Effect of Fiber on Fly-Ash Stabilized Sub Grade Layer Thickness

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Abstract
Expansive soil is collected near the mirchi yard gutur district, where NH 5 expansion is taking place. This study revealed that the fiber reinforcement improves the CBR values in admixture stabilized soil. In the present work, an attempt is made to compare the quantity of the earth required for the sub grade with and without fly ash stabilization, for 1.5% of fiber and 15 % of fly ash the thickness of the pavement is decreased by 60% and the 8610 m^3 of soil can be saved for one kilometer length of the road.
Keywords: ***Expansive soils; fiber; stabilization; fly ash; black cotton soils; pavement thickness***

I. INTRODUCTION

Coal burning electric utilities annually produce million tons of fly ash as a waste byproduct and the environmentally acceptable disposal of this material has become an increasing concern. Efforts have always been made by the researchers to make pertinent use of fly ash in road constructions in the localities which exists in the vicinity of thermal power stations. One of the most promising approaches in this area is use of fly ash as a replacement to the conventional weak earth material and fiber as reinforcement will solve two problems with one effort i.e. elimination of solid waste problem on one hand and provision of a needed construction material on other. Also, this will help in achieving sustainable development of natural resources. However, the comprehensive work is required to comprehend the influence of discrete polypropylene fibers inclusion on engineering behavior of soil-fly ash mixture. Fiber reinforcement enhances the strength of the admixture stabilized soil.

II. BACKGROUND

The results of direct shear tests performed on sand specimens by Gray and Ohashi (1983) indicated increased shear strength and ductility, and reduced post peak strength loss due to the inclusion of discrete fibers. The study also indicated that shear strength is directly proportional to fiber area ratio and length of fiber up to certain limit. These results were supported by number of researchers using consolidated drained triaxial tests like Gray and Al-Refeai (1986), Gray and Maher (1989), Al-Refeai (1991), Michaowski and Zhao (1996), Ranjan et al (1996), Michaowski and Cermak (2003). Maher and Ho (1994) indicated that increase in strength and toughness of kaolinite fiber composite was a function of fiber length and content, and the water content. It was indicated that the contribution of fibers to peak compressive strength was reduced, and ductility increased, with increasing fiber length. Consoli et al (1998) indicated that inclusion of fiber glass in silty sand effectively improves peak strength. Consoli et al (2002) indicated that due to inclusion of polyethylene terephthalate fiber in fine sand improves both peak and ultimate strength which is dependent on fiber content. Kumar S. and Tabor E. (2003) studied the strength behavior of silty clay with nylon fiber for varying degree of compaction.

Soil reinforcement is the process of improving the engineering properties of the soil and thus making it more stable. Gosavi et al. (2004) reported that soil can be reinforced with low-cost materials like natural fibers obtained from jute, coir etc. For SW-SM soil, the authors suggested that inclusion of randomly oriented polypropylene fibers increases the California bearing ratio (CBR) value and shear strength value of remoulded soil. The optimum quantity of fiber to be mixed with soil is found to be 0.75% and any addition of fiber beyond this quantity does not have any significant increase in the CBR value. Gosavi et al. (2004) also conducted tests to improve the properties of black cotton soil subgrade reinforced with synthetic fiber. Day et al. (2003) confirmed that the unconfined compressive strength (UCS) and axial strain at failure increases with an increase in fiber percentages. Ranjan et al (1996) reported that the shear strength of short, randomly distributed fiber-reinforced soil is a function of fiber weight fraction, aspect ratio and surface friction, soil characteristics (i.e. angle of internal friction) and its density and confining stress on shear strength of reinforced soils.

III. SCOPE OF PRESENT WORK

In the recent years, the research on fiber reinforced soils demonstrated that this material might be a practical and cost effective technique for reinforcement of sub grade soils in flexible pavements In comparison with systematically reinforced soils. Polypropylene is an economical material that offers a combination of outstanding physical, chemical, mechanical, thermal and electrical properties not found in any other thermoplastic. Soil stabilization is the process of improving the engineering properties of the soil and thus making it more stable. Principle of soil stabilization is the process with admixtures is covered by Metcalf (1972) and Kezdi (1979). It is required when soil available for construction is not suitable for the intended purpose. In the broad sense, stabilization includes compaction, pre-consolidation, drainage and many other such processes. Stabilization is the process of blending and mixing materials with a soil to improve certain properties of the soil. The process may include the blending of soils to achieve a desired gradation or the mixing of commercially available additives that may alter the gradation, texture or plasticity, or act as a binder for cementation of the soil. Soil stabilization is used to reduce the permeability and compressibility of the soil mass in earth structures, to reduce the swell in case of expansive soils and to increase its shear strength. Soil stabilization is required to increase the bearing capacity of foundation soils. However the main use of stabilization is to improve the natural soils for the construction of highways and airfields. In the present paper how the thickness of the sub grade layer is varying by addition of the fly ash and fibers is evaluated. How much the earth can be saved by doing the modification to the soil is evaluated.

IV. STUDY METHODOLOGY

The present dissertation work has been carried out in two stages as depicted in Figure 1 and details are discussed below.

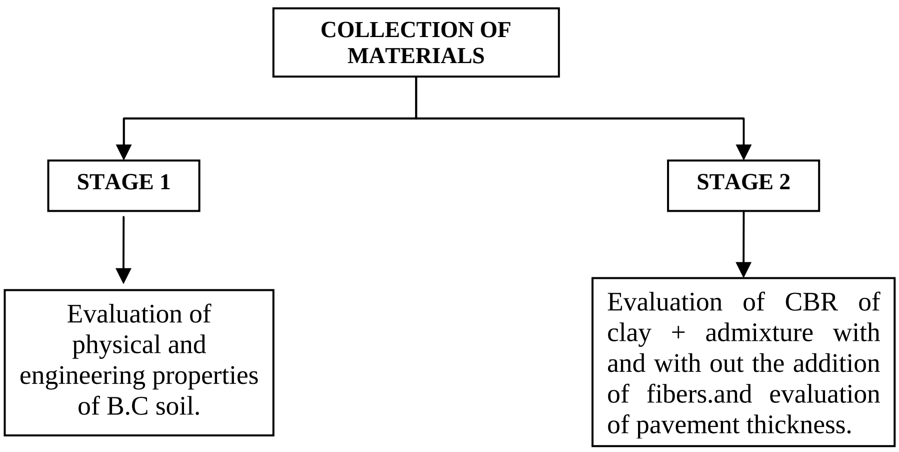


Fig.1 Study Methodology

V. MATERIALS USED

Black Cotton Soil

Soils, which exhibit a peculiar alternative, swell and shrink behaviour due to moisture fluctuations are known as expansive soils. This behaviour is attributed to the presence of clay minerals with expanding lattice structure. Among them montmorillonite clay mineral is very active and absorbs water many times its volume. The soil is hard as long as it is dry but looses its strength (stability) almost completely on wetting. On drying, the soil cracks very badly and in worst cases, the width of cracks is almost 150mm and travel down to 3m below ground level. An alkaline environment, presence of magnesium ions and a lack of leaching aid the formation of montmorillonite mineral. Such conditions are favourable in semi-arid regions with relatively low rainfall. The parent minerals for the formation of montmorillonite often consists of Ferro magnesium minerals, calcic feldspars etc. Other important clay minerals are kaolinite and illite. Kaolinite formation is favoured by prolonged leaching under acidic environment and high temperatures with permanent rocks containing ferric iron. The conditions for the formation of illinite mineral are similar to those leading to the formation of montmorillonite and in addition, the presence of potassium in the parent material is essential Indian black cotton soils are found to be formed by weathering of basalts and traps Deccan plateau.

The Black cotton soil for the study was brought from the mirchi yard, gutnur. The physical and engineering properties of the expansive clay were tabulated in Table 2.

Table-1, Physical and Engineering Properties of B.C. soil

S.No.	**Properties of B.C soil**	**Value**
1	Soil grain distribution	
	Gravel (> 4.75mm) (%)	2
	Sand (4.75-0.0 75mm) (%)	30
	Fines (<0.075mm) (%)	68
2	Atterberg’s limits	
	Liquid Limit (%)	62
	Plastic Limit (%)	26
	Plasticity Index (%)	36
	Shrinkage limit (%)	17
3	IS-Classification	CH
4	Specific gravity	2.7
5	Permeability (cm/sec)	$3.01x10^{-7}$
6	Compaction Properties	
	Optimum Moisture Content (%)	19
	Maximum Dry Density (g/cc)	1.72
7	Swell characteristics	
	Free swell index (%)	130
	Degree of expansion	High

Polypropylene Fibers

Polypropylene fibers are hydrophobic, non corrosive and resistant to alkalis, chemicals and chlorides. The improvement of the engineering properties due to the inclusion of polypropylene fibers was determined to be a function of a variety of parameters including fiber type, fiber length, aspect ratios (length/diameter), fiber content, orientation, and soil properties. Attempts were made by various researchers to determine the effect of each parameter on the different engineering properties of the composite. The properties of polypropylene used in the present study are given below (As given by the Manufacturer) in Table 2.

Table-2, Properties of polypropylene fibers

Type of Fiber	**Poly propylene**
Length (mm)	12
Aspect ratio (L/d)	300
Diameter (mm)	0.04
Specific gravity	0.91
Tensile strength (Mpa)	450
Elongation break (%)	15-25
Melting point (°c)	165
Heat resistance (°c)	<130

Fly Ash

Fly ash is a solid waste product created by the combustion of coal it is carried out of the boiler by flue gases and extracted by electrostatic precipitators or cyclone separators and filter bags. Its appearance is generally that of a light to dark gray powder of predominantly silt size. The electric power research institute has produced a comprehensive design manual for the use of fly ash in structural fills and highway embankments and for sub grade stabilization and reclamation. Fly ash is collected from a thermal power station located in Vijayawada, Dr.Narla Thatha Rao Thermal Power Station.

Table-3, Properties of fly ash

S.No	**Description of property**	**Value**
1	Specific Gravity	2.14
2	Liquid limit (%)	Non plastic
3	Plastic limit (%)	Non plastic
4	proctors maximum dry density (t/cu.m)	2.18
5	Optimum moisture content	25.80%
6	Colour	Grey

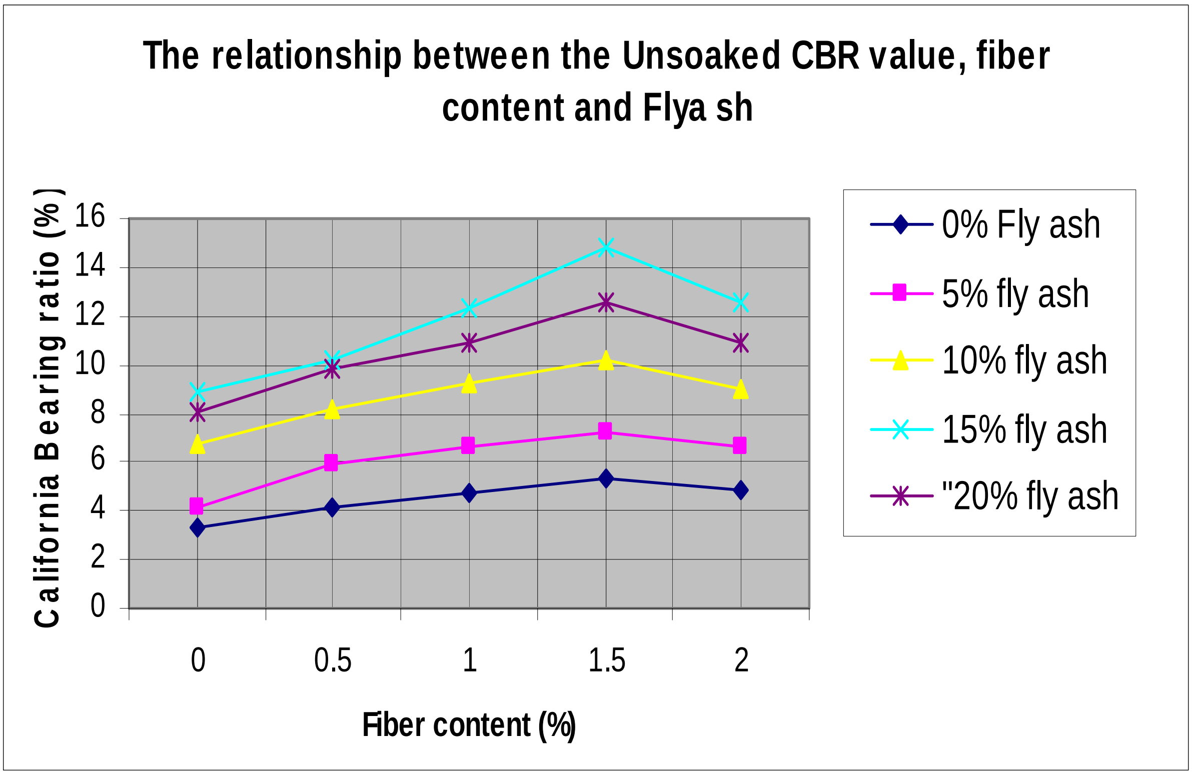
By varying the Percentage of fly ash and fiber CBR, U.C.C were done. The results are as follows. The thickness of the pavement is evaluated and the quantity of soil that can be saved is calculated

VI. RESULTS & DISCUSSIONS

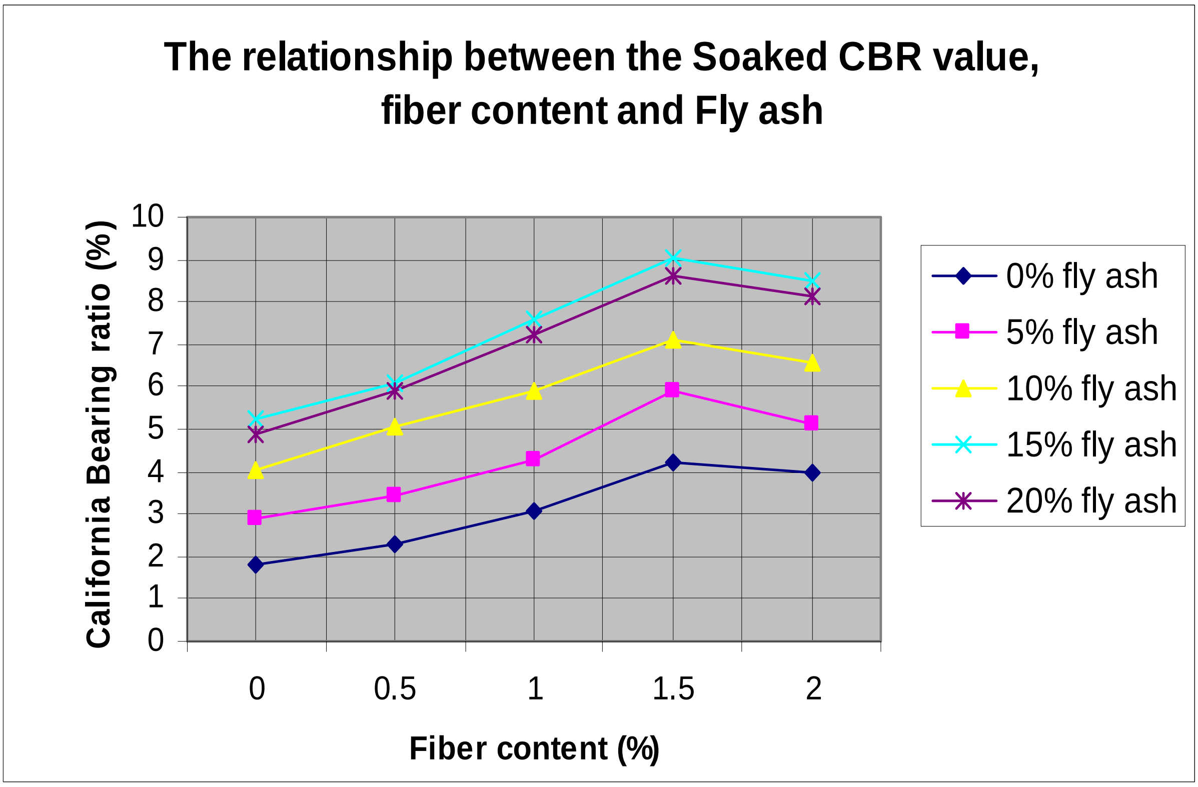
Effect of Fiber on CBR of The Fly Ash Soil Mixes:-

Numbers of C.B.R testes were carried out to know the effect of fiber on CBR value ckd clay mixes. By addition of fly ash alone the CBR of the mixture is increased nearly 2.7 times where as by addition of fiber only CBR is increased by 1.6 times only. Effect of fiber on fly ash Soil mixture is limited because of the high plasticity of the

Clay soil. The results are shown in graph 1 and 2. For the 15% of fly ash and 1.5 % of the fiber maximum CBR is obtained.



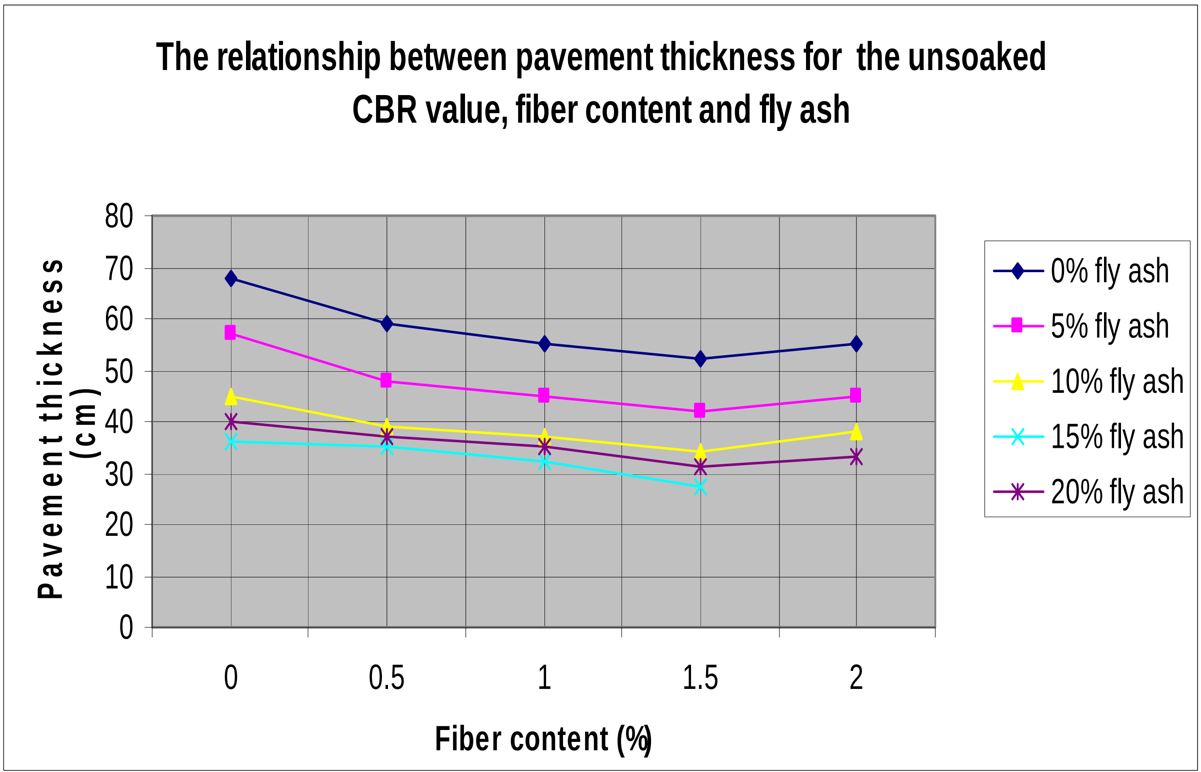
Graph-1, Variation of CBR for un soaked condition with and without addition of fibers to the fly ash Soil



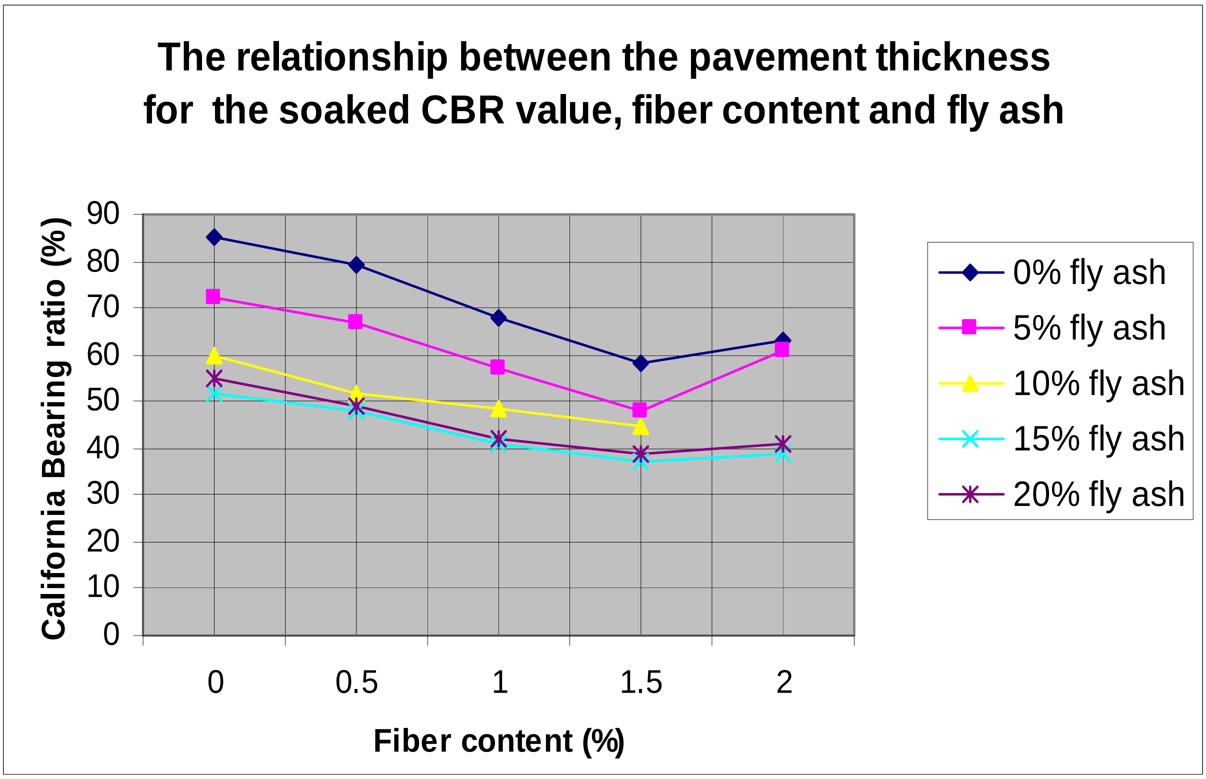
Graph-2, Variation of CBR for soaked condition with and without addition of fibers to the fly ash Soil

Effect of Fiber on the Thickness of the Soil Fly Ash Mix Sub Grade

The thickness of the pavement is reduced considerably by addition of the fibers and the fly ash. For addition of fibers alone thickness reduction will be 19% and by addition of fly ash only the reduction is 40%. By addition of both fiber and fly ash the reduction in the thickness is 60% for the reduction of 60% of. The results are shown in graphs 3 and 4.

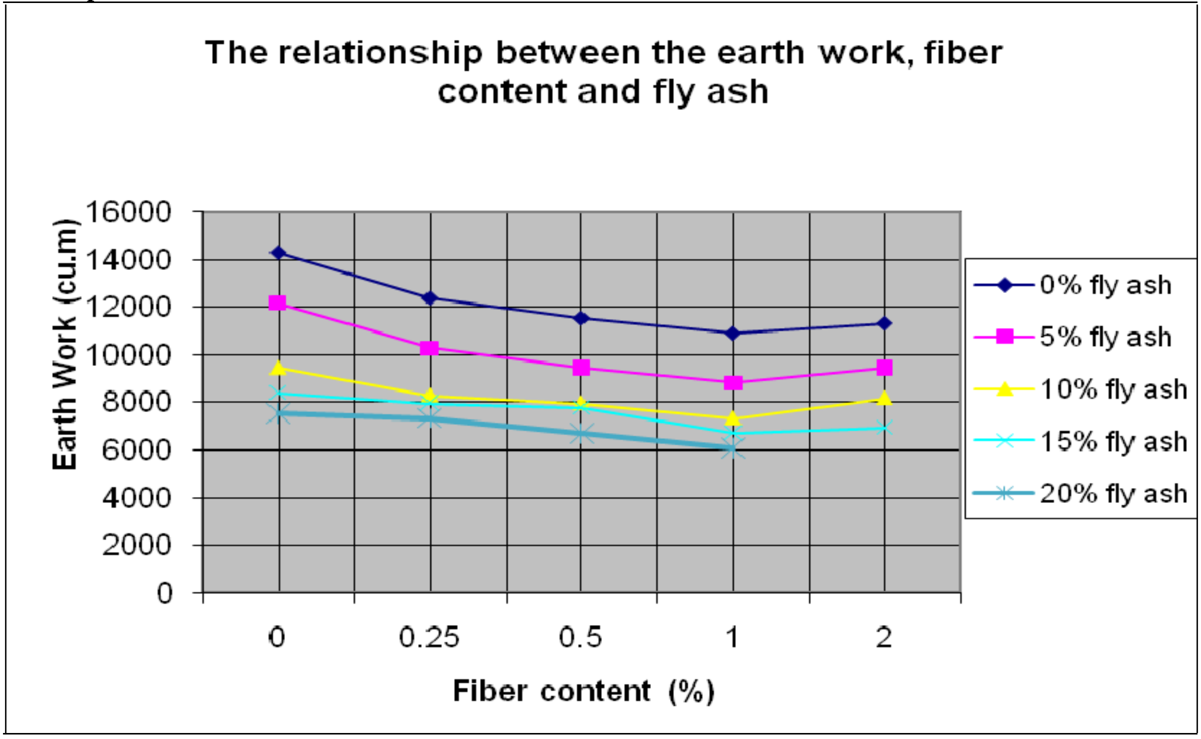


Graph-3, Variation of thickness of pavement for un soaked condition with and without addition of fibers to the fly ash Soil



Graph-4, Variation of thickness of pavement for soaked condition with and without addition of fibers to the fly ash Soil

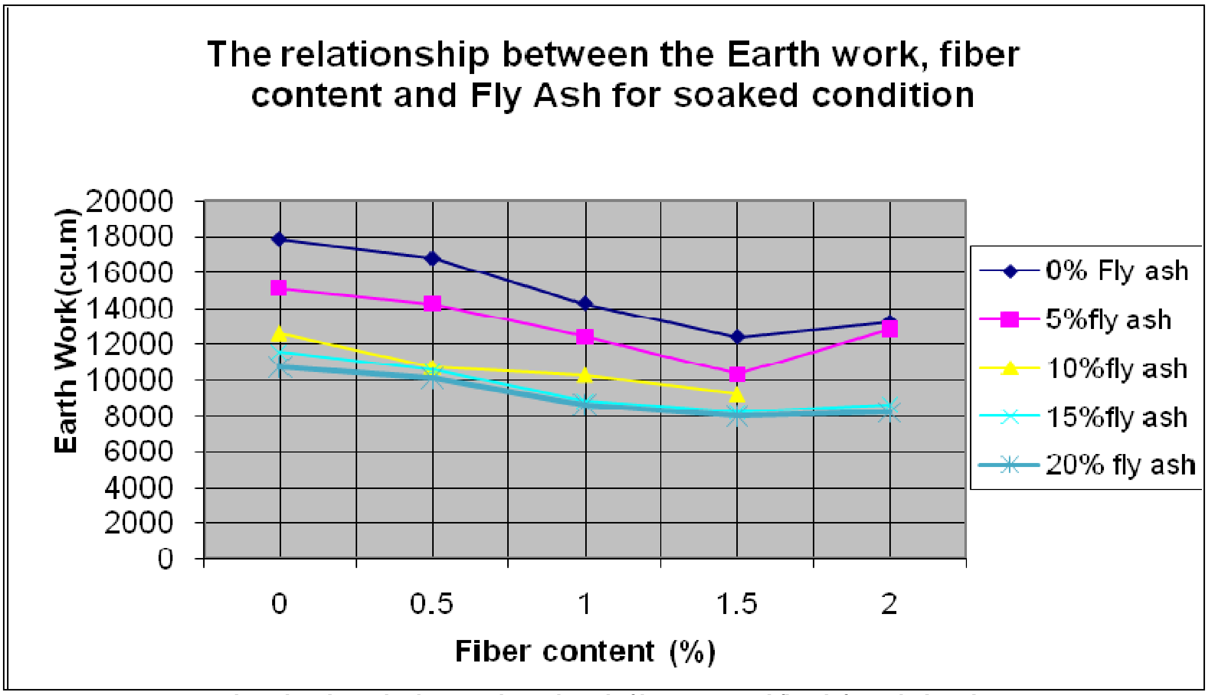
The relationship between the earth work, fiber content and fly ash for unsoaked condition is presented in the Graph 5.



Graph:5 The relationship between the earth work, fiber content and fly ash for unsoaked condition

Inference: Number of tests were carried out to know the effect of polypropylene fiber on CBR value of soil. By addition of fiber in increasing quantity with an increment of 0.5%, CBR value increased to a maximum of 2% when 1.5% of fiber is added. The thickness of sub grade is reduced considerably by addition poly propylene fiber. The maximum thickness reduction achieved was 62% by addition of fly ash only the reduction is 40%. So we can save 8610 mt^3 of earth for one kilometer length of the road for a six lane road. The results are shown in graph 5

The relationship between the earth work, fiber content and fly ash for soaked condition:



Graph 6: The relationship between the earth work, fiber content and fly ash for soaked condition

Inference: Numbers of tests were carried out to know the effect of polypropylene fiber on CBR value of soil. By addition of fiber in increasing quantity with an increment of 0.5% CBR value increased to a maximum of 2% when 1.5% of fiber is added. The thickness of sub grade is reduced considerably by addition poly propylene fiber. The maximum thickness reduction achieved was 45% by addition of fly ash only the reduction is 40%. So we can save 9870 mt^3 of earth for one kilometer length of the road for a six lane road. The results are shown in graph 6.

VII. CONCLUSIONS

On the globe we have limited quantity of good quality of earth is available. It is not possible to provide the quality soil for every construction, in such circumstances we need to go for the modification methods. An attempt has been made to use the fly ash and fiber to modify the properties of the soil which is available at the construction site.

- By\addition of the fly ash and fiber to the expansive soils the CBR value is increased.
- By increasing the CBR we can reduce the pavement thickness.
- For a six lane highway with high traffic intensity the quantity of the soil that can be saved by doing the above modification is 8610 cubic meter per one kilometer of the road.
- By doing the modification we can reduce the excessive usage of the mother earth thus avoiding the pollution.
- In soaked condition the maximum thickness reduction achieved was 45% by addition of fly ash only the reduction is 40%. Hence an 9870 mt^3 of earth for one kilometer length of the road for a six lane road can be saved.

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