ZIBELINE INTERNATIONAL PUBLISHING

ISSN: 2521-5035 (Print)
ISSN: 2521-5043 (Online)
CODEN: ESMACU

Earth Sciences Malaysia (ESMY)

DOI: http://doi.org/10.26480/esmy.01.2020.47.50

RESEARCH ARTICLE

PERFORMANCE EVALUATION OF AGRICULTURE WASTE TO ATTAIN SOIL STABILIZATION FOR CONSTRUCTION PROJECTS IN PUNJAB PAKISTAN

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ARTICLE DETAILS

Article History:

Received 08 January 2020
Accepted 12 February 2020
Available Online 11 March 2020

ABSTRACT

The soil underneath any type of structure e.g. Building, road, highways etc. should be able to resist loadings, if not so it is subjected to failure. Usually the soil at the site is not ideal from viewpoint of engineering. An approach to this problem, is to improve the soils or to adopt soil stabilization. Various methods of soil stabilization have been developed and in practice across the world. In this research an attempt was made to use the agricultural waste to improve the soil stability, as in Punjab agricultural waste is available in excess. In Punjab, major crops are wheat and rice. So wheat straw is available in excess in Punjab. In Punjab, mostly we have clayey soil. We select the representative samples from different areas of Punjab namely Kasur, Lahore and Sheikhupura and performed certain tests on these samples. The wheat straw totally failed in enhancing compaction, but compressive stress increased up to some extent. So it can be utilized in slopes of embankments of highways, railways etc. but can't be used in construction of structures. So it is recommended that the future students should very fine wheat straw to make the project better and having a more in depth analysis.

KEYWORDS

Soil Stabilization, Agriculture Waste, building construction.

1. INTRODUCTION

The basic construction material of the geotechnical engineer's design foundation is the soil. In many set of circumstances, road service layers, foundation layers and construction material cannot utilize the soil directly. The rising cost of the land, and huge demand for high rise buildings makes the improvement of soil at a site unavoidable. Therefore, it is required to revamp the quality of the soil. The expansive soil used in this research also known as black cotton soil. This soil is taken as it contains particles of montmorillonite, which absorbs water easily and thus, attains contraction and shrinking property. The humidify and scorch process of a subgrade layer comprised of black cotton (BC) soil which results into failure of pavements in form of colonization and rupture. Therefore, soil is binded to suppress the effect of such particle, which is responsible for the high percentage of expansiveness and cracks thus, it is dangerous for the construction. Therefore, it is important either to remove the existing soil and replace it with a non-expansive soil or to improve the important properties of the existing soil by stabilities prior to construction of a road on such subjugate. The cost-effective practices like explore with industrial wastes are utilized to ameliorate the acreage of the soils having mucilage value. This is done by the process of soil stabilization. This process is mainly used where the available soil is not fit for the intended purpose, it requires to be remodel.

The first experiment on soil stabilization was conducted in USA with sand or clay mixtures in 1906. The soil stabilization for road construction was done in thirties in Europe (Kezdi, 1979). Many researchers attempt to use the industrial wastes like rice husk ash (RHA), fly ash (FA) are used to revamp the geotechnical properties of a soil (Yadu et al., 2011). However, the inclination of using the waste material is being used by all over the world nowadays. Wheat straw is bi-product obtained during threshing of wheat crop. Wheat is sown on about 14.58 million acres in Punjab, from which 12.464 million tons of wheat grains is obtained and approximately an equal quantity of wheat straw is also obtained. The term soil stabilization refers to any process, natural or artificial, by which any specific soil characteristic is improved, for example a soil is made stronger and more resistant to deformation and displacement under applied load.

Stabilization is used to increase the strength and weather resistance and to reduce the permeability, compressibility and the frost action. Various

Quick Response Code	Access this article online	
	Website: www.earthsciencesmalaysia.com	DOI: 10.26480/esmy.01.2020.47.50

Cite the Article: Engr. Awais Masood Ahmed, Muhammad Ali, Ghulam Murtaza, Muhammad Ajmal Ramzani, Muhammad Siddique Qureshi, Engr. Ahmad, Engr. Ahsan Saif Ullahf, Engr. Malahat Zehra (2020). Performance Evaluation Of Agriculture Waste To Attain Soil Stabilization For Construction Projects In Punjab Pakistan. *Earth Sciences Malaysia, 4(1): 47-50.*

methods are used for soil stabilization giving varying degree of performance of processed soils under different conditions. These methods use cement, lime, rice husk, bitumen, stone dust, gypsum, stag, resinous material, heating, drainage or chemical/electrical/mechanical processes for stabilization. Problems occurring with existing soils are that which encountered by geotechnical engineers. They are considered as a high natural hazardous, which can cause extensive damage to structures such as foundations, roads, highways, building, airport runways and earth dams if not adequately treated. Damage caused by expansive soils exceeds the combined average annual damage from floods, cyclone and earthquake. Some remedial measures can be taken to prevent the damages. These are exchanging the soil under the foundation with the other soil, controlled compaction of expansive soil, moisturizing, structure of moisture barriers, lime stabilization and cement stabilization, modification of the structure and lowering the foundations from upper layer to the lower level.

1.1 Objectives of study

In this study, it has been explicitly focused to investigate the effect of agriculture waste (wheat straw) on the consistency characteristics of different soils for compaction and unconfined shear strength for which we repeated both tests by mixing various percentages of wheat straw (1, 3 and 5) considering dry density and moisture content for different (0, 3, 5 and 7) days

2. Review of Literature

Many researchers attempt to stabilize the soil with the use of Cementous materials and agricultural waste as a combination. A group researchers has stabilized the soil by collecting bagasse ash from the sugarcane industry (Amit et al., 2014). This study solves the disposal problem of sugar cane because samples for stabilization was 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 (Amit et al., 2014).

A group researchers conducted an experiment to find out the effect of wheat straw ash and rice husk on the strength properties of the ash after burning at the optimum temperature (Goyal et al., 2007). 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 (Goyal et al., 2007).

Humberto 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, increase 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 (Lal, 2007).

In other study, researchers investigated the potential of wheat husk for reinforcement in plastics by the scanning of electron using microscope (Bledzki et al., 2010). The materials incorporated in this research includes wheat husk and rye husk. The thermal, physical property was measured and analyzed by the instruments and chemical contents contained in the mixture were investigated by the electron microprobe analyzer. The improvement is due to the soft wood material in the particle size distribution range 100-200 micrometer. The impact strength and tensile strength was investigated which concludes that wheat husk contain more silicon surface than other materials (Bledzki et al., 2010).

Researches on the fertility of the soil by using wheat residues over the all seasons of the crop yielding. The results of the study are marvelous which shows that crop fertility in the field of residual crop is more as compared to the no residue soil (Salih et al., 2012). Jiguang Zhang investigates the tobacco field by analyze the effects of incorporating straw in the soil (Zhang et al., 2016). The wheat and maize straw were collected from the Zhuchengarea of Southeast Shandong province for three years. The soil here is treated with seven treatments such as no straw, use the both straws in middle level, and use it at higher level. The value of the nutrients is measured, and organic fertilizers are laid down on the fields each year. However, soil organic carbon and other related parameters were revamped by the incorporation of the both wheat and maize straws. The study reported on the field's shows that maize straw is more successful than wheat straw in improving the soil enzymes. This is because maize straw increases the soil aggregate stability of the soil. Moreover, the value of SOC and its nutrients was more in case of maize incorporation (Zhang et al., 2016).

3. Methodology

3.1 Selection of samples

Wheat straw was used as stabilizing additive, keeping in mind the fact that it is naturally available in Punjab and is used locally for soil stabilization. For stabilization purpose soils of different cities of Punjab were used. Samples were taken from West wood colony near Thokar Niaz Baig Lahore, Near Motorway at Gujranwala Road Sheikhupura and Ferozpur Road near Mustafa Abad District Kasur.

3.2 Sampling

Samples were collected from a depth of 2-4 ft. at sites. This was done to get them free of roots of grass and some surface oil. Field density was determined with core cutter and moisture content was preserved by keeping the samples in polythene bags which were then tested in laboratory keeping the sample in oven and used for the preparation of specimen sample for un-confined compressive strength test.

3.3 Determination of physical properties of soils

Different physical properties were determined to classify the soil according to AASHTO classification.

i. Specific gravities were determined to use in the calculations associated with grain size analysis and their values were 2.62 for Kasur soil, 2.855 for Lahore soil and 2.59 for Sheikhupura soil.

ii. Grain size analysis was done using Mechanical (Sieve) analysis (Code ASTM D 422-63) for particles greater than 0.075 mm and hydrometer (fine) analysis for particles finer than 0.075mm. We know that the knowledge of size of solid particles of a certain soil and its relative proportions in soil mass is used in soil classification w.r.t gradation. [9]

iii. Atterberg limits were calculated to know soil consistency (strength, permeability, compressibility, swelling and shrinkage) or ease with which it can get deformed if used as construction material.

The values for Kasur Soil were a) L.L=20% b) P.L =17% c) P.I = 3% d) G.I = 7 e) Soil passing sieve # 200% =71% and type of soil according to AASHTO classification came out as A-4 (7) SILTY SOIL.

The values for Lahore Soil were a) L.L=20% b) P.L =Non-plastic c) P.I = 0 d) G.I = 8 e) Soil passing sieve # 200% =75% and type of soil according to AASHTO classification is A-4 (8) SILTY SOIL.

The values for Sheikhupura Soil were a) L.L=26% b) P.L =18% c) P.I = 8%

d) G.I = 8 e) Soil passing sieve # 200% =93% and type of soil according to AASHTO classification is A-4 (8) SILTY SOIL.

iv. Compaction: It is an effective way to improve the properties of soil. The degree of compaction is characterized by its moisture content, nature of soil and amount of compacting effort. The dry densities are calculated using Modified AASHTO (ASTM D1557-70) and their values are 2.02 g/cc, 1.97g/cc and 2 g/cc for Kasur (M.C 10%), Lahore (M.C 9.62%) and Sheikhupura (M.C10.6%) soils respectively.

v. Effect of wheat straw on dry density and M.C: The dry density decreased as we added wheat straw and the O.M.C increased.

vi. On further increase of wheat straw the dry density further reduced and simultaneously O.M.C increased as shown in table below.

On addition of 1% wheat straw the effect was least but still negative which could lead to future settlement. The dry density started increasing with increase in % of wheat straw which was not suitable as structural point of view. O.M.C was also increasing which means more cost of construction because of more water requirement in the construction of embankment. Also, that the soil showed behavior irrespective of any specific pattern as shown in tables 1 and 2.

Table 1: Effect of wheat straw on M.C and dry densities

SOIL	Addition of 1% wheat straw		Addition of 3 % wheat straw		Addition of 5% wheat straw	
	Decrease in max dry density	Increase in O.M.C	Decrease in max dry density	Increase in O.M.C	Decrease in max dry density	Increase in O.M.C
Kasur soil	4.95 %	1.1 %	7.52 %	1.5 %	20.95 %	2.00 %
Lahore soil	4.47 %	1.0 %	7.71 %	3.08 %	17.25 %	3.48 %
Sheikhupura soil	2.25 %	0.4 %	10.0 %	1.4 %	16.00 %	3.40 %

vii. Unconfined compressive strength: By the addition of different percentages (1, 3, and 5) of wheat straw the effect on shear strength by unconfined compress was studied. The specimen were prepared adopting standard ASTM D-2166-66 (1972) using field density and moisture content. The specimen were tested on 0, 3 and 7 days. They were coated using wax to maintain the field moisture and on due dates wax was removed with a knife. Samples with 5 % wheat straw displayed so much reduced cohesion that they were deteriorated soon after preparation hence discarded.

Table 2: Effect of Wheat Straw on Unconfined Compressive Strength

SOIL	On day 0 Increase in U.C.S		On day 3 Increase in U.C.S		On day 7 Increase in U.C.S	
	1 % W.S	3 % W.S	1 % W.S	3 % W.S	1 % W.S	3 % W.S
Kasur soil	15.16 %	50.43 %	15.74 %	33.52 %	28.27 %	37.31 %
Lahore soil	43.32 %	119.85 %	10.46 %	126.35 %	9.75 %	148.73 %
Sheikhupura soil	57.72 %	219.24 %	62.16 %	205.50 %	51.38 %	173.17 %

4. Discussion on Results

The unconfined strength increased significantly on the same day with 1 % wheat straw addition even with the increase of wheat straw percentage. But on 3rd and 7th results were not consistent as some of them increased and some decreased (ASTM, 1985). Kasur soil represented increase in shear strength but after 3rd day it started loosening the strength while Lahore showed adverse effect on 1% wheat straw and increased shear strength with 3 % wheat straw up to 7 days. Sheikhupura soil which had clayey particles more than coarser particles and comparatively more L.L and P.L (tendency to absorb moisture); showed an increase in shear strength even with lapse of time of up to 3rd day which is described in table 3, table 4 and 5.

Table 3: Comparison of Unconfined Compressive Strength

SITE	0-DAY WITH DIFF. %AGE OF WHEAT STRAW N/cm²			3-DAY WITH DIFF. %AGE OF WHEAT STRAW N/cm²			7-DAY WITH DIFF. %AGE OF WHEAT STRAW N/cm²		
	0%	1%	3%	0%	1%	3%	0%	1%	3%
KASUR	3.43	3.95	5.16	3.43	3.97	4.58	3.43	4.40	4.71
LAHORE	2.77	3.97	6.09	2.77	3.06	6.27	2.77	3.04	6.89
SHEIKHUPURA	3.69	5.82	11.78	3.69	5.984	11.273	3.69	5.586	10.08

Table 4: Comparison of Grain Size Analysis

SITE	Gravel %	Sand %	Silt or clay %
Kasur	15.16	14.27	70.57
Lahore	0	25.24	74.76
Sheikhupura	0	7.17	92.83

Table 5: Comparison of Compaction Characteristics (Using Modified Procter Test)

SITE	O.M.C WITH DIFFERENT %AGE OF WHEAT STRAW				MAX. DRY DENSITY WITH DIFFERENT %AGE OF WHEAT STRAW (g/cc)			
	0%	1%	3%	5%	0%	1%	3%	5%
KASUR	10	11.1	11.5	12	2.02	1.92	3	1.67
LAHORE	9.62	11.72	12.7	13.1	1.97	1.882	1.818	1.63
SHEIKHUPURA	10.6	11	12	14	2	1.955	1.80	1.68

Cite the Article: Engr. Awais Masood Ahmed, Muhammad Ali, Ghulam Murtaza, Muhammad Ajmal Ramzani, Muhammad Siddique Qureshi, Engr. Ahmad, Engr. Ahsan Saif Ullahf, Engr. Malahat Zehra (2020). Performance Evaluation Of Agriculture Waste To Attain Soil Stabilization For Construction Projects In Punjab Pakistan. *Earth Sciences Malaysia, 4(1): 47-50.*

The Graphical representation of results of compaction and unconfined shear strength tests on different soil samples (taken from Kasur, Lahore and Shiekhupura) by mixing various proportions of wheat straw are given below from Figure 1-11.

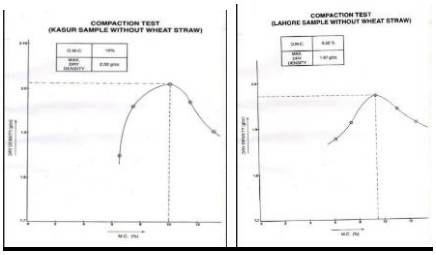

Figure 1

Figure 2

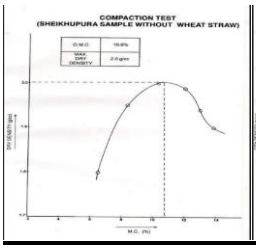

Figure 3

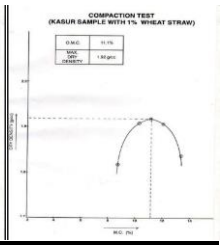

Figure 4

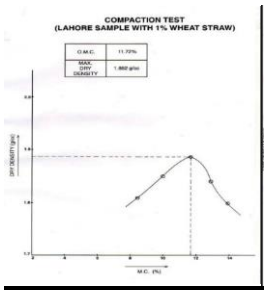

Figure 5

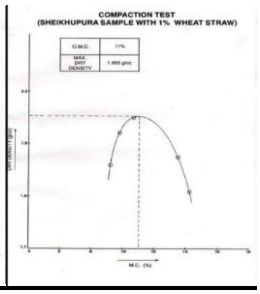

Figure 6

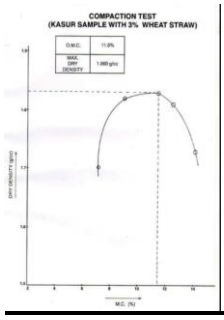

Figure 7

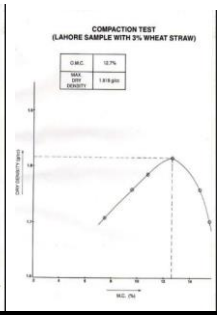

Figure 8

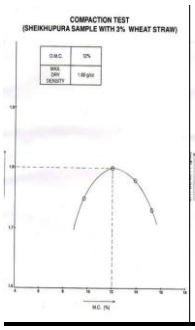

Figure 9

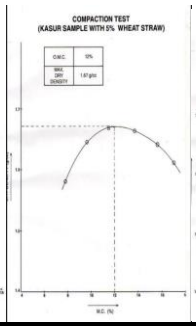

Figure 10

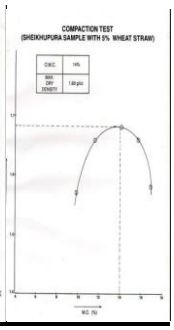

Figure 11

5. Conclusion

All types of soils showed unpredictable behavior/unspecific changes on addition of wheat straw. Since wheat straw is organic, it may decay in presence of moisture and strength may reduce. During the project study, we tried to improve the soil characteristics by using agriculture waste (wheat straw) by focusing on shear strength and compaction. By mixing various amounts of wheat straw we performed above tests. But wheat straw failed to increase compaction of soil. Somehow unconfined shear strength increased up to some extent. So wheat straw can never be used in the construction of dams, pavements and runways. Shear strength increased on mixing wheat straw with soil hence can be used in embankment of railways, highways etc. it can be used in mud plastering of walls and roofs of Kachha as well as Pucca houses because it resists shrinkage and also acts as reinforcing media. It can be used as sound absorbing material in shape of mud plaster in halls of less importance. It can also be used as insulating medium in roofs and walls economically.

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Cite the Article: Engr. Awais Masood Ahmed, Muhammad Ali, Ghulam Murtaza, Muhammad Ajmal Ramzani, Muhammad Siddique Qureshi, Engr. Ahmad, Engr. Ahsan Saif Ullahf, Engr. Malahat Zehra (2020). Performance Evaluation Of Agriculture Waste To Attain Soil Stabilization For Construction Projects In Punjab Pakistan. *Earth Sciences Malaysia, 4(1): 47-50.*