Stabilization of Clayey Soil using Steel Slag

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Abstract— *In modern days, engineers have to face different kinds of problems like construct heavy structure, heavy mobility. But some places on earth soil have poor engineering properties like bad workability, low bearing capacity and strong compressibility. So in order to improve the strength of soil, add some stabilizers. The aim of this study is to improve the engineering properties of clayey soil using steel slag. Specimens are prepared to know the properties of soil with percentage of 4%, 8%, 12%, 16% and 20% steel slag mixture passed through 180 micron and 300 micron sieve. Standard proctor test, unconfined compressive strength, liquid limit and plastic limit tests are performed to analysis compressive strength, Maximum dry density (MDD) and optimum moisture content (OMC) of soil mixture.*

Keywords— OMC, MDD, UCS, Steel Slag

I. Introduction

Soil stabilization is that term in which engineering properties of soil are changed with the help of another material and improve the engineering properties of soil. Need of soil stabilization is because of bigger structures, heavy mobility, railway tracks and poor strength quality of soil etc. In that case if soil surface is not strong enough so that will be cause of accident. In present due to improvement in industrial areas as well as improvement in their wastages and their wastages can be used as stabilizer admixture. To improve strength of soil, add some admixtures in order to improve the engineering properties of soil. There are many admixture are widely used as stabilizer like fly ash, cement, lime, slag, stone dust etc.

Clayey soil has property of plasticity due to water. It is hard, non-plastic and brittle at drying state. These types of change in property create problems on work. To solve this problem some stabilizers are mixed. Steel slag is produced when steel is in the process of making. There are many factors like fineness, carbon content, iron content, gradation etc., mainly control the strength of soil treated with steel slag.

This thesis is concentrated on the change in properties of soil due to steel slag mixture.

II. Objectives of the Study

The thesis is focused on

1) Improvement in engineering property of locally available soil.
2) Reducing the plasticity of soil to achieve more stable soil.
3) Determination of strength of soil by using standard proctor test and unconfined compressive strength test and how soil's plastic limit and liquid limit results are obtained.
4) Gain of strength characteristics of soil using different percentage of steel slag.

III. Materials

A. Soil

About 80 kg clayey soils were collected from Kaithal (Haryana) and remove impurities in college soil lab. After that soil was grind and passed in sieve through 4.75 micron to remove the fraction of gravel and prevent impurities. Soil was oven dried for 24 hours before performing of tests.

S. No.	Parameters	Result
1.	Light Compaction Test – MDD (gm/cc) – OMC (%)	 1.55 24.16
2.	Liquid Limit (%)	45.05
3.	Plastic Limit (%)	21.49
4.	Plasticity Index (%)	23.56
5.	Specific Gravity	2.54
6.	Indian Soil Classification	CI

Table 1: Physical properties of Soil

B. Slag

Around 20kg of Steel slag was taken from steel industry at Jagadhari (Yamunanagar). The steel slag was oven dried and sieved from 180 microns and 300 microns. The physical properties of slag are:

Property	Range/Value
Specific Gravity	3.2-3.6
Unit weight, Kg/m^3	1600-1920 (100-200)
Absorption	Upto 3%

Table 2: Physical property of slag

IV. Methodology

A. Compaction Test

In this part, compaction tests are performed on parent soil and soil slag mixture. Maximum dry density (MDD) and optimum moisture content (OMC) values are obtained by performed standard proctor test (compaction test) on percentages (4%, 8%, 12%, 16%, 20%) of soil slag mixture. These values are used in unconfined compressive strength test (UCS). This test confirms to IS: 2720 (Part 7)1980.

B. Unconfined Compressive Strength

In unconfined compressive strength test (UCS), compressive stress value is obtained. In a cylindrical mould of diameter 3.8cm and height of 7.6cm. Specimen is placed in seven layers of material with the help of spoon. The inside surface of mould is lubricant with oil, avoid to any damage to sample. Sample is taken under static loading for 10 minutes to avoid any swelling in sample because of water present in specimen. After that sample extruder is used to take out the sample. Sample height will be measured for further calculation of test.

C. Atterberg's Limit Test

In Atterberg's limit test included liquid limit test and plastic limit test are performed on soil and soil slag mixture. In liquid limit test shows the water content of soil at which its behaviour changes plastic to liquid and in plastic limit test has soil sample rolling out a thread of fine portion on non-porous surface like glass. If a soil sample is not rolled out of thread 3.2 mm, soil is taken as non-plastic. Rolled out sample start break at 3.2 mm diameter due evaporation of moisture.

V. RESULT & DISCUSSION

The unconfined compressive strength test (UCS), standard proctor test and Atterberg's limit test values are obtained in laboratory. The test results are discussed in following sections:

A. Compaction Test

In standard proctor test when steel slag is mixed with parent soil the value of (MDD) is in increasing order and (OMC) value is in decreasing order. Where parent soil have (MDD) value is 1.55 gm/cc and (OMC) value is 24.16% after performing the standard proctor test. Percentage of slag is mix with soil specimen the highest result of (MDD) is 1.73 gm/cc and 1.71 gm/cc for material passed through 180µ and 300µ sieve. Where highest result of (OMC) are 22.82% and 26.13% for material passed through 180µ and 300µ sieve.

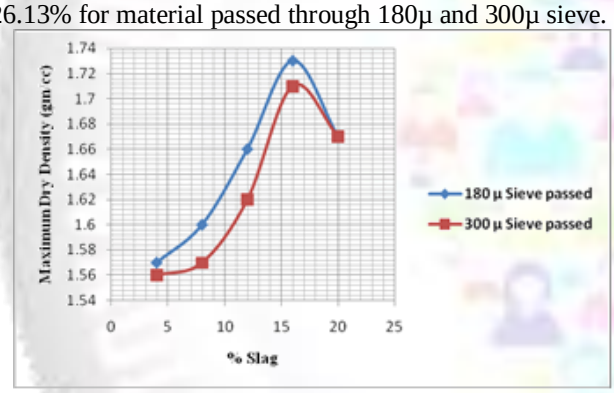

Fig. 1: Variation of MDD with Different percentage of Steel Slag for 180µ and 300µ sieve.

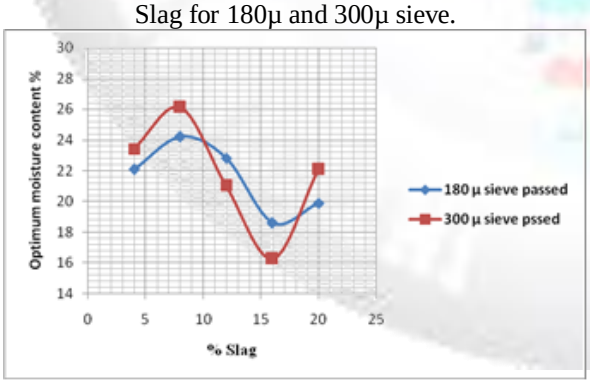

Fig. 2: Variation of OMC with Different percentage of Steel Slag for 180µ and 300µ sieve.

B. Unconfined Compression Test

The unconfined compressive quality is 3.03 Kg/cm^2 at optimum moisture content of 24.16% and MDD 1.55 gm/cc from compaction test. The unconfined compressive strength of the soil mix with steel slag shows increasing strength for some samples with the increment of steel slag. The result of UCS shows increasing order in strength.

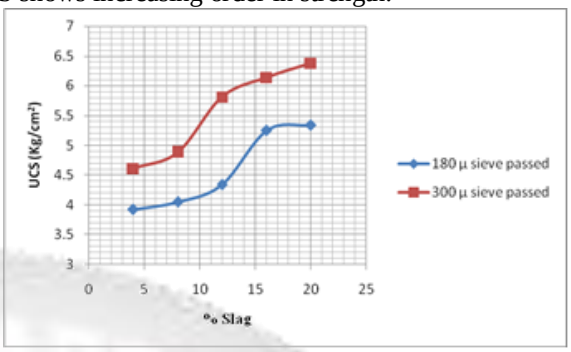

Fig. 3: Variation of UCS with Different percentage of Steel Slag for 180µ and 300µ sieve.

C. Atterberg's Limit Test

The liquid limit and plastic limit of samples show decreasing trend as we add % of steel slag for parent soil liquid limit is 45.05%, plastic limit is 21.49%, and plasticity index is 23.56% due to fineness of slag.

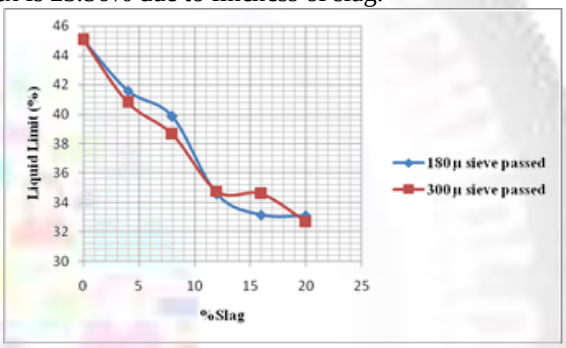

Fig. 4: Variation of Liquid Limit with Different percentage of Steel Slag for 180µ and 300µ sieve.

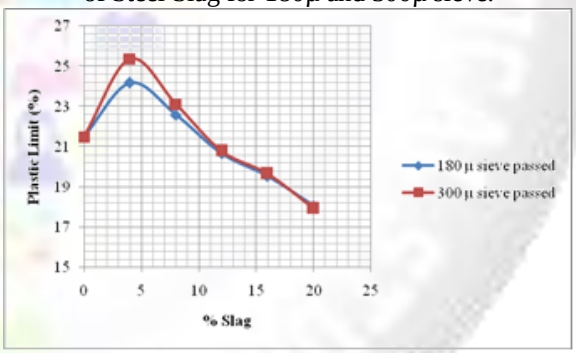

Fig. 5: Variation of Plastic Limit with Different percentage of Steel Slag for 180µ and 300µ sieve.

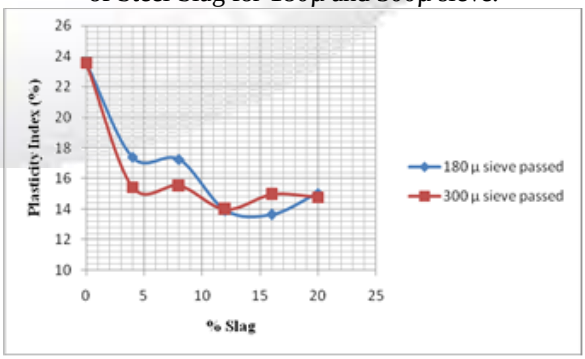

Fig. 6: Variation of Plasticity Index with Different percentage of Steel Slag for 180µ and 300µ sieve.

VI. CONCLUSION

A. Conclusion

In this project, strength characteristics of clayey soil with steel slag have been studied. The following conclusions can be made based on the test results. With the addition of slag percentage in the soil the maximum dry density in increasing order and the optimum moisture content start decreasing at both slag passed through 180 µ and 300 µ sieves.

1) The MDD result shows the increasing trend for soil slag mixture and OMC results shows the decreasing trend for soil slag mixture.
2) In UCS, the unconfined compressive strength of soil slag mixture having increasing trend.
3) There are many factors like gradation, carbon content, iron content and fineness etc., mainly control the Strength of soil treated with steel slag.
4) Samples are fails by vertical cracks and sudden failure.
5) The result of Plastic Limit increases at upto 8% of steel slag mixture with parent soil and start decreasing after 8% of steel slag mixture. And Liquid Limit results start decreasing for steel slag mixture with parent soil.
6) Due to friction between particles of steel slag, Liquid Limit result has been decreasing. Plasticity index is in reducing manner for slag passed through 180 µ and 300 µ sieves.

B. Scope of Further Studies

We know a major problem associated with socio-economic development of a country is waste disposal. Safer disposal of Industrial waste has become a challenging job. Improving properties of soil become an important matter today. There are many alternatives available in doing the same. Here are some suggestions made for further studies using steel slag.

1) Steel Slag size and percentage can be made varying in results.
2) Similar study can be made at different moisture content.
3) Other type of soil can be used for further studies.
4) Different waste material from agricultural land, municipality or industrial can be used to improve the soil characteristics.

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