An Experimental Study of Effect of Sugarcane Bagasse Ash on the Permeability of Shale Soil

Kunal Rai[1], Muhammad Rehan Hakro[1], Muhammad Junaid Memon[1], Muhammad Saleem Raza[1], Moti Ram[1], Deelip Kumar Hotwani[1], Ali Mujtaba[1]

[1]*Department of Civil Engineering, Mehran-UET Jamshoro, Pakistan.*

***Abstract*: To make soil feasible and durable for construction, stabilization is one of the most productive techniques. It is economical and easy to put into service inside the body of soil. Permeability plays a vital role among all the geological properties; it creates unwilling settlements in the structure if not examined properly. The purpose of this study is to check the effect of sugarcane bagasse ash on the permeability of shale soil, as per the situation one may treat that soil. Utilization of these waste deposits as a soil stabilizer gives us two benefits first one is to control the environment became pollute other is to use as a construction material to strengthen the existing soil. The shale soil is collected from Jamshoro was mixed with Sugarcane Bagasse Ash (SBA) in variable quantities i.e. 0%, 2%, 4%, 6%, 8%,10 and 12%. Laboratory test of permeability on each sample of soil and SBA had conducted by falling head method of permeability, to get value of hydraulic conductivity (K). Before knowing the hydraulic conductivity, each sample was subjected to modified proctor test from where, one may obtain Optimum Moisture Content and Maximum Dry Density. In accordance with obtained OMC and MDD, samples were then prepared for permeability test. Eventually, experiment study came to an end with the graph of variation of permeability with respect to quantity of sugarcane bagasse ash.**

***Keywords*: soil stabilization, permeability, optimum moisture content, maximum dry density, sugarcane bagasse ash.**

I. INTRODUCTION

Soil is a very complex material as its properties vary in inches, despite of that every kind of construction built on it or made of it. Not necessarily, available soil has efficiency to build something on it. There may be some deficiency in major properties of that soil. To make the soil feasible, stabilization will be very productive way to enhance its geotechnical properties [1].
Among all the properties, permeability contributes very important role in the durability of any structure. Different kinds of structures require different value of permeability, some built on high permeability soil strata and other may be built on low permeability soil strata, it all depends on the purpose of that structure [2]-[3]. Stabilization of soil, through waste materials is also very beneficial for the environment aspect. Sugarcane Bagasse Ash i.e. by-product of sugar, found in huge amount from industries of sugar manufacturing is used in this study. Utilization of these waste deposits as a soil stabilizer gives us two benefits, first one is to control the environmental pollution and the other one is to strengthen the existing soil. Plethora of industrial waste materials such as iron slag, fly ash, plastic wastes, wood ash, iron filings, rice husk ash and corncob ash utilized by researchers to stabilize the poor soil. As per the report of Pakistan Sugar Mill Association, 20000 metric tons bagasse yield in Pakistan in 2015, it is easily available without any cost [4]. An ample amount of sugarcane bagasse ash we have, and its growth is increasing yearly due to industrialization, so it will be very effective to stabilize soil through this material. Before going for practical stabilization of soil with sugarcane bagasse ash, we need to conduct an experimental study of it with the major properties of soil and this study carries this aim.

II. LITERATURE REVIEW

Umar Jan et. al. (2015) studied the Soil Stabilization using Shredded Rubber Tyre cut into small pieces of 15mm-25mm width and 30mm-50mm length and then mixed with soil sample in different proportions of, 4%, 6%, 8% and 10%. Two major tests were performed on the samples, Modified Proctor Test and CBR test. The study found that Optimum Moisture Content and Maximum Dry Density decreases with the increase of rubber tyre quantity in the soil sample. CBR value increases with the increase of rubber tyre up to 8% and beyond this limit, CBR will decreases in un-soaked conditions [5].

Akshaya Kumar Sabat (2012) conducted a study on the Stabilization of Expansive Soil using Waste Ceramic Dust. In this study, soil was stabilized by addition of ceramic dust, 0% to 30% with an equal increment of 5% in each case. By performing number of tests after adding ceramic dust, the authors examined that there is large variation on the geotechnical properties of soil such as plasticity index decreased, MDD increased, OMC decreased, UCS increased, 150% increase in soaked CBR, cohesion value decreased, angle of internal friction increased and swelling pressure decreased. The study concluded that the ceramic dust up to 30% can be utilized for construction of flexible pavement with saving in cost [6].

Dileep Kumar and Ashish Gupta (2014) examined the technique of ground improvement by fiber reinforcement with the use of fiber at different depth of 40 mm and 80 mm. The study established that OMC of soil increase from 15% to 15.8% and 16%,

in similar way the value of coefficient of permeability reduces from 6.043 x 10^{-6} to 4.012043 x 10^{-6} and 3.457043 x 10^{-6}, when fiber is used at depth of 40mm and 80mm [7].

Gbenga M. Ayininuola and Dr. Oluwatobi I. Olaosebikan (2013) studied the influence of Rice Husk Ash on Soil Permeability. Different soil samples from different locations, stabilized each soil with Rise Husk Ash in different proportions of 3%, 5%, 7%, 10% and 15%. The permeability test by falling head method was then performed. Results indicated that the coefficient of permeability (K) of all soil samples decreased with increase in Rice Husk Ash content [8].

Ravichandran P. et. al. (2016) worked on the assessment of Effect of Sugarcane Bagasse on Soil Properties. Four different proportions of sugarcane bagasse ash i.e. 0%, 2%, 4% and 6% thoroughly mixed with the 2kg oven dried soil sample. The permeability lab tests on each sample deduced that coefficient of permeability decreases by increasing sugarcane bagasse content [9].

Suhail Idrees Khattab and Mohammed Mukhlif Aljobouri (2012) analyzed the combine effect of Stabilization by Lime and Cement on Hydraulic Properties of Clayey samples. The samples were taken from Mosul area and stabilized by lime, cement and lime-cement in different proportions. Authors found that optimum lime for stabilization is 4% and permeability of soil increases when it is stabilized by lime, cement and lime-cement [10].

III. MATERIALS & METHODS

A. Base Soil

The soil of Shale nature taken from Jamshoro, Sindh (Pakistan) was employed for the experimental study of sugarcane bagasse ash. This is an expansive soil as its volume is changeable (shrinking to swelling). Hence, this type of soil contains expansive minerals, which have most of chances of cracks in drier seasons [11].

B. Sugarcane Bagasse Ash

Sugarcane bagasse ash was collected from Matiari Sugar Mill located at Matiari District, basically formed by crushing of sugarcane. One ton of sugarcane produce approximately 0.62% of residual ash, which after combustion mainly consist of silicon dioxide (SiO2) and other oxides [12]. The ash was used to check the effect of sugarcane bagasse ash on the permeability of soil.

C. Tests Conducted

After acquiring the base soil from Textile Engineering Department of MUET Jamshoro, different proportions of Sugarcane Bagasse Ash were incorporated in soil samples. The two major tests such as Modified Proctor Test and Falling Head Permeability Test were conducted to obtain Optimum Moisture Content (OMC) and Maximum Dry Density (MDD) of soil samples with different levels of SBA contents. The graphs were then plotted for the obtained results and based on analysis, conclusions and future recommendations were framed.

The falling head method of permeability with modified equipment was conducted in which there was not any need of shifting the soil from one mold to another and comparatively more accurate results were anticipated to be obtained.

Fig. 1: Modified Equipment

Fig. 2: Conventional Equipment

According to formula of coefficient of permeability, we have:

$$K = 2.303\ a\ L\ /A\ t \times \text{Log}\ h_1/h_2$$

where:

a= Area of standpipe = 1cm
L= Length of specimen= 11.64cm
A= Area of soil specimen= 182.41 cm^2
(Diameter of mold is 6 inches or 15.24 cm)
t= time

K= Coefficient of permeability
h_1= Initial height at t=0
h_2= Final height after final time t

IV. RESULTS

A. *Proctor Test*

Modified proctor test was performed to obtain OMC and MDD for every sample with addition of SBA concentration of 2%, 4%, 6%, 8%, 10% and 12%.

Table. 1: Variation in OMC and MDD with SBA Percentage

SBA (%)	2	4	6	8	10	12
OMC (%)	12	9.2	12	13	14	15
MDD (g/cm3)	1.867	1.928	1.89	1.714	1.77	1.864

The combined graph for SBA concentration, OMC and MDD for afore-mentioned results is plotted as under:

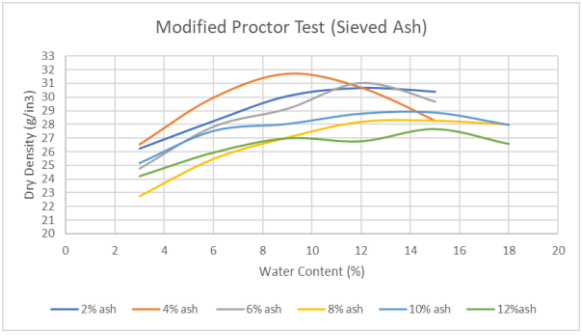

Fig. 3: Results of modified proctor test with addition of sugarcane bagasse ash

B. *Permeability Test*

The permeability test by falling head method with addition of bagasse ash gave following results.

Table. 2: SBA Concentration vs. Coefficient of Permeability

SBA Concentration (%)	Coefficient of Permeability, K (cm/sec)
0	3.11×10^{-6}
2	3.48×10^{-7}
4	2.24×10^{-7}
6	2.40×10^{-5}
8	2.45×10^{-5}
10	2.53×10^{-5}
12	2.60×10^{-5}

The relation between Sugarcane Bagasse Ash Proportion and Coefficient of Permeability obtained for each sample is plotted as under:

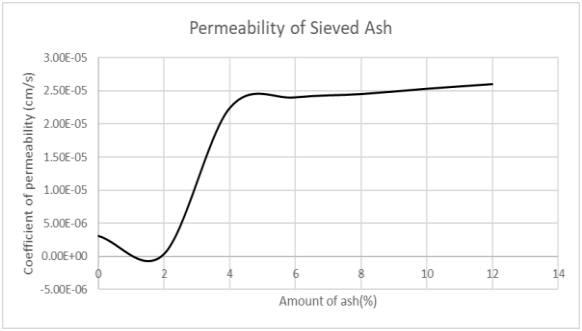

Fig. 4: Relation between Sugarcane Bagasse Ash Proportion and Coefficient of Permeability

V. CONCLUSIONS

The purpose of this research is to experimentally check the effect of sugarcane bagasse ash on the permeability of shale soil. Eventually, two graphs were obtained defining the relation between amount of ash added in the soil and variation of permeability of their mix of soil and ash. It was noticed during observations made for relationships between mix of ash and soil that, the value of permeability of soil changed rapidly. Addition of sieved ash in soil initially decreased the value of permeability and then at an amount of ash, major changes in curve happened. From that point, permeability starts to increase. Addition of 1.8% (near to 2%) of ash gives optimum point, from where major changes occur and permeability begins to increase. Again at 4.2% (near to 4%) of ash, another minor change in curve occurs, from where little bit value of permeability drops off and then nearly remain same through-out till the 12% incorporation level of SBA.

VI. RECOMMENDATIONS

Detailed research about soil permeability and its stabilization is very necessary to solve the problem of available soil and make it suitable for construction as it unquestionably reduces the cost of transportation and purchase of another soil. However, use of waste product as a stabilizer save the environment from becoming pollute and these waste deposits are easily available at cheap rates. Hence, the technique of stabilization should be adopted by incorporating other waste materials also in soil. Furthermore, many other properties of soil such as shear strength, cohesion and index properties etc. should be studied at different mixing levels of sugarcane bagasse ash in shale soil and other kinds of soils.

REFERENCES

[1]. Ashraf A. et. al. (2011), “Soil Stabilization using raw plastic bottles”, Proceedings of Indian Geotechnical Conference, December 15-17, 2011, Kochi (Paper No. H-304).
[2]. Mitchell (1993), Fundamentals of Soil Behavior, second ed., John Wiley and Sons Inc., New York, 456 pages.
[3]. Cristelo, N., S. Glendinning, T. Miranda, D. Oliveira, R. Silva, (2012), “Soil stabilization using alkaline activation of fly ash for self-compacting rammed earth construction. Construction and Building Materials, 36: 727-735.
[4]. Pakistan Sugar Mill Association Annual Report (2016), accessed online at https://www.psmacentre.com/documents/PSMA%20Annual%20Report%202018.pdf
[5]. Jan, U., et al. (2015), "Soil stabilization using shredded rubber tyre", International Research Journal of Engineering and Technology 2(9): 741-744.
[6]. Sabat, A. K. (2012). "Stabilization of expansive soil using waste ceramic dust", Electronic Journal of Geotechnical Engineering 17:3915-3926.
[7]. Kumar, D. and A. Gupta (2014), “Effects of Fibre on Strength Properties of Soil at Different Depth of Soil Layers” International Journal of Science and Research (IJSR), Volume 3 Issue 10, October 2014 pp. 657-661.
[8]. Ayininuola, G. M. and O. I. Olaosebikan (2013). “Influence of Rice husk ash on soil permeability”. Transnational Journal of Science and Technology 3(10): 29-33.
[9]. Ravichandran, P., et al. (2016). “Effect of addition of waste tyre crumb rubber on weak soil stabilization”, Indian Journal of Science and Technology 9(5): 1-5.
[10]. MukhlifAljobouri, M. (2012). "Effect of combined stabilization by lime and cement on hydraulic properties of clayey soil selected from Mosul area. “AL Rafdain Engineering Journal20(6): 139-153.
[11]. Siddiqui, A. R. (2018), “Strength Behavior of Bentonite Clay with Bagasse Fiber”, M.E Thesis, Department of Civil Engineering, Mehran University of Engineering and Technology, Jamshoro.
[12]. Idris M K, Eldin K and Yassin E 2015 Determination of the effects of bagasse ash on the properties of Portland cement, Journal of Applied and Industrial Science. 3: 6–11.