Soil Stabilization using Iron Powder

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Abstract— Soil is a base of structure, which actually supports the structure from beneath and distributes the load effectively. If the stability of the soil is not adequate then failure of structure occurs in form of settlement, cracks etc. Expansive Soils like Black cotton soils are more responsible for such situations and this is due to presence of montmorillonite mineral, which has ability to undergo large swelling and shrinkage. To overcome this problem, the properties of soil must be improved. Soil Stabilization is effective technique that addresses this problem by altering the properties of soil. The present study deals with the stabilization of Black Cotton Soil using waste Iron Powder. The admixture i.e., Iron powder is blended with unmodified soil in varying percentages to obtain the optimum percentage of admixture required for soil stabilization. The results show that Maximum Dry Density and CBR values were improved after the addition of Waste Iron Powder to the soil. In this comparative study laboratory tests such as Atterberg's limits, Compaction tests and CBR tests were carried out for both modified and unmodified expansive soil.

Keywords— Expansive Soils, Soil Stabilization, Iron Powder, Optimum Moisture Content, Maximum Dry Density, CBR tests, Atterberg's limits.

INTRODUCTION

You can put the page in this format as it is and do not change any of this properties. You can copy and past here and format Expansive soils are considered problematic in construction since they undergo large volumetric changes due to seasonal variations in moisture. These soils are found in many regions of the world, especially in arid and semi-arid regions. Vast areas in Africa, Asia, and America are covered with expansive soils [1]. Due to their vast availability & easy accessibility, these soils proved to be economical and so they are widely being used in construction of road embankments, airports, pavements, and other engineering structures. On the other hand, seasonal variations in moisture have surfaced the swelling and shrinkage ability of these soils [2]. Soil stabilization is proved as an effective technique to address this problem.

Stabilization of expansive soil has been done by addition of different types of materials like Cement [3], Lime [4], and Bitumen [5]. Nowadays, the usage of waste materials for soil stabilization has become popular by considering environment and economy. Waste materials like Wood Ash [6], Steel Slag [7]-[8], rice husk ash [9]-[11], Silica Fume [12], Quarry Dust [13]-[14], Fly Ash [15]-[16] have been used to improve the properties of expansive soils.

Iron is the second most metallic element in the earth's crust and accounts for 5.6% of the lithosphere [17]. The level of per capita consumption of Iron is treated as an important index of the level of socioeconomic development and living standards of the people in any country. The usage of large quantities of iron in the present days is resulting in the generation of large amount of Iron waste. Few attempts were made in the past to stabilize the expansive soils using Iron powder. Barazesh et al., (2012) made an attempt to improve of properties of soil using Iron powder. However, the study was carried out only on the Atterberg limits [18].

In the present study, the expansive soil is replaced with different proportions of Waste Iron Powder and various tests are carried out to find the Atterberg limits, maximum dry density and California bearing ratio Values.

MATERIALS & METHODOLOGY

The Soil is collected from Vempalli Mandal located in Kadapa District, Andhra Pradesh. The Properties of the soil sample are given in Table 1.

Table 1: Properties of Soil Sample

Liquid Limit (%)	48
Plastic Limit (%)	22
Plasticity Index (%)	26
MDD (gm/cc)	1.545
Optimum Moisture Content (%)	23.08
California Bearing Ratio (%) Soaked	0.69
Specific Gravity	2.6
Soil as per IS 1498	CI

Iron Waste Powder is collected and sieved through BS sieve 75μm. Laboratory investigations are carried out on pure soil and soil mixed with Iron Powder in accordance with the BIS specifications and their results were analyzed and compared. Atterberg's limit tests were carried out on the material passing 425 microns for clayey soil samples with and without Iron Powder in accordance to IS: 2720 – Part 5 [19]. Maximum dry density, optimum moisture content and California bearing Ratio values were ascertained in accordance with IS: 2720 - Part 7 and Part 16 respectively [20]-[21]. The soil is tested under different proportions of Soil & Iron powder and the properties of soil (i.e., Atterberg limits, Maximum Dry Density, Optimum Moisture Content and California Bearing Ratio values) were found and these properties are compared with the original properties of soil.

RESULTS & DISCUSSION

The results of liquid and plasticity limits of the soil which is stabilized with different percentages of Iron powder are tabulated in Table 2 & are shown in Figure 1 and Figure 2. From the results, it can be observed that liquid limit values are decreasing with the percentage increase of Iron powder in soil. The Plastic limit remained constant at different soil & iron powder proportions. The Plasticity Index (P.I) decreased with increase in percentage of Iron powder.

Table 2: Atterberg limits with Replacement of Iron Powder

Replacement of Iron Powder in Soil (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
0	48	22	26
2	47	22	25
4	45	22	23
6	42	22	20
8	41	22	19

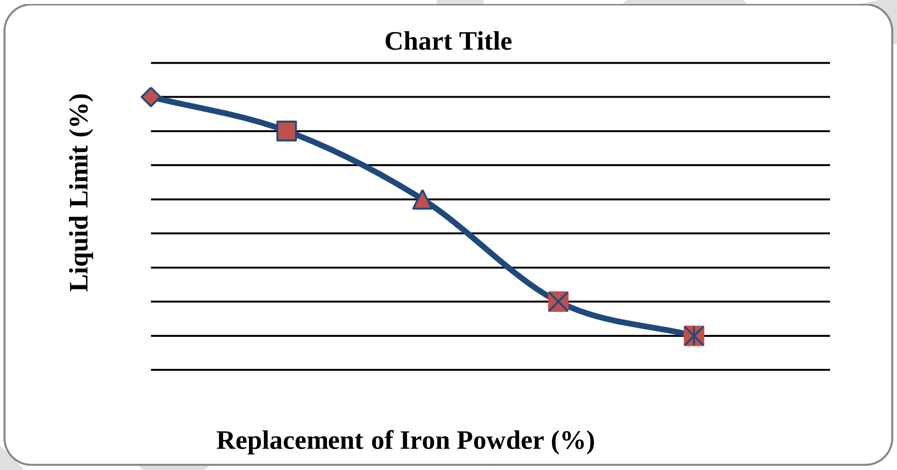

Figure 1: Variation of Liquid Limit with Iron Powder

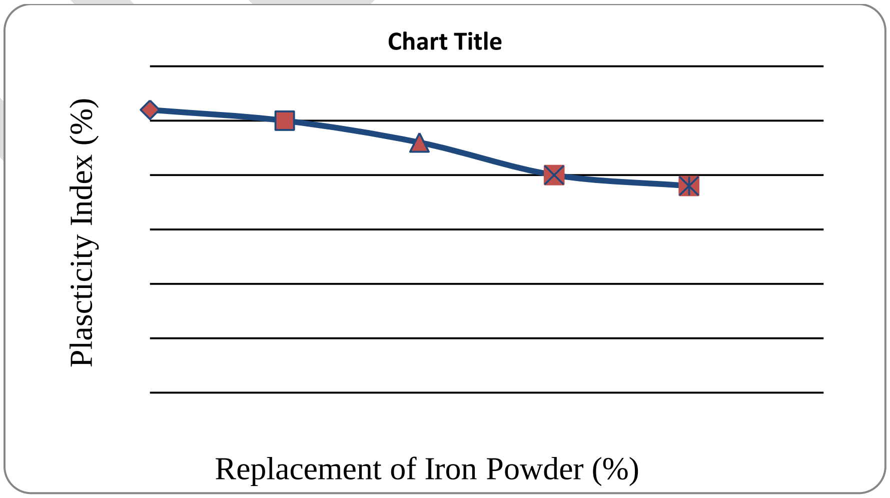

Figure 2: Variation of Plasticity Index with Iron Powder

The density of soil is an important parameter as it controls the strength, compressibility, permeability of a soil. In the present investigation a series of compaction tests were also carried out by varying soil and Iron Powder proportions. For each sample, corresponding Maximum Dry Density (MDD) and Optimum Moisture Content (OMC) values are found. The results are presented in the Table 3. It was observed from the results that the Maximum dry density increased till 6% replacement of Iron Powder and decreased further. It can also be figured that Optimum Moisture Content is decreasing with the percentage replacement of Iron Powder.

Table 3: OMC and MDD with replacement of Iron Powder in Soil

Replacement of Iron Powder in Soil (%)	OMC (%)	Maximum Dry Density (gm/cc)
0	23.08	1.545
2	21.04	1.579
4	20	1.61
6	22	1.74
8	15.4	1.637

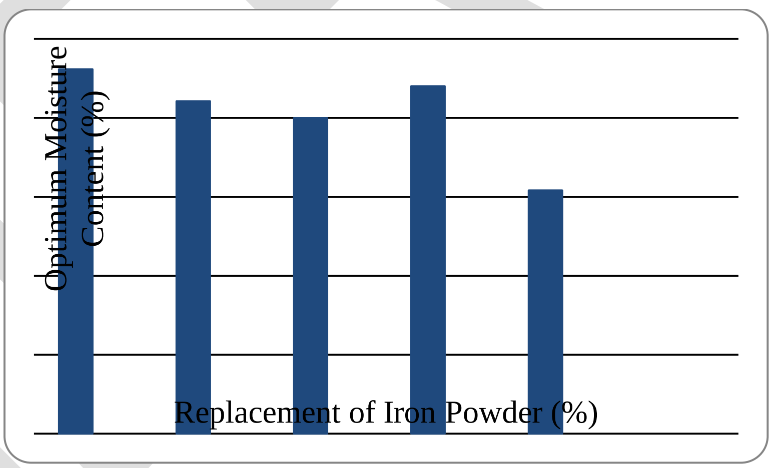

Figure 3: Variation of Optimum Moisture Content with replacement of Iron Powder

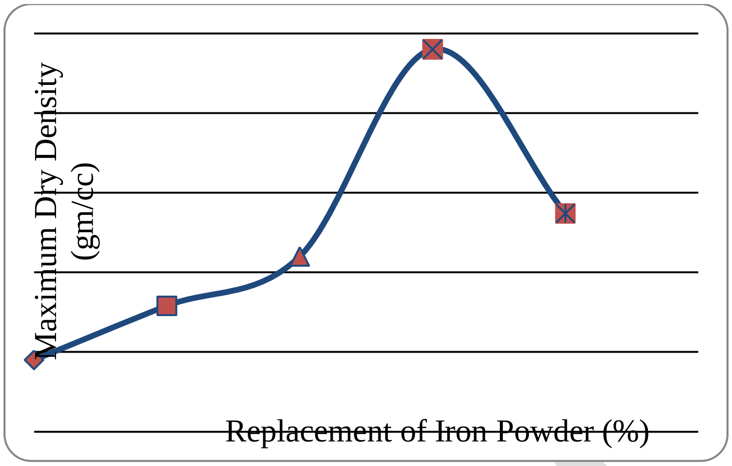

Figure 4: Variation of Maximum Dry Density with replacement of Iron Powder

California Bearing Ratio (CBR) test is a penetration test for the evaluation of strength of soils & flexible pavements. In the present, the test was conducted by varying the percentages of Iron powder in Soil as shown in Table 4 & Figure 5. From the table, it can be observed that the C.B.R values are increasing with increase in percentage of Iron Powder indicating the strength of soil is improved with the addition of Iron Powder.

Table 3: California Bearing Ratio (%) with replacement of Iron Powder in Soil

Replacement of Iron Powder in Soil (%)	C.B.R Value (%)
0	0.69
2	1.99
4	2.832
6	3.93
8	4.87

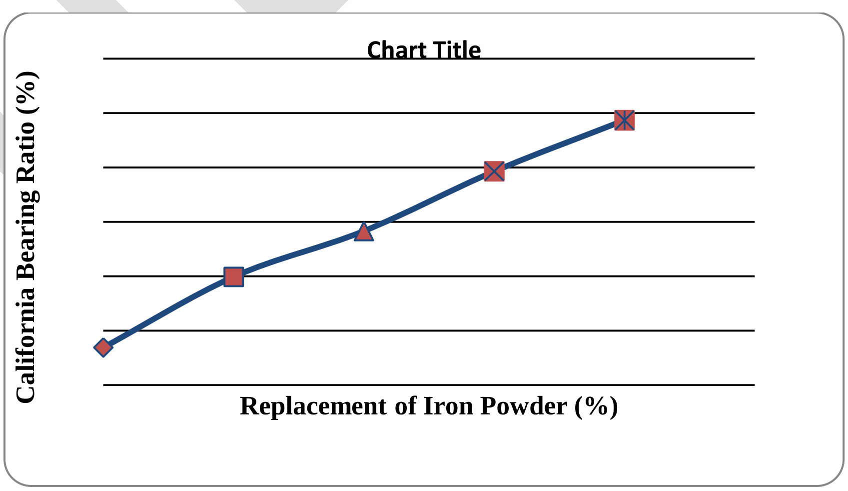

Figure 5: Variation of CBR with Iron Powder

CONCLUSIONS

An experimental investigation was carried out to study the improvement in geotechnical properties of an expansive soil stabilized with waste Iron Powder. The following conclusions are drawn from this study.

The liquid limit values are decreasing with the percentage increase of Iron Powder in the soil, while the Plastic limit remained constant. The Plasticity Index (P.I) decreased with increase in percentage of Iron Powder in Soil. The Maximum dry density increased upto 6% replacement of Iron Powder and decreased further. It was also observed that increase in the percentage of Iron powder in soil is resulting in higher CBR values. By the comparison of the tests conducted (Atterberg's Tests, Compaction Tests and CBR Tests), 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.

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