Flowable Fill; Shear Strength

Introduction

EPS Geo-foam blocks are used in a wide range of geotechnical applications as a light weight fill. The primary function of Geo-foam is to provide a lightweight void fill below a highway, bridge approach, embankment or parking lot [1]. EPS Geo-foam minimizes settlement on underground utilities. Geo-foam is also used in much broader applications, the major ones being as lightweight fill, green roof fill, compressible inclusions, thermal insulation, and (when appropriately formed) drainage. Expanded polystyrene (EPS) Geo-foam has been used as a geotechnical material since the 1960s. EPS Geo-foam is approximately 1% the weight of soil and less than 10% the weight of other lightweight fill alternatives. As lightweight fill, EPS Geo-foam reduces the loads imposed on adjacent and underlying soils and structures [3].

EPS Geo-foam is not a general soil fill replacement material but is intended to solve engineering challenges. The use of EPS typically translates into benefits to construction schedules and lowers the overall cost of construction because it is easy to handle during construction, often without the need for special equipment, and is unaffected by occurring weather conditions [3]. EPS Geo-foam can be used to replace compressible soils or in place of heavy fill materials to prevent unacceptable loading on underlying soils and adjacent structures. The high compressive resistance of EPS Geo-foam makes it able to adequately support traffic loadings associated with secondary and interstate highways [4]. Also, using EPS Geo-foam eliminates the need for compaction and fill testing, reduces the construction time and minimizes impact to the existing roadway and adjacent structures and/or buried utilities [5]. Experimental work was carried out on two groups of mixture (A&B) and different ratios of (Geo-foam beads + CBPD) were added to the mixture to study its effect on the geotechnical properties.

Experimental Program

Material characteristics

The soft clay was dried in the oven at 110°C. It is passing through sieve size of 0.25mm. Soft clay characteristics are listed in Table 1.

Table 1: Properties of tested soft clay soil.

Soft clay properties	Value
Average liquid limit, %	48
Average plastic limit, %	26
Plasticity index, %	22
Soft clay type (A-line chart)	CI

Also, the unit weight of the Geo-foam beads is 15.0kg/m3. The size of the Geo-foam beads is 5.0mm Figure 1a.

Figure 1: Mixing the samples.

Mixture proportions

The experimental work was divided into two groups, each with the same size of 600cm3. Group A was divided into five sub-samples without the use of Geo-foam and mixed with increasing percentages of CBPD (50g) for each sample and different percentages of water. In addition, the B group was divided into five sub-samples and mixed with increasing percentages of Geo-foam (5g) for each sample as well as different percentages of water with stable weight of CBPD as shown in the following Tables 2-5.

Table 2

Group	Mix	Soft clay (gm)	CBPD (gm)	Geo-foam (gm)	Water (gm)
A	A1	1000	50	0	240
	A2	1000	100	0	250
	A3	1000	150	0	250
	A4	1000	200	0	260
	A5	1000	300	0	310

Table 3

Group	Mix	Soft Clay, %	CBPD (%)	Geo-foam (%)	water (%)
A	A1	77.52	3.88	0	18.6
	A2	74.07	7.41	0	18.52
	A3	71.43	10.71	0	17.86
	A4	68.49	13.7	0	17.81
	A5	62.11	18.63	0	19.25

Table 4

Group	Mix	Soft Clay (gm)	CBPD (gm)	Geo-foam (gm)	Water (gm)
B	B1	1000	200	5	340
	B2	1000	200	10	320
	B3	1000	200	15	400
	B4	1000	200	20	450
	B5	1000	200	25	640

Tables 5: Grouping of tested mix samples.

Group	Mix	Soft Clay, %	CBPD (%)	Geo-foam (%)	water (%)
B	B1	64.72	12.94	0.32	22.01
	B2	65.36	13.07	0.65	20.92
	B3	61.92	12.38	0.93	24.77
	B4	59.88	11.98	1.2	26.95
	B5	53.62	10.72	1.34	34.32

Experimental Work and Results

Flow consistency

Samples were mixed for groups A-B for different percentages of water as shown in Figure 1b. The consistency flow of the samples was measured for each sample. It is found that the flow consistency increased slightly for group B than for group A. So, the flow consistency was measured in laboratory as listed in (Tables 6-7) for the two groups. Although the percentage of water present in the B samples, the effect of the presence of Geo-foam beads than bypass cement dust on soil was clear as shown in Figure 2.

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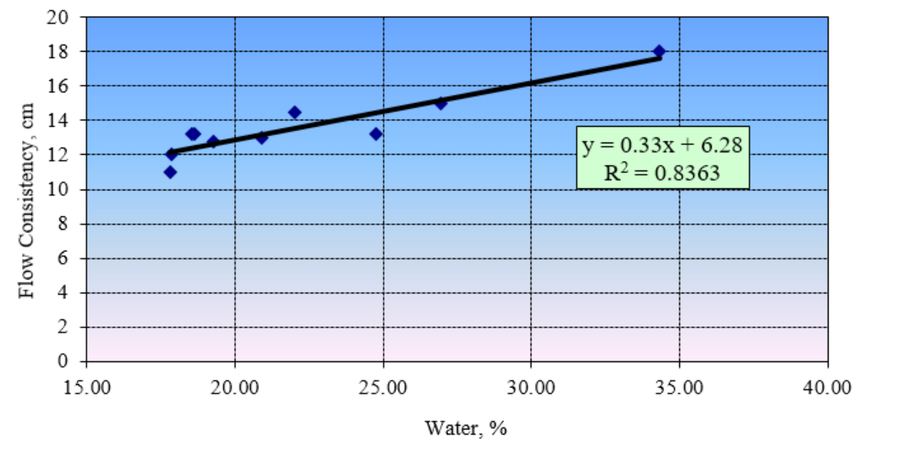

Figure 2: Flow consistency for group (B).

Table 6: Measurements of flow consistency (Group A).

Group	Mix	Water (gm)	Flow Consistency, cm
A	A1	240	13.25
	A2	250	13.25
	A3	250	12
	A4	260	11
	A5	310	12.75

Table 7: Measurements of flow consistency (Group B).

Group	Mix	Water (gm)	Flow Consistency, cm
B	B1	340	14.5
	B2	320	13
	B3	400	13.25
	B4	450	15
	B5	640	18

Unconfined compressive strength

Figure 3: Typical shear failure of mixtures.

The studied mixtures for each group were molded and hardened. Unconfined compressive strength was obtained by the Triaxial test for the studied mixtures as shown in Figures 3. It was found that with the increase of cement bypass dust, the unconfined compressive strength increased significantly and especially for the samples (A4 - A5) compared to a slight increase in the values of the strain% as shown in Figure 4. Also, compressive strength values are also stabilized with increasing mixing rates in cement bypass dust from approximately 14 to18% as shown in Figure 5. This shows the significant effect of cement bypass dust on compressive strength of studied samples.

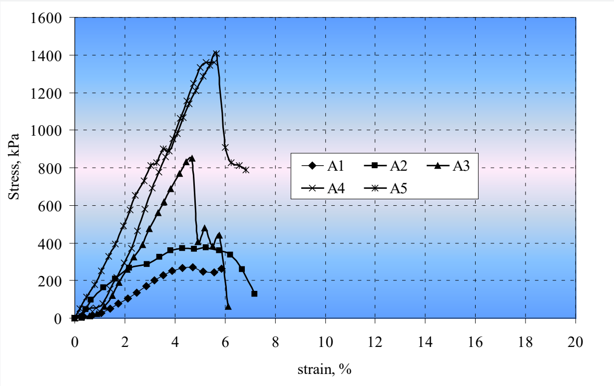

Figure 4: Typical stress-strain curve for group (A) samples.

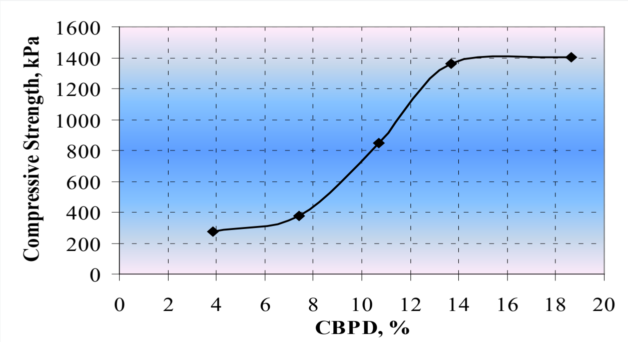

Figure 5: Effect of cement bypass dust on compressive strength.

Shear strength

Shear box test was carried out on the studied samples. The samples were loaded with increasing stresses (50-100-150kPa)

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and the shear stresses were calculated versus horizontal displacement (mm). We took samples (A4-B4) for examples as shown in Figures 6-7. Shear strength parameters were obtained from direct shear test and it is concluded that CBPD affected in the cohesion of the group A samples as shown in Figure 8. On the contrary, angle of internal friction was increased significantly when increasing the ratio of Geo-foam beads for group B samples as shown in Figure 9 [6-10].

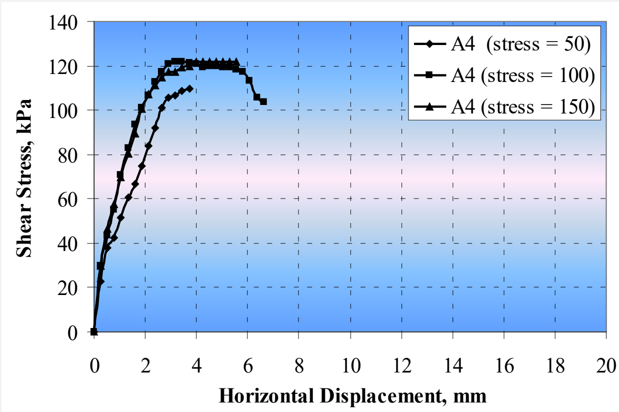

Figure 6: Shear strength versus horizontal displacement for (A4).

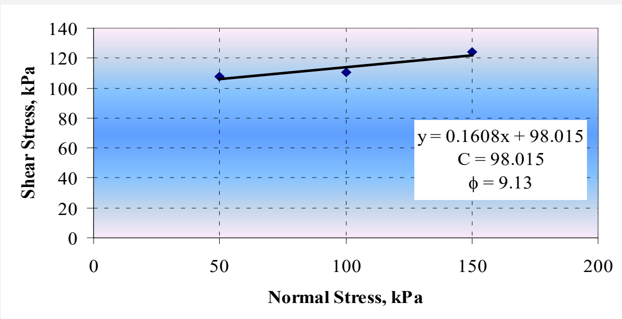

Figure 7: Shear strength parameters for sample (A4).

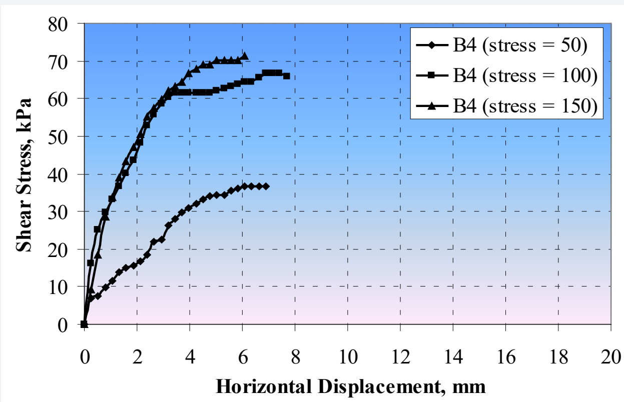

Figure 8: Shear strength versus horizontal displacement for (B4).

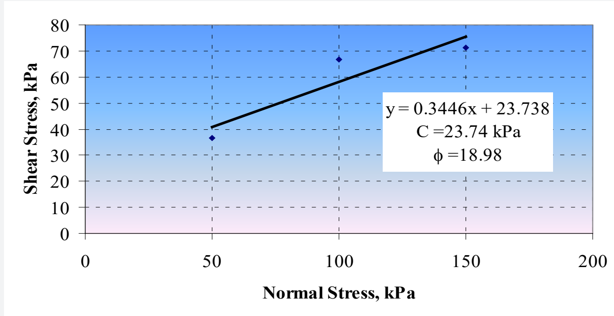

Figure 9: Shear strength parameters for sample (B4).

Conclusion

This paper presented an experimental study of various samples of soft clay mixed with different percentages of Geo-foam beads and cement bypass dust. The following conclusions may be drawn:

A. The results of test conducted on the materials illustrated that, cement bypass dust and excess foundry sand can be successfully used to procedure self-compaction, self-leveling excavatable flowable fill material.

B. The dry unit weight of the studied mixtures for group without Geo-foam ranged between 1.40 and 1.6 gm/cm3 at CBPD between 3.88% and 18.63%.

C. The dry unit weight of the studied mixtures for group with Geo-foam ranged between 0.65 and 1.20 gm/cm3 at Geo-foam between 0.32% and 1.35%.

D. The unconfined compressive strength of the studied mixtures without Geo-foam ranged between 271.8kPa and 1405.14kPa at CBPD between 3.88% and 18.63%.

E. The unconfined compressive strength of the studied mixtures with Geo-foam ranged between 230kPa and 120kPa at Geo-foam between 0.32% and 1.35%.

F. The Cohesion values for group without Geo-foam with ranged between 62kPa and 105kPa at CBPD between 3.88% and 18.63%.

G. The Cohesion values for group with Geo-foam with ranged between 50kPa and 20kPa at Geo-foam between 0.32% and 1.35%.

H. The friction angle of group without Geo-foam with ranged between 30° and 11° at CBPD between 3.88% and 18.63%.

I. The friction angle of group with Geo-foam with ranged between 10° and 22° at CBPD between 0.32% and 1.35%.

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