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Soil stabilization by using waste paper sludge

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ABSTRACT: An increasing quantity of people are using chemical ground treatment to enhance low-quality soils for building in order to encourage environmentally friendly building methods. Alternative stabilizers are looked after since the manufacture of traditional soil stabilizers, like cement or lime, uses non-renewable natural resources, energy, and produces a lot of carbon dioxide. Three distinct clays were treated in this study using waste paper sludge ash (PSA). The objective was to evaluate PSA's efficacy as a clay stabilization substitute for cement or lime based on its volumetric stability, water retention, unconfined compressive strength (UCS), and plasticity properties. In this study investigation carried 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 (WPS) is waste product from the Paper mill industries. The WPS can produce a cementitious material because WPS contains a large amount of CaO while it is pozzolanic material. In this present study the soil sampling was collected from Vagra region of Bharuch district. The soils were classified as CH as per Indian Standard Classification System. Different percentages of waste paper sludge i.e. 2%, 4% and 6% 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, Free swell index, California bearing ratio (CBR) and unconfined compressive strength test (UCS).

KEY WORDS: *Solid waste management, waste paper sludge ash, chemical soil stabilisation, geotechnical properties, clay soils*

I.INTRODUCTION

Soil Stabilization is the process of altering some soil properties by different methods, mechanical or chemical in order to produce an improved soil material which has all the desired engineering properties. Paper mill sludge is a major environmental problem for the paper industry. The ma terial is a by-product of the de- inking and re-pulping of the paper. The total quantity of paper mill sludge produced in annually is large quantity. The main recycling and disposal routes for paper sludge and land spreading as agricultural fertilizer, incineration in plant at the paper mill, producing paper sludge or disposal to landfill. The scope for landfills spreading is limited. Usage of paper increased to a great extent now days, results in large production of Waste Paper Sludge (WPS). A large percentage of WPS produced are used for land filling and it run out of the storage space. So, we need to find alternative uses of Waste Paper Sludge. This study explored the possibility of utilizing WPS for ground improvement schemes in geotechnical engineering applications.

Soil stabilization refers to the process of changing soil properties to improve strength and durability. There are many techniques for soil stabilization, including compaction, dewatering and by adding material to the soil. This summary will focus on mechanical and chemical stabilization based on Indian standard recommendations. Mechanical stabilization improves soil properties by mixing other soil materials with the target soil to change the gradation and therefore change the engineering properties. It also reduced the index properties. Chemical stabilization used the addition of other by-product materials to improve the soil properties. There a number of industrial waste materials that can be used individually, or mixed with other materials, to achieve soil stabilization. In present study adding waste paper sludge to soil at different percentages 2%.

In Civil Engineering Construction like Railway lines, Highway Network, Airport Runways etc are required on Soil Embankment for construction. There are various processes like chemical, mechanical, biological or combined method

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Vol. 12, Issue 5, May 2025

in order to improve soil properties such as compressibility, strength, permeability and durability. Industrialization and urbanization is a major area of every country which is growing up in each year. Industrialization is one of the areas of each country in which numbers of industries are increasing year by year. These industries manufacture many items and also produce thousands of tones waste material. Paper mill Industries is one of them which create waste material every year.

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 tende ncy 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.

Urbanization is the required for the growth of country resulting developing the lives of its country people. Civil construction is also a part of urbanization. Sometimes site engineers faces the problems in the field due to poor the strength of soil. Conventionally different materials like cement, lime and fiber etc are used to mix with soil for improving the strength of soil. These materials increase the cost of construction, results an uneconomical construction. In many industries waste materials are available which is not recycled yet for their utilizing purpose. Paper mill industries are one of them in which Waste Paper Sludge (WPS) is a waste materials dumped around the industry premise. This waste material also covers a large area to landfill. When this waste material dried in presence of sun light creates dust which leads to the air pollution in nearby areas which also affects human health.

III. LITERATURE SURVEY

Effect of Waste Paper Sludge on Engineering Behaviors of Black Cotton Soils - (R BARANI DHARAN)
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 (WPS) is waste product from the Paper mill industries. The WPS can produce a cementitious material because WPS contains a large amount of CaO while it is pozzolanic material. WPS is incinerated from waste paper sludge. In this present study the soil sampling was done on 2 different sites as per IRC recommendations. The soils were classified as CH as per Indian Standard Classification System. Different percentages of waste paper sludge ash i.e. 4%, 6%, 8%, 10 and 12% 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 8% WPS shows improvement in unconfined compressive strength (UCS) from 165 KN/m2 to 417.5 KN/m2 and 138 KN/m2 to 349.5 KN/m2 for soil samples 1 and 2 respectively. Furthermore California bearing ratio (CBR) values improved from 5.1 % to 26.4 % and 3.8 % to 18.6 % for soil samples 1 and 2 respectively.

Strength development of soft soil stabilize with waste paper sludge:
The main objective of this study is to investigate the use of waste materials in geotechnical applications and to evaluate the effects of waste paper sludge on strength development of soft soil. This review discusses the effect of waste paper sludge on stabilized soils. In this paper, attempts are made to utilize the same for the soil improvement. The application of Waste Paper Sludge (WPS) will be investigated in this study by conducting laboratory tests, compaction and unconfined compressive strength. Soil with 2% and 5% WPS have an optimum moisture content more closed to OMC of clay soil alone. The addition of WPS has increased the strength at 5% and it was found to be a constant and optimum

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Vol. 12, Issue 5, May 2025

value of strength to soil. In general it was found that WPS is a suitable waste material for strengthening soft soil. The beneficial reuse of the paper sludge also saved landfill space.

Improvement of Properties of Highly Swelling Soil by using Waste Paper Sludge:
The highly swelling soil causes major effect to structures. Due to presence of Montmorillonite mineral soil has High swelling property. Before construction we need to reduce this swelling and shrinkage
property of the soil. The main objective of our study is Stabilization of high swelling soil by using of waste paper sludge to reduce high swell at low cost and an eco- friendly method. The proctor tests results indicates that with the increase in waste paper sludge percentage there was an increase in the Optimum Moisture Content (OMC) and reduction in the Maximum Dry Density (MDD). At optimum value 14% we got good results Swelling also reduced.

Stabilization of Black Cotton Soil by the Waste Paper Sludge (Hypo-Sludge):
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 (WPS) is waste product from the Paper mill industries. The WPS can produce a cementitious material because WPS contains a large amount of CaO while it is pozzolanic material. WPS 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.

Strength Development of Soil using Waste Paper Sludge (WPS):
Soil strength development involves the process of improving geotechnical properties of soil. There are thousands of industries growing in many countries like in India, in which industrial waste become a serious problems. In those industries paper mill industry is one of them, which produce thousands of tones waste material every year. Utilization of this waste material in required civil engineering area can be proved a good additive in construction. Waste Paper Sludge (WPS) is a lime sludge wastage material come from Paper Industry generally dumped into sites around the Industries. 2 %, 4 %, 6 %, 8 % and 10 % Waste Paper Sludge (WPS) added to the soil and conducted test for analysis of strength properties of soil. Laboratory experiments results showed that 6 % is the optimum percentage of Waste Paper Sludge (WPS) which is mixed in the soil for obtained higher strength. In civil engineering construction like Railway lines, Highway Network, Airport Runways etc are required a good strength of soil embankment, where Waste Paper Sludge (WPS) become a good additive for improving strength of soil.

IV. METHODOLOGY

The proportions of Waste Paper Sludge Ash used along with the soils in the study are 2%, 4% and 6%. The following tests were conducted on the soil samples mixed at different proportions of WPS the liquid limit and plastic limit tests were conducted as per IS: 2720 (Part 5) - 1985. Heavy compaction test was carried out according to IS: 2720 (Part 8) - 1983. Unconfined compressive strength tests were conducted at OMC and MDD as per IS: 2720 (Part 10)- 1991. The California Bearing Ratio tests were conducted as per IS: 2720 (Part 16) - 1987.

The methodology adopted to achieve the objective of the project is detailed as follows. The properties of the soil get modified with the addition of stabilizers. Experiments have to be done to determine the physical properties of the soil and the change in the geotechnical properties of the soil with the addition of this amendment.

Replacement of soil by Hypo-sludge of 2%, 4%, and 6% 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 IS 1377:1990.

ISSN: 2350-0328

International Journal of AdvancedResearch in Science, Engineering and Technology

Vol. 12, Issue 5, May 2025

V. EXPERIMENTAL RESULTS

The soil stabilization used in the investigation has been collected from Vagra – District of Bharuch State in Gujarat. Laboratory investigation has been carried out to determine the engineering properties of soil without Waste Paper Sludge and with Waste Paper Sludge. It is not preferable to compact expansive soil under heavy compaction conditions as it results in higher swelling. So, compaction characteristics of the soil have been evaluated from the standard proctor test preferred by IS: 2720 (Part-7) – 1983. The result was compared with the tests that is been carried out without WPS. Here the result obtained by adding WPS with expansive soil and performing standard proctor test for the same. From the result it can be clearly seen that there is increase in maximum dry density and optimum moisture content.

Properties of the Black Cotton Soil:

Expansive black cotton soil (BCS) collected from Vagra – District of Bharuch (Gujarat) was kept for oven drying and then crushed by means of mechanical ball mixing machine. After testing physical properties of the soil, it was found to be of CH type, as per IS classification system. The properties of expansive soil are found out using standard methods prescribed in relevant IS codes (IS: 2720).

Table 1.1 Geotechnical Properties of Expansive Soil

Sr. No.	Index and engineering properties	Result	Relevant IS Code
1.	Specific Gravity	2.40	IS 2720 Part 3- 1980
2.	Atterberg"s Limits		IS 2720 Part 5- 1985
	Liquid Limit (%)	59.26	
	Plastic Limit (%)	30.98	
	Plastic Index (%)	28.28	
	Shrinkage Limit (%)	20.18	
	Shrinkage Ratio Volumetric Shrinkage (%)	1.69	
		56.08	
3.	Standard Proctor Test		IS 2720Part 7- 1980
	➢ Maximum Dry Density	1.552	
	➢ Optimum Moisture Content	18.6	
4.	Unconfined Compressive Strength – 42µ pass (kg/cm2)	0.227	IS 2720 Part 10 - 1991
5.	California Bearing Ratio (%)	17.08	IS 2720 Part 16- 1987
6.	Free Swell Index (%)	50	IS 2720 Part 40- 1977
7.	IS Classification Of Soil	CH	

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Vol. 12, Issue 5, May 2025

Evaluation of Engineering properties of black cotton soil:

Atterberg's Limit

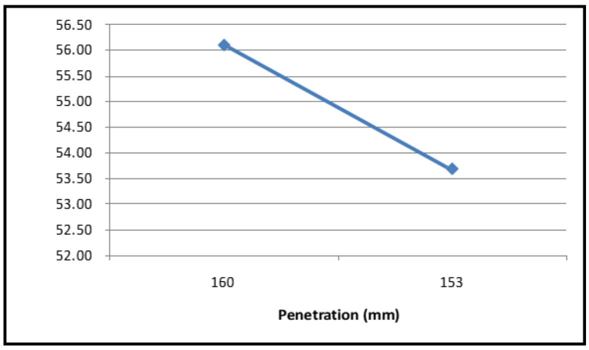

Fig 1.1 Graph of Liquid Limit

Standard Proctor Test

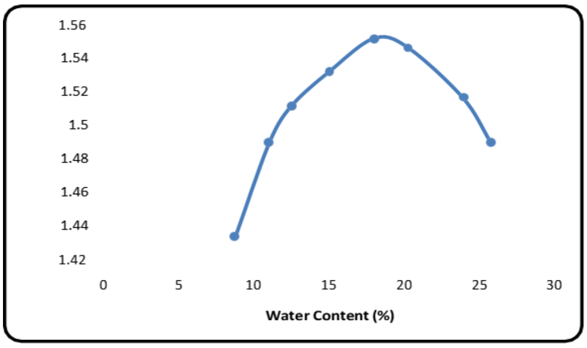

Fig 1.2 Graph OMC vs. MDD

CBR Test

Table 1.2 CBR Test Observations

Penetration(mm)	Reading	Load kg(f)
2	53	184.97
2.5	67	233.83
5	120	418.8

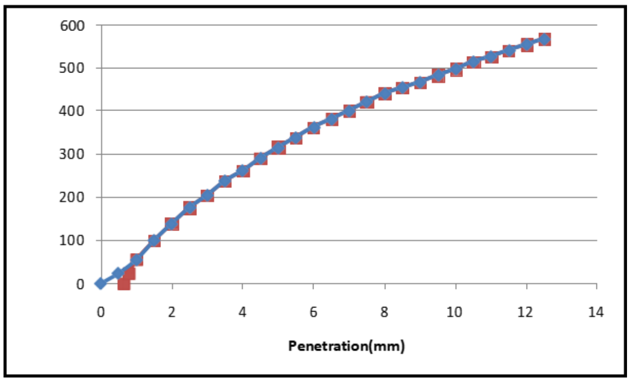

Fig 1.3 Graph of CBR Value

Free Swell Index

Table 1.3 Free swell Index Test Observations

Volume of soil sample (gm)	10
Volume of soil in distilled water (ml)	15
Volume of soil in kerosine	10
Free swell index (%)	50

Properties of expansive (black cotton) soil with waste paper sludge:

Table 1.4 Geotechnical Properties of Expansive Soil with WPS

Sr. No.	Index and engineering properties	Result			Relevant IS Code
		2 %	4 %	6 %	
1.	Specific Gravity (%)	1.5	1.19	1.39	IS 2720 Part 3- 1980
2.	Atterberg‟s Limits				IS 2720 Part 5- 1985
	Liquid Limit (%)	65.01	27.87	37.14	
	Plastic Limit (%)	64.01	37.74	30.22	
	Plastic Index (%)	71.37	32.64	38.74	
3.	Standard Proctor Test				IS 2720 Part 7- 1980
	➢ Maximum Dry Density(g/cc)	1.444	1.415	1.379	
	➢ Optimum Moisture Content (%)	26.01	24.63	22.70	

ISSN: 2350-0328
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Vol. 12, Issue 5, May 2025

4.	Unconfined Compressive Strength (kg/cm^2)	0.184	0.256	0.408	IS 2720 Part 10-1991
5.	California Bearing Ratio (%)	3.94	3.11	4.13	IS 2720 Part 16- 1987
6.	Free Swell Index (%)	36.36	28.57	20	IS 2720 Part 40- 1977
7.	IS Classification Of Soil	CH			

Evaluation of Engineering Properties of Black Cotton Soil with Waste Paper Sludge:

Atterberg's Limit

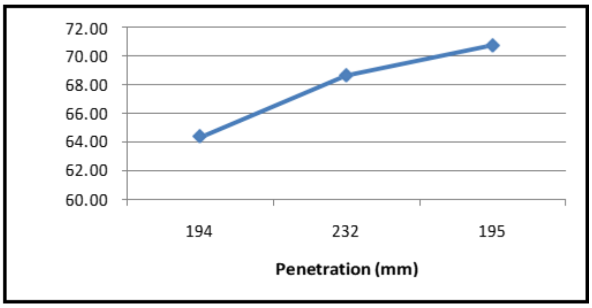

Fig 1.4 Graph of Liquid Limit using WPS of 2%, 4% and 6%.

Standard Proctor Test

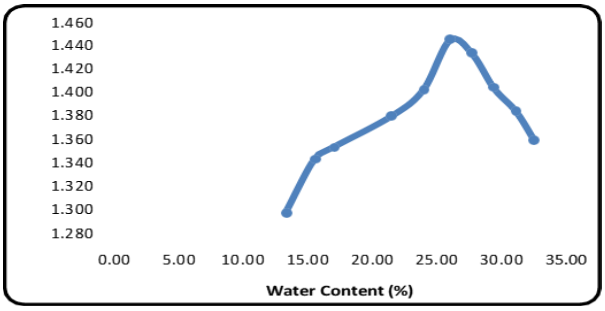

Fig 1.5 Graph of OMC v/s MDD of 2% WPS.

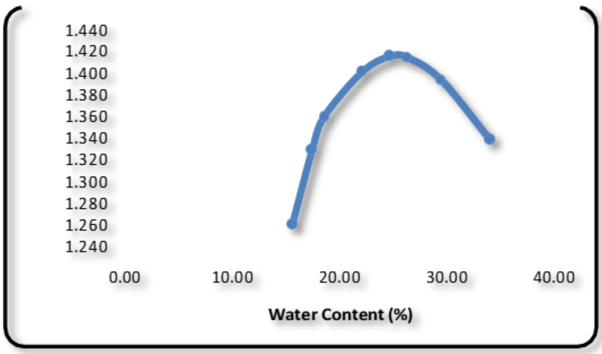

Fig 1.6 Graph of OMC v/s MDD of 4% WPS.

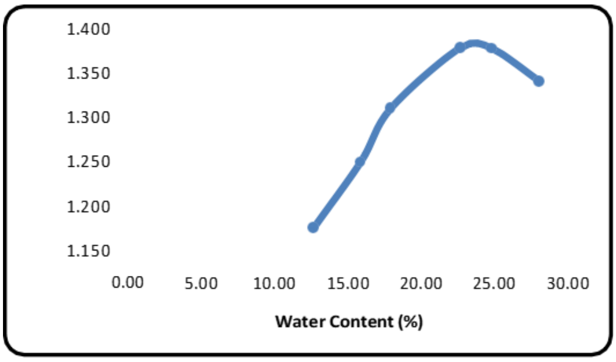

Fig 1.7 Graph of OMC v/s MDD of 6% WPS.

CBR Test

Table 1.5 CBR Test Observations using 2% WPS

Penetration (mm)	Reading	Load kg(f)
2	17.5	46.025
2.5	21	55.23
5	29.5	77.585

Table 1.6 CBR Test Observations using 4% WPS

Penetration (mm)	Reading	Load kg(f)
2	14	36.82
2.5	16	42.08
5	23	60.49

ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 12, Issue 5, May 2025

Table 1.7 CBR Test Observations using 6% WPS

Penetration(mm)	Reading	Load kg(f)
2	16	42.08
2.5	19.5	51.285
5	30.5	80.215

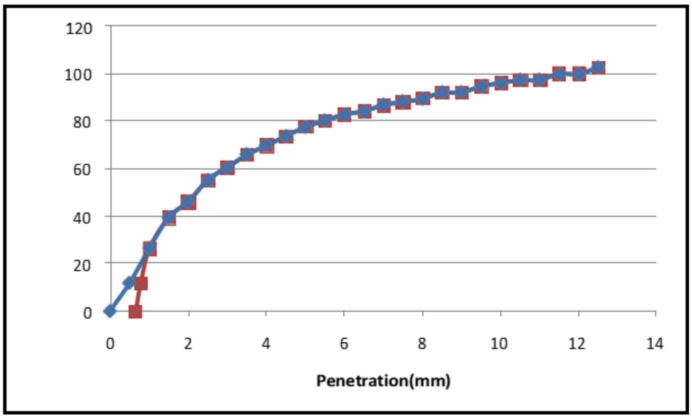

Fig 1.8 Graph of CBR value of 2% WPS.

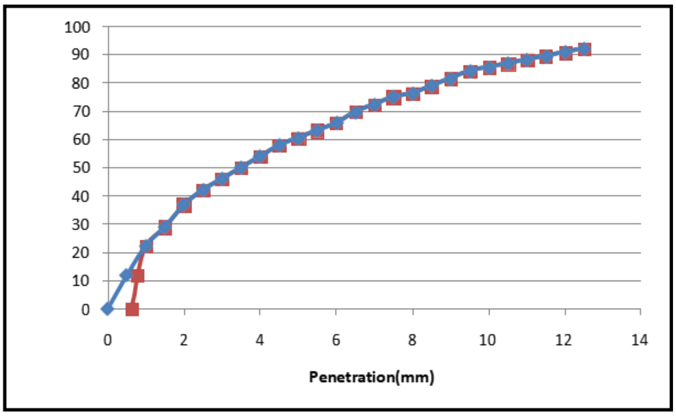

Fig 1.9 Graph of CBR value of 4% WPS.

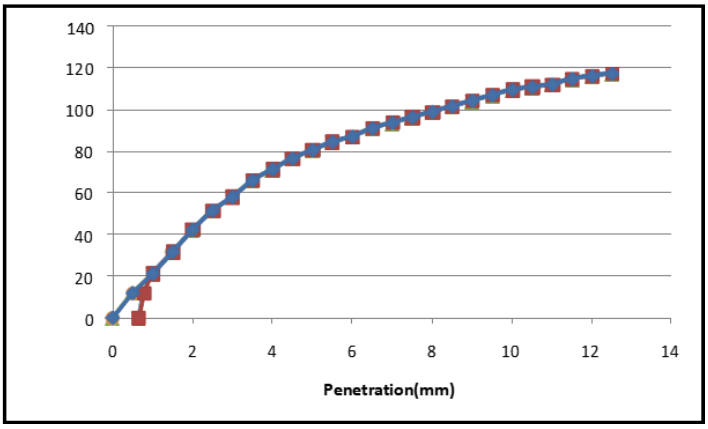

Fig 1.10 Graph of CBR value of 6% WPS.

Free Swell Index

Table 1.8 Free Swell Index using WPS in Soil

Percentage of WPS	2%	4%	6%
Volume of soil sample (gm)	10	10	10
Volume of soil in water (ml)	15	18	18
Volume of soil in kerosene (ml)	11	14	15
% Free swell	36.36	28.57	20.00

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Vol. 12, Issue 5, May 2025

VI. CONCLUSION AND FUTURE WORK

It can be further concluded that on addition of WPS to the black cotton soil the overall strength and the bearing capacity of soil increases and the free swell decreases which gives better stability and durability to the soil. The specific gravity decreases as the % of WPS increases. The Atterberg"s limit increases as the % of WPS increases. The value of MDD and OMC also decreased as the increases in the % of WPS.The compressive strength of the soil increases on addition of WPS.The CBR value also increases on increases in the % of WPS.The swelling of soil decreases on addition of WPS.As the plasticity increases the ability of the black cotton soil to regain its properties and strength also increases.The positive findings give promise for the potential of com mercial exploitation of PSA in the ground engineering/construction industry, as an alternative route to landfilling. In addition to the sav ings for the construction industry in terms of stabilisers, this would also help the paper-making industry to meet current and emerging sustainability targets by significantly reducing the costs of landfilling.

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International Journal of AdvancedResearch in Science, Engineering and Technology

Vol. 12, Issue 5, May 2025

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