Stabilization of Black Cotton Soil by the Waste Paper Sludge (Hypo-Sludge)

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***Abstract*: In this paper present investigation is to assess the usefulness of industrial waste as a soil admixture, and focused to improve the compressive strength of the black cotton soil. Waste paper sludge ash (WPSA) is waste product from the Paper mill industries. The WPSA can produce a cementitious material because WPSA contains a large amount of CaO while it is pozzolanic material. WPSA is incinerated from waste paper sludge. In this present study the soil sampling was done at local site Jabalpur. The soils were classified as CH as per Indian Standard Classification System. Different percentages of waste paper sludge ash i.e. 5%, 10%, 15% and 20% were used to stabilize the black cotton soil. The soil was evaluated using physical and strength performance tests such as specific gravity, plasticity index, compaction, California bearing ratio (CBR) and unconfined compressive strength test (UCS). From the results it is observed that at the optimum percentage of 10% WPSA shows improvement in unconfined compressive strength (UCS) from 165 KN/m2 to 357.37 KN/m2 soil samples. Furthermore California bearing ratio (CBR) values improved from 5.1 % to 8.86 % for soil samples.**

Keywords: Waste paper Sludge Ash, Soil Stabilization, Unconfined compressive strength, California bearing ratio.

1. Introduction

Civil Engineers face many difficulties when construction activities are to be done in expansive soils such as Black Cotton Soil because of their unconventional behaviour. These soils have large tendency to swell and shrink with respect to variation moisture content, thus causing serious problem to the structures build on them. The high cost of repairing the damaged structures has drawn attention to the need for more reliable investigation of such soils and necessitates methods to eliminate or at least reduce the effect of volume change in the soil and increase the strength. Soil stabilization aims at increasing or maintaining the stability of soil mass and chemical alteration of soils to enhance their Engineering Properties.

The rapid industrialization has resulted in generation of large quantities of wastes. These materials possess problems of disposal, health hazards and aesthetic problem. Most of the wastes do not find any effective use and create environmental and ecological problems apart from occupying large tracts of valuable cultivable land. It has been observed that some of these wastes have high potential and can be gainfully utilized in stabilization works. The utilization of the industrial solid wastes Stabilization works will help in solving the environmental pollution problems associated with the disposal. In the present work materials such as Blast furnace Slag, Cement Kiln Dust, Cattle Waste Ash and Hypo-sludge is being used for stabilization of soil and their effect is being studied on the Unconfined Strength of Black Cotton Soil.

2. Literatures Reviews

Anupam et.al (2010) studied the efficiency of FA, RHA, and BA in increasing the load bearing capacity of medium compressible clay soil underlying a road to be constructed. The admixtures were mixed with the soil at 5 percentage equal intervals up to 35 % replacing the soil by part. Shrinkage limit, OMC and CBR increased and MDD decreased with addition of these admixtures and cured for 3-28 days.

Dilip kumar Talukdar et al. (2015) examined the effect of waste paper sludge (Hypo-Sludge) in three different clay soil. The study includes Atterberg limits, the compaction, and swelling properties of three types of expansive soil. Compaction characteristics, strength characteristics and CBR values were analysis for soil treated with (0%,5%,10%,15%) of waste paper sludge and decrease in plasticity index, maximum dry density, and increase in OMC, CBR values were observed in soil treated with Lime sludge. It increases the CBR values with addition of lime mud in all types of soil sample. At 15% addition of lime sludge, the increase in CBR in 19.76% for Soil Sample1, Soil 2, and soil 3 the increases in 23.90% and 9.33% respectively.

Neva Elias (2015) presented the effect of waste paper sludge on plasticity, free swell index, compaction, unconfined compressive strength and CBR in soft clayey soil. Compressive strength was increased by adding 5% WPSA (Hypo-Sludge) about 314 KN/m^2 to 496 KN/m^2 and 284 KN/m^2 to 590 KN/m^2 of 7 days, 28 days curing period respectively. Furthermore UCS values increased 107.9% by using 5% of WPSA (Hypo-Sludge) in 28 days curing.

Norzlan K et.al (2012) presented the effect of WPSA on unconfined compressive strength and California bearing ratio of sandy clay soil. WPSA consist of 62.39% Cao, 23.25% of SiO_2 and 5.26% of Al_2O_3. It effect of waste paper sludge ash on Engineering behaviour of black cotton soil International Journal of Earth Science and Engineering ISSN 0974-5904, vol 09 No.03, june 2016,pp 188-191 189 is concluded that increase in WPSA content improve unconfined compressive strength content about 2 times by the

addition of 10% WPSA. The addition of 10% WPSA were increased the CBR values about 1.5 times in unsoaked condition and 3.6 times in soaked condition compared with untreated soil sample.

Hypo sludge (R. Srinivasan, et.al,1999) determined the optimum percentage replacement of cement with hypo-sludge. The optimum replacement percentage was found to be 30%.

3. Materials and Methods

3.1. Black cotton soil

Black cotton soil is the main material used in this study and the sample shown in Figure 1 was collected from Bilahari, District Jabalpur, Madhyapradesh, India at an approximate depth of 1.5 m from ground level. The sample was collected in large quantity and the sample was in Black color.

Table 1 Physical properties of Black cotton soil

Properties	Values
Liquid Limit (%)	64
Plastic Limit (%)	27.63
Shrinkage Limit	10.48
Plasticity Index	36.37
Specific Gravity	2.58

3.2. Hypo Sludge (Paper Waste)

Hypo Sludge is also called as Paper waste shown in Figure 2 which is produced from pulp and paper industries and belongs to the group of organic wastes. They fall into two general classes with regard to their physical state, viz. suspended and dissolved. Most effluent pollution difficulties arise from this waste result in the discharge of fairly coarse suspended matter composed largely of fibre and other organic debris. The specific gravity of the collected paper waste is 2.39 and its chemical composition was given in the Table 3.

Table 2 Physical properties of waste paper sludge ash (WPSA)

Properties	**Values**
Specific Gravity	**1.65**
Particle size distribution **Sand** **Silt** **Clay**	 **0.08** **99.92** **0.0**
Classification (ASTMC618)	**Class- C**

Table 3 Chemical Properties of Hypo Sludge

Chemical Properties	**Hypo-Sludge**
Silicon Dioxide(SiO_2)	5.28 %
Calcium Oxide (CaO)	47.84 %
Magnesium Oxide (MgO)	6.41 %
Sulphur Trioxide	0.19 %
Aluminium Oxide (Al_2O_3)	0.09 %
Ferric Oxide (Fe_2O_3)	0.73 %
Loss of Ignition	38.26 %

4. Mix Proportion

Following mix has been prepared by mixing soil with different percentage of Hypo-sludge.

1) Soil+ 0 % Hypo-sludge
2) Soil+ 5 % Hypo-sludge
3) Soil+ 10 % Hypo-sludge
4) Soil+ 15 % Hypo-sludge
5) Soil+ 20 % Hypo-sludge

5. Methodology

Replacement of soil by Hypo-sludge of 5%, 10%, 15% and 20% were chosen for research work. The laboratory testing been done in this study to determine the physical properties of Black cotton soil and Hypo-Sludge samples such as particle size distribution, specific gravity, atterberg limit, moisture content, compaction characteristic and natural moisture content. All the entire testing based on BS 1377:1990.

Unconfined Compression Test

This is a quick and simple testing to determine the compressive strength. The samples were mixed and compacted at maximum dry density and at optimum moisture content. After that the specimen were extruded from the moulds into cylindrical specimens of 38mm diameter and 76mm high based on BS 1377-7:1990 for unconfined compressive test (UCT).

Table -4: Value of UCS for Hypo sludge

Mixed Used	UCS (KN/m2) for Hypo sludge
Soil + 0 % Hypo Sludge	165
Soil + 5 % Hypo Sludge	325.5
Soil + 10 % Hypo Sludge	357.37
Soil + 15 % Hypo Sludge	323.63
Soil + 20 % Hypo Sludge	320.16

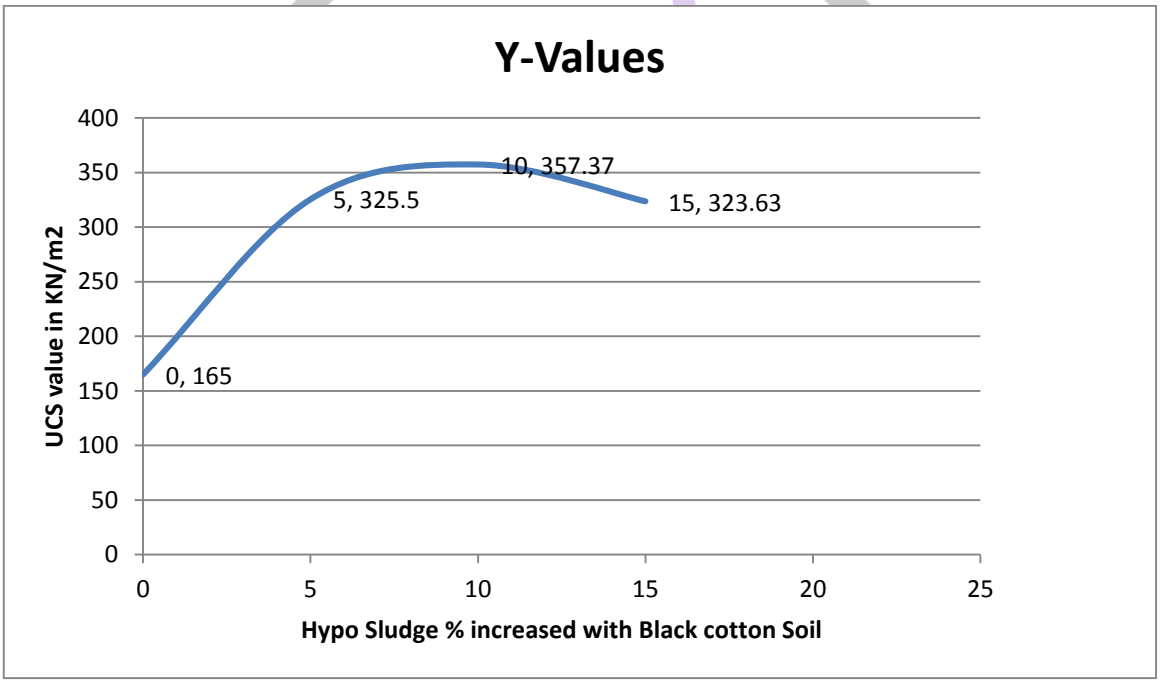

Fig 1 USC value with increase % of Hypo sludge in Black cotton Soil

California Bearing Ratio (CBR) test

California Bearing Ratio (CBR) test is conducted to determine the CBR value of the samples and to evaluate the effective of clay or Black cotton soil sample stabilized using Hypo-Sludge. This test carried out based on the standard procedure given in BS1377-4: 1990 and ASTM D1883. CBR defined as the ratio of the load sustained by the specimen at 2.5 or 5.0 mm penetration to the load sustained by standard load aggregates at corresponding penetration level. This laboratory study involved the CBR test for soaked and unsoaked condition of clay soil sample stabilized with optimum percentage of WPSA. The samples were prepared with its optimum moisture content and were compacted at their maximum dry density using static compaction machine.

Table 5 Value of CBR for Hypo sludge

Mixed Used	CBR(%)
Soil + 0 % Hypo Sludge	5.81
Soil + 5 % Hypo Sludge	7.16
Soil + 10 % Hypo Sludge	8.86
Soil + 15 % Hypo Sludge	7.67
Soil + 20 % Hypo Sludge	5.44

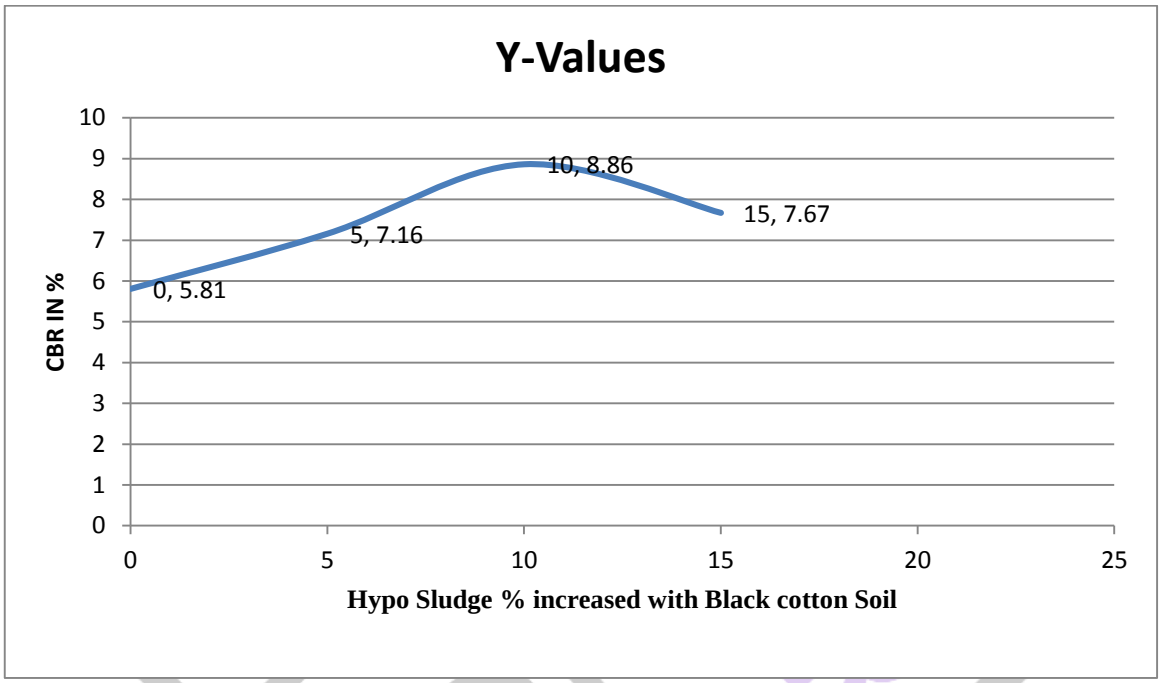

Fig 2. CBR value with increase % of Hypo sludge in Black cotton Soil

6. Result and Discussions

1) Compressive strength of soil is maximum i.e. 357.37 KN/m2 for 10.% Hypo Sludge mixed to the soil and after percentage of increase of hypo sludge slightly decrease as per table no.4 and fig 1 graph.

2) Maximum dry density followed a decreasing trend with increasing the percentage of Hypo Sludge or Lime sludge.

3) CBR value of soil is maximum i.e. 8.86 KN/m2 for 10.% Hypo Sludge mixed to the soil and after percentage of increase of hypo sludge slightly decrease as per table no.5 and fig 2 graph. The increase strength of soil of with hypo sludge 10& is 1.5 time of normal soil of CBR.

7. Conclusion

It has been identified that 10 % of Hypo Sludge with black cotton soil as additives provides optimum stabilization to the soil and it is proven with the help of unconfined compression test. The maximum strength reached by blocks at optimum percentage of Hypo Sludge wit 10 % this may be due to better Pozzolanic reaction between soil and Hypo Sludge along with the additives. The California Bearing Ratio (CBR) test conducted on clay soil stabilized with 10% at optimum percentage of WPSA and Figure 2 presents the laboratory result for CBR value for black cotton soil.

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