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AN EXPERIMENTAL STUDY OF LATERITE SOIL STABILIZED WITH WASTE PAPER SLUDGE

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ABSTRACT

In this paper to complete an difficult is made to use waste paper sludge combination with lateritic soil and also planning to find the properties such as Compaction, Shear, CBR and Durability, when lateritic soil is replaced with 0%, 2%, 4%, 6%, 8% and 10% of waste paper sludge. The result has shown that at 6% good strength towards Waste Paper Sludge.

Keywords: Laterite, WPS, Modified Proctor Test, UCC Test and CBR Test.

I. INTRODUCTION

In all around the world selection of sites with the best soil is very important in the building of any structure. For any structure foundation would be built on stable and strong soils. Some soils are so strong which can able to support a skyscraper while other soils are weak such that they are not able to support even the weight of a human. If the foundation constructed on the weak soil then there may arise some crack in the foundation or it may sink so the building may collapse. The physical properties of soil & good structure are responsible for the stability and strength of soil. Soil should withstand wet and dry cycle so that soil expansion will not responsible to produce crack in roads or foundations. If the condition is such that soil strength is very poor and in that particular site there have to build a structure. Then soil properties have to improve by any alternative methods it may be soil stabilization.

Soil stabilization means a process of changing the properties of the soil by mixing the soil with other materials or stabilizers using different methods like mechanical, alternative and chemical methods. In mechanical method of stabilization mechanical energy like rollers, tampers, compactors are used, in chemical method of stabilization oils or chemicals are mixed with the soil to improve property of soil. Soil stabilization process is applied on the situations where sub soils are not suitable for construction and construction of highways, bridges, dams, runways; buildings etc. Stabilization will improve drain ability, stability, and durability, and bearing capacity, shear resistance of soil and reduces settlement, plasticity index, swelling potential, pavement thickness. Stabilization improves the construction materials properties and considerable proportion of their strength is retained after saturation with water.

There will be reduction in surface deflection, increase in the elastic moduli of layers constructed above stabilized layer and higher in the stiffness and strength of the soil layer with the usage of admixture. Stabilization sometimes may cause shrinkage and thermal cracks which can allow water to enter into the pavement and Strength of layer can decrease due to reversible stabilization reaction by the attack of CO_2 to the material. Compare to unstabilized materials more skill is required to the construction operation.

Utilization of locally available materials for construction projects will helps to save construction cost, transportation charges and protects environment. At present environmental and economic situation, more pressures are put on engineers to find suitable methods to re-use any waste materials which are locally available so that project cost will be less and the impact of waste on environment can be minimized. In the ground improvement methods to improve geotechnical properties of soil, waste materials like scrap tires, WASTE paper sludge/ash, effluent treatment plant fly ash and sludge are also used. Waste materials acts as alternative materials to use as stabilizer in soil stabilization process. They showed good potential for improving stability and strength of weak soil. In this work, the possibility of using Waste Paper Sludge as an additive to

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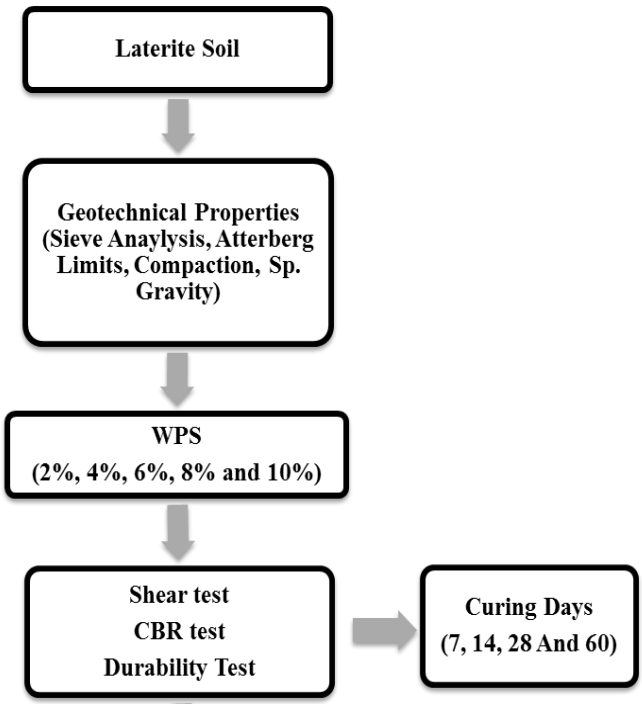
stabilize locally available laterite soil is studied.

II. METHODOLOGY



Physical and geotechnical properties of the collected LS sample and soil with the replacement of proportion 2%, 4%, 6%, 8% and 10% of WPS is determined. By the replacement of WPS to the LS properties will get modified. Stabilized soil specimens are tested for different curing days of 0, 7, 14, 28 and 60.

III. SCOPE OF THE STUDY

The proposed study is conducted to inspect the effect on the strength, durability and stability of laterite soil (LS) with the replacement of different proportion of Waste Paper Sludge (WPS). Geotechnical properties of LS were changed because of the replacement of WPS in different proportions. In this study the application of WPS can be investigated by conducting different laboratory tests. The study will reveal the effect of WPS on stabilized soils.

IV. OBJECTIVES OF THE STUDY

- To study the geotechnical properties of Laterite Soil.
- To investigate the geotechnical properties of Waste Paper Sludge mixture with LS.
- To determine the optimum moisture content (OMC) and maximum dry density (MDD) for the various mixtures.
- To determine the change in California Bearing Ratio (CBR), Shear strength with addition of different percentages of Waste Paper Sludge.

V. NEED FOR THE STUDY

Every year a large quantity of WPS is getting generated and accumulated. There are no proper methods for optimum utilization of these wastes. At present paper sludge is being used as fertilizers, fuel and in landfill, but not even 10% of WPS are reutilized. If these wastes are not reutilized then they may become hazardous for environment, Therefore there is a growing need for the study of best utilization of WPS. There are many attempts have been made by the researchers towards the study of reutilization of these wastes and have shown to be effective in protecting environment and protecting natural resources

VI. BACKGROUND

Surya et al. (2016) conducted a study on stabilized high swelling soil with 2%, 4%, 6%, 8%, 10%, 11% and 14% of WPS. Liquid limit (LL), plastic limit (PL), plasticity index (PI), Free Swelling and Proctor tests were

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conducted. LL, PL, PI and differential swelling index decreased to 34.3%, 22.48% 11.82% and 91% respectively and concluded that by adding WPS, high swelling soil properties were improved.

Usha (2016) made a study to enhance the soil property by the addition of Hypo sludge and Lime in different proportions like 0%, 2%, 4%, 6%, 8% and 10%. Atterberg limits, compaction & CBR value tests were conducted. Results shown that there will be decrease in LL, PL and PI, increase and decrease in OMC & MDD respectively by the addition of hypo sludge in different proportion and CBR value is optimum at 8% addition of hypo sludge and concluded that hypo sludge and lime are the economical waste management solution.

Santosh (2016) investigated on the clay soil by adding 2%, 4%, 5%, 6%, 7% and 10% WPS as stabilizing agent and evaluated the strength & moisture content. M.D.D decreased and O.M.C was increased by the addition of WPS. The UCC for soil enlarged to good strength with WPS addition of up to 5% it was the optimum value for strength to soil.

VII. EXPERIMENTAL INVESTIGATION

Laterite soil

Laterite is a word derived from the Latin word means brick. Laterite soil is a type of soil which is rich in iron and aluminium and is formed in hot and tropical regions. Rusty red coloration of LS is Because of the presence of more iron oxide content. LS used in this study were collected at the depth of 1m from Balladka region which is at a distance of 5km from Sullia located in Dakshina Kannada district. Wet sieve analysis, dry sieve analysis, Atterberg's limit, specific gravity and moisture content tests are conducted for the collected soil samples.

Waste Paper Sludge

Now a day WPS is the new soil stabilizing agents which used to increase any soil property. In the previous few years reuse of WPS is one very important topics of interest. The paper sludge for the study was collected from a recycled paper manufacturing company the South Indian Paper Mill, Nanjangud.

Figure 1: Collected WPS

It is in the form of fibers which is produced from the deinking process, whose texture will be soft after partially dewatered. WPS which is collected freshly will be smell less and it consists of fibers, inks, dyes, clay, glues and chemicals. Table 1 shows composition and general property of WPS respectively.

Table 1: General Properties of WPS

Properties	Description
Specific Gravity	1.33
pH	7.04
Colour	Gray

VIII. GEOTECHNICAL PROPERTIES

Specific Gravity

The test procedure of specific gravity of soil is determined by using IS: 2720 (Part III)-1980. The results are helpful in finding out the degree of saturation, void ratio and soil unit weight. Formula used to calculate the specific gravity is as follows

Specific gravity (G) = (Density of substance)/ (Density of reference substance)

Particle Size Distribution

The test procedure for Particle size distribution is calculated by IS: 2720 (Part IV) – 1985. Particle size distribution of soil is very important to know the physical, chemical properties, strength and soil load bearing

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capacity. There are 2 methods they are, wet sieve analysis and dry sieve analysis to find particle size distribution. Wet sieve analysis is done by removing fine particles that may cause delay in the method of separation. Dry sieve analysis is one simple and most commonly used technique to evaluate the particle size distribution

Atterberg's Limit

Atterberg's limit consists of liquid limit, plastic limit and plasticity index which depend on the amount and type of clay in a soil and form the basis for soil classification system. Liquid limit is the min water content where the soil is still in liquid state but it has small seeding strength against soil which is measured by using standard procedure. Plastic limit is water content where a soil just begins to crumble when it is rolled into a thread approximately 3mm in diameter. Plasticity index is the difference between liquid limit and plastic limit.

Compaction Test

Compaction is a process which is used to decrease the volume and increase the dry density of the particles of soil are rearranged artificially and packed into nearer state of contact by the mechanical means.

Depending upon the soil type the compaction (Fig 2) process can be finished by tamping, rolling or by vibration.

In this study relationship between MDD & OMC of soil using heavy and light compaction as per IS 2720 (Part7) and IS 2720 (Part 8) respectively are studied.

Figure 2: Compaction Test

Shear Test

The max loads which can transmit to the sub-soil by foundation depend on the resistance of soil. An axial load exerted at a constant weight of strain to soil specimen and increased until failure occurs. The compression load per unit area needed by soil specimen to fail is known as the unconfined compression test of soil. This UCC test (Fig 3) is applicable for cohesive soils and is determined as in IS 2720 (Part 10).

Figure 3: UCC test.

California Bearing Ratio (CBR) Test

The test procedure for CBR is carried out by IS 2720 (Part 16) – 1979. CBR test (Fig 4) was developed by California State Highway Department of USA for evaluation of subgrade strength of highway and airlift pavement.

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CBR is the load per unit area ratio needed to penetrate the soil mass by the standard rate to that corresponding required for penetration of a standard material. The standard material is one defined as having CBR value of 100%.

CBR result can be used to carry out the thickness of flexible pavement using IRC specifications.

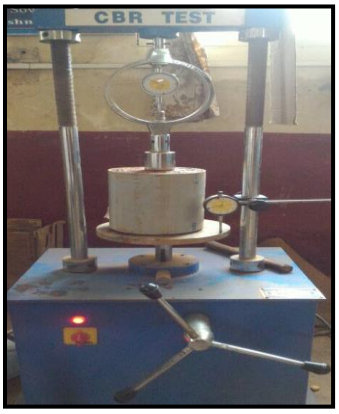

Figure 4: CBR Test

IX. RESULTS AND DISCUSSIONS

Laterite Soil

Table 2 shows the LS properties determined after testing the collected LS.

Table 2: Properties of Laterite Soil

SL No.	Property	Laterite Soil
1	Specific Gravity	2.29
2	Grain Size Distribution (%)	
	a) Gravel	5
	b) Sand	52
	c) Silt and Clay	43
3	Consistency Limits (%)	
	a) Liquid Limit	53.95
	b) Plastic Limit	30.48
	c)Plasticity Index	23.47
4	IS Soil Classification	CH
5	Engineering Properties	
	I.S Modified Compactions	
	a) MDD ϒdmax (g/mm)	3.06
	b) OMC (%)	8.35
6	CBR Value (%)	0.67
7	UCC Test	320.42

Tests like grain size analysis, LL, PI, PL, specific gravity, water content, compaction, UCC and CBR were conducted and the result were tabulated to compare with properties of stabilized soil.

Particle Size Distribution

For grain size distribution of LS dry and wet sieve analysis tests were conducted according to IS 2720 (part4) 1985.

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Wet sieve analysis

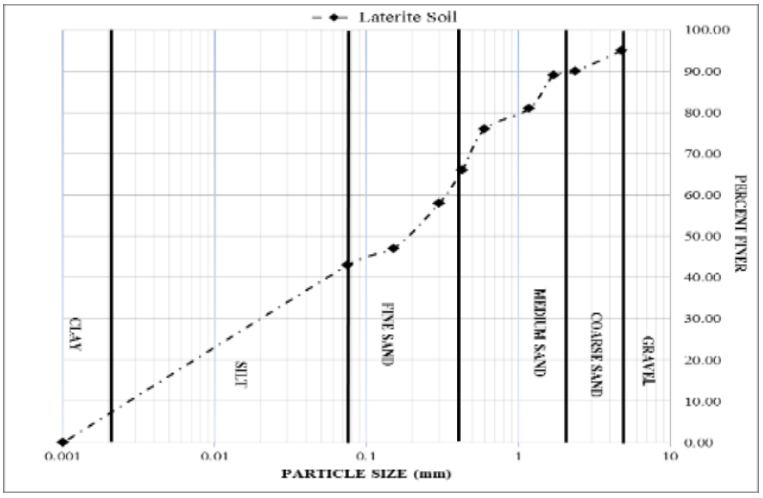

Figure 5: Grain Size Distribution of Laterite Soil by Wet Sieve Analysis

Dry sieve analysis

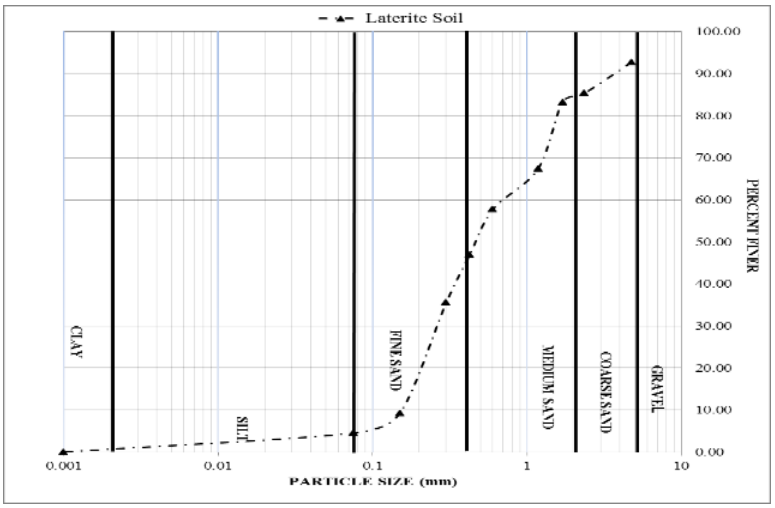

Figure 6: Grain Size Distribution of Laterite Soil by Dry Sieve Analysis

Specific Gravity

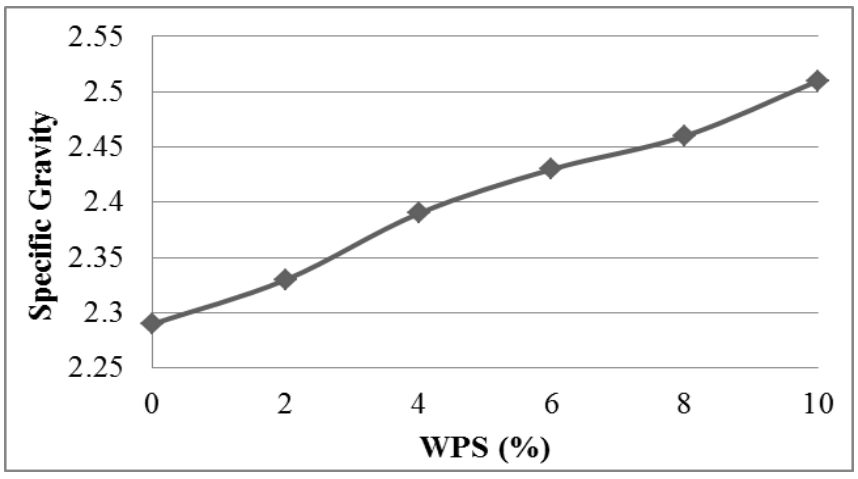

Figure 7: Variation of Specific Gravity with the replacement of varying percentage of WPS

The Specific gravity test was carrying out on LS and soil replaced with 2, 4, 6, 8 and 10 percent WPS by weight. WPS with varying proportions increases the specific gravity. This increase in the specific gravity makes soil denser.

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Atterberg's Limit

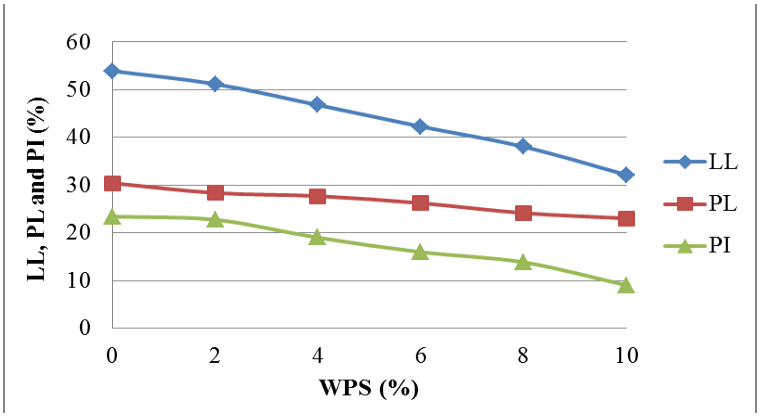

Figure 8: Atterberg's Limit with varying percentage of WPS

Atterberg's limits like LL, PI and PL tests are conducted to determine soil critical w/c and soil with replacement of different proportion of WPS content. Results are presented.

It is observed that the replacement of WPS with varying proportions decreases the LL, PI and PL up to 40.31%, 61.22% and 24.21% respectively. This decrease in the PL, PI and LL indicates improvement in soil. Here the PI value is greater than 17% therefore the soil is highly plastic. According to the IS classification of soil based on the result of LL and PI of LS, LS is classified as inorganic clay of high plasticity (CH).

Compaction Test

The compaction test was conducted on LS and soil replaced with 2, 4, 6, 8 and 10 percent WPS by weight to study the behavior of compaction. Compaction tests were conducted to find out the MDD & OMC of LS and LS replaced with different proportion of WPS.

Modified Proctor test (Heavy Compaction)

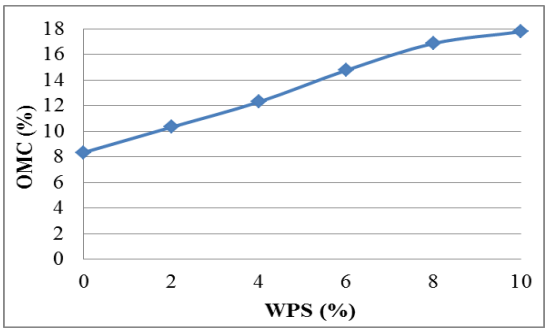

Figure 9: OMC with varying percentage of WPS

It was observe that as the replacement of percentage of WPS increases, the MDD goes on decrease and OMC get increases showing the behaviour of LS connected with the replacement of stabilizer.

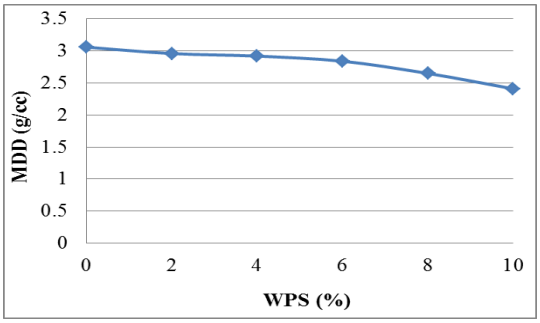

Figure 10: Variation of MDD with the replacement of varying percentage of WPS

It is observe that the value of MDD is less and OMC is more with the replacement of WPS to the LS when compared with the soil without WPS. When compared with the other percentages of WPS, replacement of 2%

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WPS to LS will provide the highest MDD. There is increase in OMC from 8.35% to 16.8% with increase in replacement of WPS to LS. The increase in OMC is about 101% is because of the replacement of WPS, which decreases the content of clay and create coarser materials that requires lot of water to compact the mixture of LS and WPS.

There is increase in MDD from 3.06g/cc to 2.51g/cc with increase in replacement of WPS to LS. The increase in MDD is about 18% is because of the replacement of WPS, which is having specific gravity 1.33 lower than the specific gravity of LS that is 2.29.

UCC Test

This results show that the UCC values get increases from 320.42 to 500.52 kN/m2 about 56.20%, 340.12 to 545.63 kN/m2 about 60.42%, 360.82 to 609.85 kN/m2. About 69.01%, 380.12 to 660.82 kN/m2 about 73.84% and 399.20 to 712.54 kN/m2 about 78.49% for 0, 7, 14, 28 and 60 days respectively up to 6% and after it get decreases. Strength and stiffness of soil increases with increase in replacement of WPS and at the same time the loss of ductile or cohesive nature of the soil will occur.

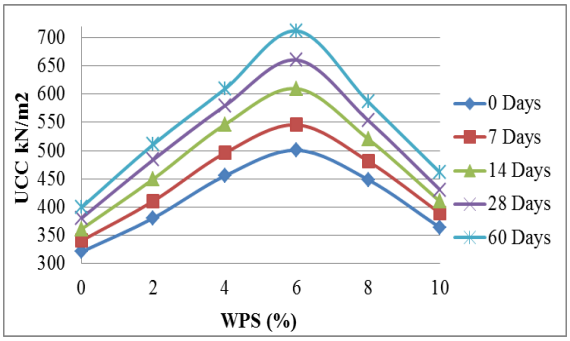

Figure 11: Variation of UCC with the replacement of varying percentage of WPS

As the axial strain decreases soil become more brittle by increasing the replacement of WPS contents. Hence After 6% replacement of WPS UCC values considerably get decreases.

CBR Test

This results show that the CBR values get increases with increase in replacement of WPS. With increase in replacement of different percentage of WPS the CBR value also get increases about 6.46%, 6.73%, 6.96%, 7.10% and 7.23% that is about 6 to 7 times the soil for 0, 7, 14, 28 and 60 days respectively up to 10%. The increase in the CBR value is because of the pozzolanic reaction and the cementation process of WPS.

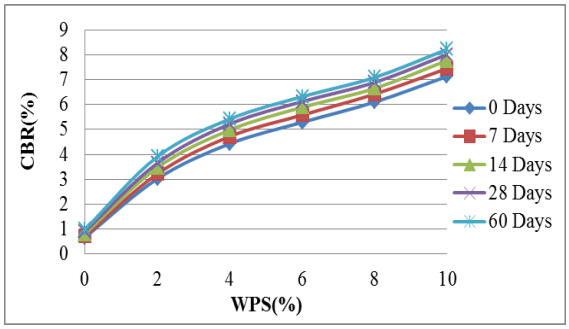

Figure 12: Variation of CBR with varying percentage of WPS

X. CONCLUSION

- In this study based on the experimental investigation, following conclusions can be made
- Increase in the replacement of different proportions of WPS decreases the LL, PL and PI about 40.31%, 24.21% and 61.22% respectively.
- Proportions of Waste Paper Sludge to the LS. Increase in OMC will decreases the clay content and forms coarser materials that needs more water to compact the mixture of laterite soil and WPS. MDD decreases with increase in replacement of WPS because of its lower
- Strength and stiffness of soil increases with increase in replacement of WPS and at the same time the loss of ductile or cohesive nature of the soil will occur. As the axial strain decreases soil become more brittle by

increasing the replacement of WPS contents. Hence After 6% replacement of WPS UCC values considerably get decreases.

- The increase in the CBR value is because of the pozzolanic reaction and the cementation process of WPS.
- Waste paper sludge is an advanced material which can be used as ground improvement material and this is an effective and efficient solution for waste management.

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