International Journal of Civil Engineering Research.
ISSN 2278-3652 Volume 5, Number 1 (2014), pp. 77-82

http://www.ripublication.com/ijcer.htm

Influence of Micro Silica Fume on Sub Grade Characteristics of Expansive Soil

Chayan Gupta[1] and Ravi Kumar Sharma[2]

[1]P.G. Student, Department of Civil Engineering, National Institute of Technology, Hamirpur, Himachal Pradesh, India.
[2]Department of Civil Engineering, National Institute of Technology, Hamirpur, Himachal Pradesh, India

Abstract

As India is on the way of development, industrialization is increasing rapidly and also a great scarcity of land is there, the demand for utilization of industries wastes which coming from industries is increasing. From geotechnical point of view, the marble dust, rice husk, fly ash, blast furnace slag, foundry sand, glass waste, tiles waste, ceramics waste etc are the commonly used waste materials having effective characteristics required by a good soil stabilization admixture. The current research shows the effective utilization of micro silica fume in the improvement of sub grade characteristics of expansive soil. A number of test were conducted in laboratory which shows that the micro silica fume is a good alternative for the improvement of sub grade characteristics of expansive soil. The Standard compaction test were conducted in laboratory for obtaining the maximum dry density (mdd) and optimum water content (omc) corresponding to 5 % to 20 % of micro silica fume mixed with expansive soil in the variation of 5 %each. After the determination of omc and mdd of different proportion, the laboratory California bearing ratio (cbr) tests were conducted with the above proportion of micro silica fume and it was concluded that soaked cbr value of expansive soil blended with 10 % silica fume increased from 2.69 to 5.87 i.e. 108.85 % similarly unsoaked cbr value increased from 7.45 to 15.56 i.e. 118.21 %.

Keywords: Compaction, California bearing ratio, Expansive soil, sand, micro silica fume.

1. Introduction

The soil improvement or modification technique is basically used for improving the geotechnical properties of soil such as sub grade characteristics, shear strength, swelling and shrinkage characteristics, bearing capacity. The expansive soil, which also known as black cotton soil, is found in major parts of Madhya Pradesh and Andhra Pradesh of India and it covers $0.75X10^6$ km² approximately 21-24 % land area. It is types of a problematic soil contain the montmorillonite as a clay mineral hence whenever it comes in the contact of water they causes swelling and when water content removes, shrinkage occurs in the soil. The estimated results shows that it causes the structural damage of about $1000 Millions in USA, £150 UK, and many billions pounds in worldwide annually (Gourley *et al*., 1993).in recent years for the purpose of soil improvement, the industrial waste materials such as marble dust, fly ash, rice husk ash, phosphor-gypsum, cement kiln dust, copper slag, bagasse ash ceramic dust, waste steel chips, brick dust and lime were frequently used. The micro silica fumes are non crystalline waste by product produced from the electric arc furnace in the production of silicon or alloy containing silicon. About 100,000 tons of micro silica fumes are produced per year worldwide. The micro silica fumes generally having the particle size less the 1 micron. In recent few years it is used in as construction materials of concrete design as an alternative of Portland cement, hence in these research positive attempt is taken for effective utilization of micro silica fume as an admixture of soil improvement technique.

2. Literature Review

Sridharan *et al* (1985) shows the free swell index of Indian expansive soils. The volumetric change, due to seasonal moisture variation in expansive soil is reported by (Hausmann, 1990). Ramana Murthy (1998) studied the swelling pressure and the method of controlling swell of expansive soil. Choudhary *et al* (2011) shows 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 such as, Cokca (2001), White (2005), Bhuvaneshwari (2005), Edil *et al* (2006), Chauhan *et al* (2008), Brooks (2009), and Bose (2012) and they shows the effect of fly ash on the geotechnical properties of expansive soil. Similarly many researchers such as Abd.El-Aziz M.et al.(2004), Al-Azzawi et al.(2012), Kalkan et al. (2004), M.Karimi et al. (2011),M. Qamruddin et al.(2013)**,** Negi Chhaya et al.(2013) investigate the effectiveness of silica fume on the geotechnical properties such as swelling characteristics ,sub grade characteristics, unconfined compressive strength of soil.

3. Experimental Program

3.1 Materials

The expansive soil is obtained from Gupta Farm House, Bagli Dewas, Mahya Pradesh (INDIA). Silica fume is obtained from Ropar power plant. According to ASTM classification system (ASTM D2487-11), the expansive soil was classified as clay with

high plasticity (CH) and the properties of expansive soil are given in Table 1. The micro silica fume (msf) is obtained as residue left after electronic precipitation of the burnt gases. The chemical composition of micro silica fume 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 expansive soil and micro silica fume are presented in Table 1.

Table 1: Physical properties of expansive soil, micro silica fume.

Property	Expansive Soil	Micro silica fume
Specific gravity	2.31	2.12
Maximum dry density, g/cc	1.514	
Optimum moisture content, %	22.08	
Particle size	-	< 1µm
Activity	2.76	-
Differential free swell index, %	58.84	-
Liquid limit, %	62.6	-
Plastic limit, %	32.6	-
Plasticity index, %	30.0	-
Uniformity coefficient, Cu	-	-
Coefficient of curvature, Cc	-	-
Soaked CBR, %	2.67	-

Table 2: Chemical composition of micro silica fume.

Chemical Composition	Chemical Composition (%)
Silica (Sio_2)	98.84
Alumina (Al_2o_3)	.04
Calcium oxide (Cao)	.63
Iron oxide (Fe_2O_3)	.03
Potassium Oxide (K_2O)	.07
Magnesium Oxide (Mgo)	.01

The hydrometer analysis tests were conducted as per ASTM D422-63. The particle size distributions of exansive soil tested as per ASTM D6913-04 (2009) are given in “Fig.” 1.

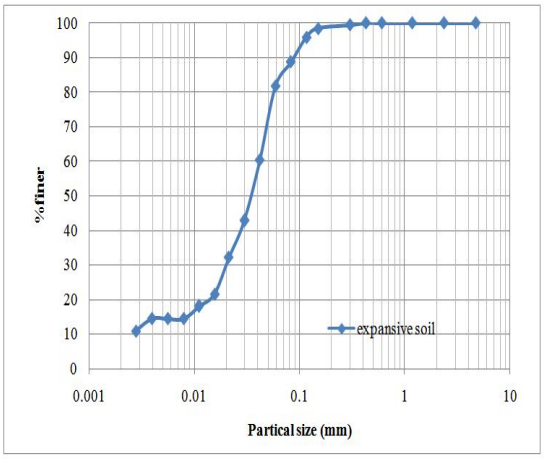

Figure1: Particle size distribution of expansive soil.

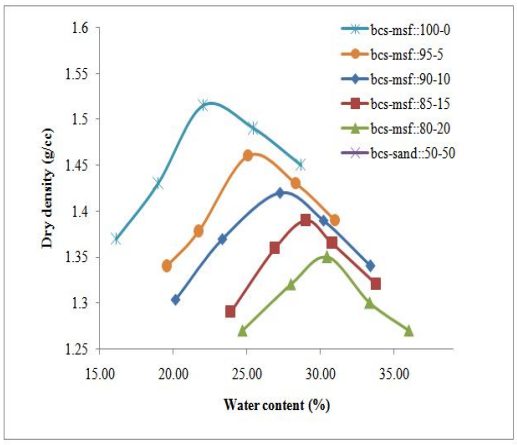

Figure 2: Compaction characteristics of expansive soil-Micro silica fume mixes

4. Results and Discussions

4.1. Compaction Tests

The standard compaction tests were performed in laboratory in accordance with ASTM D698-07E1.The water content-dry density curves of expansive soil mixed with micro silica fume varying from 5% to 20% are shown in Fig. 2. It is observed that maximum dry density (MDD) of the expansive soil-micro silica fume composite decreases with the increase in micro silica fume content up to 20% whereas the optimum water content (OMC) increases. This occurs due to the reason that the void spaces between the micro silica fume particles are occupied by the expansive soil particles.

4.2. California Bearing Ratio Test

The California bearing ratio tests were performed in laboratory in accordance with ASTM D1883-05.

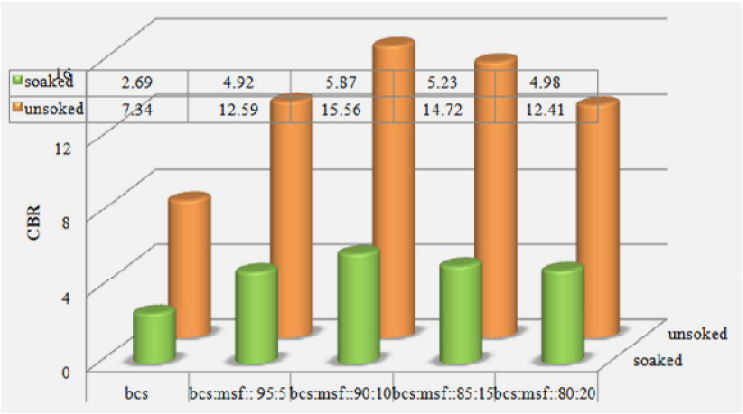

Figure 5: Variation of soaked CBR value with optimum mix.

5. Conclusions

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

1. The maximum dry density of expansive soil blended micro silica fume mix is reduced as addition of micro silica fume (Fig. 2). This occurs due to the reason that the void spaces between the micro silica fume particles are occupied by the expansive soil particles.
2. The optimum water content (OMC) of expansive soil blended micro silica fume mix is increased as addition of micro silica fume (Fig. 2).
3. The soaked California bearing ratio value of expansive soil improved significantly i.e. from 2.69% to 5.87% approximately % with expansive soil-micro silica fume (90:10) composite mix (Figure 5).
4. Thus, expansive soil stabilized with micro silica fume can be used as a sub-grade material for construction of flexible pavements in rural roads with low traffic volume.

References

[1] Abd El-Aziz.,Abo-Hashema M., and El-Shourbagy M., "The effect of Lime-Silica Fume Stabilizer on Engineering Properties of Clayey Subgrade",.Fourth Mansoura International Engineering Conference (4th IEC), Faculty of Engineering ,Mansoura University,Eygpt,April 2004.

[2] Adel A. Al-Azzawi, Khalida A. Daud ,Muhammed A. Abdul Sattar "Effect of Silica Fume Addition on the Behavior of Silty-Clayey Soils" Journal of Engineering and Development, Vol. 16, No.1, March 2012.

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

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

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

[6] 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.

[7] 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.

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

[9] 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.

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

[11] 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.

[12] 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.

[13] 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.

[14] 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.

[15] 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.

[16] 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.

[17] 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.

[18] Hausmann, M. R. (1990), Engineering Principles of Ground Modification, *Mc Graw Hill Book Co*., New Delhi.

[19] Kalkan,E. and Akbulut,S., "The Positive Effects of Silica Fume on the Permeability, Swelling Pressure and Compressive Strength of Natural Clay Liners", Journal of Engineering Geology, Vol. 73,2004,pp. 145-156.

[20] M Karimi & Ali G."Stabilization of silty sand soils with lime and micro silica admixture in pressure of sulphates".Pan –Am CGS, Geotechnical Conference 2011.

[21] M.Qamruddin, Kalurkar L.G.., (2013). "Effect Of Unprocessed Rice Husk Ash As A Cementitious Material In Concrete". international Journal of Civil Engineering and Technology (IJCIET) Volume 4, Issue 2, March - April (2013),

[22] Negi Chhaya , Yadav R.K., Singhai A.K. (2013), "Effect of Silica Fume on Engineering Properties of Black Cotton Soil" *International Journal of Computational Engineering Research, Volume 03,Issue, 7*

[23] Negi Chhaya , Yadav R.K., Singhai A.K. (2013), "Effect of Silica Fume on Index Properties of Black Cotton Soil" International Journal of Scientific & Engineering Research, Volume 4, Issue 8, August-2013.

[24] Ramana Murthy (1998), Study on swell pressure and the method of controlling swell of expansive soil, *Ph.D, thesis, Kakatiya University*, NIT, Warangal.

[25] 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.

[26] 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.*