Behaviour of Polyurethane Resin In Fibre Reinforced Low Plastic Clay

Roshini M[1], Dr Vijayakumari P L[2]
[1, 2] Dept of Civil Engineering
[1, 2] Marian Engineering College, Trivandrum, Kerala

Abstract- *Soil is very important in civil engineering constructions. The poor engineering properties of the local soils may present many difficulties for construction and therefore need to improve their engineering properties. Stabilization techniques can be used to improve the properties of soil. Soil stabilization improves various engineering properties e.g. bearing capacity, compressibility, strength, and various other properties of soil. In this paper the studies are done to know the impact of polyurethane resin in fibre reinforced clay. The strength characteristics is determined by compaction tests, unconfined compressive strength tests and CBR tests. The aim of this study is to find out whether the soil is suitable for pavement construction.*

Keywords- Polyurethane resin, stabilization, fibre reinforced clay.

I. INTRODUCTION

Soils are complex mixtures of minerals, water, air, organic matter, and countless organisms. Various types of soil available in India like alluvial soils, black cotton soils, laterites soils, mountain soils, desert soils, red soils. Soil is the upper most part of earth and it is cheapest and readily available construction material. Soil is generally categorizes into four basic types (such as): Gravel, Sand, Clay and Silt. Out of them, few possess montmorillonite in high amount resulting in sudden swelling and shrinkage upon contact with water. Such soils are not useful in construction directly but can be made useful after their stabilization.

Soil is defined as an unconsolidated material, composed of soil particles, produced by the disintegration of rocks and chemical decomposition. On the basis of shear strength, soil can be divided into three types: cohesion less soils, purely cohesive soils and cohesive soils.

Soil stabilization is used for foundation, embankment and highway construction, airport and village roads to highways or expressway. Soil stabilization improves the bearing capacity, compressibility, strength, and other properties of soil. Soil stabilization is the popular method of soil improvement. Various methods of soil stabilization are used like mechanical method, chemical method, thermal method, additive method (fiber reinforcement). In case of road construction the aim of stabilization of soil is to increase the stability by increasing its bearing capacity and hence increasing its strength and reduction in pavement thickness. Soil stabilization improves the strength of the soil, thus, increasing the soil bearing capacity, used to decrease the permeability and compressibility of the soil mass in the earth structures, more economical both in terms of cost and energy to increase the bearing capacity of the soil rather than going for deep foundation or raft foundation, improves the workability and the durability of the soil and maximize the lifecycle costs of projects.

The aim of this study is to determine the strength characteristics of resin in fibre reinforced clay. Also to determine whether the soil is suitable for pavement construction.

II. MATERIALS

A. Thonnakkal clay

Soil used in this study is collected from Thonnakal region, Thiruvananthapuram, Kerala, India. It is collected at a depth of 65m from the ground level. The soil collected from the site is dried and powdered. Then the initial properties of soil are determined using standard procedures and the results are tabulated in table 1 and figure 1 shows the plasticity chart. From the test results, the soil can be classified as poorly graded sand according to Indian Standard Classification system.

TABLE I : PROPERTIES OF THONNAKAL CLAY

Properties	Result
Specific Gravity	2.63
Clay (%)	71
Silt (%)	20
Sand (%)	9
Liquid limit (%)	34.2
Plastic limit (%)	14.52
Shrinkage limit (%)	12.36
Plasticity index (%)	19.68
IS Classification	CL

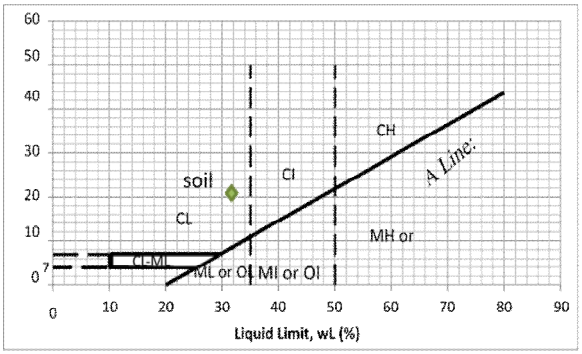

FIGURE I PLASTICITY CHART OF THONNAKKAL CLAY

B. Polypropylene Fibres

The common synthetic fibres used are polypropylene fibres, glass fibres and nylon fibres. They are basically by-products of petroleum. It is exhaustive and relatively costly compared to natural fibres. Polypropylene is normally tough and flexible, especially when copolymerized with ethylene. This allows polypropylene to be used as an engineering plastic, competing with materials such as acrylonitrile butadiene styrene (ABS). It is reasonably economical. Polypropylene has good resistance to fatigue. The Polypropylene fibres(12mm) were collected from Fibrezone India Navrangapura, Ahmedabad

TABLE II : PROPERTIES OF POLYPROPYLENE FIBRE

Modulus of elasticity	3500MPa
Fusion point	165 ° C
Burning point	590° C
Acid and alkali resistance	Very good
Dispersbility	Excellent
Aspect ratio	353

C. Polyurethane resin

Polyurethane is a polymer composed of organic units joined by carbamate (urethane) links. While most polyurethanes are thermosetting polymers that do not melt when heated, thermoplastic polyurethanes are also available. It is Highly elastic ,Balanced in hardness and Capable of adhering well to substrates.

TABLE III : PROPERTIES OF POLYURETHANE RESIN

properties	Mixed
Colour	Clear
Specific gravity (g/ml)	1.11
Viscosity (m.Pa.s)	700
Mix ratio by volume	1.1
Mix ratio by weight	0.92:1

III. RESULTS AND DISCUSSIONS

A. Compaction

In The strength of weak soils can be altered by the addition of PP fibres. Also the dry density can be increased by the addition of polyurethane polymers. Polyurethane resin is an effective soil stabilizer which increases the binding of the soil particles.

The test were conducted by varying percentages of resin (1%,2%,3% and 4%) in fibre reinforced soil. The fibre percentages is taken as 0%,1%,1.5%,2%,2.5%. effect of resin on OMC and MDD in fibre reinforced soil are shown in fig 2. The optimum moisture content when resin is added in fibre reinforced was 2% . The test indicates that the optimum moisture content decreases in fibre reinforced soil when resin is added.This is due to the formation of viscous membrane in the voids in the soil due the compounds present in the resin. As a result water cannot be entrapped in the voids, so the moisture content decreases.

But the dry density is increasing with the increasing percentage of resin in fibre reinforced soil. This may be due to the dense packing of fibre-soil mix. The resin binds the soil particles together and this decreases the void spacing. As a result the dry density increases.

TABLE IV : OMC AND MDD VARIATION OF PU RESIN IN CLAY-FIBRE MIX

PP fibre (%)	OMC (%)	MDD(g/cc)
	clay+ 2%PU Resin	
0	26.58	0.97
0.5	24.12	1.52
1	23.85	1.95
1.5	20.48	2.35
2	22.27	2.98
2.5	21.38	3.52

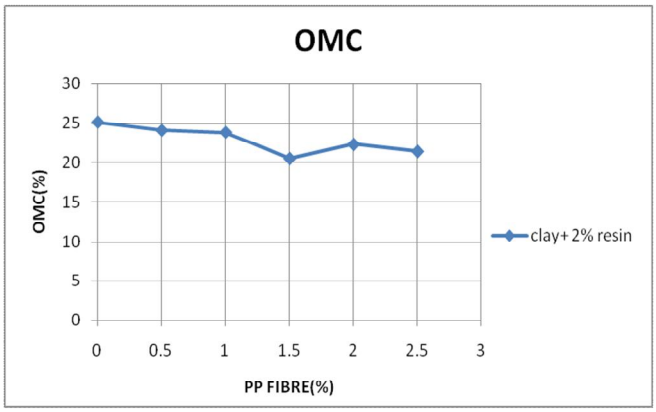

FIGURE II OMC VARIATION OF RESIN IN CLAY-FIBRE MIX

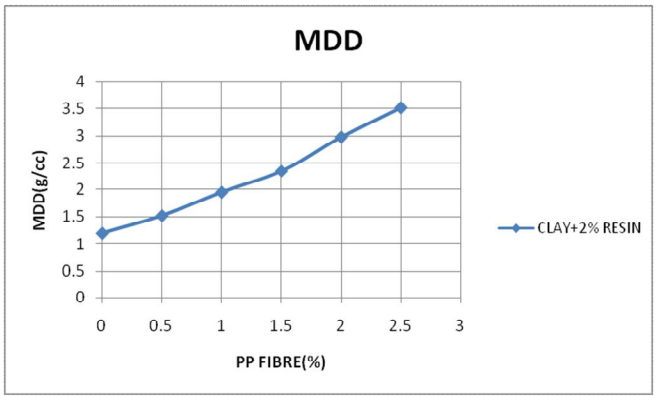

FIGURE III MDD VARIATION OF RESIN IN CLAY-FIBRE MIX

B. Unconfined Compressive Strength

Ucs tests were conducted in fibre reinforced soil. The effect of resin in various percentages of fibre reinforced soil is examined. Figure shows the ucc variation of polyurethane resin in fibre reinforced clay. The test was conducted in optimum dosage of resin in fibre reinforced clay. Figure shows that the ucc strength increases in optimum dosage of resin.

TABLE V : UCC VARIATION OF PU RESIN IN CLAY-FIBRE MIX

PP FIBRE (%)	UCS q_u (kPa) (0 days)	UCS q_u (kPa) (3days)	UCS q_u (kPa) (7days)
	Clay+2% resin	*Clay+2% resin*	*Clay+2% resin*
0	100.12	100.12	100.12
0.5	104.21	106.52	108.15
1	108.29	109.85	111.23
1.5	112.35	115.28	118.8
2	105.33	107.52	110.41
2.5	101.25	105.68	106.2

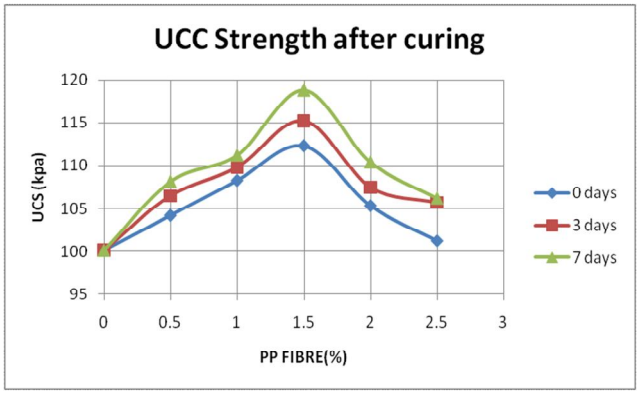

FIGURE IV UCC VARIATION OF RESIN IN CLAY-FIBRE MIX

This is due to the reason that the resin polymer can fill up the voids and adsorbs ions on the surface of clay particle. The elastic and viscous membrane structure is formed through physicochemical bonds between molecules and clay particle to improve the soil strength and . While the polymer materials are mixed with fiber to treat the soil, the cohesion of reinforced clay will be improved with the increment of connected force.

C. CBR Tests

CBR tests were conducted on fibre clay mix with optimum dosage of PU resin. From the graphs it is found that the CBR value increases with increasing fibre with optimum dosage of PU resin. The pavement thickness is also shown with effect of resin in fibre soil mix.

TABLE VI : CBR VARIATION OF PU RESIN IN CLAY-FIBRE MIX

PP FIBRE (%)	CBR VALUE (%)
	Clay+2% resin
0	6.55
0.5	7.56
1	8.92
1.5	9.85
2	10.12
2.5	11.56

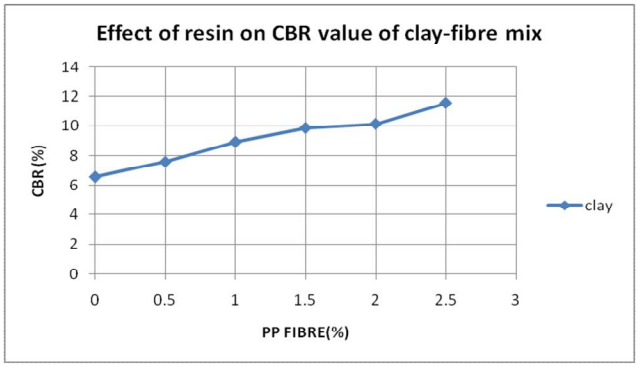

FIGURE V CBR VARIATION OF RESIN IN CLAY-FIBRE MIX

TABLE VII : PAVEMENT THICKNESS FOR PU RESIN IN CLAY-FIBRE MIX

PP Fibre (%)	CBR Value (%)	Pavement thickness (mm) IRC chart 2, 37 : 2001		
	Clay+2% resin	*Light traffic*	*Medium traffic*	*Heavy traffic*
0	6.55	310	330	360
0.5	7.56	280	310	350
1	8.92	270	290	320
1.5	9.85	260	270	300
2	10.12	250	250	280
2.5	11.56	230	240	270

From the results it is clear that pavement thickness decreases with increase in fibre percentage with optimum dosage of resin. Resin fibre mixed soil shows more decrement in pavement thickness with unreinforced soil by as much as 34%.

IV. CONCLUSIONS

From the test results it is noted that

- The optimum moisture content decreases and MDD increases with effect of resin in fibre reinforced clay. This is because of the dense packing of resin fibre mix.
- The UCC strength increases with curing in resin fibre clay mix because of the formation of viscous membrane formed between fibre reinforced clay.
- The CBR value increases in resin fibre clay mix and also the pavement thickness show a decrement when the fibre content is increased in optimum dosage of PU Resin

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