

Strength Development of Soil using Waste Paper Sludge (WPS)

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Abstract - 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.

Key Words: Compaction, Compressive Strength, Road Pavement, Strength Development, Waste Paper Sludge (WPS).

1. INTRODUCTION

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 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.

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.

2. MATERIALS AND METHODS

2.1 Materials:

2.1.1 Sample of Soil: The sample of soil shown in Fig. 1 was collected from the fields of Sitarganj (Khatima), U. S. Nagar (Uttarakhand), India.



Fig. 1: Sample of soil

2.1.2 Waste Paper Sludge (WPS): Waste Paper Sludge (WPS) is a waste material shown in Fig. 2 collected from paper mill situated at Lal Kuan, U. S. Nagar (Uttarakhand), India.



Fig. 2: Sample of WPS

2.2 Methods:

2.2.1 Grain Size Analysis:

Grain size analysis of soil was performed according to IS: 2720 Part IV-1985 to determine percentage of clay, Silt and sand particles.

2.2.2 Atterberg Limit:

As per IS 2720 Part IV-1985 liquid limit, plastic limit and shrinkage limit were conducted on soil for finding out Atterberg limits.

2.2.3 Proctor Compaction Test:

The standard proctor test is used to determine optimum moisture content and maximum dry density of soil in the laboratory. In this method the soil filled into the mould in three layers and each layer compacted by 25 number of blow from a 2.6 kg hammer weight with fall of 310 mm. The process is repeated for different soil sample to determine optimum moisture content and maximum dry density. The plot between dry density and water content is drawn on graph to find out optimum moisture content and maximum dry density.

'Standard Proctor Test' is conducted as per IS: 2720 Part VII-1980 to perform experiment.

2.2.4 Unconfined Compressive Strength Test:

An Unconfined compression test is a special case of triaxial test in which no confined pressure is given to soil. Unconfined compressive strength test is simpler and quicker test to perform in the laboratory. The compressive load required to fail the UCS sample is called Unconfined Compressive Strength of soil.

'Unconfined Compressive Strength Test' is conducted as per IS: 2720 Part X-1991 to perform experiment.

3. RESULTS AND DISCUSSION

3.1 Geo-technical Properties of Soil:

A series of laboratory test performed to determine the basic engineering properties of soil. The geotechnical parameters of soil are presented in Table-1.

3.2 Standard Proctor Test:

Standard proctor tests were conducted on 2 %, 4 %, 6 %, 8 % and 10 % Waste Paper Sludge (WPS) mixed to the soil. Optimum moisture content increased and maximum dry density decreased of soil with addition of Waste Paper Sludge (WPS) up to 10 %. The relationship graph between dry density and water content plot as shown in figs. 3, 4, 5, 6 and 7 for different percentage of Waste Paper Sludge (WPS) mixed to soil.

Table -1: Geotechnical Properties of Soil

S. No.	Geotechnical Properties of Soil	
	Parameter	Results
1.	Grain size distribution	
	a) Clay size fraction	15.30
	b) Silt size fraction	61.40
	c) Sand size fraction	23.30
	Soil type as per IS: 1498 – 1970	ML – CL
2.	Liquid limit (%)	26.08
3.	Plastic limit (%)	19.18
4.	Shrinkage limit (%)	19.47
5.	Plasticity index (%)	6.90
6.	Maximum dry density (KN/m ³)	17.06
7.	Optimum moisture content (%)	16.00
8.	Unconfined compressive strength (KN/m ²)	
	a) 0 days	242.00
	b) 7 days	298.00
	c) 14 days	315.00

The relationship graph between dry density and water content plot as shown in figs. 3, 4, 5, 6 and 7 for different percentage of Waste Paper Sludge (WPS) mixed to soil.

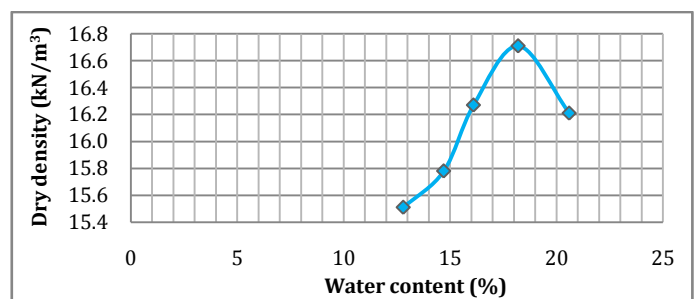


Fig. 3: Dry density and water content relation of soil with 2 % WPS

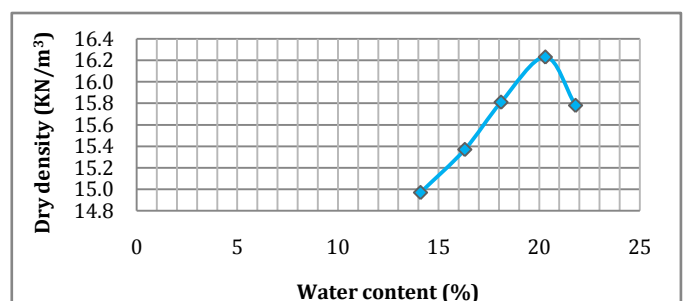


Fig. 4: Dry density and water content relation of soil with 4 % WPS

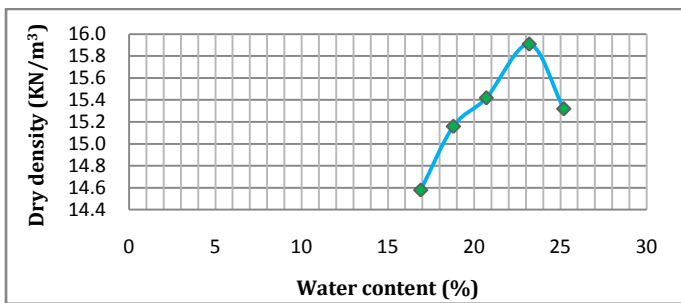


Fig. 5: Dry density and water content relation of soil with 6% WPS

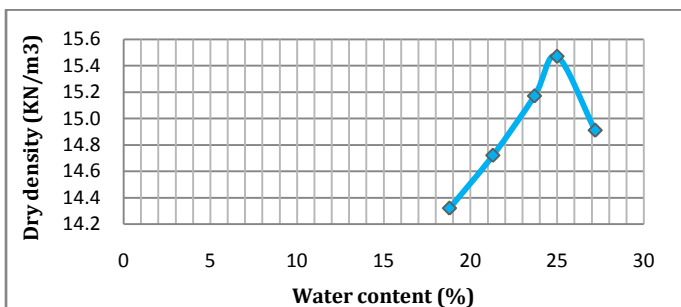


Fig. 6: Dry density and water content relation of soil with 8% WPS

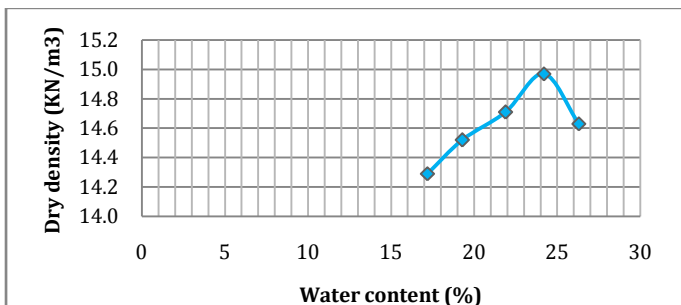


Fig. 7: Dry density and water content relation of soil with 10% WPS

The results obtained after standard proctor test for each mix of soil and Waste Paper Sludge (WPS) have been summarized in Table 2. From above graphs the value of OMC and MDD are following:

Table 2: OMC and MDD values of soil with WPS

S. No.	Material Used	OMC (%)	MDD (KN/m³)
1	Soil + 2% WPS	18.2	16.71
2	Soil + 4% WPS	20.3	16.30
3	Soil + 6% WPS	23.2	15.91
4	Soil + 8% WPS	25.0	15.47
5	Soil + 10% WPS	24.2	14.97

3.2 Unconfined Compressive Strength Test:

Unconfined compressive strength test is the special case of triaxial test when no confining pressure given to the soil sample. For unconfined strength of soil with different percentage of Waste Paper Sludge (WPS) was tested for 0, 7 and 14 days cured specimen. From test results, it was found that 6% is optimum percentage of Waste Paper Sludge (WPS) for maximum strength of soil. UCS values are summarized in Table 3, 4 and 5 for 0, 7 and 14 days respectively.

Table 3: UCS values of soil with WPS at 0 days

S. No.	Sample	Unconfined compressive strength (KN/m²)
1	Soil + 2% WPS	262
2	Soil + 4% WPS	272
3	Soil + 6% WPS	288
4	Soil + 8% WPS	279
5	Soil + 10% WPS	256

Table 4: UCS values of soil with WPS at 7 days

S. No.	Sample	Unconfined compressive strength (KN/m²)
1	Soil + 2% WPS	316
2	Soil + 4% WPS	331
3	Soil + 6% WPS	352
4	Soil + 8% WPS	324
5	Soil + 10% WPS	279

Table 5: UCS values of soil with WPS at 14 days

S. No.	Sample	Unconfined compressive strength (KN/m²)
1	Soil + 2% WPS	444
2	Soil + 4% WPS	480
3	Soil + 6% WPS	507
4	Soil + 8% WPS	496
5	Soil + 10% WPS	385

Variation of UCS with different percentage of Waste Paper Sludge (WPS) for 0, 7 and 14 days are shown in figs 8 respectively.

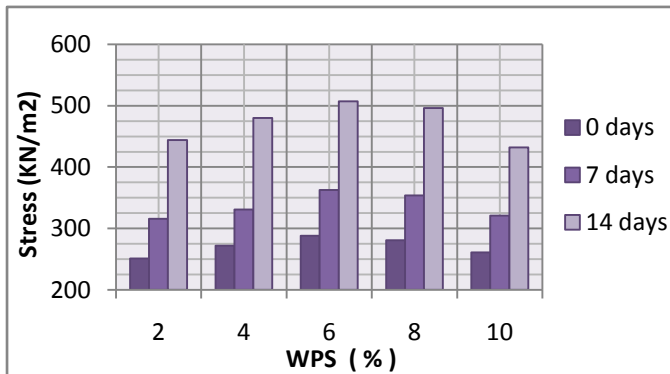


Fig. 8: Variation of UCS with different percentage of WPS for 0 days

3. CONCLUSIONS

- Maximum Dry Density is decreasing with increasing percentage of Waste Paper Sludge (WPS) mixes to soil from 17.06 KN/m² and 14.97 KN/m².
- Optimum Moisture Content increase from 16.0 % to 25.0 % with increasing the percentage waste paper sludge (WPS) to the soil.
- As the percentage of Waste Paper Sludge (WPS) increases to soil, the unconfined compression strength increased up to optimum mix.
- The Optimum percentage of Waste Paper Sludge (WPS) mixed to soil was found 6 % after conducting a series of laboratory test.

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BIOGRAPHIES



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