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Characterization of Controlled Low Strength Material using Native Soil

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Abstract:
Soil is the important material used for the structural fills, back filling material, bridge approaches, pavement structures, large pipe line works and embankments. But soil is having less compressive strength, due to which it undergoes settlement and also it is not self compacting. So to satisfy these characteristics we replace soil by a material called "Controlled low strength material" (CLSM) which has compression strength more than soil or any other compacted fill. So now our challenge is to find what are the optimum percentage of the ingredients should be used to get a perfect sample which satisfy both strength and flowability. In the present study locally available native soil is used for CLSM preparation and tests are conducted for Atterberg's limits and fineness modulus by hydrometer analysis. Tests on individual materials of CLSM were also conducted like unconfined compression strength and flowability as the controlled low strength material strength ranges from 2.1MPa to 8.3MPa. CLSM specimen used were having dimensions 40mmx80mm in hardened state for different water cement ratios and percentages of ingredients, observations and calculations will be done. Finally the optimum percentages of the ingredients to get perfect CLSM sample satisfying both strength and flowability was found by phenomenological model. Results showed the CLSM of strength ranging from 2.1MPa to 4.1 MPa can be achieved and depending on the field requirement it can be used for various applications.

Keywords: Controlled low strength materials, Fly ash, Binder, Atterberg's limit, unconfined compression strength. Relative Flow Area, flowable fill, compacted, phenomenological.

I. INTRODUCTION

Controlled low strength material (CLSM) or Flowable fill is defined as the self compacting cementations' material which is a replacement material for compacted fills. Flowable fill, plastic soil cement, soil cement slurry, are the some of the other names for the CLSM. It has some of the advantages like lesser soil settlement, self compaction, cheaper compared to the chemically treated and compacted sub soils. For the large construction projects sustainability becomes the key factor because the use of sustainable and re utilization of materials i.e. native soil will reduce the cost of the project, which is very beneficial in large construction projects and also economical friendly. So this sustainable CLSM is used in case of Structural fills and back filling materials in embankments in road or railway construction, embankment of the highways and rail road constructions, foundation under the building constructions and it is also used in case of erosion control Work drainage works and dams, in case of sewers water pipe lines project and also in transmission line constructions.

II. OBJECTIVE

The main objective of my project is to determine, what is the optimum quantity of binders, fine aggregates, and water to be required to get a perfect specimen i.e., which satisfies both strength and flowability characteristics and to get a phenomenological model, and we are also using native soil as a fine aggregate which is abundantly available in the working sites, mainly in the case of large pipe line works which makes our project economical and environmental friendly. After getting the phenomenological model and quantity of the materials to prepare that satisfying both workability and strength that ratio of materials will be used according to the requirements and it is used for structural fills, backfilling, bedding materials, pavement works, basement of the slabs etc.

III. APPLICATIONS OF CLSM

Back fill and structural fill applications

As CLSM requires less or no compaction so it can be effectively used for the back filling material, in place of compacted fills and also reducing the dimensions of the trenches, even back fill is compacted properly in thickness of layers it cannot achieve uniformity and density of CLSM. Later pressure of flowable fill should also be considered when it is used as a back filling material for retaining walls. CLSM should be placed in such a way that each layer should be hardened before placing next layer. It will reduce many of the settlement problems regard to soil. Structural fills CLSM will have the compressive strength varying from 0.7 to 8.3 MPa, according to this strength CLSM can be used for the foundation supports, and as structural fills. It can be distributed over a large area in case of weak soils, it can also be used under the foundations, footings and slabs. Depending upon the project requirement compression strength of the CLSM will vary. Thickness of the slabs can be reduced depending upon the strength of CLSM.

Pavement applications

For pavement bases, sub grades and sub bases the CLSM will be used. Placing is also very easy it can be directly placed from mixture to the pavement bases and sub grades between the existing curbs, and for base coarse design and flexible pavements, depending on the strength structural co efficient will differ. Depending on structural co efficient obtained vary from 0.16 to 0.28 for compressive strength of 2.1 to 8.3MPa. And it requires the good drainage condition, including curb and gutters, storm sewers, and proper pavement grades, for pavement construction these qualities should be required.

Pipe line applications

For any pipe line works like water pipe line, electric works, telephone wires, etc CLSM is the excellent bedding material. As it is having self leveling property so it will fill the voids beneath the pipe lines. It is also used as the erosion resistant material beneath the conduit in some countries like Iowaetc it is used under the culverts since mid-1970s, on CLSM bedding.

Erosion controlling

Compared too many other filling materials CLSM is the excellent erosion controlling material according to laboratory and many field studies. When water of velocity 0.52 m/s which will be applied on various sands and clay materials CLSM is the good erosion resisting materials. In related to both amount of material loss and suspended solids from the material and also these are superior materials. It is also used for the embankment protection, below the dam spill ways to hold the rock pieces in position, in the flexible fabric condition to increase weight and strength.

Void filling

(TUNNEL SHAFT AND SEVERS) In case of abandoned tunnels and severs continuous supply of material to the greater distance is required so in such cases CLSM will be used. The tunnel which is passed under river Menomonee in downtown for filling that tunnel CLSM will be used such that CLSM material spreads over an area of71.6m. in other case an abandoned sever Milwaukee over an area of 635 m^3 CLSM can flowed over an area of 90m. For the construction of Mount Baker ridge tunnel an exploratory shaft of 37m deep, 3.7m diameter, and 9.1m long branched tunnels. Only 4 hrs will be needed to fill the area of $601m^3$ (BASEMENT AND UNDERGROUND STRECTURE).

Nuclear Facilities

CLSM will also be used in case of convectional granular back fills to decrease the personal radiations that provides the significant advantages such as nuclear facilities, waste stabilization, encapsulation of waste disposal sites and encapsulation of decommissioned pipe lines and tanks

Bridge Reclamation

CLSM is used in most of the bridge rehabilitation processes as it is a cost effective to handle the hydrology requirement enough bridge culverts will be put under the bridges. That in the culverts we are using the CLSM material.

IV. MATERIALS AND METHODOLOGY

Laboratory test on cement like specific gravity, normal consistency and setting time tests were conducted. Soil tests were conducted to find native soils Atterberg's limits the liquid limit obtained is 31.50%, Plastic limit value of 21.16% and the type of soil classified was Medium Clayey (MC) soil as per IS classification of soil. Fineness modulus obtained was 4.5112. The use of CLSM material which was under the large pipe lines will be re-excavatable so that the CLSM should have re-excavatable property, for repair and maintenance work of the pipe line works, so that it is required that upper limits of the CLSM is 2.1 MPa to 8.3 MPa, 2.1 MPa is the minimum strength required for the CLSM used under the pipe lines for the purpose of re excavatability when it is required. Relative Flow Area (RFA) is defined as follows

$$RFA = (D^2 - 100^2)/100^2 = [(D/100)^2 - 1] \quad (1)[6]$$

TABLE. I. MATERIALS AND MIX PROPORTION QUANTITIES

SL NO	SERVICE (F/C)	w/B	WATER (%)	B/w	CEMENT (gms)	FLY ASH (gms)	NATIVE SOIL (gms)	WATER in (ml)
1	6.66	0.6	30	1.70	150	1000	1170	702
		0.7	35	1.40	150	1000	1170	819
		0.8	40	1.30	150	1000	1170	936
		0.9	45	1.10	150	1000	1170	1053
2	5.0	0.6	30	1.70	200	1000	1200	720
		0.7	35	1.40	200	1000	1200	840
		0.8	40	1.30	200	1000	1200	960
		0.9	45	1.10	200	1000	1200	1080
3	4.0	0.6	30	1.70	250	1000	1250	750
		0.7	35	1.40	250	1000	1250	875
		0.8	40	1.30	250	1000	1250	1000
		0.9	45	1.10	250	1000	1250	1125
4	3.33	0.6	30	1.70	300	1000	1300	780
		0.7	35	1.40	300	1000	1300	910
		0.8	40	1.30	300	1000	1300	1040
		0.9	45	1.10	300	1000	1300	1170
5	2.85	0.6	30	1.70	350	1000	1350	810
		0.7	35	1.40	350	1000	1350	945
		0.8	40	1.30	350	1000	1350	1080
		0.9	45	1.10	350	1000	1350	1215

TABLE. II.VALUES OF FLOW AND UCS AT 3, 7 AND 28 DAYS FOR DIFFERENT RATIOS

SL.NO	SERIES	w/B RATIO	w in %	B/w RATIO	VALUES			
					FLOW	STRENGTH in Mpa		
					RFA	3 DAYS	7 DAYS	28 DAYS
1	F/C=6.66 1:1 MORTAR	0.60	30	1.7	3.25	0.586	1.230	2.480
		0.70	35	1.4	8.46	0.483	0.900	2.101
		0.80	40	1.3	11.23	0.392	0.651	1.810
		0.90	45	1.1	16.06	0.300	0.461	1.520
2	F/C=5.0 1:1 MORTAR	0.60	30	1.7	2.06	0.690	1.621	3.160
		0.70	35	1.4	8.90	0.540	1.302	2.850
		0.80	40	1.3	14.72	0.489	0.961	2.391
		0.90	45	1.1	18.53	0.411	0.687	2.120
3	F/C=4.0 1:1 MORTAR	0.60	30	1.7	4.71	0.851	2.271	3.880
		0.70	35	1.4	9.25	0.690	1.950	3.670
		0.80	40	1.3	14.32	0.563	1.560	3.220
		0.90	45	1.1	18.34	0.450	1.121	2.780
4	F/C=3.33 1:1 MORTAR	0.60	30	1.7	3.83	1.442	3.110	4.225
		0.70	35	1.4	7.36	1.220	2.670	4.370
		0.80	40	1.3	11.64	0.975	2.010	3.650
		0.90	45	1.1	15.07	0.735	1.440	3.230
5	F/C=2.38 1:1 MORTAR	0.60	30	1.7	3.337	2.350	3.650	5.560
		0.70	35	1.4	8.47	2.110	3.130	5.220
		0.80	40	1.3	11.38	1.870	2.610	4.580
		0.90	45	1.1	15.23	1.560	1.980	4.01

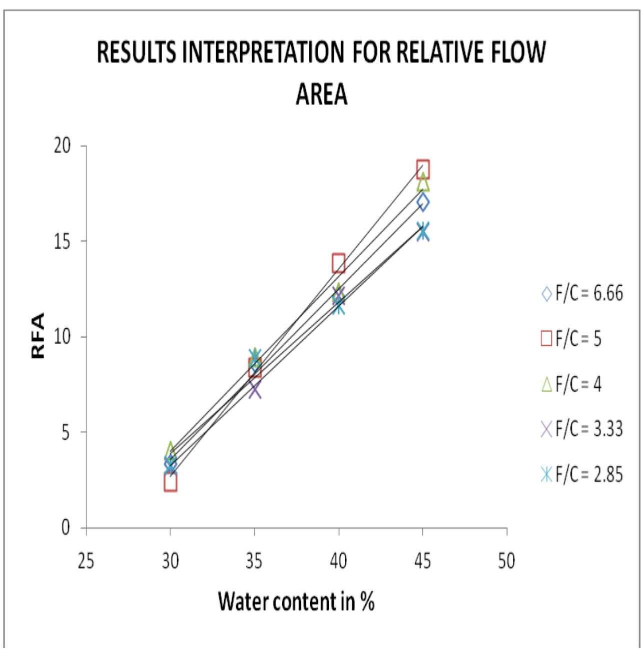

Figure.1.Variation of Combined Rfa V/S Water Content [2]

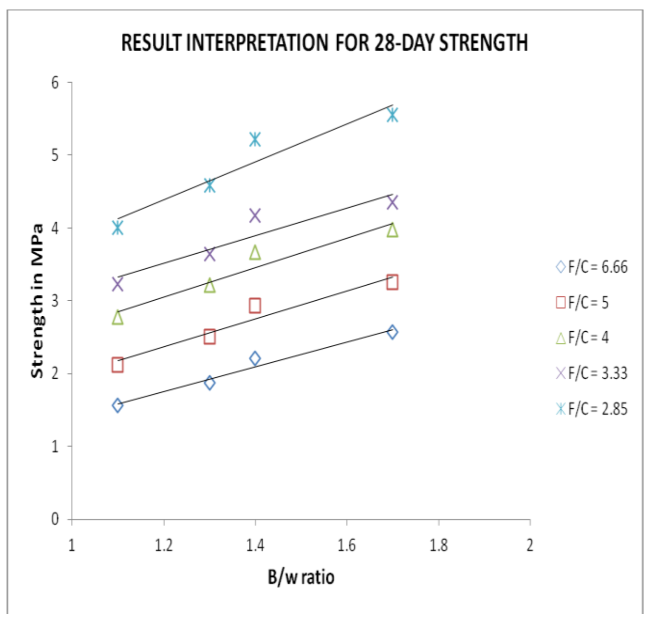

Figure.2.VARIATION OF 28-DAY COMBINED STRENGTH V/S B/W

TABLE.III. NORMALISED FLOW AND STRENGTH VALUES @ 3, 7 AND 28 DAYS FOR DIFFERENT RATIOS VALUES OF NORMALIZED FLOW AND COMPRESSIVE STRENGTH @ 3, 7 AND 28 DAYS

SL.NO	SERIES	w/B RATIO	w in %	B/w RATIO	VALUES			
					FLOW	STRENGTH in MPa		
					RFA	3 DAY	7 DAY	28 DAY
1	F/C=6.66 1:1 MORTAR	0.6	30	1.7	0.289	1.213	1.366	1.18
		0.7	35	1.4	0.753	1	1	1
		0.8	40	1.3	1	0.812	0.728	0.861
		0.9	45	1.1	1.43	0.621	0.512	0.723
2	F/C=5.0 1:1 MORTAR	0.6	30	1.7	0.139	1.277	1.245	1.108
		0.7	35	1.4	0.604	1	1	1
		0.8	40	1.3	1	0.905	0.74	0.838
		0.9	45	1.1	1.25	0.761	0.527	0.743
3	F/C=4.0 1:1 MORTAR	0.6	30	1.7	0.329	1.233	1.164	1.057
		0.7	35	1.4	0.646	1	1	1
		0.8	40	1.3	1	0.815	0.804	0.838
		0.9	45	1.1	1.28	0.652	0.574	0.757
4	F/C=3.33 1:1 MORTAR	0.6	30	1.7	0.283	1.165	1.164	0.996
		0.7	35	1.4	0.632	1	1	1
		0.8	40	1.3	1	0.799	0.752	0.835
		0.9	45	1.1	1.28	0.602	0.539	0.739
5	F/C=2.38 1:1 MORTAR	0.6	30	1.7	0.297	1.113	1.166	1.065
		0.7	35	1.4	0.745	1	1	1
		0.8	40	1.3	1	0.886	0.883	0.887
		0.9	45	1.1	1.34	0.739	0.632	0.768

Phenomenological model

To identify the specific value of relative flow area (RFA) and level of strength, the method which is rapid rational and simple to get the combination of ingredients required at the required age is desirable due to the following cases Depending upon the end usage the development of flow in terms of RFA is done. A simple procedure is needed to find that required water content. At that water percentage it is required to find the binder to fluid ratio.

Phenomenological model for flow data

To develop the phenomenological model for the flow in reference with the value of relative flow area for the water percentage 40% of water content (no segregation and bleeding the range of optimum relative flow area of 0.276 to 1.412) for the mortar ratio of 1:1 are identified. The reference values of these data points are normalized according to the flow lines. Normalized values of all the series for the flow for the particular ratio are drawn below, according to the water content and relative flow area it is calculated by using the optimum RFA of the different percentages of water content. Dividing all RFA with this optimum RFA we get the values as shown in the table below.

Phenomenological model for the strength data

For the development of phenomenological model we are using Abrams law, a reference value is required to identify this for B/W ratio of 1.4 has been calculated it proves that trial test has been done at this ratio will give relation between all the ingredients, as explained in the table and the graphs below the relation of the data is done because according to Bolemey's the inverse of W/B is used to transform the data in to a linear form based on cement composites. The linear relation is based on combination of cement and fly ash and native soil

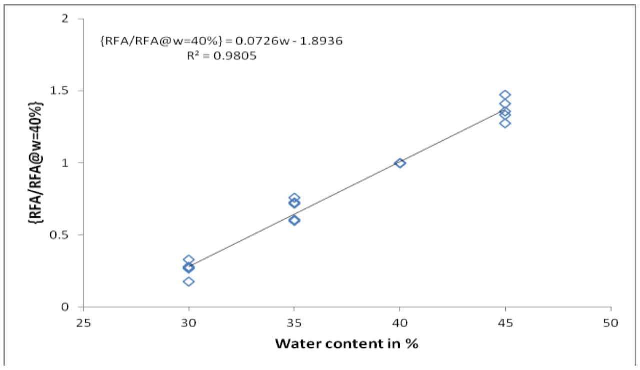

Figure. 3.variation of combined rfa v/s water content

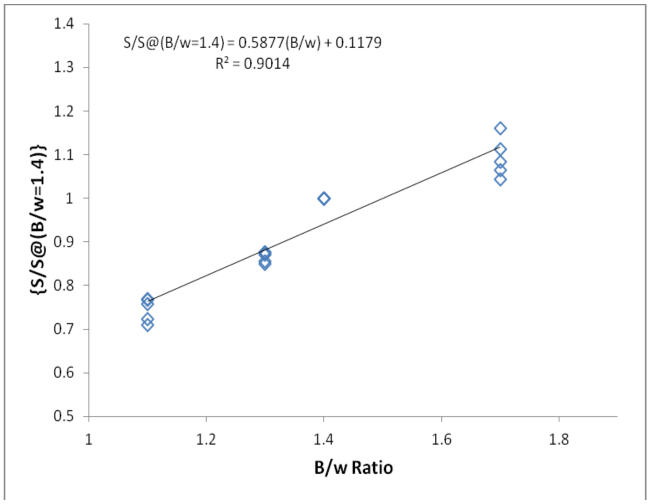

Figure. 4.variation of combined rfa v/s water content

V. CONCLUSION

- Depending on the results obtained for Flowability and Compression strength we can say that for flow is maximum for 45% of water content and strength is maximum for 30% of water content and B/W of 1.7.
- But we need to find the perfect specimen which provide both strength and flowability, the perfect specimen we have considered is F/C is 2.38, water content is 35%
- (RFA 8.47) and B/w is 1.7 is taken as a phenomenological model.
- As we are using the Native soil as our fine aggregate in CLSM so that the cost of the overall project will be reduced resulting in economy.
- And Sustainability also an important aspect in large constructions like Pipe line works, Bridges, Road pavement etc our project will satisfy that.

VI. REFERENCES

[1]. ASTM. (2003). "Specification for concrete aggregates." ASTM Standard C33, ASTM International, West Conshohocken, PA

[2]. ASTM. (2008). "Standard test method for time of setting of concrete mixtures by penetration resistance." ASTM Standard C403,

[3]. ASTM International, West Conshohocken, PA.

[4]. ASTM. (2013). "Standard test method for unconfined compressive strength of cohesive soil." ASTM Standard D2166, ASTM International, West Conshohocken, PA.

[5]. Chittoori, B., Puppala, A. J., Reddy, R., and Marshall, D. (2012). "Sustainable reutilization of excavated trench material." Geo Congress 2012, ASCE, Reston, VA, 4280–4289.

[6]. Hamilton County and the City of Cincinnati, Ohio (HAMCIN). (1996). "A performance specification for controlled low strength material controlled density fill."

[7]. American concrete institute 229-R code.