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# Studying and Comparing the Effects of Straw Ash and Crusher Sand on UCS of Silty Soil

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**ABSTRACT:** In present scenario a lot of research work is being carried out in the area of using locally available materials in road construction which are not only available in nearby area of construction site but give good soil subgrade strength also. Present paper describes the effects of mixing Straw ash and Crusher sand on Unconfined Compressive Strength of local silty soil of Kurukshetra (Haryana). Straw ash and Crusher sand which are generally treated as waste products found mostly in Haryana and Rajasthan states of India, can play a role of good soil stabilizer. Various experimental investigations which include Index properties determination (Specific gravity, Atterberg's limits and Wet sieve analysis), Modified Proctor Compaction tests and Unconfined Compressive Strength (UCS) tests were conducted to observe the effects of mixing Straw ash and Crusher sand to silty soil. Straw ash and Crusher sand were mixed with silty soil in various proportions starting from 2 %, 4 %, 6 %, 8 % and 10 % by weight of soil. Experimental results revealed that as the content of Straw ash and Crusher sand is increasing, the Unconfined Compressive Strength of treated soil is also increasing. After comparing UCS value of Soil - Straw ash mixture with Soil - Crusher sand mixture, it can be said that Crusher sand helps more effectively in improving UCS value of silty soil as compared to Straw ash.

**KEYWORDS:** Straw ash, Crusher sand, Silty soil, Modified Proctor Compaction test, Unconfined Compressive Strength test.

### I. INTRODUCTION

Materials specified for use in the construction of sub-grade must possess adequate strength and at the same time they must be economical for use and also conform to the quality and compaction requirements. Several methods of soil improvement using pozzolanic materials have been developed and used successfully in practice regarding various civil engineering works. In recent years the use of various waste products in civil engineering construction has gained considerable attention in view of the shortage and high costs of conventional construction materials and the increasing costs of waste disposal and environmental constraints [1].

India produces a huge amount of waste materials as by-products from different sectors like industrial, construction, agricultural, etc. These waste materials if not deposited safely, may be hazardous. A large quantity of waste material is dumped at land filling sites, which if investigated properly can be utilized in road construction sector. The utilization of these waste materials can be an economical and eco-friendly alternative in nearby areas for rural road construction. In India, research is currently underway to examine the potential for use of some locally available wastes in road construction. The results, to date, indicate that there is a wide scope for the use of such materials. However, in India, only a few materials have been used and that too on experimental basis. An attempt has been made in the similar directions for investigating the potential use of some industrial waste materials viz. cement and lime kiln dusts, quarry waste, slags, fly ash, construction & demolition wastes, rice husk ash bagasse ash, etc. for rural road construction [2].

In present study, Straw ash and Crusher sand are used as stabilizers to study their effects on UCS value of local soil of Kurukshetra which is silty soil. Soil stabilization is a proven technique for improving the performance (strength) of

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subgrade soil. Experimental Investigations consist of Evaluation of Index properties (Specific gravity, Atterberg's limits and Wet sieve analysis), Maximum dry density, Optimum moisture content and UCS tests on silty soil and silty soil treated with Straw ash and Crusher sand as additives. A series of Modified Proctor Compaction tests and UCS tests were carried out on silty soil and silty soil mixed with Straw ash and Crusher sand in various percentages i.e. 2 %, 4 %, 6 %, 8 % and 10 % by weight of dry soil.

### II. MATERIALS USED

#### A. Silty soil

In order to study the effects of local silty soil mixed with Straw ash and Crusher sand as additives, a sample of silty sub-grade soil was collected from an excavated pit inside the NIT Kurukshetra campus, Haryana state. According to IS soil classification system IS (1498) : 1970 [3], the soil is classified as silty soil of low plasticity which is fine and inorganic in nature (ML) and having the particle size between 0.002 mm and 0.075 mm.

Silt is produced by the mechanical weathering of rock, as opposed to the chemical weathering that result in clays. This mechanical weathering can be due to grinding by glaciers, abrasion (sandblasting by the wind) as well as water erosion of rocks on the beds of rivers and streams. Silt is sometimes known as 'rock flour' or 'Crusher sand', especially when produced by glacial action. Mineralogically, silt is composed of mainly quartz and feldspar. Silt has little plasticity; dries quite quickly on the hands and can be dusted off. Silt has a smooth or silky touch, but grittiness can be detected between the teeth. Lumps dry quickly, and when dry have a granular appearance and can be powdered easily [4].

Inorganic silt consists of bulky, equidimensional grains of quartz. It has little or no plasticity and is cohesionless. Silty soil is semi-permeable to impervious in nature, it has medium compressibility, has fair shear strength and workability [5].

The various Index properties of soil are determined as per Indian standard test procedure (IS 2720 Part 4 1985 [6], IS 2720 Part 5 1985 [7] and IS 2720 Part III/Sect 2 1980 [8]). As the percentage passing through 75 micron sieve is greater than 50 %, so it is classified as fine silty soil of low plasticity. These index properties are tabulated in Table 1.

Table 1 Index properties of Parent soil

Sl. No.	Properties	Test Results
1	Wet sieve analysis (Sieve Size)	% Passing
	4.75 mm	100.0
	2.0 mm	100.0
	1.0 mm	100.0
	425 $\mu$	99.4
	75 $\mu$	73.0
2	Specific gravity	2.68
3	Liquid limit (%)	19.7
4	Plastic limit (%)	18.9
5	Plasticity Index (%)	0.8
6	Optimum moisture content (%)	12.09
7	Maximum dry density (g/cc)	1.997
8	Unconfined Compressive Strength (kg/cm <sup>2</sup> )	2.8132

#### B. Straw ash

Straw ash which is an agricultural waste residue obtained from local grass fields and wheat fields, can be availed locally free of cost. It is sieved by 425 micron sieve for removing impurities from it. Its use in soil stabilization not only improves the soil subgrade strength but the pollution created by its dumping here and there can be minimized. Wet sieve analysis result and specific gravity of straw ash is summarized in Table 2. It has black colour and contained some impurities. As the percentage passing through 75 micron sieve is greater than 50 %, so the nature of straw ash is fine.

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Flax straw provides a source of natural fibers suitable for the application in road strengthening. This is mainly contributed to the tough properties of the fibers and slow biodegradability. During the construction procedure the flax straw is mulched into smaller stem pieces and rotomixed with in situ materials such as the existing asphalt mat and subgrade material. This creates a geocomposite consisting of the in situ material and randomly oriented natural flax straw fibers. Despite data available from the various data collection methods the results are inconclusive as to the real performance of the flax straw test segments compared to the conventionally strengthened test sections. At best, there might be only some marginal advantages of having the natural fibers mixed into the subgrade. On the other hand, if a road agency is already rotomixing its existing road, then adding mulched flax straw can only be a benefit because it can be essentially obtained from the farming community at almost no extra cost [9].

Table 2 Properties of Straw ash

Sl. No.	Properties	Test Results
1	Wet sieve analysis (Sieve Size)	% Passing
	4.75 mm	100.0
	2.00 mm	100.0
	1.00 mm	100.0
	425 $\mu$	99.8
	75 $\mu$	75.6
2	Specific gravity	2.37

### C. Crusher sand

Crusher sand which is also known as Stone dust is a natural material obtained from the river bed as aggregates. After grinded in crusher's plant and converted to powder form it can be successfully used as a soil stabilizer in improving soil sub grade strength. In crusher's plant big aggregates are cutted into small and desired shapes, the residue remained is of no use which is Crusher sand. If it can be used as a substituting agent in road construction it can considerably save the construction cost and the menace of dust created by the crusher's plant can be minimized. The quarry dust/ crusher dust is obtained as solid wastes, during crushing of stones to obtain aggregates. The annual production of quarry dust is roughly around 200 million tonnes (Soosan et al.2005). The disposal of which creates a lot of geo environmental problems [10].

Wet sieve analysis result and specific gravity of Crusher sand is summarized in Table 3. The crusher sand which is taken for the experimental work is a combination of coarse and fine particles. Its colour is light pink. As the percentage passing through 75 micron sieve is lower than 50 %, so the nature of crusher sand is coarse.

Table 3 Properties of Crusher sand

Sl. No.	Properties	Test Results
1	Wet sieve analysis (Sieve Size)	% Passing
	10.0 mm	100.0
	4.75 mm	95.2
	425 $\mu$	49.3
	75 $\mu$	20.8
	Specific gravity	2.67

### D. Water

Potable water was used for experimental work. Water was taken from Highway Engineering laboratory of NIT Kurukshetra (Haryana).

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### III. TESTING PROGRAMME

Testing for Index properties of the soil, Modified Proctor Compaction, and UCS were carried out as per the procedures and guidelines laid down in Indian Standards Codes of practice. A total of eleven samples of Soil (one sample), Soil - Straw ash mixture (five samples) and Soil - Crusher sand mixture (five samples) were made (2%, 4%, 6%, 8% and 10 % of the total dry weight of the soil). After the determination of various Index properties of soil, Modified Proctor Compaction tests were conducted, followed by UCS tests.

### IV. EXPERIMENTAL RESULTS

#### A. Modified Proctor Compaction test results

Modified Proctor Compaction tests were carried out on silty soil and silty soil mixed with 2%, 4%, 6%, 8% and 10 % each of Straw ash and Crusher sand in accordance with IS: 2720 (Part 8) 1983 [11]. It is recommended to use a mould of 1000 ml capacity having an internal diameter of 100 mm and an internal effective height of 127.5 mm. The rammer has a mass of 4.89 Kg with a drop of 450 mm. Soil samples were filled in five layers in the mould and each layer was given 25 blows. Maximum dry density and Optimum moisture content data (as obtained from experiments) of Soil - Straw ash and Soil - Crusher sand mixture are shown in Table 4. Both additives increased the Maximum dry density of parent soil but the overall trend of MDD and OMC is irregular.

Table 4 Modified Proctor Compaction test results of Soil stabilized with Straw ash and Crusher sand

Sample type	Maximum Dry Density (g/cc)	Optimum Moisture Content (%)
Soil	1.997	12.09
Soil + 2 % Straw ash	2.005	9.75
Soil + 4 % Straw ash	2.011	12.02
Soil + 6 % Straw ash	2.021	8.63
Soil + 8 % Straw ash	2.001	12.17
Soil + 10 % Straw ash	2.007	11.62
Soil + 2 % Crusher sand	2.052	10.00
Soil + 4 % Crusher sand	2.071	10.07
Soil + 6 % Crusher sand	2.056	9.17
Soil + 8 % Crusher sand	2.030	10.22
Soil + 10 % Crusher sand	2.057	7.59

Figure 1 shows Maximum dry density (MDD) and corresponding Optimum moisture content (OMC) curve for silty subgrade soil and silty soil mixed with Straw ash in various percentages. The overall pattern of this curve is irregular due to the values obtained during experimental work.

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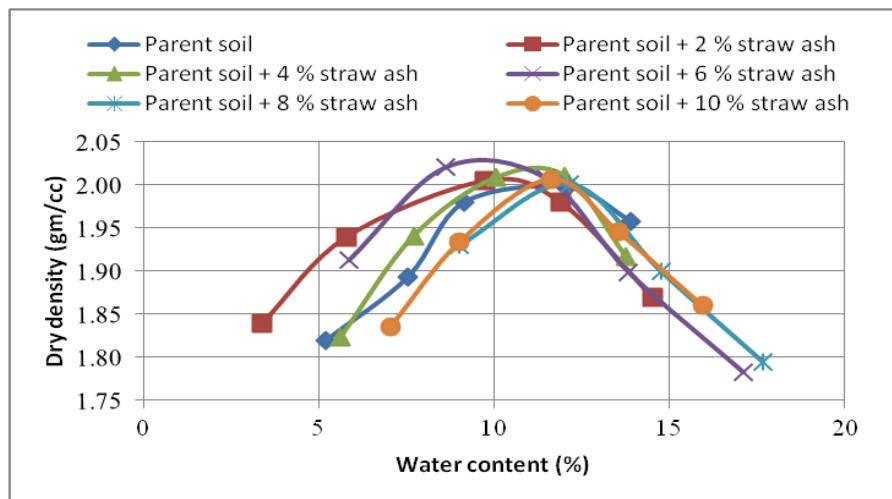


Fig.1 Modified Proctor Compaction test results of Soil – Straw ash mixture

Figure 2 shows Maximum dry density (MDD) and corresponding Optimum moisture content (OMC) curve for silty subgrade soil and silty soil mixed with Crusher sand in various percentages. The overall pattern of this curve is irregular due to the values obtained during experimental work but crusher sand increased the MDD of parent soil to a greater extent than straw ash.

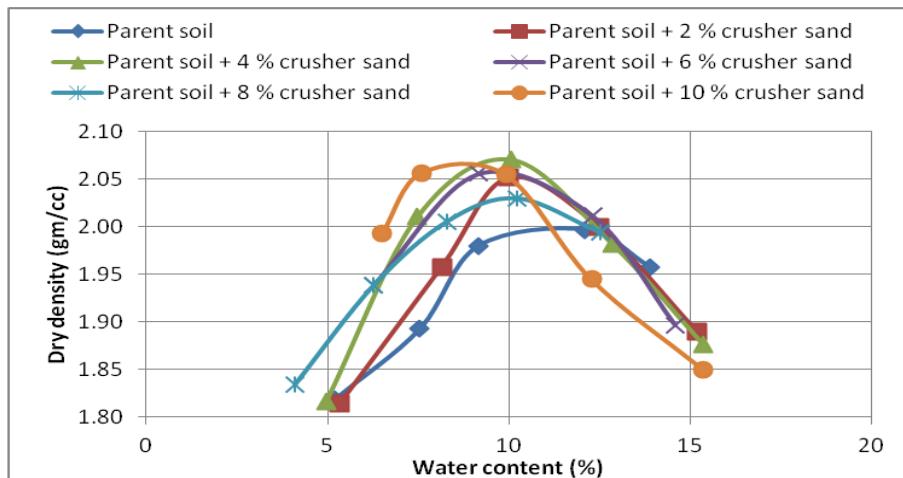


Fig.2 Modified Proctor Compaction test results of Soil – Crusher sand mixture

### B. Unconfined Compressive strength test results

Although UCS tests are recommended for clayey type of soil yet an attempt has been made for evaluating the changes in the properties of silty soil stabilized with various percentages of Straw ash and Crusher sand. Samples were made on Maximum dry density and Optimum moisture content obtained from the Modified Proctor Compaction tests as per the procedure laid down in IS 2720 Part (10) 1991[12]. Seven days curing of samples was done to obtain the results. Straw ash and Crusher sand were mixed with soil in various percentages of 2 %, 4 %, 6 %, 8% and 10 % of dry weight of soil. Table 5 shows UCS test results of Soil - Straw ash and Soil - Crusher sand mixture. It can be seen from the table that

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both additives increased the UCS value of parent soil but Crusher sand increased UCS value of parent soil more than that of Straw ash.

Table 5 UCS test results of Soil - Straw ash and Soil - Crusher sand mixture

Sl. No.	Sample type	U.C.S. (kg/cm <sup>2</sup> )
1	Soil	2.8132
2	Soil + 2 % Straw ash	3.0990
3	Soil + 4 % Straw ash	3.1456
4	Soil + 6 % Straw ash	3.2419
5	Soil + 8 % Straw ash	3.4156
6	Soil + 10 % Straw ash	4.0040
7	Soil + 2 % Crusher sand	3.9145
8	Soil + 4 % Crusher sand	3.9881
9	Soil + 6 % Crusher sand	4.2965
10	Soil + 8 % Crusher sand	4.5573
11	Soil + 10 % Crusher sand	5.1159

Figure 3 shows Stress v/s Strain curve of Soil - Straw ash mixture. This Stress v/s Strain curve of Soil - Straw ash mixture shows a direct relationship between Stress and Strain. As the percentage of Straw ash increases the UCS value of stabilized soil also increases.

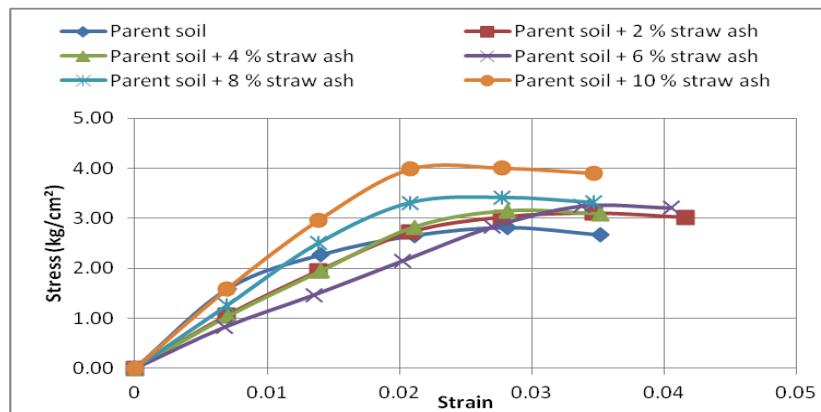


Fig.3 UCS test results of Soil – Straw ash mixture

Figure 4 shows Stress v/s Strain curve of Soil - Crusher sand mixture. This Stress v/s Strain curve of Soil - Crusher sand mixture shows a direct relationship between Stress and Strain. As the percentage of Crusher sand increases the UCS value of stabilized soil also increases.

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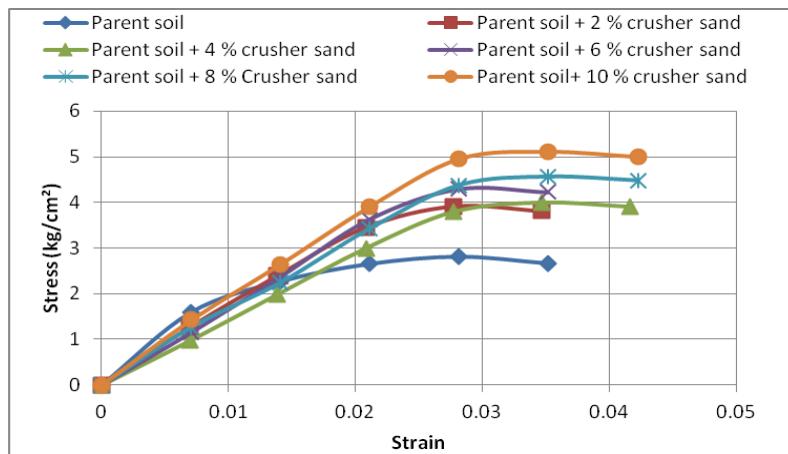


Fig.4 UCS test results of Soil – Crusher sand mixture

Table 6 shows a comparison of UCS increment between Soil - Straw ash and Soil - Crusher sand mixture. The percentage increase in UCS value of Soil - Crusher sand mixture at 10 % content is almost double of that of Soil - Straw ash mixture. This signifies that Crusher sand is more effective than Straw ash in improvement of UCS value of silty soil.

Table 6 UCS increment test results of Soil - Straw ash and Soil - Crusher sand mixture

Soil - Straw ash mixture	Soil - Crusher sand mixture	UCS increment with respect to parent soil (%)		Ratio (Col. B / Col. A)
		Soil - Straw ash mixture (A)	Soil - Crusher sand mixture (B)	
2 % content	2 % content	10.15	39.14	3.85
4 % content	4 % content	11.81	41.76	3.53
6 % content	6 % content	15.23	52.72	3.46
8 % content	8 % content	21.41	62.00	2.89
10 % content	10 % content	42.32	81.85	1.93

Figure 5 shows a comparison of UCS increment between Soil - Straw ash and Soil - Crusher sand mixture. It is cleared from the figure that ratio of UCS values of Soil - Crusher sand and Soil -Straw ash mixture shows a decreasing trend when both additives are added with soil from 2 % to 10 % content. Both additives increased the UCS value of stabilized soil but the percentage increase of UCS value of Soil - Crusher sand mixture is more than that of Soil - Straw ash mixture.

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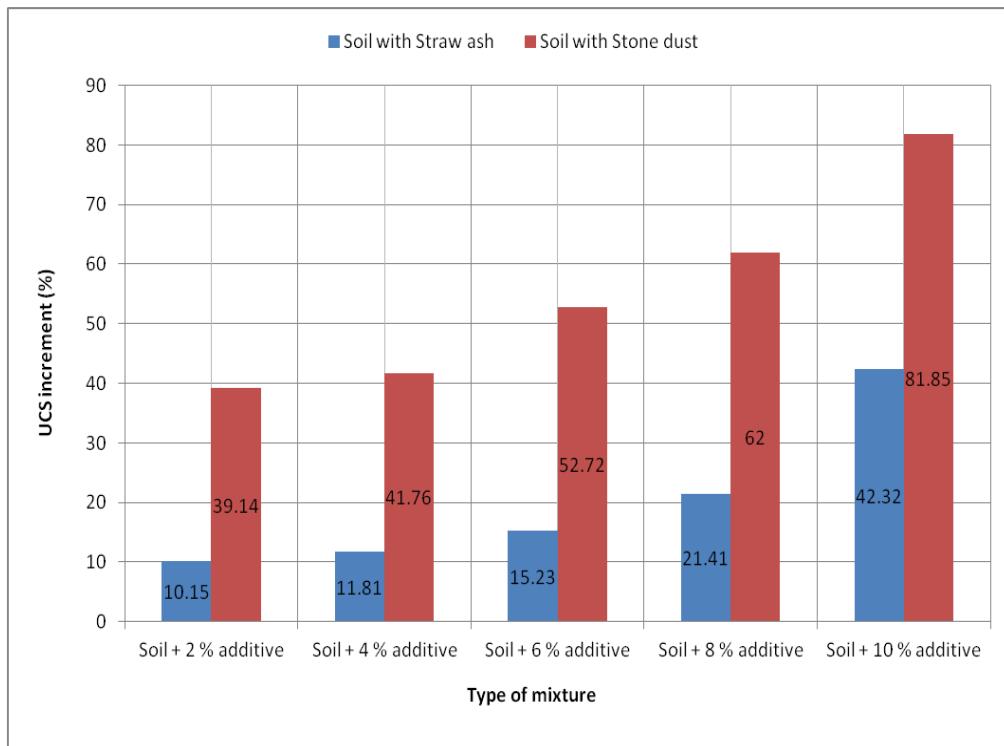


Fig.5 UCS increment test results of Soil - Straw ash and Soil - Crusher sand mixture

### V. CONCLUSION

The following conclusions were made on the basis of results obtained from the experiments performed: There is no clear cut trend of MDD and OMC obtained from the Modified Proctor Compaction tests on Soil - Straw ash and Soil - Crusher sand mixture. The probable reason for this may be temperature conditions and various laboratory conditions.

Straw ash and Crusher sand show an increasing trend in UCS value of stabilized soil as the percentage of Straw ash and Crusher sand increases from 2 % to 10 % in the soil.

10 % each of Straw ash and Crusher sand gives maximum value of UCS when added to silty soil. UCS value at 10 % Soil - Straw ash and Soil - Crusher sand mixture is 1.42 and 1.81 times respectively of UCS value of parent soil. The percentage increase in UCS value of Soil - Crusher sand mixture at 10 % content is almost double of that of Soil - Straw ash mixture. This signifies that Crusher sand is more effective than Straw ash in improvement of UCS value of silty soil.

After observing the UCS results it is noted that the ratio of UCS values of Soil - Crusher sand and Soil -Straw ash mixture shows a decreasing trend when both additives are added with soil from 2 % to 10 % content. It can be inferred that lower percentages of additives can help in improving UCS value of silty soil effectively as compared to higher percentages.

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