Effect of Clay on Soil-Cement Slurry

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Abstract

Soil-cement slurry is a combination of soil, Portland cement, and adequate amount of water so that the mixture has the consistency of a thick liquid. Effect of kaolinite and bentonite clay of the behavior of soil-cement slurry is not well understand. The slurry is increasingly used as backfill materials for flexible pipes and retaining structures. In this study, flowability and mechanical properties of the slurry were investigated. Compressive strength tests and flowability tests were performed to assist in the design of the soil-cement slurry mix. An admixture was added to further optimize the mixture by reducing water to cement ratio and increasing the slurry flowability measured using flow table and flow cylinder equipment to quanlity flowability. The 28 day compressive strengths was increased from 30 to 150 psi with admixture without affecting the flowability.

1. Introduction

Soil-cement slurry is referred to as plastic soil-cement, soil-cement grout, or CLSM (controlled-low-strength-material). It is typically used as a backfill material around structures, particularly in confined or limited spaces. Typically, soil-cement slurry contains about 5 to 10% cement. One of the definite advantages is that the soil-cement slurry may be produced using local soils. The soil for the soil-cement slurry can contain up about 20 to 25% nonplastic or slightly plastic fines.(ASTM D 4832). For the required flow properties, the soil-cement slurry has the water-cement ratio of varied from 4 to 7. For maintaining good compressive strength and flow characteristics, the admixture was added to the mix.

2. Testing program

Mixtures used in the investigation are summarized in Table 1.

Table 1. Composition of Soil-Cement Slurry

Type	Mix 1	Mix 2	Mix 3
Blasting sand	80%	80%	90%
Portland cement	5%	5%	5%

Kaolinite clay	20%	20%	-
Bentonite clay	-	-	10%
Admixture	-	0.5%	1.5%
Water	35%	20%	40%
W/C	7	4	4
Remarks	No Admixture	Kaolinite with admixture	Bentonite with higher admixture

1.5" diameter cylindrical specimens were used to charaterize the compressive strength tests. The flowability tests were done using flow table (ASTM C 230) and flow cylinder (ASTM D 6103) (details are in CIGMAT FF 1-99).

3. Results

In the flow table test, table was raised and dropped 10 times in 6 seconds by rotating the handwheel continuously at a uniform rate. In the flow cylinder test, a 3"x6" open ended is placed cylinder vertically on a level surface and filling the cylinder to the top with the slurry. The cylinder is then lifted vertically to allow the material to flow out onto the level surface. The flowability is quantified as a percentage using the following relation in the both methods:

$$\text{Flowability} = \frac{\text{New Diameter - Original Diameter}}{\text{Original Diameter}} \quad 100$$

Mixtures summarized in Table 1 had 100% flowability. One type of admixture was added to Mix 2 and Mix 3 to reduce the water-cement ratio but keep the same flowability as the Mix 1. The admixture affected the material properties. The dosage of the superplasticizer was 0.5% to 1.5% by weight of soil.

The compressive strengths were determined after specified period of curing using the ASTM C 39. With the different properties of slurry, compressive strength and initial modulus, the Mix 2 and Mix 3 (w/c=4, with admixture) was stronger than the Mix 1 (w/c=7, without admixture). Addiction of admixture increased the 28th day compressive strength by 7fold.

Following are the details of the various tests conducted on the slurry specimens:

Table 2. Compressive Strength and Modulus of Soil-Cement Slurry

Curing period	Compressive strength (psi)			Initial modulus (1x104psi)		
(days)	Mix 1	Mix 2	Mix 3	Mix 1	Mix 2	Mix 3

7	15	60	80	0.10	0.70	0.60
28	20	140	240	0.15	1.40	1.80
70	32	200	320	0.10	1.75	3.20

4. CIGMAT Standard

CIGMAT Test Method for Flowability of Soil-Cement Slurry was used in quantifying the flowability (CIGMAT FF 1-99)

5. Conclusions

1) Addition of admixture can improve the flowability and compressive strength of the

kaolinite and bentonite soil slurry.

2) The soil slurry with an admixture gained over 100 psi in strength in 28 days.

3) Strength more than doubled from 7 to 28 days for mixtures with the selected admixture.

4) CIGMAT Standards are being developed.

6. Acknowledgment

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7. References

ASTM D 4832-88, "Standard Test Method for Preparation and Testing of Soil-Cement Slurry Test Cylinders", Annual Book of ASTM Standards, Volume 04.08, pp.900~903.

ASTM C 230-90, "Standard Specification for Flow Table for Use in Tests of Hydraulic Cement", Annual Book of ASTM Standards, Volume 04.02.

If you have any questions, please contact **Dr. C.Vipulanandan**