

## USE OF GEOSYNTHETIC MATERIAL, TO ENHANCE AND SUSTAIN SUBGRADE CHARACTERISTICS

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**ABSTRACT** : Sustainable development can not be done without adaptation of new technology to make the structure cost effective and enduring. More than 40 years ago, a new composite construction material known as Reinforced Earth was invented. Reinforced Earth is a soil mass strengthened by using various materials - natural or synthetic to improve its performance. From very beginning, the earth reinforcement of choice was discrete linear strips made up of galvanized steel. From time to time, from small walls, for commercial developments to enormous structures at industrial terminals, reinforced earth has been selected for its significant cost benefits with savings in the range of 20-50 % when compared with alternate solution. With the implementation of the design built for major construction works, reinforced earth, more than ever before is in the forefront of consideration by Civil Engineers and contractors. Now a days to increase the strength of soil, geosynthetic is widely used. Satisfactory performance of road depends on the sub grade soil conditions, the soil characteristics change under varied conditions, the maintenance operation involves assessing of road conditions diagnosis of the problems and adopting the most appropriate measures. The safety and convenience of traffic using the roads are governed to a large extent by the quality of maintenance which is carried out, but the maintenance is reduced to a large extent by using geosynthetic material. In this paper, it is best attempted to correlate between reduction in maintenance expenditure and optimum use of geosynthetic material. A case study has been narrated for a road length of 3.5 km of Aurangabad city (M.S.).

Keywords : Black cotton soil, Geosynthetic, Woven fabric

### 1. INTRODUCTION

Satisfactory performance of road in rural areas depends on the sub grade soil condition. If the sub grade soil consist of black cotton soil or the soil, which swells after increase in water content and loses its strength, there by stability of road pavement reduces. Soil reinforcement is an effective and reliable technique for improving strength and stability of soils. Also irrespective of the season, rural roads in India have invariably been observed to have puddles of water standing on the surface, regardless of whether or not they have been provided with a side trench. They are usually in a deplorable state, caused not only by rainfall, poor drainage but also by sewage accumulating on the surface. Reinforcing black cotton soil by a geosynthetic is of great importance in the field of road construction. The well-built and maintained roads play major role in the development of nation, if the weak subgrade of black cotton soil is stabilized or reinforced, the crust thickness will be less. The rutting is also restricted resulting in less repairs and overall economy. Use of

geosynthetic in the subgrade assumes a great promise and comparatively easier for construction.

### 2.LITERATURE REVIEW

In the 1920's the state of South Carolina used a cotton textile to reinforce the underlying materials on a road with poor quality soils. Evaluation several years later found the textile in good workable condition. They continued their work in the area of reinforcement and subsequently concluded that combining cotton and asphalt materials during construction reduced cracking, raveling and failure and the base course.

When synthetic fibers became more available in the 1960's textiles were considered more seriously for roadway construction and maintenance.

The work of reinforced earth was done by Vidal H in 1969. Vidal mentions the use of reinforced earth mat to improve the bearing capacity of soft subsoil foundation in France.

In 1972 in Japan geogrids made of synthetic material where used as reinforcement of soft ground under guidance of Prof. Yamanovchi. At the same time

Japanese national railway used reinforcement for railway embankment.

Dr. Narayana Swami K.R. and Shetty P.P. (1989) have reinforced soil for the pavement construction by making use of cement, coir, geosynthetic and fibre separately and together.

### 3. METHODOLOGY

The effort in this work is made to assess the improvement in strength and stability characteristics by using geosynthetics. A geosynthetic any permeable material used with foundation, soil, rock, earth etc. that is an integral part of a constructed project, structure or system. It may be made of synthetic or natural fibers.

Textiles were first applied to roadways in the days of pharaohs. Even they struggled with unstable soils, which rutted or washed away. They found that natural fibers, fabrics or vegetation improved road quality when mixed with soils, particularly unstable soils only recently, however have textiles been used and evaluated for modern road construction. Geosynthetic related materials are fabrics formed into mats, webs, nets grids or formed plastic sheets. Modern geosynthetic are usually made from synthetic polymers, polypropylenes, polyesters, polyethylenes and polyamides that do not decay under biological and chemical processes. This makes them useful in road construction and maintenance. Geosynthetic can also be made of materials which are most commonly used. The properties of the same are tabulated in table 1

**Table 1 : Properties of Geosynthetic**

Sr.No.	Particulars	Values
1	Fabric type	Woven Variety (polypropylene)
2	Maximum width (cm)	100
3	Unit weight (g/m <sup>2</sup> )	250
4	Specific gravity	0.91
5	Thickness (mm)	0.80
6	Pore size (μm)	150
7	Tensile strength (N/mm <sup>2</sup> )	200

The fabrics used in the work are added in layers by percentage weight of soil at the rate of 1%, 1.5%, 2 % 2.5% & 3% respectively.

### 4. CASE STUDY

The road from Seven Hill Flyover to Shahnoormiya Darga is a major road of Aurangabad city with heavy traffic intensity. This road starts from seven hill and runs through the major part of the city, Gajanan Maharaj temple, Jawahar Nagar Police Station, Sutgimi Centre, Shahnoormiya Darga. The total length of the road is 3.55 km. for the improvement we selected this part of the road because –

1. From flyover onwards, towards Baba Petrol Pump, no heavy traffic is allowed in the city, due to which this traffic uses the said road for getting to the Beed by pass.
2. Due to rapid growth of the city, land along the road is occupied by residential and public buildings and hence, infiltration of rainfall is not taking place. Also due to construction, natural drains are blocked and no proper care of constructing roadside drainage is taken during construction of the existing road. The texture of the soil is black cotton soil. Soils samples are collected and tested in the laboratory for engineering properties of soil and CBR values. Soils samples taken at the depth of 0.6 meter. The properties obtained by conducting laboratory tests are given in table 2.

**Table 2 : Engineering properties of Black Cotton Soil**

Sr. No.	Particulars	Values
1.	Liquid Limit %	43.80
2.	Plastic Limit %	27.96
3.	Plasticity index %	15.84
4.	Specific gravity	2.55
5.	IS Light Compaction- Optimum Moisture content % Maximum dry density gm /cm <sup>3</sup> .	17 1.66
6.	Shear Parameters – Cohesion KN/m <sup>2</sup> Angle of internal friction (Φ) in degrees	4.90 24.44

#### 4.1 Traffic Details

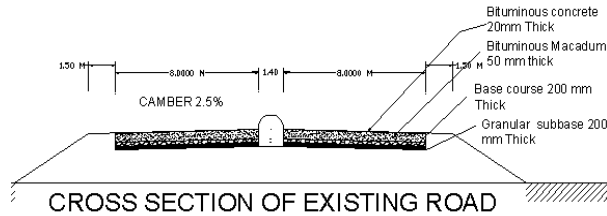
The details of the traffic belonging to the site for certain duration is achieved by calculating the different type of vehicles on the common road. The spots for calculating the vehicles are at Seven Hills, Gajanan Maharaj Temple, Jawaharnagar Police Station, Sutgimi Centre, Shahnoormiya Darga. The vehicles are differentiated into light, medium, heavy categories. Traffic volumes study is made by manual counting and then statistical analysis of peak hourly traffic is given in table 3.

**Table 3 : Traffic Volume in peak hours**

Sr No	Locations	Light	Medium	Heavy
1.	Seven Hill	4100	1294	198
2.	Gajanan Maharaj Temple	1920	588	58
3.	Jawahar Nagar Police	640	180	14

	Station			
4.	Sutgimi Centre	3660	720	104
5.	Shahnour Miya Darga	3080	560	258
	Total	13400	3342	632

**4.2 Existing C/S. of Road and its Details**



1. It consists of carriage way - 8 m.
  2. Slope of camber – 2.5 %
  3. The courses are –
    - (a) Bituminous concrete – 20 mm thick.
    - (b) Bituminous macadam – 50 mm thick
    - (c) Base Course – 200 mm thick.
    - (d) Granular sub base – 200 mm thick.
  4. The main drawback is side drain is not provided.
  - 5 Traffic separator – The main function of traffic separator is to prevent head on collision between vehicles moving in opposite direction on adjacent lanes. Traffic separator i.e. divider is of 1.4 m. in width.
- IRC : 37 -2001 recommends simple design chart and catalogue of pavement design for –
1. Sub grade CBR values ranging from 2 to 10 %.
  2. Design traffic varying from 1 msa to 150 msa.

Wearing Course is damaged due to improper pavement design, improper drainage and improper geometric design.

**Computation of Design traffic**

As per IRC : 37 -2001, the design traffic is considered in terms of cumulative number of standard axles to be carried during the design life of the road. This can be computed by using the relations –

$$N = \frac{365 \{ (1+r)^n - 1 \} \times A \times D \times F}{r}$$

where

N = cumulative number of standard axles to be catered for in the design in terms of msa.

A = initial traffic in the year of completion of construction in terms of number of commercial vehicles per day.

D = lane distribution factor

F = vehicle damaged factor

n = Design life in years

r = annual growth of commercial vehicles (for 7.5 % annual growth rate, r=0.075)

**5. RESULT AND DISCUSSION**

The attempt is made to know the causes for the change in different characteristics of black cotton soil due to addition of varying % of woven fabric in the soil.

**5.1 Compaction Characteristics**

The optimum moisture content and maximum dry density of soil without geosynthetic and with addition of geosynthetics are tabulated in table 4.

**Table 4 : Compaction Characteristics of Reinforced Black Cotton Soil**

Sr No	Particulars	Percent Fabric					
		0%	1%	1.5 %	2%	2.5 %	3%
1	Optimum moisture content (%)	17	20	21.3	23	26.7	16.3
2	Maximum dry density (gm/cm <sup>3</sup> )	1.66	1.6	1.53	1.44	1.15	1.14

Increase in OMC and decrease in MDD are due to the fact that woven fabric is very light material compared to soil and even a small quantity of it has a large bulk. Addition of this lighter material replaces a large amount of heavier material like soil.

The purpose of compaction is to improve the quality of soil used either as subgrade material for roads or in the dams. The important properties are high shear strength, low permeability and little tendency to settle under repeated loading. The maximum compaction is possible at the OMC and MDD of the soil. Therefore, these values of OMC and MDD serve as guide and basis to get the maximum compaction in the field

**5.2 Shear Strength Characteristics**

The shear strength characteristics found by conducting direct shear tests on geosynthetic woven fabric reinforced soil sample are given in table 5.

**Table 5 : Shear strength Characteristics**

Sr. No.	Percentage Woven Fabric	Cohesion (C) KN/m <sup>2</sup>	Angle of internal friction (Φ)
1.	0	4.90	24.44
2.	1	14.71	23.96
3.	1.5	24.52	22.61
4.	2	39.24	21.25
5.	2.5	49.05	16.69
6.	3	14.71	18.43

From the values given above, it is observed that there is reduction in angle of internal friction and increase in the value of cohesion due to the presence of

woven fabric reinforcement. This reduction may be due to low density of woven fabric and its smooth surface and the increase in the value of cohesion may be due to the bond developed between the soil and fabric.

It appears that as the woven fabric content is increased, there is increase in cohesion and decrease in angle of internal friction up to 2.5 % woven fabric. Beyond 2.5 %, addition of woven fabric, there is decrease in cohesion and increase in angle of internal friction. This is because of the fact that woven fabric of low density occupy relatively large volumes in the reinforced soil.

Thus with higher woven fabric content the quantity of soil matrix available for holding the fabric is insufficient to develop an effective bond between fabric and soil. The placing of the fabric in soil is practically difficult after the fabric content is increased beyond 2.5 % as balling up of fabrics takes place, and uniform distribution can not be made.

### 5.3 California Bearing Ratio values

The CBR values for 2.5mm, 5mm, 7.5mm, 10mm, 12.5mm penetration are given in table 6

**Table 6 : California bearing ratio values**

Sr. No.	Reinforcement status	CBR values % Plunger Penetration in mm.				
		2.5	5	7.5	10	12.5
1.	Reinforcement status without geosynthetic	2.54	2.43	2.23	1.91	1.81
2.	Black cotton soil + 1 % geosynthetic	3.18	2.65	2.32	1.98	1.87
3.	Black cotton soil + 1.5 % geosynthetic	3.5	2.86	2.40	2.12	1.93
4.	Black cotton soil + 2 % geosynthetic	3.81	2.97	2.48	2.12	1.93
5.	Black cotton soil + 2.5 % geosynthetic	3.97	3.28	2.73	2.33	2.11
6.	Black cotton soil + 3 % geosynthetic	3.18	2.48	1.98	1.71	1.57

CBR % increase is 25.19 % for 1 % geosynthetic and 56.29 % for 2.5 % geosynthetic. With addition of 3 % geosynthetic, there is decrease in CBR value.

### 6. CONCLUSIONS

From the present study, following conclusions are drawn:-

1. The value of optimum moisture content increases with the increase in geosynthetic woven content up

to 2.5 % and beyond 2.5 %, there is decrease in optimum moisture content.

2. The maximum dry density decreases with the increase in geosynthetic woven fabric content.
3. There is significant increase in the value of cohesion as the percentage of geosynthetic woven fabric increases up to 2.5 % and beyond 2.5 %, there is decrease in cohesion.
4. The angle of internal friction decreases with the increase in geosynthetic woven fabric content.
5. The soaked CBR value of the black cotton soil without any kind of reinforcement is 2.54%.
6. Pavement of roads may be surfaced or subsurfaced can store large amount of water in different layers if there is no outlet for the water then it create a bath tub. The entrapped water in the base, subbase or subgrade of a pavement is one predominant single factor which causes premature deterioration and destruction of pavement.

Therefore it is necessary that the entrapped water should be removed from the layer of pavement as early as possible to prevent the premature failure

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