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Effect of Iron Dust on Lime Stabilized CL Soil

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Abstract - Clayey soil is highly problematic soil that covers almost all regions in India. Soils with poor or inadequate engineering properties were usually removed and replaced or design would be changed to suit the weak soil. This would often be expensive and time consuming. In this context, soil stabilization is an attractive alternative for its simplicity and economy. Cost can be minimized by replacing certain portion with industrial wastes. Soil stabilization using industrial waste materials has become trendy from the point of view of environment and economy. Use of industrial solid wastes in geotechnical fill applications can be an effective avenue for waste management purposes. The current study is to improve various engineering properties of the lime stabilized CL soil by using waste material Iron dust. Iron dust which is mixed with lime stabilized soil at different percentage (0%, 2, 4, 6 and 8%) by weight of soil. The use of lime and Iron dust may serve as an effective and efficient way to stabilize the soil and minimize disposal problem caused by the waste materials.

Keywords—: Soil stabilization, Lime, Iron dust, Atterberg's limits, OMC (Optimum Moisture Content), MDD (Maximum Dry Density).

1. INTRODUCTION

Soil Stabilization is the alteration of soils to enhance their engineering properties. Stabilization can increase shear strength, control the shrink-swell properties of a soil, improving the load bearing capacity of a sub-grade to support pavements and foundations. Chemical stabilization involves use of chemical agents for initiating reactions within the soil for modification of its geotechnical properties. Stabilization of soil is carried out by adding lime, cement, coconut coir, fly ash, plastic fiber etc. with the soil. Studies indicate that cement manufacturing is the third largest CO_2 producers. For every one tons of cement production, 1.25 tons of CO_2 is released in the air. Bituminous stabilization is also used for road surfacing all over the world, but has its own disadvantage mainly due to energy loss during heating and it's dependent on machines to ensure maximum production and quality had a negative effect on the environment and human exposed to the hazardous emissions produced in the industry.

Due to rapid industrialization and urbanization more than 15 million tons of waste are released to the environment each year but only 200 tons are collected, transported and treated well and the rest of the waste from industrial zones is directly disposed without treatment. These industrial waste affect the environment very badly. Industrial waste causes air, soil and water pollution that are harmful to people health. One of the effective method for the disposal of these industrial wastes is it to use for soil stabilization. Thus soil stabilization using industrial waste materials has become trendy from the point of view of environment and economy. Use of industrial solid wastes in geotechnical fill applications can be an effective way for waste management purposes.

Lime chemically transforms unstable soils into structurally sound construction foundation. The use of lime in stabilization creates change in engineering behavior in soil, including improved strength, improved resistance to fatigue and permanent deformation, reduced swelling, improved resilient properties and resistance to the damaging effects of moisture. There are mainly three types of lime soil reaction occurred in lime stabilization. They are cation exchange, flocculation and pozzolanic reaction.

Iron is the 4th most element in the earth's crust and it makes up about 6.2% of the earth crust by weight. Iron is an important metal which is widely used in India in every field. As a result a large quantity of Iron powder or Iron dust generated from different fields. Iron powder metallurgy has a rich heritage under the branch of powder metallurgy. Iron powders also termed as zero valent iron (ZVI) powders are basically manufactured under three branches namely physical, chemical and mechanical processes. The increasing amount of waste iron is one of the major environmental issues. The large amount of wastes originates from the industrial sector. This are usually disposed in the landfill creating more problems. In the current work weak soil is improved by using industrial waste iron dust as an admixture along with lime. In this study the optimum percentage of lime is taken as 4% which shows maximum improvement in properties of CL soil.

2. LITERATURE REVIEW

Bell, F.G., (1996) conducted lime stabilization of clay minerals and soils. Clay soil can be stabilized by the addition of small percentages by weight of lime, thereby enhancing many of the engineering properties of the soil and producing an improved construction material. Kaolinite, montmorillonite and quartz were subjected to a series of tests. All materials experienced an increase in their optimum moisture content and a decrease in their maximum dry density, as well as enhanced California bearing ratio, on addition of lime. Some notable increases in strength and Young's Modulus occurred in these materials when they were treated with lime. The optimum gain in strength appears to be with 4-6% lime.

Arash Barazesh et al., (2012) studied the effect of adding Iron powder on Atterberg's limits of clay soils. In this research, iron powder combined with clay soils in order to examine its effects on the Atterberg's limits of the soils. Five different types of soil with initial plasticity indices of 26, 31, 35, 39, and 49 are used for this experiment. Plasticity indices (i.e. LL, PL, and PI) of the sample soils combined with different percentages of waste iron powder examined and compared with the plasticity of the original soils.

Ankith et al., (2013) conducted a study on soil stabilization using lime. Addition of quick lime on soil release heat, it can evaporate additional moisture present in soil. Initial mixing produce migration of calcium ions from hydrated lime to soil and displaces water ions. This causes reduction in plasticity index. Lime acts immediately and improves various property of soil such as resistance to shrinkage during moist conditions, reduction in plasticity index, increases in CBR value and subsequent increase in the compression resistance with the increase in time.

Kumar M Rupas et al., (2015**)** studied soil stabilization using Iron Powder. In this study deals with the stabilization of Black Cotton Soil using waste Iron Powder. Results showed that Maximum Dry Density and CBR values were improved after the addition of Waste Iron Powder to the soil. It is recommended to replace 6% of Iron Powder in Soil to get maximum dry density, higher CBR Values which are the indicators of strength of a soil.

K J Osinubi et al., (2015) conducted cement modification of tropical black clay using iron ore tailings as admixture. In this research, natural soil was treated with up to 4% cement and 10% IOT by dry weight of soil. Specimens of treated soil compacted with British Standard light, BSL or standard Proctor were subjected to index, sieve analysis, compaction, and shear strength parameters tests. Results showed that properties of the modified soil improved when treated with cement–IOT blends. Microanalysis of the natural and optimally (4% cement/6% IOT) modified soil using scanning electron microscope (SEM) showed a change in the fabric orientation of the soil particles.

Khatate et al., (2017) studied the Stabilization of Black Cotton Soil by Using Iron Dust. This study use industrial waste material like Electric Arc Furnace Dust (EAFD) iron dust and dolime fine for the soil improvement.

Rajpura et al., (2017**)** studied the application of Industrial waste Iron sludge for subgrade soil stabilization-A Case Study of Bagodara-Dhandhuka Highway, Gujrat. This Study reveals the benefit from adding 20% Iron Sludge for Soil stabilization can save 83,950 Rs per 100 m of 7.5 meter wide stretch. From results it is clear that Industrial waste similar to iron sludge can be utilized for soil stabilization and it is economical.

D M Kruthika et al. (2018) studied the combined effect of recycled plastic mesh and iron powder on strength properties of soft subgrade soil. Results showed that 6% was the optimum percentage of iron powder .With the introduction of plastic mesh in soil sample, the CBR value has increased 3.2 times to the normal soil.

Pandit et al., (2018) studied the effect of Iron Dust on Compaction Characteristics of Soil. Black cotton soil was mixed with iron dust at different percentage (0%, 1.5%, 3%, 4.5%, 6%) by weight of soil. Addition of iron dust in the soil from 0% to 3 %, OMC increases and MDD decreases. Further addition of Iron dust in soil OMC decreased and MDD increased. Result concluded that optimum point of Iron dust was 3%.

3. OBJECTIVES OF THE STUDY

- To identify and classify the natural soil by performing experiments.
- To study the Atterberg's limits of soil with different percentage of Iron dust on lime stabilized soil.
- To study the compaction characteristics with different percentage of Iron dust on optimum lime stabilized CL soil.

4. MATERIALS USED

A. Soil

The soil used for this investigation was brought from Attingal, Trivandrum, Kerala. The soil samples were obtained from a depth of 1.5m. The properties of soil are shown n Table 1.

TABLE 1. SOIL PROPERTIES

Properties	Value
Natural moisture content	17%
Specific Gravity	2.67
Clay Fraction (IS 2720 PART 4)	54%
Silt Fraction (IS 2720 PART 4)	38%
Sand Fraction (IS 2720 PART 4)	8%
Liquid Limit (IS 2720 PART 5)	33%
Plastic Limit (IS 2720 PART 5)	19.5%
Shrinkage Limit	29.83%
Plasticity Index (IS 2720 PART 5)	13.5%
IS classification	CL
Optimum Moisture Content (IS 2720PART 7)	24%
Maximum Dry Density (IS 2720 PART 7)	1.63g/cc
UCC Strength (IS 2720 PART 10)	67.67kN/m^2

B. Lime

Hydrated lime used for the study was collected from Akshar Chemical & Exim Co. Pvt Ltd.

TABLE 2. Composition of hydrated lime (source: from manufacturer)

Constituent	Percentage (%)
SiO_2	6.21
$Al_2 O_3$	2.18
$Fe_2 O_3$	3.57
CaO	59.47
MgO	3.91
Na_2O	0.61
K_2O	0.79
TiO_2	0.3286
$P_2 O_5$	0.208
MnO	0.2785
SO_3	0.58

C. Iron Dust

Industrial waste Iron dust was collected from Gogga Minerals and Chemicals, Hospet, Karnataka.

Fig. 1: Iron Dust

TABLE 3. Chemical properties of Iron Dust, (source: from manufacturer)

Properties	Percentage (%)
Ferric Oxide($Fe_2 O_3$)	98.06
Silica (SiO_2)	0.27
Alumina ($Al_2 O_3$)	0.83
Sulphur (S)	0.008
Specific Gravity	3.5

5. METHODOLOGY

The prime part of the study is to determine the geotechnical engineering properties of the collected sample through various laboratory analysis. The study was carried out by performing Atterberg's limit and compaction test by adding varying percentages of Iron dust (i.e., 2, 4, 6, and 8%) with constant lime content (4%).

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6. RESULTS AND DISCUSSIONS

A. Atterberg's Limit

Liquid limit, plastic limit and plasticity indexes of CL soil treated with Iron dust and optimum lime is presented in table 4.

TABLE 4: Atterberg's limit of variousb percentage Iron dust on lime, stabilized soil

4% Lime + Iron Dust (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
4L+0I	29.5	20.2	9.3
4L+2I	27.05	20.9	6.19
4L+4I	26.2	20.9	5.3
4L+6I	24	20.9	3.1
4L+8I	23.12	20.9	2.22

From the table it can be observed that, the liquid limit value of soil treated with optimum 4% lime was found to be 29.5%, which decreased to 23.12% by the addition of Iron dust. The plastic limit remains constant for higher percentages of Iron dust. The plasticity decreased from 9.3 to 2.22% with the addition of varying percentage of Iron dust on lime stabilized CL soil.

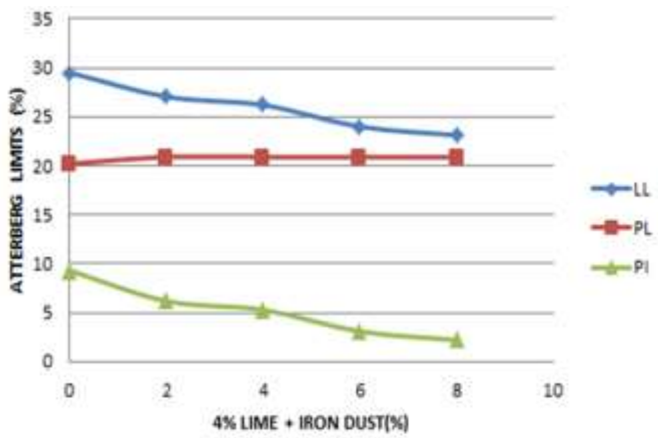

Fig. 1: Variation of Atterberg's limits with different percentage of Iron dust on lime stabilised soil

B. Compaction Characteristics

Compaction tests were conducted for optimum lime content and various Iron dust content. Addition of Iron dust on CL soil with optimum lime content causes increase in maximum dry density up to 4% and decrease in optimum moisture content. Increase in maximum dry density up to 4% is due to the high specific gravity of Iron dust.

TABLE 5: Compaction Characteristics of various percentage Iron dust on lime stabilized soil

4% Lime + Iron Dust (%)	OMC (%)	MDD (g/cc)
4L+0I	28.67	1.51
4L+2I	26.05	1.57
4L+4I	25.7	1.84
4L+6I	23	1.72
4L+8I	20.4	1.64

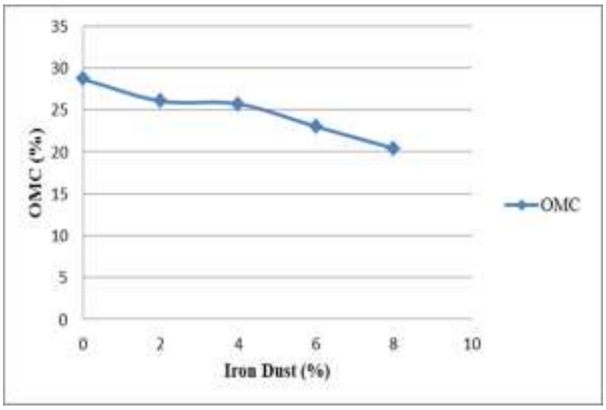

Fig. 2: Variation of OMC with different percentage of Iron dust on lime stabilised soil

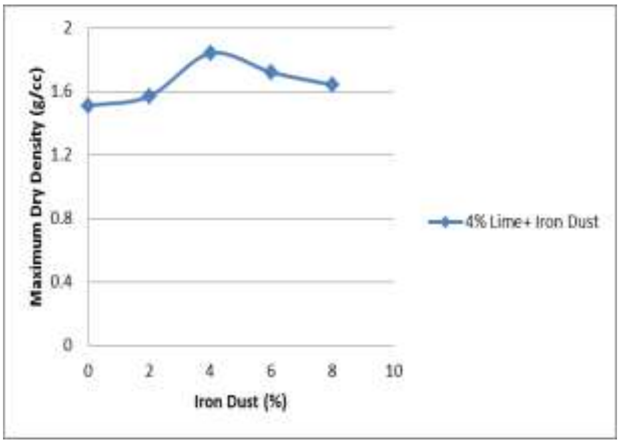

Fig. 3: Variation of MDD with different percentage of Iron dust on lime stabilised soil

7. CONCLUSIONS

The conclusions drawn from the above studies have been stated below in a quantitative form to the extent possible.

- The test results obtained in this study clearly shows that the liquid limit decreases with increase in percentages of Iron dust on Lime stabilized CL soil.

- The plasticity also decreases with increase in percentages of Iron dust on optimum 4% lime stabilized CL soil.

- The optimum moisture content decreases with increase in percentage of Iron dust on lime stabilized CL soil.

- The maximum dry density increases up to 4% Iron dust on lime stabilized soil, beyond which it is reduces.

- The optimum amount of Iron dust in 4% lime stabilized CL soil is found to be 4% by weight of dry soil.

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