www.ijifr.com | Volume 4 | Issue 11 | July 2017

International Journal of Informative & Futuristic Research | ISSN: 2347-1697

An Experimental Study on Black Cotton Soil Stabilized with Rice Husk Ash and Randomly Distributed Sisal Fibres

Paper ID	IJIFR/V4/ E11/ 001	Page No.	8101-8111	Subject Area	Civil Engineering
Key Words	BC Soil, Rice Husk Ash, Sisal Fibre, OMC, MDD, CBR, Swelling				

1st	Vikas Kumar Shrivastava	M.Tech. Scholar, Department of Civil Engineering, Lakshmi Narain College of Technology, Bhopal, India
2nd	Vikash Kumar Singh	Assistant Professor, Department of Civil Engineering, Lakshmi Narain College of Technology, Bhopal, India
3rd	Abhay Kumar Jha	Associate Professor, Department of Civil Engineering, Lakshmi Narain College of Technology, Bhopal, India

Abstract

Transportation infrastructure is the key element for the growth of any country and is essential for good physical connectivity in very small villages, remote areas and hilly areas can be accessed only by roads."Pradhan Mantri Gram Sadak Yojna" (PMGSY) – it was estimated that about 330,000 out of its 825,000 villages and habitations were without any all-weather road access. This Centrally Sponsored Scheme was introduced in 2000 by the Prime Minister of India Shri Atal Bihari Vajpayee. It is under the authority of the Ministry of Rural Development, Government of India and began on 25 December 2000. It is fully funded by the Central Government. For executing the transportation facilities, the quality of a pavement depends on the strength of its soil sub-grade. Soil is very basic and important element in civil engineering field. Usually each structure depends on the type and characteristics of foundation which depends on type of soil. Basically black cotton soil is

ISSN: 2347-1697
International Journal of Informative & Futuristic Research (IJIFR)
Volume - 4, Issue -11, July 2017
Continuous 47th Edition, Page No.: 8101-8111

rather a difficult one to use in foundation because of its shrinkage and swelling properties.There are many methods to make black cotton soil stable for various constructions. Black cotton soil is comfortable for road work, compared to other types of soil. There are two ways to enhance the quality of subgrade soil -"Replacement of soil" or "Soil stabilization". Soil stabilization can be done chemically or mechanically. Chemical stabilization is carried out by adding different chemicals in suitable proportion, while Mechanical stabilization is achieved by addition of admixtures which helps to improve the properties of soil. Today, the amount of waste has increased year by year and then it becomes serious problem in disposing large quantity of agricultural waste like Sugarcane Bagasse Ash, rice husk ash and Sisal fiber etc.

I. INTRODUCTION

Black Cotton (B.C) soil is highly plastic clayey soil. In dry state, it is very stiff that clods may not be effortlessly pulverized to be treated for its use in road construction. This poses severe troubles when considered in respect to subsequent performance of road .In addition, the softened subgrade has a tendency to upheave into the upper layers of pavement, mainly when sub-base consists of stone soling with lot of voids. Regular intrusion of soaked B.C soil perpetually leads to road failure. Roads resting on B.C soil base develop undulation on pavement top because of strength loss of subgrade through softening at time of monsoons. Soaked laboratory CBR standards of B.C soil are usually found in range of 2 to 4%. Due to very small CBR values on subgrade B.C soil, enormous pavement stratum is vital to design flexible pavement. Research & Development (R&D) efforts were made for a long time to advance strength characteristics of B.C soil with new technologies.

For rectification of embankment performance problems produced by lack of strength or uniformity, entire pavement section would have to be replaced or either removed. Embankment that is to be built should be strong, uniform, durable, resilient and economical as possible. An economical embankment is one that performs well for many decades, present methods to help attain adequate stiffness, strength, and uniformity for a given embankment soil. The course of action initiates with a good soil survey at the site so that accurate designing and construction procedures can be included for the project. Efforts are therefore made to strengthen sub grade soil through mechanical stabilization or soil-cement, lime-fly ash, soil-rice husk ash or geosynthetics to advance its performance and a latest technique is soil reinforcement. Soil reinforcement is reliable and efficient practice to enhance stability and strength of soil.

Engineering and chemical properties of Indian ashes of various Industries tested at CRRI have been found to be favorable to construction of roads and embankments. Properties of RHA from different Industries vary and therefore it is recommended that characterization of ash proposed to be used should be conducted to establish the design parameters. The significant properties of RHA that must be considered when it is used

ISSN: 2347-1697
International Journal of Informative & Futuristic Research (IJIFR)
Volume - 4, Issue -11, July 2017
Continuous 47th Edition, Page No.: 8101-8111

for construction of road embankments are gradation, compaction characteristics, shear strength, compressibility and permeability properties.

Table 1 - Properties and Classification of BC Soil

Specific Gravity	2.58
Grain Size Distribution	
Sand (%)	8.0
Siltand Clay (%)	92
Natural Moisture Content (%)	41
Maximum Dry Density (gm/cm^3)	1.56
O.M.C. (%)	18.60
Liquid Limit (%)	72
Plastic Limit (%)	29
Plasticity Index (%)	43
CBR (%)	1.67 (Soaked)
IS Classification	CH

II. LITERATURE REVIEW

- Individual RHA particles are spherical in shape, generally solid, though sometimes hollow. RHA possesses a silty texture and its specificgravity would be in the range of 2.2 to 2.4, which is less than natural soils. RHA is a non-plastic material. Zach Thomas (2002) carried out the experiments to found out the effects of adding RHA to soil were evaluated in some common soil tests. When RHA and soil are mixed and compacted immediately, the RHA causes the mixture to have a higher dry unit weight, by filling in voids with ash particles. Use of fiber inclusions to improve the properties of compacted soil is becoming increasingly common in geotechnical engineering projects. However, the technique requires extensive testing before it can be implemented.
- Gosavi et al, 2004, did an attempt to investigate the strength behavior of locally available BC Soil reinforced with randomly mixed (i) geotextile woven fabric and (ii) fibreglass. Results showed that there was an increase in the value of cohesion and slight decrease in the value of OMC with the addition of 2% of these fibres in black cotton soil. The trend was reverse with 3% addition of the fibres. CBR value of the black cotton soil alsoincreased considerably due to the addition of the fibres in the soil. Santoni et al. (2001) laid full length pavement section over 1 % fiber reinforced subgrade soil.
- The test track was tested using simulated C-130 aircraft and military cargo trucks. Rakesh et al. (1999) studied the characteristics of fibre reinforced sand by conducting CBR tests, triaxial tests and plate load tests. McGowan et al (1978) classified the reinforcement in to two major categories, namely the soil reinforced with ideally inextensible inclusions (like metal strips and bars) known as reinforced earth, and the soil reinforced with ideally extensible inclusion (natural and synthetic fibers, plant roots, polymeric fabric) known as Ply soil.

- The effect of polymer fibre inclusion on plain SCBA was studied by Chakraborty and Dasgupta (1996)by conducting triaxial tests. The fiber content ranging from 0 to 4 % by weight of RHA was used with constant fibre aspect ratio of 30. The study indicates increase in friction angle. The study on soil SCBA mixture reinforced with 1% polyester fibres (20 mm length) was conducted by Kaniraj and Havanagi (2001), which indicated the combined effect of RHA and fibre on soil. Kaniraj and Gayatri (2003) indicated that 1% polyester fibers (6 mm length) increased strength of RHA and change their brittle failure into ductile one. Dhariwal, Ashok (2003) carried out performance studies on California bearing ratio values of SCBA reinforced with jute and nonwoven geo fibres. A review of the literature revealed that various laboratory investigations have been conducted independently either on SCBA / lime stabilization of soil or fibre reinforced soil. Studies concerning RHA and lime utilization for soil stabilization have been conducted in the past years by many investigators like **Prof MayuraYeole and Dr. J.R. Patil (2013)** executed a laboratory CBR test on granular soil in presence and in absence of geotextile which was located in 1 or 2 layer in the mould. Single layer of geotextile was placed at depth of (25, 50, 100 mm) from top of mould, the maximum CBR obtained was at 25mm and when the geotextile was located in 2 layers at { (25 &75 mm),(50 &75 mm), (50 &100 mm)} CBR was increased and it was maximum at 25 & 75mm geotextile layer by 38.21% when correlated to CBR with absence of geotextile.
- M. Bagra (Aug 2013) In this, experimental learning was executed out on nearby existing (Doimukh, Itanagar, Arunachal Pradesh, India) soil with reinforcement of Jute fibres. Here soil samples were formulated at its MDD analogous to its optimal moisture content in CBR mould with and without reinforcement. Percentage of Jute fibre by dry weight of soil - 0.25%, 0.5%, 0.75% and 1% was taken. In the current investigation lengths of fibres were taken as 30 mm, 60 mm and 90 mm and two dissimilar dia, 1mm and 2mm were considered for each fibre length. Test results indicate that CBR value of soil rises on inclusion of fibre content. It was also seen that on increasing diameter & length of fibre further raises CBR value of reinforced soil and this rise is substantial at fibre content of 1 % for 90 mm fibre length having diameter 2 mm.Thus there is considerable rise in CBR value of soil with reinforcement of Jute fibre and this rise in CBR value will significantly reduce pavement subgrade thickness.
- Dr. P Senthilkumar & R. Rajkumar (2012) Flourishing utilization of geosynthetics is guaranteed for a given geotechnical application, as it is compatible & effective to improve soil properties when appropriately placed. In his study, performance of woven and non-woven geotextile, interfaced between soft subgrade and unbound gravel in an unpaved flexible pavement system and is performed out experimentally, utilizing the CBR test arrangement. In order to assess out performance, reinforcement ratio is obtained based on CBR load –

penetration relation of both soft subgrade-gravel and soft subgrade-geotextile-gravel, separately, for woven and nonwoven geotextile. Effect of introducing geotextile layer between subgrade soil and base course layer and found that resistance to penetration increases with introduction of geotextile layer. He used equation given by (Koerner, 2005) to calculate reinforcement ratio i.e. loads with geotextile to load without geotextile and proposed that reinforcement ratio is greater than one throughout the test. Hence it was concluded that utilization of geotextile is most advantages in roads with soft subgrade at higher penetration. But author had performed test effectively on soil of class CH having an MDD of 1.562 moreover he has focused on the woven and non-woven geotextile but he has not mentioned percentage of geotextile reinforcement neither its aperture size nor its thickness. Hence results are not validated.

III. METHODOLOGY

In the present study, Sieve analysis, Specific Gravity Test, Consistency Indices Liquid Limit, Plastic Limit, and Plasticity Index Modified Proctor's Test, and California Bearing Ratio tests were conducted on the Black Cotton Soil first by mixing with varying percentage of RHA to stabilize the soil and then the varying percent of RHA at which the maximum CBR is gained is selected for the next step of the experiment. The optimum percentage of fly ash at which maximum CBR is achieved is then selected and gets reinforced with varying percentage of Sisal fibre. Among these varying Percentages of the reinforcement the optimum quantity of fibre required to get maximum strength are known.

Table 2- Combinations of materials and the tests

Materials combination	Tests conducted for all combination
Block Cotton Soil only Block Cotton Soil + SCBA Block Cotton Soil + SCBA + Core Fibre	Specific Gravity ConsistencyIndices Modified Proctor's Test (HeavyCompaction)CBRTest (Soaked)

IV. RESULTS

In the present study, Specific Gravity Test, Consistency Indices Liquid Limit ,Plastic Limit ,and Plasticity Index, Modified Proctor's Test, and California Bearing Ratio (CBR) Tests were conducted on the Black Cotton first by mixing with varying percentage of RHA to stabilize the soil. The optimum percentage of RHA at which maximum CBR is achieved is then selected and gets reinforced with varying percentage of synthetic Sisal fibre. Among these varying percentages of the reinforcement the optimum quantity of fibre required to get maximum strength is known. For better understanding of the experiment the results are presented in the graphical form and where possible in tabular forms. it is analyzed that the rate of increment in engineering properties of the mix or combination is high up to aspect ratio of 40, but after that the properties are getting lowering down to the before maintained aspect ratio. Thus, the outcome is that the aspect ratio of 40 is more suitable for the Sisal fibre used in the experiment and the fiber concentration at which highest result is obtained is 0.75 percent by weight of the sample.

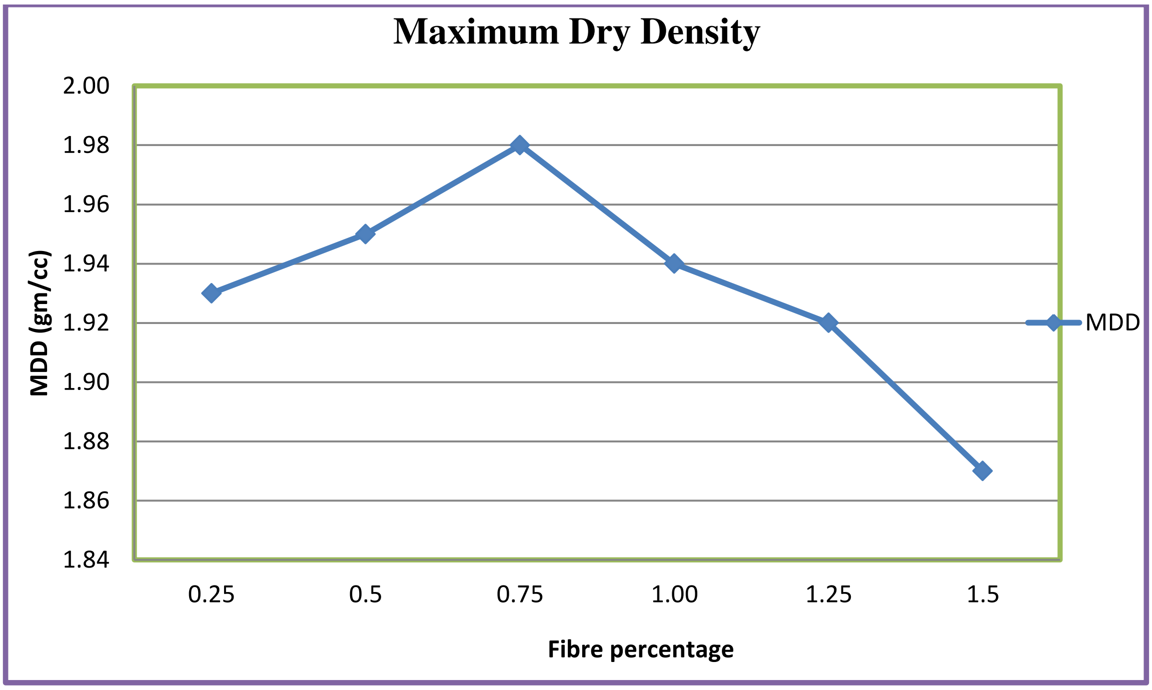

Figure 1–MDD graph for Black Cotton Soil

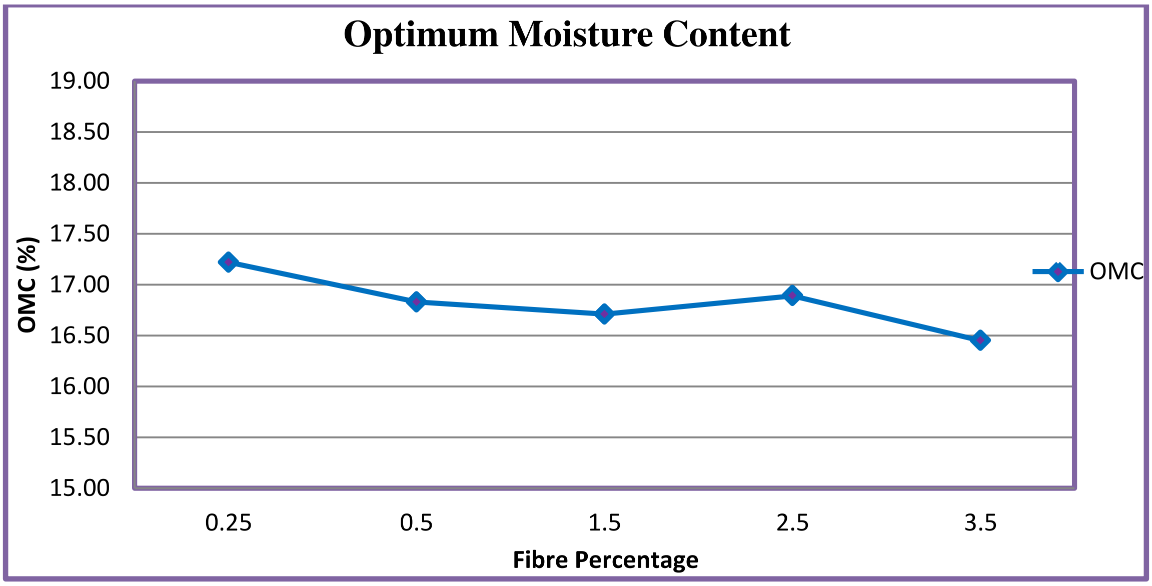

Figure 2 – OMC graph for Black Cotton Soil

ISSN: 2347-1697
International Journal of Informative & Futuristic Research (IJIFR)
Volume - 4, Issue -11, July 2017
Continuous 47th Edition, Page No.: 8101-8111

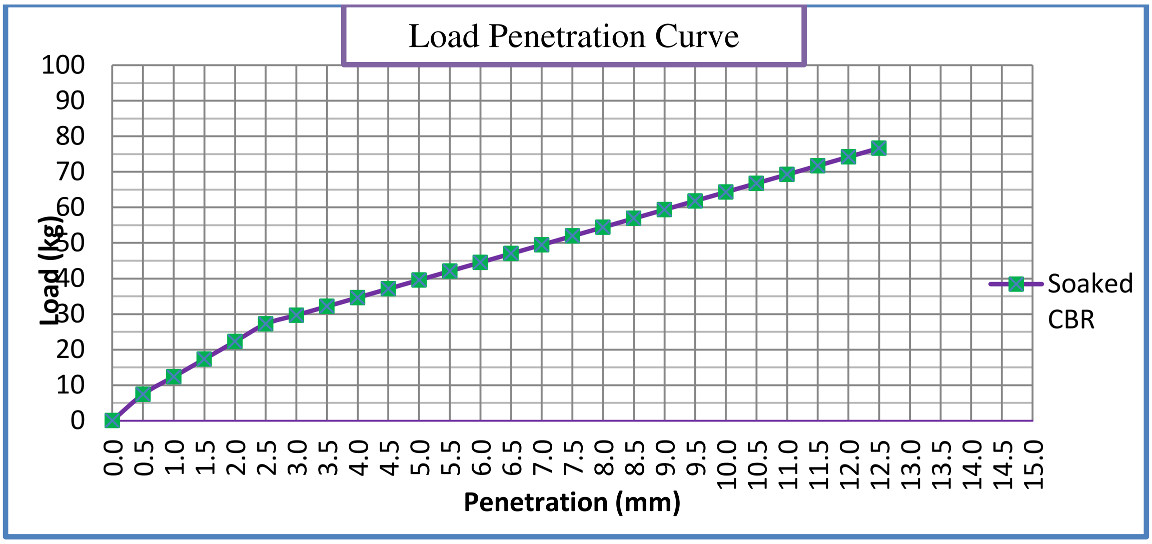

Figure 3 – CBR Graph plotted for Black Cotton Soil

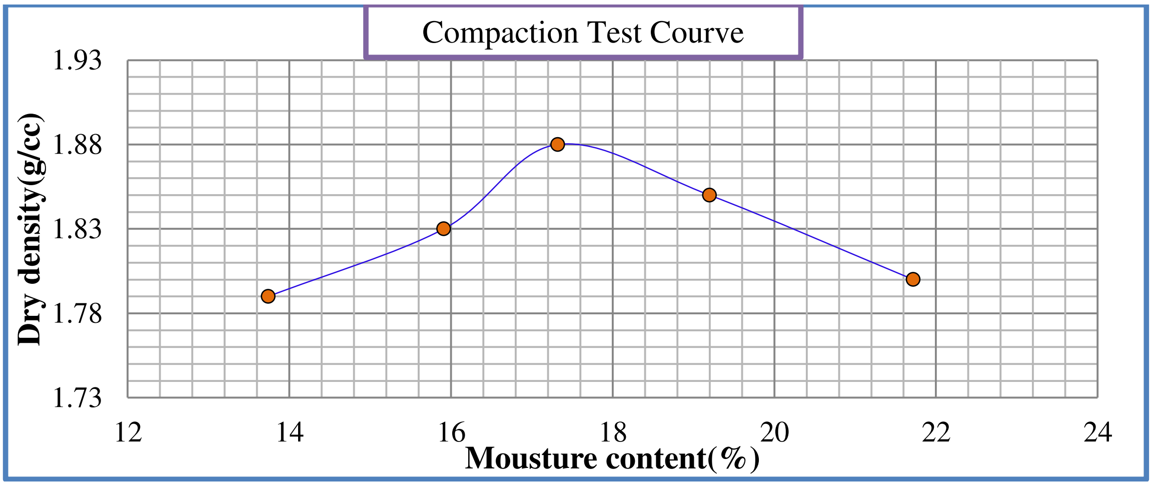

Figure 4 - MDD and OMC for BC Soil+20% RHA

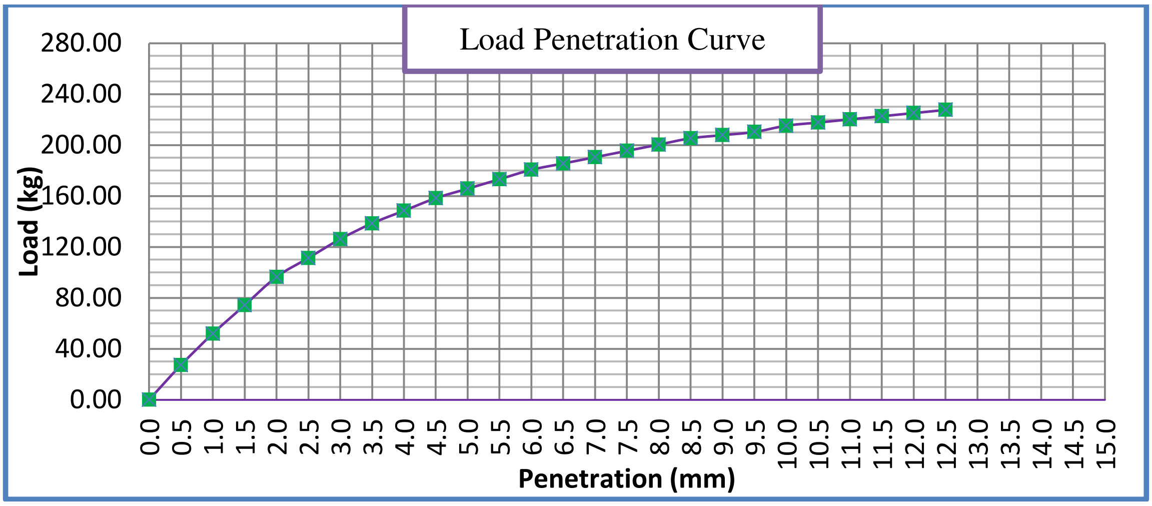

Figure 5 – CBR Graph plot for 20% RHA + B.C Soil

ISSN: 2347-1697
International Journal of Informative & Futuristic Research (IJIFR)
Volume - 4, Issue -11, July 2017
Continuous 47th Edition, Page No.: 8101-8111

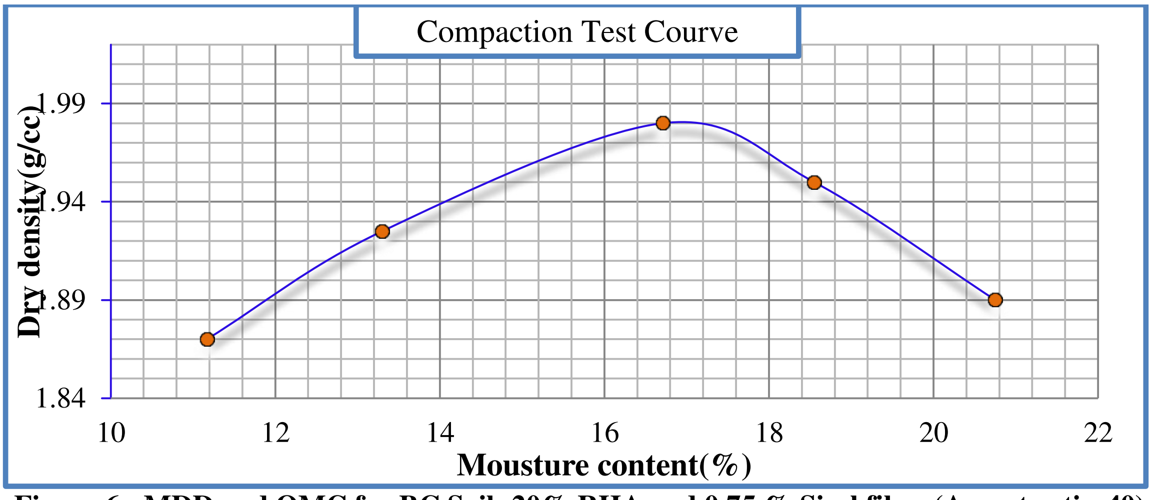

Figure 6 - MDD and OMC for BC Soil+20% RHA and 0.75 % Sisal fibre (Aspect ratio-40)

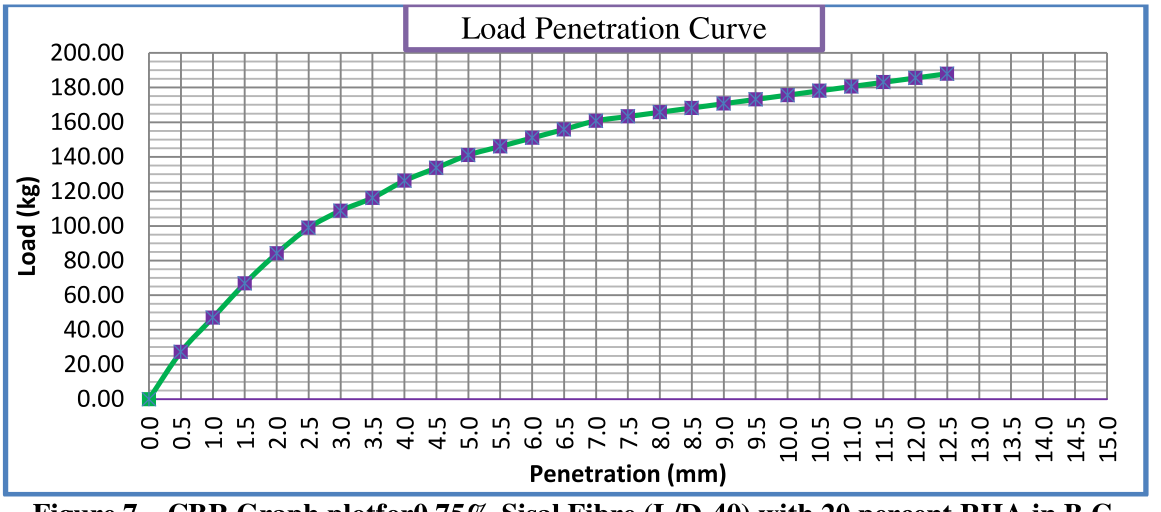

Figure 7 – CBR Graph plotfor0.75% Sisal Fibre (L/D-40) with 20 percent RHA in B.C. Soil

Table- 3 : Combined results for B.C. Soil with RHA

Properties	B.C.Soil	10% RHA + B.C.Soil	20% RHA + B.C.Soil	30% RHA + B.C.Soil	40% RHA + B.C.Soil
SpecificGravity	2.58	2.53	2.46	2.37	2.23
LiquidLimit(%)	72.00	58.00	52.50	48.60	45.00
PlasticLimit(%)	29.00	25.00	23.50	21.70	20.10
PlasticityIndex (%)	43.00	33.00	29.00	26.90	24.90
MDD (gm/cc)	1.56	1.82	1.88	1.85	1.81
O.M.C. (%)	18.60	16.74	17.32	17.43	17.88
CBR %(Soaked)	1.67	4.63	4.87	3.56	3.33

ISSN: 2347-1697
International Journal of Informative & Futuristic Research (IJIFR)
Volume - 4, Issue -11, July 2017
Continuous 47th Edition, Page No.: 8101-8111

Table- 4 : Combined results for BC Soil, RHA with Sisal fibre

Properties	20%Flyash + B.C.Soil+ 0.75 Sisal FibrePercentage					
	0.25% Sisal Fibre	0.5% Sisal Fibre	0.75% Sisal Fibre	1.00% Sisal Fibre	1.25% Sisal Fibre	1.50% Sisal Fibre
M.D.D.(gm/cc)	1.93	1.95	1.98	1.94	1.92	1.87
O.M.C. (%)	17.22	16.83	16.71	16.89	16.45	16.87
CBR%(Soaked)	6.67	6.92	7.22	6.44	6.33	6.22

Table- 5: Combined results for varying fibre concentration with 20 percent SCBA and Clayey Soil at fibre aspect ratio (L/D) of 40.

Properties	20% SCBA + B.C Soil + 0.75 Sisal Fibre Percentage					
	0.25 % Fibre	0.50% Fibre	0.75% Fibre	1.00% Fibre	1.25% Fibre	1.50 % Fibre
M.D.D. (gm/cc)	1.93	1.95	**1.98**	1.94	1.92	1.87
O.M.C. (%)	17.22	16.83	**16.71**	16.89	16.45	16.87

After analysis of Table 5, it is concluded that maximum favorable changes in engineering properties of RHA – fibre – soil mix is achieved at fibre concentration of 0.75 percent by weight of sample at an aspect ratio of 40. Variation in CBR value is remarkable which increased from 1.67 to 7.22, which are about more than 4 times superior than initial CBR of B.C Soil. Taking the optimal combination of 0.75 % Core fibre with 20 % RHA and remaining B.C Soil, one more experiment is performed to study effect of providing this combination at certain depth only and remaining depth is of Soil and 20 percent RHA mix without fibre. For that purpose the depth is segregated into 5 equivalent parts, each of depth 1/5 and then the variation in properties is studied. Results are also shown in tabular outline in Table.

V. CONCLUSION

In the present research work, black cotton soil of Bhopal, which is highly compressible in nature is mixed with the varying percentages of RHA (Rice husk ash which is utilized in this project is taken from Shakti Rice Mill Pvt Ltd Mandidip (M.P). ranging from 10 % to 40 % by weight of soil and changes on behavior of soil is studied including soaked CBR. The combination of soil and optimum percentage of RHA mixed soil is added with varying percentage of Sisal fiber of 0.40 mm diameter. The percentage of fiber content varied from 0.25 % to 1.50 % on different aspect ratios of 20, 40, 60 and 80 and soaked CBR value in each case was determined. The percentage of fiber giving maximum strength at specific aspect ratio is identified and termed as optimum percentage of Sisal fibre, When the soil is mixed with optimum quantity of RHA and Sisal fibre of 0.40 mm diameter at different aspect ratio and fiber content the results obtained are :-

i.) At aspect ratio of 40 with 0.75 % fibre content in 20 % RHA mixed soil, the maximum value of CBR isachieved which is 7.22. It is 4.24 times greater than the CBR value of raw soil.

ii.) ii. Irrespective of the aspect ratio, the soaked CBR value of the RHA mixed soil increases up to 0.75 % Sisal fibre content and after this value it starts decreasing. Thus for the black cotton soil used in the present study, the optimum quantity of RHA and Sisal Fibre are 20% and 0.75 % (at aspect ratio of 40) respectively for achieving maximum soaked CBR.

VI. REFERENCES

[1] GMurtaza,SS Shah and M. Ahmad,"*Improvement of Load Bearing Characteristics of RHA using Geo fabrics*", ProceedingsofFirstGeotechnical Conferenceon Reinforced Soil and Geotextile, 1988, ppF59-F63.

[2] Maher, M.H. and Gray, D.H., (1990),"*Static Response of Sands Reinforced with*

[3] *RandomlyDistributed Fibers*",J. Geotech. Eng.,ASCE, Vol.116, No.11

[4] Consoli, N.C., Prietto, P.D.M., and Savitripasa, G.(2002),"*Engineering Behaviourof SandreinforcedwithPlasticwaste*",JournalofGeotechnical and Geoenvironmental Engg.,ASCE, Vol.128,No.6

[5] KRShetty,N Swamy and SVG Rao."*Characterization of Fibre Reinforced Laterite Soil*".Proceeding Indian Geotechnical conference,Bangalore, volI, 1987

[6] Steinberg,M.C.(1985),"*ControllingExpansiveSoilDestructivenessbyDeepVertical Geo-membranes on FourHighways*", Transportation Research RecordNo.1032,

[7] J.N.Mandaland VishwaMoha, "*Performance Studies on California Bearing Ratio ValuesUsingGeo-synthetics*",Indian Geotechnical Conference (IGC),Visakhapatnam, December1989, Vol.I.

[8] G Ranjan, RM Vasanand H D Charan. "*Randomly Distributed Discrete FibreReinforcedSilt*".*ProceedingIndian*

[9] *GeotechnicalConference*, volI, 1994

[10] SMurugesan."*A Study of Fibres as Reinforcement for Subgrade of Flexible Pavement*".Proceeding ICGGE-2004,IIT, Mumbai

[11] DavidJ.White(2003),"*Fly Ash Soil Stabilization for Non-Uniform Subgrade Soils*",VolumeI:Engineering PropertiesandConstructionGuidelines(IHRB ProjectTR-461, FHWA Project 4)

[12] Al-Refeai, T.O. (1991), "*Behaviourof Granular Soils Reinforced with Discrete*

[13] *Randomly Oriented Inclusions*",Geo-textiles and Geo-membranes, Vol.10,pp-319-333.

[14] Al-Wahab, R.M., and Al-Ourna, H.H. (1995), FiberReinforced Cohesive Soil for application in compactedearth Structure, Geo-synthetics, Vol.16, pp. 433-446.

[15] Consoli,N.C.,Casagrande,M.D.TandPrietto,P.D.M,(2003),"*Plate LoadTestonFibre Reinforced Soil, JournalofGeotechnicaland Geo-environmentalEngineering*", ASCE, Vol.129, NO.10, pp.951-955.

[16] Zachary G. Thomas (2002), "*Engineering Properties of Soil-SCBASubgrade*

[17] *Mixtures",* Graduate Research Report, Lowa State University, Ames,Lowa.

[18] Consoli, N.C.,Vendruscolo, M.A.and Pritto,P.D.M.,(2003),"*BehaviourofPlateLoad Teston SoilLatersImproved with Cementand Fibre*", Journalof Geo-technicaland Geo-environmental Engineer,ASCE, Vol.129, No.1, pp.96-101.

[19] Holtz,W.G. (1959), "*Expansive Clays Properties and Problems*", Quarterly of the

[20] Colorado School of*Mines*, Vol.54

[21] AKChoudhary,Jha,J.N.and Gill, K.S.,"*Shear Strength Characteristics of Reinforced SCBA*", Proceedings ofIndian Geotechnical Conference, 2010, pp 583-586.

[22] .AKChoudharyandBPVerma,"*Strength and Deformation Characteristics of Fiber Reinforced Flyash*", Proceedings of Recent Advances in Civil Engineering (RACE), CUSAT, 2004, pp. 234-242.

[23] A.Sridharan, NS Pandian, S Srinivas,"*Use of Flyash toImprove the CBR of Soils*", Proceedings of Indian Geotechnical Conference, 1998, pp 261-264.

[24] A.Bhoominathan, J. Rathna Raju,"*Lime Treated SCBA as Embankment Material*", Proceedings ofIndian Geotechnical Conference, Vol 1, 1996, pp 523-526.

TO CITE THIS PAPER

Shrivastava, K.V. , Singh, K.V. , Jha, K.A. (2017) :: "An Experimental Study on Black Cotton Soil Stabilized with Rice Husk Ash and Randomly Distributed Sisal Fibres" *International Journal of Informative & Futuristic Research (ISSN: 2347-1697*), Vol. (4) No. (11), July2017, pp. 8101-8111, Paper ID: IJIFR/V4/E11/001.
Available online through- http://www.ijifr.com/searchjournal.aspx