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The impact of Marbel dust and lignosulfonate on the geotechnical aspects of clay

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Abstract:

Problematic clayey soil has a poor shear strength, is highly susceptible to moisture, is cohesive by nature, is incredibly unstable, and is prone to volumetric shrinkage. Cement, Marbel dust, fly ash, rice husk ash, furnace slag and other soil stabilisers are commonly used alone or in combination. These pozzolonic components combine to generate a cementitious compound in clayey soils when Marbel dust is added as an admixture. To stabilise the soil, waste items must be used. In the Punjabi district of Ludhiana, India, at the village of Lohatwadhi, soil samples were collected. This study looked at the effects of lignosulfonates on clayey soil at various concentrations, both by themselves and in combination with marbel dust.

Keywords **- Pozzolanic Materials, Furnace slag, Marbel dust, Lignosulfonates, Soil Stabilization.**

I. INTRODUCTION:

Problematic clayey soil has a poor shear strength, is highly susceptible to moisture, is cohesive by nature, is incredibly unstable, and is prone to volumetric shrinkage. Approximately 23% of India's land area is made up of clayey soil, mostly in the country's centre. The majority of these locations have these deposits, with an average depth of 3.6 metres. Clayey soil is often stabilised by admixtures, such as cement, Marbel dust, fly ash, rice husk ash, furnace slag or blends of

The fundamental concept of employing these minerals to enhance clayey soils several admixtures. These are included because pozzolonic minerals (SiO_2 and Al_2O_3) are abundant in these waste items.is based on the pozzolonic interaction between the pozzolonic elements and Marbel dust. A cementitious compound is produced when pozzolonic minerals are added to clayey soils and react with the Marbel dust that is provided as an admixture. This specific chemical is responsible for the enhanced properties of the clayey soil.

Based on studies for California bearing ratio (CBR) and compaction conducted by Yadu and Tripathi (2013), it was shown that 3% of fly ash + 6% GBS was the optimal amount for stabilising soft soil. Jha and Gill (2006) evaluated the use of rice husk ash (RHA) as a pozzolona for improving Marbel dust treatment of residual soil and found that the addition of RHA increased the strength and durability of the soil. The results of the compaction test demonstrated that the maximum dry density and optimal water content of the soil dropped as the RHA concentrations increased.

The CBR values increased with the addition of RHA in both the soaked and unswollen samples. This work discusses the use of lignosulfonates in combination with marbel dust to improve clayey soil. Lignosulfonates and cement were both utilised in (Bilal Salman, et al. 2014). Marbel dust should be used in this experiment instead of cement because lignosulfonates contain a considerable amount of pozzolonic components.

II. MATERIALS USED IN STUDY:

2.1 Marbel dust

Since calcium carbonate ($CaCO_3$) makes up the majority of marble, this compound is the predominant component of marble dust's chemical composition. The precise makeup may differ slightly based on the particular marble variety and any impurities found in the original rock. Marble dust may also include trace amounts of other minerals and elements present in the source rock, in addition to calcium carbonate. Nonetheless, calcium carbonate is the main ingredient that gives marble its distinctive qualities.

Fig. 1 Lignosulfonates

2.2 Marbel dust

In cohesive soils with a high plasticity index, marbel dust interacts with the preexisting clay elements. This reaction makes the soils less malleable and more drawn to water, which makes it easier to pulverise soils treated with Marbel dust. Because marbel dust has the capacity to bond, treated soil gains strength as well.

III. EXPERIMENT VALUES:

Liquid Limit 38.85%, Plastic Limit 18.38%, Plasticity Index 21.53%, OMC 18.17%, MDD 1.74 gm/cc, Specific gravity 2.69, CBR 2.1, UCS 2.78 kg/cm2, and Indian Soil Classification (CI) are the outcomes of geotechnical properties.

3.1 LIGNOSULFONATES

The pulp industry uses sulphite pulping techniques to remove cellulose from wood, which results in lignosulfonates. In order to create raw liquor for heating the wood, sulphur dioxide (SO_2) is combined with an aqueous base solution during the sulfite pulping process. Sulphur dioxide and water combine to make sulphurous acid (H_2SO_3), which breaks down and eventually sulfonates lignin by substituting a sulfonate group for a hydroxyl group. This allows lignin to become soluble and separate from cellulose in a non-precipitated form.

IV. MIXINGS PROPORTIONS:

In the early phases of the experiment, lignosulfonates were added in percentages of 3%, 6%, 9%, and 12% by soil weight as stabilisers. In the second step, combinations of marbel dust and lignosulfonates were used in the following ratios: 2:1, 3.5:1.5, 4.5:2.5, and 6.5:3.5.

V. RESULTS AND DISCUSSION:

5.1 Liquid Limit

Table 1: Atterberg Limits for LS: S

Lignosulfonates: Soil	*L.L%*	*P.L%*	*P.I%*
0:100	37	17.5	20.5
3:97	35	16	20
6:94	33	15.5	18.5
9:91	32	15	18
12:88	31	14.5	17.5

Table 2: Atterberg Limits for S: L: LS

Soil: Marbel dust: Lignosulfonates	L.L%	P.L%	P.I%
100:0:0	35.5	16.5	20
97:02:01	34.5	17	20
95:3.5:1.5	34.5	17	17
93:4.5:2.5	31	19	14
90:6.5:3.5	29	18	13

5.2 Result of compaction test

Table 3: Test Results for S: LS

Soil: Lignosulfonates	MDD	OMC%
100:0	16.5 Kg/m^3	17.5
97:03	16.4 Kg/m^3	18.4
94:06	16.30 Kg/m^3	18.8
91:09	16.18 Kg/m^3	19.2
88:12	16.14 Kg/m^3	19.5

Table 4: Compaction Test Results for S:L:LS

Soil: Marbel dust: Lignosulfonates	MDD	OMC%
100:0:0	16.5 Kg/m^3	16
97:2:1	16.3 Kg/m^3	17.4
95:3.5:1.5	16.2 Kg/m^3	17.8
93:4.5:2.5	15.90 Kg/m^3	19
90:6.5:3.5	15.85 Kg/m^3	20.1

5.3 CBR Test Results

For soil with Lignosulfonates, the CBR values are 2.2, 2.5, 2.9, and 3.6 at 97:3, 94:6, 91:9, and 88:12, respectively, and 5.85, 6.5, 7.45, and 9.55 after 14 days of curing. For the soil, Marbel dust, and Lignosulfonates combinations, the corresponding values are 5.1, 8.15, 13.05, and 14.2 at 97:2:1, 95:3.5:1.5, 93:4.5:2.5, and 90:6.5:3.5. The CBR results are 13.3, 19.25, 31.05, and 34.5 after 14 days of cure, in that order.

Table 5: Compaction Test Results for S:LS

Soil: Lignosulfonates	CBR value	CBR value after curing
100:0	2	5
97:3	2.2	5.85
94:6	2.5	6.5
91:9	2.9	7.45
88:12	3.6	9.55

Table 6: Compaction Test Results for S:LS

Soil: Marbel dust: Lignosulfonates	CBR value	CBR value after curing
100:0:0	5	13
97:2:1	5.1	13.3
95:3.5:1.5	8.15	19.25
93:4.5:2.5	13.05	31.05
90:6.5:3.5	14.02	34.5

5.4 UCS Test Results

Table-7 Results of UCS Testing for Soil and Lignosulfonates at Initial and 14-Day Curing

Soil:Lignosulfonates	UCS value (kg/cm2)	UCS value after curing	Cohesion Property	Result after curing
100:0	02.64	04.95	01.33	02.52
97:03	03.05	06.59	01.53	03.32
94:06	03.59	08.09	01.80	04.19
91:09	04.49	09.49	02.35	04.78
88:12	04.04	08.71	02.15	04.47

Table-8 Results of UCS Tests for Soil, Marbel dust, and Lignosulfonates at Initial and 14-Day Curing

Lignosulfonates:Marbel dust: Soil	UCS (kg/cm2)	UCS after curing	Cohesion	Cohesion after curing
0:0:100	2.71	5.25	1.33	2.4
01:02:97	5.14	7.25	1.81	3.7
1.5:3.5:95	5.32	11.98	2.79	5.89
2.5:4.5:2.5	7.60	16.24	3.49	8
3.5:6.5:90	6.97	15	3.47	7.47

VI. DISSCUSSION:

The liquid limit that results from adding 3%, 6%, 9%, and 12% of Lignosulfonates is 35%, 33%, 32%, and 31%, in that order. When 6.5% Marbel dust and 3.5%Lignosulfonatesare added, it is seen that the liquid limit drops to 29%. Since the plastic restriction for virgin soil is 17.5%, the plastic limit was lowered to 14.5% upon the addition of 12% Lignosulfonates. The results of the plastic limit test indicate that the sample containing 4.5% Marbel dust and 2.5% Lignosulfonates has a higher plastic limit of 19% after the addition of Marbel dust and Lignosulfonates.

The PI value solely decreases in the case of Lignosulfonates, going from 20.5% for virgin soil to 17.5% at 12% Lignosulfonates. Parallel to this, the PI value for Lignosulfonates + Marbel dust decreases from 20% for raw soil to 13% with 6.5 Marbel dust and 3.5 Lignosulfonates addition. The mechanisms of cation exchange, flocculation of clay particles, carbonation, and pozzolonic reactions may be responsible for these differences in the plasticity qualities of soil with the addition of Lignosulfonates and Marbel dust. Because pozzolonic reactions are a time-dependent phenomenon, extended cure is necessary. Because carbonation uses weak cementing chemicals, it may negatively affect the treated soil's strength.

The virgin soil's MDD is 16.50 kG/cumec; however, when 9% Lignosulfonates was added to the raw soil alone, the MDD dropped to 16.18 kG/cumec. The findings of the compaction test, which involved adding Marbel dust and Lignosulfonates to raw soil, demonstrate that the MDD gradually decreased. The effect of Marbel dust and Lignosulfonateson the treated soil's maximum dry density may result in a decrease in the treated soil's density, which may be caused by differences in the specific gravities of the virgin soil and the soil-Marbel dust mix. The bulking of soil caused by water addition may be the reason of the treated soil's decreased density.

The low unit weigh could be caused by capillary forces that oppose particle rearrangement against compressive energy. The addition of 12% Lignosulfonates to virgin soil resulted in an increase in OMC for raw soil, according to standard proctor test results. The findings of the compaction test conducted on virgin soil samples after Marbel dust and Lignosulfonates were applied demonstrate that the OMC rose to 20.10% following the addition of 6.5% Marbel dust and 3.5% Lignosulfonates. The greater water required for the exothermic reaction between the pozzolonic materials and CaO in the various treated soil situations could be the cause of the rise in OMC.

The findings of the CBR test indicate that the soil's CBR value has slightly improved, rising from 2.2 for virgin soil to 3.60 for soil that has had 12% Lignosulfonates added to it. On the other hand, the maximum CBR value achieved after 14 days of sample curing is 9.55 when 12% Lignosulfonates is added. As a result, this CBR increment is insufficient, and in order to get better results, Marbel dust, an excellent binding ingredient, must be added with Lignosulfonates.

Good results are obtained when Marbel dust and Lignosulfonates are added; the CBR value increases to a maximum of 14.20 when 6.5% Marbel dust and 3.5% Lignosulfonates are added. It is found that this ratio increases the soil's CBR value to the greatest extent possible. However, after the samples are allowed to cure for 14 days, the highest CBR value that can be achieved with the addition of 3.5% Lignosulfonates and 6.5% Marbel dust is 34.50. A 2% to 3% increase in CBR is seen following a 14-day curing period for the samples.

After adding 9% Lignosulfonates, the soil's UCS value improved to 4.49 kg/cm², compared to 2.64 kg/cm² for virgin soil. Following a 14-day curing period, the treated samples' unconfined compressive strength rose by over 2%, or 9.49 kg/cm², following the addition of 9% Lignosulfonates. When 4.5% Marbel dust and 2.5% Lignosulfonates are added to soil, the results indicate that the UCS value increases to 7.60 kg/cm². The UCS increased to a high of 16.24 kg/cm² for the 4.5 Marbel dust and 2.5 Lignosulfonates sample after these samples were cured for 14 days.

Strength indicators, such as CBR value and unconfined compressive strength, improve mostly as a result of the pozzolonic reaction that occurs when Marbel dust and Lignosulfonates are applied to the soil. There are two main and secondary mechanisms that result in the cementitious reaction between the admixtures and clay minerals. A binder is created during the initial step of hydration, often known as the primary phase, and it is this binder that holds the soil particles together. Strength growth occurs during the secondary step when the pozzolonic elements in the clay react with the CaOH generated during the primary stage to form a cementitious gel. When Marbel dust is added, the strength is increased to its maximum potential and then may begin to decrease or remain constant. The low friction and cohesiveness of Marbel dust itself may be the cause of this occurrence.

VII. CONCLUSIONS:

It was studied how strong the soil, Marbel dust, and Lignosulfonates combination were. The following lists the key conclusions:

The CBR value of clayey soil does not significantly improve when Lignosulfonates is used alone as a stabiliser. Therefore, in order to achieve the desired outcomes, a binder must be used in addition to Lignosulfonates.

To stabilise the soil, a dosage of 2.5% Lignosulfonates and 4.5% Marbel dust by weight of soil can be considered ideal. The compressive strength of the soil increases with 4.5% Marbel dust and 2.5% Lignosulfonates, going from 2.64 kg/cm² for virgin soil to 7.60 kg/cm² (without curing) and 16.24 kg/cm² (14 days curing). The results indicate that UCS increased by 65% without curing and by 83.5% after 14 days of cure. The liquid and plastic limits decreased as the amount of Lignosulfonates increased, which in turn caused the soil's plasticity index to decline. On the other hand, adding Marbel dust to Lignosulfonates results in a slight increase in the plastic limit but a drop in the liquid limit. The maximum dry density dropped and the ideal moisture content rose as the percentage of Lignosulfonates increased. The same outcomes were seen when Lignosulfonates was also added to the Marbel dust.

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