Soil Stabilisation by Wheat Straw Ash and Cement

Nishant Kumar[1], Nidhi Gautam[2], and Deepak Chaturvedi[3]

[1,2,3]*(Department of Civil Engineering, G. L. B. G. I., Mathura, India)*

ABSTRACT

Stabilisation of soil is a major work in current scenario of construction field as it bears the total load of foundation and structure. The techniques employed for soil stabilisation becoming costly day by day and hazardous to environment too because of using material such as cement, lime etc. Therefore, need for its alternative option without compromising to degree of effectiveness has been reviewed. The present work briefly describe the use of locally available agriculture waste i.e.wheat straw ash (WSA) as a partial replacement of cement and is also to minimize the amount of waste to be disposed off to the environment causing environment pollution. Soil sample taken for experiment is clay with high plasticity and it is stabilized with different percentage of wheat straw ash and cement. The test performed on the soil sample is to observe the different soil properties like maximum dry density (MDD), optimum moisture content (OMC), California bearing ratio (CBR) and unconfined compressive stress (UCS). Result of study indicated that optimal proportion of wheat straw ash (WSA) is reducing the cost of Soil Stabilisation as well as reducing the amount of waste to be disposed off in environment and also replace partial volume of cement that can protect our environment.

Keywords :*California Bearing Ratio (CBR), Maximum Drydensity (MDD), Optimum Moisture Content (OMC), Soil Stabilisation, Unconfined Compressive Stress (UCS), Wheat Straw Ash (WSA).*

1. INTRODUCTION

Constructions located at soft and weak soil have traditional method to improve bearing capacity. Soil stabilisation is one of the suitable methods to improve the bearing capacity of soft soil to sustain the load. Soil stabilisation is most common in road pavement where main objective is to increase the bearing capacity of loose soil and decrease the cost of construction by using suitable locally available low cost material. First of all this type of work done in Amsterdam Europe [1]. Cement and lime are two most common materials which are used to strengthen the soft soil, but these materials also increase the cost rapidly. Thus the use of agriculture waste such as wheat straw ash considerably reduce the cost of construction and also reduce the environment hazard which caused by cement or lime. Wheat straw is an agricultural waste and locally available material, generally used for feeding the animals. Wheat straw production in India is 86.5 Million Ton in 2016-2017 [2]. So stabilisation by using wheat straw should be encouraged for improving the bearing capacity of weak soil. The previous work with wheat straw shown that it has a good potential to improve the engineering properties of soil, so this work is focused on determination of the optimum amount of wheat straw at which bearing capacity of soil show its highest value. However WSA can only be the partial replacement of cement or lime because it has inadequate cementious property and less binding capacity with satisfactory durability. Thus in the present experiment a small amount of cement mixed with WSA and noticed the engineering properties of soil. This reflects tremendous improvement in soil characteristics and shows cost effectiveness in construction.

1.1 Wheat Straw Ash (WSA)

The sample of material used in this test is taken from the locally available site of MATHURA, U.P, INDIA from the depth of 1 m. The properties of this soil sample given below in table 1.

Table 1: Engineering properties of Natural Soil Sample

Characteristics	Description
Normal Moisture content (%)	20.5%
Passing IS sieve 75 micron	79
Specific Gravity	2.23
Liquid Limit (%)	52
Plastic Limit (%)	40
Plasticity Index (%)	12
Maximum Dry Density (gm/cc)	10
Optimum Moisture Content (%)	19
California Bearing Ratio (Unsoaked) (%)	13.3
Unconfined Compressive Strength (kN/m^2)	270.5

Wheat straw collected from the market located near Bhuteshwar Temple, Krishna Nagar, Mathura, (UP). WSA is a good pozzolonic material. It is a waste product of food which contains living organisms as well as non-living organisms. It also has a great calorific value as 3.5 kcal/ gm. Generally it burnt by farmers after extracting the grains. It is taken from the field or market and burn at 600 degree centigrade and converts it into fine ASH. Generally it is a crop waste and non- plastic in nature.

Fig. 1(a) wheat straw

Fig. 1(b) wheat straw ash

Its properties vary with the temperature at which it burn. It contains different composition which is mentioned in table 2.

Table2: composition of WSA at 600 degree centigrade(3)

Compound	Value (%)
Silicon Oxide (SiO_2)	43.22
Potassium Oxide (K_2O)	11.3
Magnesium Oxide (MgO)	0.99
Iron Oxide (Fe_2O3)	0.84
Sodium Oxide (Na_2O)	0.16
Chromium Oxide (Cr_2O_3)	0.0004

3. OBJECTIVE OF STUDY

The main objective of the study is to improve the bearing capacity of the weak soil by using low cost material and also the best utilisation of waste flour nutshell ash. Addition of this type of material increases the physical as well as chemical property of soil. This research will help to know an adequate amount of WSA required.

4. LITERATURE REVIEW

Number of research work has been done on different agriculture waste as soil stabilizer.Amit S. Kharade (2014) stabilizes the soil by collecting bagasse ash from the sugarcane industry. This study solves the disposal problem of sugar cane because samples for stabilization were collected from sugarcane industry situated in Maharashtra. The bagasse ash contains the fibrous material in which silica is present. The laboratory tests such as CBR,UCS, compaction and Atterberg's test was conducted to find the potential of the stabilized material. Tests were conducted with partial replacement of different percentages and it is noticed that 6% bagasse ash surges the significant chemical, physical and geotechnical properties of the soil. In the initial study, it is concluded that black cotton soil has low compressibility and bearing capacity. With the addition of ash, the shear strength and bearing capacity strengthened. The resulted material vigor the flexibility of the black cotton soil [4]. Ajay Goyal (2007) conducted an experiment to find out the effect of wheat straw ash and rice straw on the strength properties of the ash after burning at the optimum temperature. Ash materials are burned at an appropriate temperature to extract the fibrous material to achieve the aim. Therefore, under controlled temperature only 10% ash was occupied. Compressive and flexural strength test was conducted to verify the relative quality and strength development of mortar. The results concluded from the experiment shows that addition of wheat ash and rice ash is optimum to synergize the mortar. The reason behind improvement is the optimization of pozzolanic and filler effect. Moreover,the significant improvement was examined due to the presence of wheat straw ash [5]. Humberto(2007) quantified the research on finding out the bond between the crop residue and soil

which shows alterations in soil organic carbon (SOC) concentration. Thus, addition of ash alters the properties of the soil by the process of mulching which shows that straw mulching with soil retains the soil organic carbon for longer times. This research focuses only on segregating soil organic carbon, increases the tensile strength and didn't increase the shear strength. This is because 2/3 of wheat straw ash doesn't converted into SOC.Thus, mulched soil shows higher amount of carbon in contrary to non-mulched one [6]. Nazar Omer Hassan Salih(2012) researched on the fertility of the soil by using wheat residues over the all seasons of the crop yielding. The results of the study are marvellous which shows that crop fertility in the field of residual crop is more as compared to the no residue soil [7]. Ogunribido(2012)utilizes the wheat straw ash for the stabilization of some soils. He basically stabilized soil by collecting different samples of soil from different locations. The quantity of wheat straw ash ranges from 2 to 10% to analyze the properties of the soil like specific gravity, compaction, California bearing ratio, shrinkage limit etc. The results are amazing which concluded that prior to the addition of the cane ash the tests are poor but adding the ash as sub grade material ameliorates the geotechnical properties of the soil. He concluded that bagasse ash is not good stabilizing material for the lateritic soil [8]. Isak R. Shaikh (2013) conducted research using wheat straw straw. The sample was prepared at the room temperature. The MCM-41 type sample is used here to extract the silica. This silica is beneficial as it is a fibrous material useful for reinforcement. The researchers in this paper focus to bring forth development of chemical technologies which aids the ecological and environmental health on the planet. This can be done by identifying and implementing scientific trends in utilization of biomass and valorisation of ashes. The aim of the future work is to develop the catalyst which is environmental friendly from chlorides using this silica material. The conducted experiment proves successful of collecting ashes from the power stations have a great help in recycling industrial waste [9]. Mr. Santosh (2015) conducted an experiment using the wheat straw ash and slag, which is a by-product of the iron industry, from the blast furnace. This is because stabilization using admixtures are more advantageous than the mechanical, cement, lime, bituminous and earth reinforcement method. The major reason for stabilization is that black cotton soil contains special mineral which absorbs water. This gives shrinking and contraction to the pavements which is seen in the form of cracks. So, research is conducted to stabilize the expansive soil by adding admixture. The main focus is on the use of the industrial waste. Here, potential of the applied material is checked by the specific gravity, grain size distribution, liquid limit, plastic limit, UCS and standard proctor test. The compaction test was modelled by stress vs number of days. The results showed that adding 9% of WSA and GBS to the soil decrease the water content up to a limit. This research is suitable and gives most effective results on 7 days curing period. Thus, 9% is an optimum percentage to enhance the properties of the required soil [10].

5. METHODOLOGY

For testing, wheat straw washes thoroughly with distilled water and dries it in sunlight. This wheat straw dried in preheated oven at 600 degree centigrade. Resulted ash then experimented for various tests.

Soil sample then sieved through required sieves according to the need of different tests, and weight.

For different blend mix, the ash content was taken according to certain percentage by weight of dry soil and mix with soil sample. This criterion of different percentage and ratio of wheat straw ash and cement are (5 %+1 %), (10 % + 2 %), (15 % + 4 %) and (20% + 5%). This mixed sample is use to perform various test.

6. RESULT

6.1 MDD and OMC: Proctor test give the result and correlation between MDD and OMC. Result of this test given in Table 3

Table 3: MDD and OMC using different proportions of WSA ash

Replacement of stabilize material (%)	Soil+WHA	
	MDD(g/cc)	OMC (%)
0	1.55	24
5	1.32	36
10	1.49	32
15	1.62	29
20	1.35	27

It observed from table 3 that MDD increases and OMC decrease as the increasingamount of WSA.

6.2 Atterberg Limits:

There are three types of Atterberg limits which represent the plastic nature of soil. Here only two limits are required naming liquid limit and plastic to determine the plasticity index. Plasticity is the property of soil caused by absorbed water. The change in plasticity after adding WSA shown in table 4.

Table 4: Atterberg limits as soil mix with WSA

Percentage of Enhancement (%)	Soil+different percentages of WHA		
	Liquid Limit	Plastic Limit	Plasticity Index
0	52	40	12
5	46	36	10
10	47	38	11
15	50	37	13
20	45	33	12

6.3 California Bearing Ratio: CBR value represents the shear strength and bearing capacity of soil. There are two types of CBR test perform on soil. In this test soaked sample use to determine CBR value and shown in table 5.

Table- 5: Effect of soaked WSA on CBR Value

Percentage of Enhancement (%)	Soil+different percentages of WHA California Bearing Ratio (CBR Value) soaked
0	13.30
5	17.56

10	22.27
15	26.42
20	24.35

6.4 Unconfined Compressive Strength:

UCS test provide the result of compressive strength. Compressive strength basically equal to the half of untrained shear strength. Table 6 represent the effect of UCS with the application of WSA.

Table 6: Variation of UCS with application of WSA

Percentage of Enhancement (%)	Soil+different percentages of WHA Unconfined Compressive strength (UCS values)
0	270.5
5	291.7
10	302.6
15	342.8
20	315.6

7. CONCLUSION

This study conclude that the partial replacement of WSA and cement provide different effects on loose soil with various percentage. After the testing it is found that the suitable percentage of WSA and cement for soil stabilizing is 15 % and 5% respectively.

8. REFERENCES

[1] A. Kezdi, "Stabilized Earth Roads". Amsterdam: Elsevier Scientific Publishing Company, 1979.

[2] Food Outlook June 2017, by Food and Agriculture organisation of united nation.

[3] Maninder Singh1, Rubel Sharma2, Abhishek3 SOIL STABILIZATION USING INDUSTRIAL WASTE (WHEAT HUSK AND SUGARCANE STRAW ASH)International Research Journal of Engineering and Technology (IRJET)Volume: 04 Issue: 09 | Sep -2017

[4] Amit S. Kharade, V. V. Suryavanshi, B. S Gujar and R. R. Deshmukh, Waste product bagasse ash' from sugar industry can be used as stabilizing material for expansive soils, International Journal of Research in Engineering and Technology,2014, 3(3), pp. 506-512.

[5] Ajay goyal, Hattori kunio, Hidehiko ogata, Monika garg, A.M. Anwar, M. Ashraf and mandala" Synergic effect of wheat straw ash and rice- husk ash on strength properties of mortar",2007,Journal of applied sciences 7 (21): 3256-3261.

[6] R. Lal "Soil structure and organic carbon relationships following 10 years of wheat straw management in no-till",2007, Volume 95, Issues 1–2, Pages 240–254.

[7] NazarOmerHassanSalih , A. R. Mubarak, A.A.Hassabo" Effect of crop residues on soil fertility and yield of wheat (Triticumaestivum) - guar (Cymopsistetragonoloba) crops in dry tropics"International Journal of Scientific& Engineering Research Volume 3, October-2012, Issue 10, ISSN 2229-5518.

[8] Ogunribido T.H.T. MNMGS, MTRCN, Potentials of Sugar Cane Straw Ash for Lateritic Soil Stabilization in Road Construction, International Journal of Scientific Emerging Technology,2012, 3(5), pp. 102-106.

[9] IsakRajjakShaikh and Alamgir Abdulla Shaikh" Utilization of Wheat Husk Ash as Silica Source for the Synthesis of MCM-41 Type Mesoporous Silicates: A

Sustainable Approach towards Valorization of the Agricultural Waste Stream" Research Journal of Chemical Sciences, November 2013,Vol. 3(11), 66-72.

[10] Mr. Santosh, Prof. Vishwanath C.S." Stabilization of Expansive Soil by using WheatHusk Ash andGranulated Blast Furnace Slag" International Journal for Scientific Research & Development,2015, Vol. 3, Issue 04,ISSN (online): 2321-0613. [11] IS 2720 – (Part III, IV, V, VI, VII and X)