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Stabilization of Soil in the Capital Region of Andhra Pradesh using Cutback Asphalt

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Abstract

The quality and life of pavements are prominently affected by the sub-grade Strength. The key objective of this paper is to enhance the properties of black cotton soil using cutback asphalt MC-30. A Laboratory investigation is carried out to study the effect of cutback Asphalt on engineering and index properties of the Black Cotton Soil. The soil used in the study is brought from Thullur mandal, Andhra Pradesh, a major extent of this region is covered by black cotton soil.A series of laboratory tests are conducted, namely, USCS soil classification, specific gravity,optimum moisture content, maximum dry density, liquid limit, plastic limit, swell pressure, free swell index, California bearing ratio are conducted on soil samples with varied bitumen content ranging from 0% - 13% leaving intervals at 1, 5, 9, and 13 %, and tested thereafter. The results stand out the increase in liquid limit and plastic limit, and the fall in the swell pressure, free swell index on addition of optimum cutback asphalt. However, in case of stability case there is increase in California bearing ratio in soaked and unsoaked condition with increase in stabilizer (cutback bitumen).

Keywords

Sub-grade, Stabilization, MC-30 Cutback Asphalt, Black Cotton Soil, Engineering Properties, Index Properties.

Introduction

In many cases it is expensive to remove larger volumes of unsatisfactory soil and replace them with relatively stable material. So, improving soil properties through mechanical or chemical methods known as soil stabilization methods were developed ,which can be achieved by following (any of) controlled compaction, proportioning and addition of stabilizing agent etc . Subgrade, the lowest layer of the pavement structure consists of various locally available soil that might be soft and/or wet that may not possess enough strength to support pavement loading. Hence, stabilization is needed for such subgrade layers, which are adversely effected by drainage, shrinkage and swelling [1].The black cotton soils are expansive in nature, which are prone to large volumetric changes that expands on addition of water and shrinks in the dry conditions , due to the presence of mineral montmorillonite, which is an expansive lattice. This poses serious problems with regards to subsequent performance of the pavement. Ancient civilizations of the Chinese, Romans and Incas exploited various methods to improve soil strength etc., some of these methods are so effective that their buildings and roads still exist. In India, the modern era of soil stabilization began in early 1970's. In the recent times, with the increase in the demand for infrastructure, raw materials and fuel, soil stabilization started to take a new shape. With the availability of better research, materials and equipment, it is emerging as a popular and cost-effective method for soil improvement [2].The paper discusses the addition of cutback asphalt to the soil, for recognizing its engineering and index characteristics. Andalso describes the beneficial use of cutback asphalt stabilizer.

Literature Review

Cut-back asphalt provided a good solution to improve the gypseous soil properties. Gypsum when contacted with water, an increase in strength and CBR values are observed. From test results it is found that, (6-8) percent of optimum cut-back asphalt is required by the soil. Suitable percentage of cutback asphalt added to the type of soil will improve its physical, strength and water proofing properties [3], [4].Addition of emulsion and sea shell powder as a soil stabilizer by adding in proportion, increases the unconfined compressive strength of black cotton soil. It was concluded that the addition of stabilizer increases the unconfined compressive strength of soil. The maximum strength obtained at 24% of bitumen emulsion is 559.67KN/m2, for sea shell powders it is 273KN/m2 at 16% and 67.28KN/m2 at natural soil conditions [5].Optimum binder content stabilizes the granular soil, and with addition of bitumen content there is a raise in the maximum dry density (MDD) and California bearing ratio (CBR). 6% of bitumen addition resulted in a decrement of trend in the MDD and CBR, due to the excess bitumen content [6].Soil plasticity can be reduced by addition of 1.5% of lime content,which converted the property of clayey soil tonon-plastic, with a considerable reduction in liquid limit (WL), specific gravity (Gs), max.dry density (γd), swelling pressure and swelling percent. It can be concluded that the optimum values of stabilization of this type of clay are (1.5%) lime addition with (2-4%) of Emulsified asphalt (E.A) which can be used in road embankments [7] ,[8].Effect of stabilizing gypseous soil using liquid asphalt types such as cutback and emulsion on its behavior in shear strength is considerably observed. Addition of liquid asphalt provides cohesion strength to the soil mass and also acts as a waterproofing agent. Cutback asphalt increases the resistance of gypseous soil to permeability, such resistance increases as void ratio increases. The emulsion reduces void ratio, and the permeability at both dry and saturated testing conditions [9].Using emulsified asphalt as stabilization material the results indicate that emulsified asphalt can improve physical, chemical, and mechanical characteristics of sandy clay loam. Plasticity and shear strength of soil increase with the increase of emulsified asphalt concentration. Chemical binding occurs between minerals in the soil and chemical elements by using emulsified asphalt [10].Cementing and waterproofing qualities of soil can be improved by using asphalt as a stabilizing agent. The cementation property is most effective in providing increased stability of soil. The overall stability is acceptable results forsandy soils and MC-2 cutback asphalt, when there is little or no mixing moisture [11], [12].Geotechnical characteristics of black cotton soils for use in sub-grades can be improvised in using cement as a stabilizer. Addition of cement leads to increase the California bearing ratio values gradually. The relative decrease in the plasticity index of the soils, increases the workability of these soils. There is a considerable decrease in linear shrinkage and swelling of the black cotton soil with addition of cement. Cement soil stabilization technology is found useful, cost-effective and suited for manual methods of construction [13].Optimum emulsion asphalt content of 6% varied the unconfined compressive strength of the soil-emulsion mixture under dry and absorption test conditions. When the soil was stabilized by emulsified asphalt and aerated for two hours and tested under dry condition, the cohesion (c) was found to be 168 kPa, so the cohesion is improved by 21.5%, improving the stabilized soil without aeration [14].

Study Area

Thulluru, a mandal located in Guntur district of Andhra Pradesh situated on the banks of river Krishna. After a chaotic bifurcation of the original Andhra Pradesh into two states, Thulluru village (16.5275°N, 80.4681° E) and its surroundingregions including pedamarimi, mangalgiri, anatavaram and suburbs of Vijayawada urban was officially announced to be the state capital by the state government. The soil samples used in the study are obtained wholly from this region.

Materials

Soil: Remoulded soil samples are collected from Thullur, a village located in Guntur district of Andhra Pradesh situated on the banks of river Krishna. A laboratory testing programis carried out to evaluate the geotechnical properties of the soil samples. The scope of the laboratory testing program is summarized in Table 1.

Cutback Asphalt: The type of asphalt used in this study is Medium Curing Cut-Back (MC-30) Liquid

Laboratory Test	Result
Soil Classification	Highly Compressible clay (CH)
Specific Gravity (G)	2.09
Liquid Limit (Wl)	76%
Plastic Limit (WP)	36%
Swell Pressure	6.87 Kg/cm2
Free Swell Index (F.S.I)	25%
Optimum Moisture Content (O.M.C)	17%
Maximum Dry Density (M.D.D)	1.39 g/cc
California Bearing Ratio (C.B.R) Unsoaked	4.92%
California Bearing Ratio (C.B.R) soaked	0.46%

Table 1.Geotechnical Properties of Soil

Asphalt. It is manufactured by diluting 70% of 80/100 Grade asphalt with 30% of Kerosene. It is obtained from hpcl plant at kondapalli, near Vijayawada. The properties of Medium Curing cutback asphalt (MC-30) are shown in Table 2.

S.no	Properties	Grade
1	Kinematic Viscosity at 60^0 C	30-60
2	Distillate Volume Percentage of total distillate up to 360^0 C	
	Up to 225^0 C	25Max
	Up to 260^0 C	40-70
	Up to 315^0 C	75-93
3	Residue from distillation up to 360^0 C , Percent by mass	50Min
	Tests on residue from distillation up to 360^0 C	
	Viscosity at 60^0 C	30-1200
	Ductility at 27^0 C	100Min
4	Matter Soluble in trichloroethylene ,	99Min

	percent by mass	
5	Water content , percent by mass	0.2 Max

Table 2.Properties of Cutback Asphalt

Methodology

Atterberg Limit tests areemployed on soil by which the Index properties are determined. The California bearing ratio (cbr) is determined as the stable value for the subgrade soil. The stabilizer percentages adopted are 1%, 5%, 9% and 13% respectively. By adding the stabilizer to soil by volume, and by thorough mixing, the diluent will get vaporized and the residue will be left over as a binder, after leaving the mixture for a curing period. This makes the fine soil particles conglomerate together and form hefty particles.Thereby, the binder clogs the voids and forbear the capillary action endured at the subgrade level.

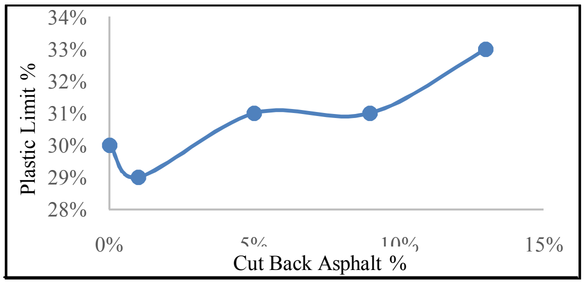
Results

Effect of cutback asphalt on geotechnical properties of soil with altered percentages, 0%, 1%, 5%, 9% and 13% are shown below.

Plastic Limit

Table 3 Results of Plastic Limit values with varying cutback Asphalt percentage

Property	0%	1%	5%	9%	13%
Plastic Limit %	30%	29%	31%	31%	33%



Graph 1Relationship between Cutback Asphalt & Plastic Limit

Liquid Limit

Table 4 Results of Liquid Limit values with varying cutback asphalt percentage

Property	0%	1%	5%	9%	13%
Liquid Limit%	76%	76%	79%	83%	86%

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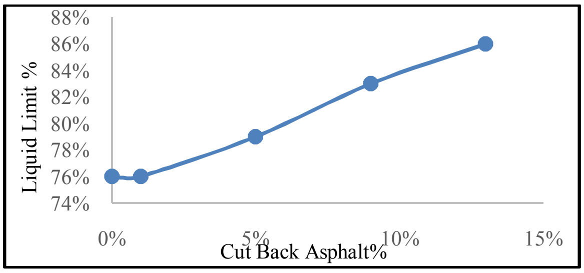
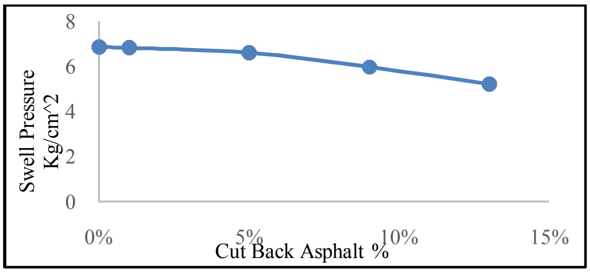


Graph 2 Relationship between Cutback Asphalt & Liquid Limit

Swell Pressure

Table 5 Results of Swell Pressure values with varying cutback Asphalt percentage

Property	0%	1%	5%	9%	13%
Swell Pressure Kg/cm2	6.87	6.83	6.62	5.97	5.21

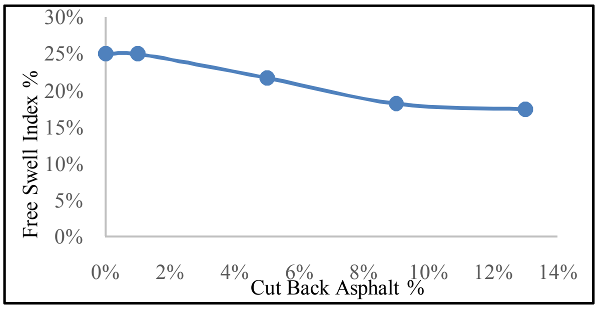


Graph 3Relationship b/w Cutback Asphalt & Swell Pressure

Free Swell Index

Table 6 Results of Free Swell Index values with varying cutback Asphalt percentage

Property	0%	1%	5%	9%	13%
Free Swell Index %	25%	25%	21.73%	18.18%	17.43%

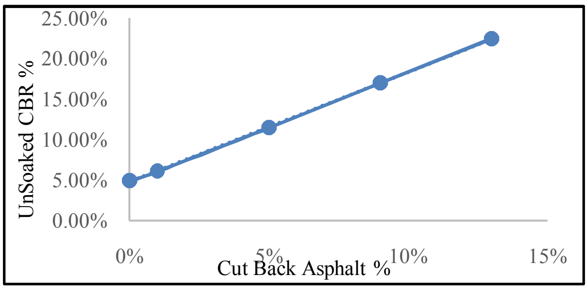


Graph 4 Relationship between Cutback Asphalt & Free Swell Index

California Bearing Ratio

Table 7 Results of Unsoaked cbr values with varying cutback Asphalt percentage

Penetration	0%	1%	5%	9%	13%
2.5mm	4.92%	6.10%	11.50%	17%	22.47%
5mm	3.21%	5.85%	11.55%	16%	20.79%

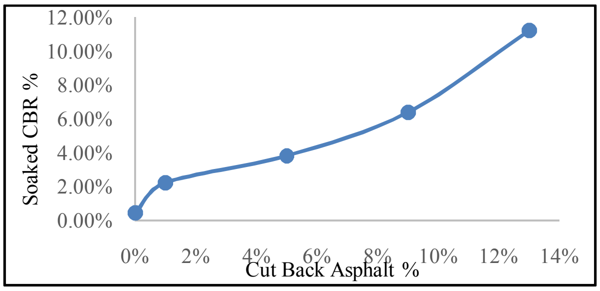


Graph 5 Relationship between Cutback Asphalt & Unsoaked cbr

California Bearing Ratio

Table 8 Results of Soaked cbr values with varying cutback Asphalt percentage

Penetration	0%	1%	5%	9%	13%
2.5mm	0.46%	2.24%	3.84%	6.40%	11.23%
5mm	0.46%	2.14%	3.63%	5.93%	10.70%



Graph 6Relationship between Cutback Asphalt & Soaked cbr

Conclusions

1- Unstabilized soil sample has a low cbr value, and high atterberg limits and swelling percentage.
2- The sample has shown a considerable reduction in swell pressure and free swell index of stabilized soil sample, at optimum percentage of cutback asphalt.
3- Liquid Limit and plastic limit increases, as the percentage of cutback asphalt increases.
4- With addition of 1% of cutback asphalt to the sample, soakedand unsoaked California bearing ratio (cbr %), free swell index and swell pressure tend to have a considerable increase.
5- Cutback asphalt stabilization improved the stability of black cotton soil.
6- As this method is temperature dependent, it can be encouraged in the low temperature regions.
7- Using cutback asphalt soil properties can be enhanced with increase in curing period.

References

[1] Navtaj Singh Dhanoa, (2014) ‘‘Effect of Soil Stabilizers on the Structural Design of Flexible Pavements,’’ M.Sc. Thesis, Thapar University.

[2] Arpan Sen, Rishabh Kashyap, (2012) ‘‘Soil Stabilization Using Waste Fiber Materials, ’Thesis, National Institute of Technology, Rourkela.

[3] Dr. Ali J. Kadhim, (2014) ‘‘Stabilization of Gypseous Soil by Cutback Asphalt for Roads Construction,’’ Journal of Engineering and Development, Vol. 18, No.1,pp: 46-67.

[4] Al-Deffaee, A. H., (2002), “The Effect of Cement and Asphalt Emulsion Mixture on the Engineering Properties of Gypseous Soils”, M.Sc. Thesis, Department of Civil Engineering, Al-Mustansiriya University.

[5] K.Jayaganesh, S.Yuvaraj, D.Yuvaraj, C.Nithesh and G.Karthik, (2012) ‘‘Effect of Bitumen Emulsion and Sea Shell Powder in the Unconfined Compressive Strength of Black Cotton Soil,’’ International Journal of Engineering Research and Applications, Vol. 2, Issue 3, pp.242-245.

[6] Olumide Moses ogundipe, (2014) ‘‘Strength and Compaction Characteristics of Bitumen-Stabilized Granular Soil,’’ international journal of scientific & technology research volume 3, issue 9, pp.218-221.

[7] Al-Khashab, Mohammad Natheer,Al-Hayalee, Mohammed Thafer, (2008) ‘‘Stabilization of Expansive Clayey Soil Modified by Lime with an Emulsified Asphalt Addition,’’ Eng. & Technology, Vol. 26, No.10, pp.46-67.

[8] Al-Khashab, M.N. and Al-Harbawy, A.F.Q., (2004) "The Effect of Emulsified Asphalt Addition on Some of the Engineering Properties of Expansive Clayey Soils,’’ Eng. And Technology, No.2 vol. 23 pp.51-71.

[9] Saad I. Sarsam, Salah W. Ibrahim, (2008) ‘‘Contribution of Liquid Asphalt in Shear Strength and Rebound Consolidation Behaviour of Gypseous Soil,’’ Eng. &Tech.Vol26, No.4, pp.478-489.

[10] Elifas Bunga, H.Muh.Saleh Pallu, Mary Selintung, M.Arsyad Thaha (2011) ''Stabilization of Sandy Clay Loam with Emulsified Asphalt.''International Journal of Civil & Environmental Engineering Vol: 11 No: 05, pp.52-62.

[11] Ramanath Keshavarao Katti (1958) ''Stabilization of Iowa soils with cutback asphalt,'' Ph.D. Thesis, Iowa State College.

[12] Andrews, A. C. and Nobel, G. G. (1949) ''A study of bituminous soil stabilization by methods of physical chemistry, 'ProceedingsHighway Research Board. 29:496-519.

[13] Githaiga Esther Nyakarura, (2009) ''Cement Stabilized Black Cotton Soil for Pavement Subgrade Construction,''Thesis, University OfNairobi.

[14]Dr.Mahmood D. Ahmed(2014)''Assessing the Dynamic Behavior of Asphalt Stabilized Gypseous Soil,'' Eng. & Tech. Journal, Vol.32, Part (A), No.4, pp.822-8