Stabilization Analysis of Black Cotton Soil by using Groundnut Shell Ash

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Abstract

Black Cotton soil is fertile and very good for agriculture, horticulture, sericulture and aquaculture. Though black cotton soils are very good for agricultural purposes, they are not so good for laying durable roads.The study is a potential stabilization of black cotton soils in Gujarat state using Groundnut Shell ash. Index properties of the natural soil showed that, the soil is a poor for engineering use. Liquid limit and Plasticity index values of 83.36 % and 89.32 % respectively for the natural soil suggest that the soil is highly plastic. There was gradual decrease in the free swell to a minimum value of 2.91% at 10% GSA (Groundnut Shell Ash) as compared to the natural value of 15.25%. The soaked CBR for the natural soil is 1.67% which increased to 2.17% at 10% GSA. This value fell short of specification requirement of the CBR value to be used as sub-base or base material. However, there was increase in strength for UCS of 21 days curing period from a value of 134kN/m2 as compared to 313kN/m2 for the unstabilized soil. This research is aimed at evaluating the possibility of utilizing groundnut shell ash (GSA) in the stabilization of black cotton soils.

Keywords: Atterberg's limit, black cotton soil, consistency of soil, Free swell Index, Groundnut shell ash, Montmorillonitic soil

I. INTRODUCTION

Good road network is a basic requirement for the all-round development of an area. Unfortunately, poor road network is hampering the full-fledged development of the otherwise prosperous areas. Application of solid waste (Groundnut Shell Ash) disposal for soil stabilization is a significant which serves various benefits to the environment. The term solid waste includes all those solid and semi-solid materials that are discarded by the community. Improper management of solid waste causes adverse effects on ecology which may lead to possible outbreaks of diseases and epidemics. The over dependence on industrially manufactured soil improving additives (cement, lime etc) have kept the cost of construction of stabilized road financially high. This hitherto have continued to deter the underdeveloped and poor nations of the world from providing accessible roads to meet the need of their rural dwellers who constitute large percentage of their population which are mostly rural farmers. Furthermore, the World Bank has been expending substantial amount of money on research aimed at harnessing industrial waste products for further usage. Black cotton soils are expansive clays with potential for shrinking or swelling under changing moisture condition. The soils are formed under conditions of poor drainage from basic rocks or limestones under alternating wet or dry climatic conditions. They usually exhibit high shrink-swell characteristics with surface cracks, opening during the dry seasons which are more than 50mm or more wide and several mm deep. These cracks close during the wet season and an uneven soil surface is produced by irregular swelling and heaving. Such soils are especially troublesome as pavement sub-grades. Groundnut Shell is an agricultural waste obtained from milling of groundnut. In the world, the total hectare planted to groundnut is over 20 million hectares per year. Groundnuts are mostly intercropped. Groundnut contains about 25% Protein and 45 to 50 % oil. In this work, an exercise is done to utilize groundnut shell ash (GSA) to improve the engineering performance of Black Cotton soil which may be an economical solution of soil stabilization.

II. STUDY AREA

Groundnut shell is an agricultural waste obtained from milling of groundnut from the Shreenathji Agricultural fuel factory situated on Patapur road which lies between 21o 27' 55" North Latitude and 70o 28' 30" East Longitude. It is located in Junagadh district of Saurastra region of Gujarat state. In winter season, the temperature varies from 60 to 180 and in summer season, the variation is from 350 to 450.

III. METHODOLOGY

A. Soil Stabilization

Soil stabilization is the alteration of one or more soil properties, by mechanical or chemical means, to create an improved soil material possessing the desired engineering properties. Soils may be stabilized to increase strength and durability or to prevent erosion and dust generation.

B. Mechanical Stabilization

Soil stabilization can be achieving thorough physical process by altering the physical nature of native soil particles by either induced vibration or compaction or by incorporating other physical properties such as barriers and nailing.

C. Chemical Stabilization

Chemical stabilization involves mixing or injecting the soil with chemically active compounds such as Portland cement, lime, fly ash, calcium or sodium chloride or with viscoelastic materials such as bitumen. Chemical stabilizers can be broadly divided in to three groups: Traditional stabilizers such as hydrated lime, Portland cement and Fly ash; Non-traditional stabilizers comprised of sulfonated oils, ammonium chloride, enzymes, polymers, and potassium compounds; and By-product stabilizers which include cement kiln dust, lime kiln dust etc. Among these, the most widely used chemical additives are lime, Portland cement and fly ash. Although stabilization with fly ash may be more economical when compared to the other two, the composition of fly ash can be highly variable. (Dallas and Syam 2009).

IV. RESULTS AND DISCUSSIONS

Index Properties of Black cotton Soil

Table 1:
Geotechnical properties of the unstabilized black cotton soil

PROPERTY	*VALUE/DESCRIPTION*
Liquid limit	*83.36%*
Plastic Limit	*44.40%*
Plasticity Index	*38.92%*
Linear Shrinkage	*19.22%*
Free Swell	*15.25%*
Optimum Moisture Content (OMC)	*27.50%*
Maximum Dry Density (MDD)	*1.4mg/m^3*
California Bearing Ratio (CBR)	*1.67%*
Unified Soil Classification System (UCS)	*134kN/m^2*

Table 2:
Variation of Atterberg limit with GSA content

GSA content	*LL*	*PI*	*PL*	*LS*
0	*82.37*	*39*	*45.6*	*20.56*
1	*82.37*	*39*	*45.6*	*20.56*
2	*80.99*	*60.28*	*22.38*	*22.87*
3	*80.99*	*60.28*	*22.38*	*22.87*
4	*82.1*	*59.2*	*26.4*	*25*
5	*82.1*	*59.2*	*26.4*	*25*
6	*86.89*	*61.39*	*27.5*	*24.12*
7	*86.89*	*61.39*	*27.5*	*24.12*
8	*102.5*	*75.38*	*27.78*	*24.11*
9	*103.71*	*75.88*	*27.8*	*24.71*

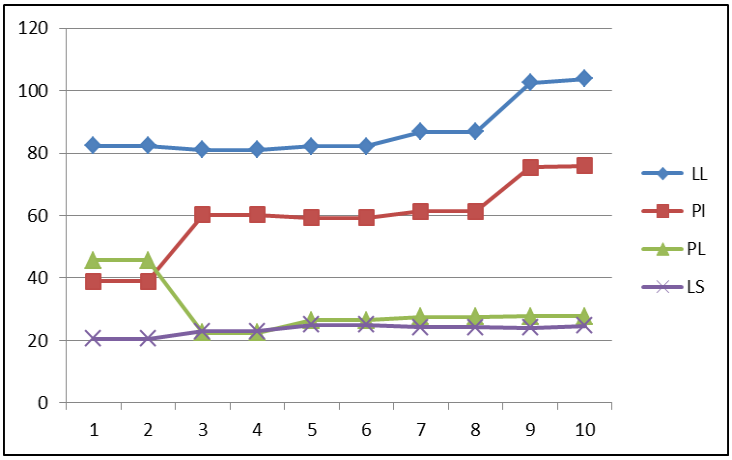

Fig. 1: Variation of Atterberg limit with GSA content

Table 3:
Variation of Free Swell with GSA content

GSA content	*0*	*2*	*4*	*6*	*8*	*10*
Free swell	*15.38*	*11.8*	*10.71*	*9.07*	*4.76*	*3.02*

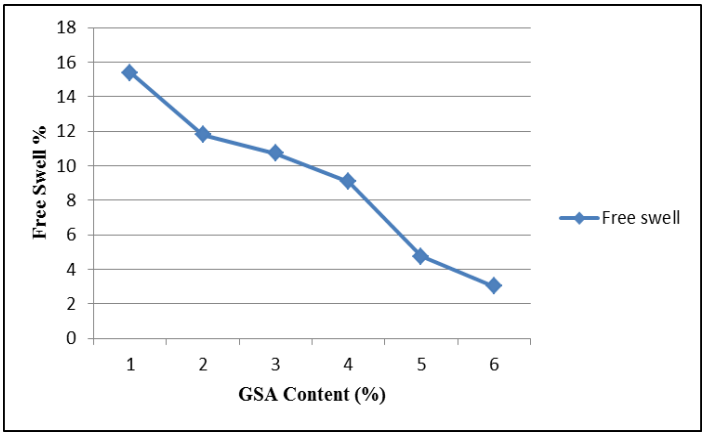

Fig. 2: Variation of Free Swell with GSA content

Table 4:
Variation of OMC with GSA content

GSA content	*0*	*2*	*4*	*6*	*8*	*10*
Optimum Moisture content	*27.5*	*27.83*	*30.2*	*24.3*	*22.8*	*25.3*

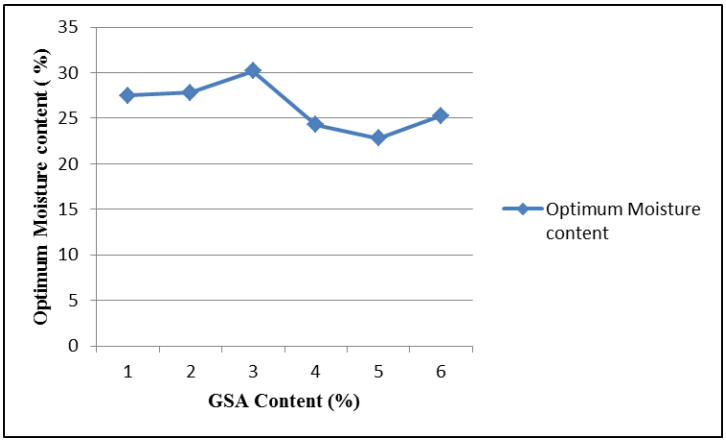

Fig. 3: Variation of OMC with GSA content

Table 5:
Variation of MDD with GSA content

GSA content	*0*	*2*	*4*	*6*	*8*	*10*
Max Dry Density (MDD) (Mg/m³)	*1.403*	*1.4*	*1.33*	*1.39*	*1.45*	*1.43*

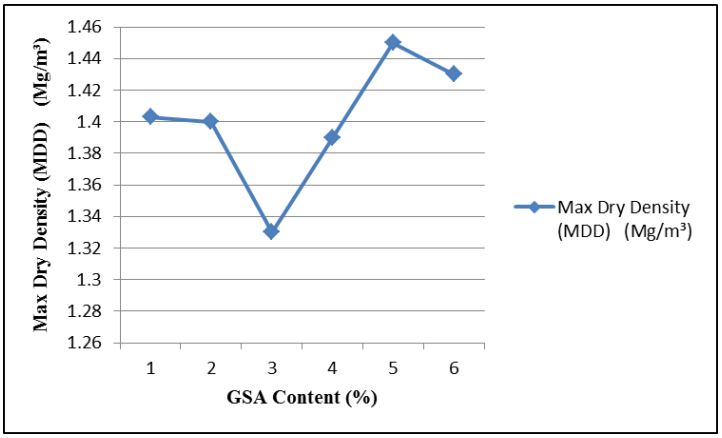

Fig. 4: Variation of MDD with GSA content

Table 6:
Variation of CBR with GSA content

GSA content	*0*	*2*	*4*	*6*	*8*	*10*
Soaked CBR %	*1.68*	*1.56*	*1.59*	*1.61*	*1.63*	*2.19*
Unsoaked CBR %	*2.2*	*2.08*	*1.46*	*3.38*	*6.31*	*5.83*

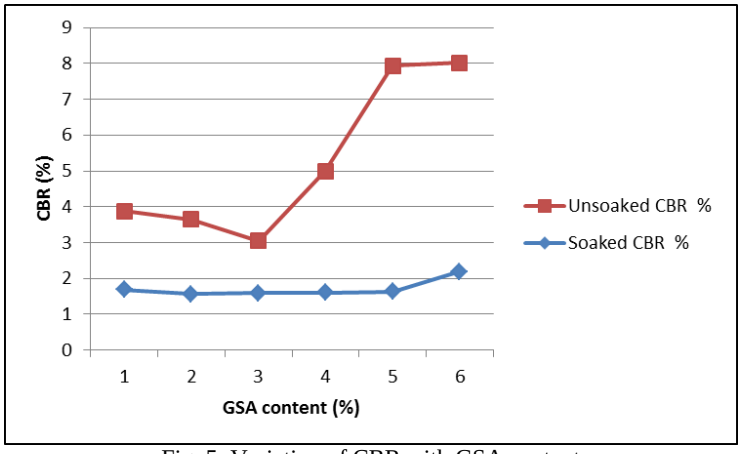

Fig. 5: Variation of CBR with GSA content

V. CONCLUSION

The soil is classified under the A-7-6 subgroup of the AASHTO classification system. Liquid limit and Plasticity index values of 83.36 % and 89.32 % respectively suggest that the soil is highly plastic. Thus, from the results obtained, the soil falls below the standard recommended for most geotechnical work (Butcher and Sailie, 1984). Groundnut Shell Ash (GSA) is used as a stabilizer for improving the geotechnical characteristics of black cotton soils. Addition of Groundnut Shell Ash significantly improves the index properties, compaction and strength characteristics of black cotton soil under study and the effect of GSA vary depending upon the quantity of GSA that is mixed with the black cotton soil samples. The plastic limit of the soils decrease with the addition of GSA which indicates a desirable change as the BCS with GSA mix can gain shear strength at an early stage than the virgin soil. The relative increase in the liquid limit and Plasticity index of the soils is an unfavourable change since decrease in LL and PI increase the workability of these soils. The linear shrinkage of the soils increases with the addition of groundnut shell ash, which facilitates in checking the volume change behaviour of the soils over a large variation in the moisture content as the season changes. Addition of GSA brings in an improvement in the compaction parameters of the study soils, by increasing the maximum dry density of the soils with decrease in the corresponding values of optimum moisture content. The unconfined compressive strength (UCS) of these soils increases upon the addition of GSA. The trend of improvement in the UCS

is observed to be more pronounced with the curing of the soil and GSA mix. A curing period of 28 days is observed to yield the maximum enhancement in the unconfined compressive strength. The peak of the California bearing ratio (soaked) value of 2.17% was attained at 10% GSA. This value fail to satisfy the specification for base and sub-base materials as recommended by the Indian Standard Specification and suggest that the GSA cannot be used as a standalone stabilizer for road construction work. The result obtained from this work show that groundnut shell ash can be used more profitably as an admixture with a conventional stabilizer such as lime and cement. It also can be used as the agricultural fertilizer due to its index properties. The use of groundnut shell ash in soil with other stabilizers can decrease the cost of stabilization. Due to the use of the agricultural waste, it is more Eco friendly then other soil stabilizers.

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