IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684, p-ISSN: 2320-334X
PP 13-18
www.iosrjournals.org

Influence of Marble Dust, Fly Ash and Beas Sand on Sub Grade Characteristics of Expansive Soil

Chayan Gupta[1], Dr. Ravi Kumar Sharma[2]
[1]P.G. Student, Department of Civil Engineering, National Institute of Technology, H.P., India, (chayanbagli@gmail.com)
[2]Professor, Department of Civil Engineering, National Institute of Technology, H.P., India, (rksnthp61@gmail.com)

ABSTRACT*:The marble is a most prefer stone of India and available mostly in Rajasthan and Madhya Pradesh. The Rapid growth of industries of marble produces hazardous waste materials at a large extent which creates a big problem to the humans surrounding them as well as acts as a pollutant so affect the ecological system of the environment. It shows that there is urgent need for exploring the alternative of disposal of these materials. As we know that the black cotton soil having lack of construction problem due to insufficient stability naturally. The aim of research is, showing that the influence of waste materials such as marble dust, fly ash on the sub grade characteristics of black cotton soil. The series of test conducted in laboratory on fly ash, sand stabilized black cotton soil which further blended with 0-20 % marble dust and concluded that the 15% marble dust is sufficient to increases the California bearing ratio soaked value up to 200% approximately.*
Keywords: *Compaction, California bearing ratio, black cotton soil, sand, fly ash, marble dust.*

I. INTRODUCTION

The black cotton soil is an expansive soil. In India, it is found in major parts of Madhya Pradesh and Andhra Pradesh. In India, the black cotton soil covers $0.7X10^6$ km² approximately 20-25 % land area. When the black cotton soil comes in the contact of water then they causes swelling and when water content decreases shrinkage occurs in the soil. The estimated results shows that the black cotton soil causes the structural damage of about $1000 Millions in USA, £150 UK, and many billions pounds in worldwide annually (Gourley *et al*.,1993). The black cotton soil contains high percentage of montmorillonite mineral which imparts expansive nature to it. Sridharan *et al* (1985) studied the free swell index of Indian expansive soils. The change in the volume, due to seasonal moisture variation in black cotton soil is reported by (Hausmann, 1990). Ramana Murthy (1998) reported a study on swell pressure and the method of controlling swell of expansive soil. ElKholy (2008) reported that the effect of coarse-grained soil (sand) on the swelling characteristics of black cotton soil. The swelling nature of black cotton soil is reduced as increasing percentage of coarse-grained soil (sand). Choudhary *et al* (2011) reported the improvement in CBR values of expansive soil sub grade using geo synthetics. Numerous researchers have worked on the stabilization of soil using fly ash. Cokca (2001) showed the effect of class C fly ash on the stabilization properties of an expansive soil. White (2005) showed the effect of fly ash on the compaction, hydration, plasticity, durability and compressive strength characteristics of black cotton soil. Bhuvaneshwari (2005) concluded that workability and maximum dry density was achieved at 25% of fly ash. Edil *et al* (2006) indicated the effectiveness of fly ashes for stabilization of fine grained soils. Chauhan *et al* (2008) observed that optimum moisture content increases and maximum dry density decreases with increased percentage of fly ash mixed with silty sand. Brooks (2009) showed the effect of fly ash and rice husk ash on the unconfined compressive strength ,California bearing ratio and swelling characteristics of black cotton soil and reported that the unconfined compressive strength increased about 97% and California bearing ratio increased about 47% on addition of fly ash at 0-25% and similarly the stress and strain increased about 106 % and 50 % respectively on addition of rice husk ash at 0-12%, hence 25% fly ash and 12% rice husk ash is recommended for improving strength of black cotton soil. Bose (2012) reported that maximum dry density increases up to 20 % fly ash mix, and then gradually decreases whereas the optimum moisture content decreased with increase in fly ash and also CBR values of clay-fly ash mixes tested under un-soaked conditions, shows peaks at 20% and 80% ash content. The marble dust is a type of a solid waste which is generated from cutting and polishing of marble stone. The number of research has been done in the direction of utilizing of marble dust waste into the soil stabilization technique. Swami (2002), Baser (2009) and Palaniappan (2009), Agrawal et al (2011), Sabat et al (2011), Viswakarma et al (June 2013),had investigated that marble dust is effective waste material in soil stabilizing technique which improves the compaction characteristics ,sub grade characteristics

,swelling characteristics , compressive strength characteristics as well as index properties of soil like liquid limit ,plastic limit shrinkage limit. However, there is a gap in combined utilization of sand, fly ash and marble dust in stabilization of black cotton soil. So in this paper, sub-grade characteristics of black cotton soil blended with sand, fly ash and marble dust in different proportions has been studied.

II. EXPERIMENTAL PROGRAM

2.1 MATERIALS:

The black cotton soil is obtained from Gupta Farm House, Bagli Dewas, Madhya Pradesh (INDIA). Sand used in this experimental investigation has been obtained from river Beas. Fly ash is obtained from Ropar thermal power plant. Marble dust is obtained from marble stone shop locally. According to ASTM classification system (ASTM D2487-11), the black cotton soil was classified as clay with high plasticity (CH) and the properties of black cotton soil are given in Table 1. The fly ash (fa) is obtained as residue left after electronic precipitation of the burnt gases. The chemical composition of fly ash is given in Table 2 (ASTM D5239-2004). The chemical composition of marble dust (md) is given in Table 2. The specific gravity tests, consistency limit tests and the standard proctor tests were conducted in accordance with ASTM D854-10, ASTM D4318-10 and ASTM D698-07e1 respectively. The physical properties of black cotton soil-sand, fly ash and marble dust are presented in Table 1.

Table 1: Physical properties of black cotton soil, sand, fly ash & marble dust

Property	**Black Cotton Soil**	**Sand**	**Fly Ash**	**Marble Dust**
Specific gravity	2.30	2.635	1.966	2.64
Maximum dry density, g/cc	1.515	1.592	1.164	-
Optimum moisture content, %	22.03	7.0	32.0	-
Activity	2.73	-	-	-
Differential free swell index, %	58.86	-	-	-
Liquid limit, %	62.5	-	40.0	-
Plastic limit, %	32.5	-	-	-
Plasticity index, %	30.0	-	-	-
Uniformity coefficient, Cu	-	1.73	-	2.07
Coefficient of curvature, Cc	-	1.02	-	1.11
Soaked CBR, %	2.69	9.09	1.94	-

Table 2: Chemical composition of Fly Ash

Chemical Composition	**Chemical Composition**
Silica (Sio_2)	55.69
Alumina (Al_2o_3)	26.33
Calcium oxide (Cao)	3.43
Iron oxide (Fe_2O_3)	6.90
Potassium Oxide (K_2O)	0.98
Sulphur (SO_3)	0.45
Magnesium Oxide (Mgo)	0.62
Loss on ignition	5.60

Table 3: Chemical composition of Marble Dust

Chemical Composition	Chemical Composition
SiO2	6.2
Fe2O3	0.8
Al2O3	4.8
CaO	30.1

The hydrometer analysis tests were conducted as per ASTM D422-63. The particle size distribution of black cotton soil, sand, fly ash and marble dust tested as per ASTM D6913-04 (2009) are given in “Fig.” 1.

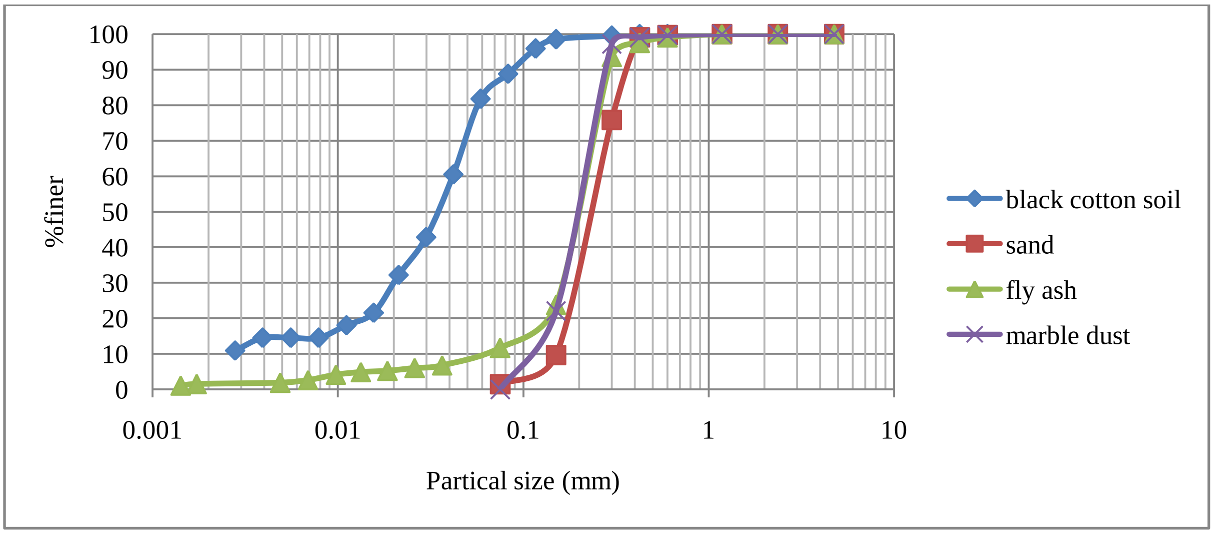

Figure1: Particle size distribution of black cotton soil, sand, fly ash and marble dust

III. RESULTS AND DISCUSSIONS

3.1. COMPACTION TESTS:

The standard compaction tests were performed in laboratory in accordance with ASTM D698-07E1.The water content-dry density curves of black cotton soil mixed with sand content varying from 10% to 50% are shown in Fig. 2. It is observed that maximum dry density (MDD) of the black cotton soil-sand composite increases with the increase in sand content up to 50%. This occurs due to the reason that the void spaces between the sand particles are occupied by the black cotton soil particles.

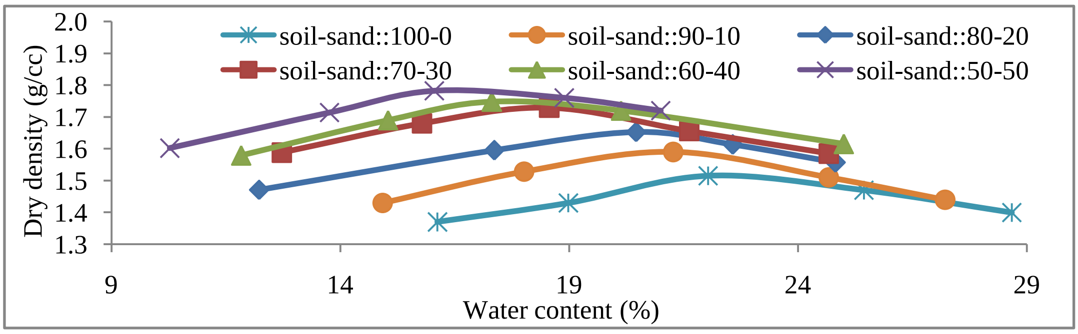

Figure 2: Compaction characteristics of black cotton soil- sand mixes

The water content-dry density curves of the black cotton soil-sand (70:30) composite with fly ash content varying from 5% to 20% is shown in Fig. 3. The maximum dry density achieved after the addition of fly ash is lesser compared with black cotton soil-sand mix. This is due to the reason that the black cotton soil particles can fill most of the voids in the sand when mixed in the ratio of 70:30 (black cotton soil: sand). Further, it is observed that as the fly ash content increases, the maximum dry density decreases but the optimum moisture content increases.

The water content-dry density curves of the black cotton soil-sand –fly ash composite with marble dust content varying from 8% to20 % is shown in "Fig.4". The maximum dry density achieved after the addition of marble dust, is more compared with black cotton soil-sand-fly ash mix. When the soil mixed in the ratio of black cotton soil-sand-fly ash-marble dust:: 52.36%-22.44%-13.20%-12%,maximum density is achieved . It is observed that maximum dry density of black cotton soil- sand-fly ash-marble dust composite increases with increase in tile waste content up to 12% after which it is reduced. The voids between the sand and marble dust particles are occupied by the black cotton soil particles when the marble dust content is less but larger marble dust content segregates the particles and the maximum dry density decreases.

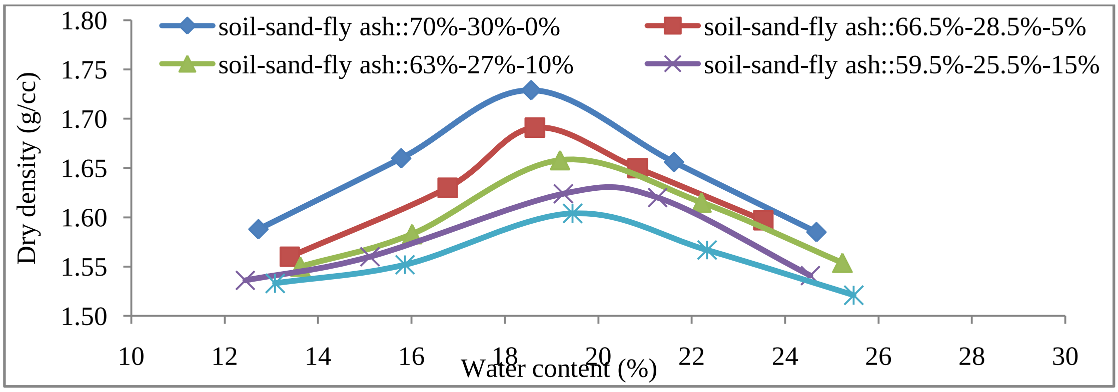

Figure 3: Compaction characteristics of black cotton soil-sand-fly ash mix

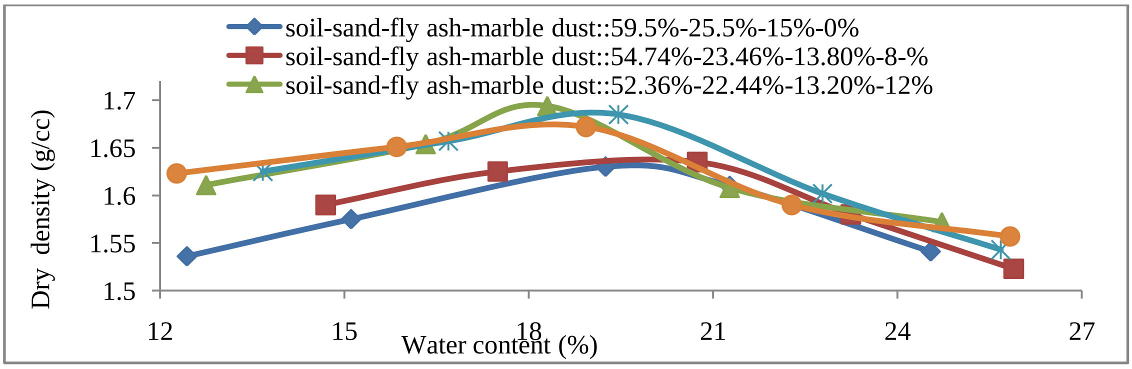

Figure 4: Compaction characteristics of black cotton soil- sand-fly ash-marble dust mix

3.2. CALIFORNIA BEARING RATIO TEST:

The California bearing ratio tests were performed in laboratory in accordance with ASTM D1883-05. The improvement in CBR value may be attributed to better compaction and packing of the mix particles with addition of sand, fly ash and marble dust. The California bearing ratio provides a basis of designing the sub-grades of flexible pavements. Usually, a value of CBR more than 5.0 is considered to be satisfactory for the design of flexible pavements with traffic intensity of 1 to 10 million standard axles (msa). Thus, the black cotton soil blended with sand, fly ash and marble dust can be effectively used in the construction of sub-grades of roads with low traffic volume.

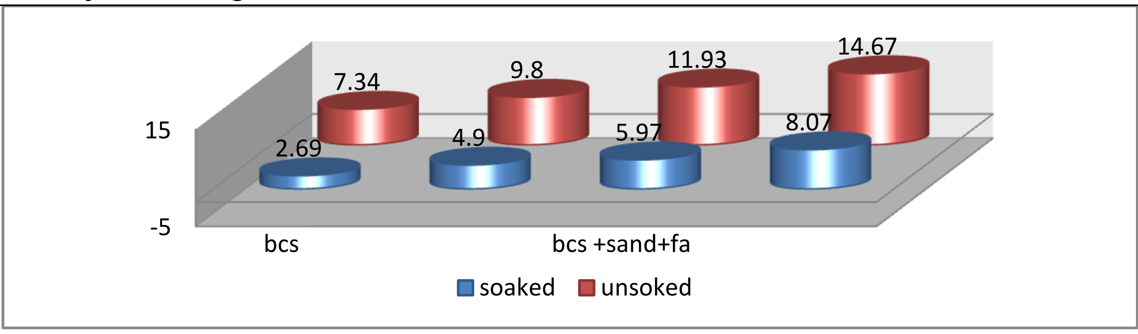

Figure 5: Variation of soaked and unsoked CBR value with optimum mix

IV. CONCLUSIONS:

Based upon the above study the following conclusions can be drawn:

The optimum value of maximum dry density is achieved for black cotton soil-sand mix of 70:30 followed by other proportions (Fig. 2). On further increasing the percentage of sand in the composite, amount of sand required increases and composite becomes uneconomical.

The maximum dry density of black cotton soil-sand (60:30) mix decreased with addition of fly ash which is a light weight material as compared to black cotton soil and sand "Fig". 3. (since the fly ash particles are much finer and rounded in shape) as compared to that of black cotton soil and sand (Table 1).

The highest value of maximum dry density is achieved for black cotton soil-sand-fly ash-marble mix of 52.36%-22.44%-13.20%-12%, followed by other proportions "Fig." 4.

The soaked California bearing ratio value of black cotton soil improved significantly i.e. from 2.69% to 8.07% approximately 200% with addition of sand, fly ash and marble dust in appropriate proportion. (Figure 5).

Thus, black cotton soil stabilized with sand, fly ash and marble dust can be used as a sub-grade material for construction of flexible pavements in rural roads with low traffic volume.

REFERENCES

Agrawal Vinay,Gupta Mohit (2011) "Expansive Soil Stabilization Using Marble Dust," *International Journal of Earth Sciences and Engineering* ISSN 0974-5904, Volume 04, No 06 SPL, October 2011, pp 59-62.

ASTM D422-63, "Standard test methods for hydro meter analysis of soils," *American Society for Testing of Materials,* Pennsylvania, PA, USA.

ASTM D698-07e1, "Standard test methods for laboratory compaction characteristics of soil using standard effort," *American Society for Testing of Materials,* Pennsylvania, PA, USA.

ASTM D854-10, "Standard test methods for specific gravity of soil," *American Society for Testing of Materials,* Pennsylvania, PA, USA.

ASTM D1883-05, "Standard test methods for California bearing ratio test for soils," *American Society for Testing of Materials,* Pennsylvania, PA, USA.

ASTM D2487-11, "Standard practice for classification of soils for engineering purposes (unified soil classification system)," *American Society for Testing of Materials,* Pennsylvania, PA, USA.

ASTM D4318-10, "Standard test methods for liquid limit, plastic limit, and plasticity index of soils," *American Society for Testing of Materials*, Pennsylvania, PA, USA.

ASTM D5239-2004, "Standard practice for characterizing fly ash for use in soil stabilization," *American Society for Testing of Materials,* West Conshohocken, PA, USA.

ASTM D6913-04, "standard test methods for particle size distribution of soils," *American Society for Testing of Materials*, Pennsylvania, PA, USA.

Bhuvaneshwari, S., Robinson, R.G. and Gandhi, S.R., "Stabilization of expansive soils using fly ash, "*Fly Ash India, 2005, Fly Ash Utilization Program (FAUP), TIFAC, DST,* New Delhi.

Bose, B. (2012), "Geo engineering properties of expansive soil stabilized with fly ash," *Electronic Journal of Geotechnical Engineering,* Vol. 17, Bund. J.

Brooks, R.M., (2009), "Soil stabilization with fly ash and rice husk ash. *International Journal of Research and Reviews in Applied Sciences,* 1(3): 209-217.

Chauhan, M.S., Mittal, S. and Mohanty, B. (2008), "Performance evaluation of silty sand sub-grade reinforced with fly ash and fiber," *Geotextiles and Geomembranes,* Vol. 26, Issue 5, pp. 429-435.

Choudhary AK, Gill KS & Jha KN (2011), "Improvement in CBR values of expansive soil sub grade using geo synthetics," *Proc. Indian Geotechnical Conference,* 569-572.
Cokca, E. (2001), "Use of class C fly ash for the stabilization of an expansive soil," *J Geotech Geo-environment Enggineering ASCE* 127(7):568–573.
Edil, T.B., Acosta, H.A., and Benson, C.H. (2006), "Stabilizing soft fine grained soils with fly ash," *Journal of Materials in Civil Engineering, ASCE* 18(2), 283-294.
ElKholy, Sherif M. (2008), "Improving the Characteristics of expansive soil using coarse-grained soil," *Journal of Engineering and Computer Sciences, Qassim University,* Vol. 1, No. 2, pp. 71-81.
Gourley, C. S., Newill, D., and Shreiner, H. D., (1993), "Expansive soils: TRL's research strategy," Proc., 1st Int. Symp. on Engineering Characteristics of Arid Soils.
Hausmann, M. R. (1990), Engineering Principles of Ground Modification, *Mc Graw Hill Book Co*., New Delhi.
Ramana Murthy (1998), Study on swell pressure and the method of controlling swell of expansive soil, *Ph.D, thesis, Kakatiya University*, NIT, Warangal.
Sridharan, S. M. Rao and Murthy, N. S. (1985), "Free swell index of soils–A need for redefinition," *Indian Geo-tech. J.,* 15, 94–99
Sabat A. K., "effect of marble dust on strength and durability of Rice husk ash stabilised expansive soil", *International Journal of Civil and Structural Engineering* Volume 1, No 4, 2011.
Viswakarma Amit and Rajput Rakesh Singh (2013) "Utilization of Marble Slurry To Enhance Soil Properties And Protect Environment" *Journal of Environmental Research And Development* Vol. 7 No. 4A.
White, D.J., 2005. "Fly ash soil stabilization for non-uniform subgrade soils". *Iowa State University. Volume I: Engineering Properties and Construction Guidelines (IHRB Project TR-461, FHWA Project 4.*