INVESTIGATION OF SUBGRADE STRENGTH OF SOIL MIXED WITH INDUSTRIAL EFFLUENTS AND STABILIZING WITH POLYOLEFIN FIBRE

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Abstract: **The world getting urbanizing and industrializing in past few years because of the improvement of technology and increase in population. Most of the industries discharge their waste water into the ground. It influences the engineering property of soil increased or decreased. Here an analysis done to study the effect of Printing effluent, Textile effluent, Mining effluent, sugar mill effluent on to the soil subgrade strength with CBR value. If there is a decrease in strength soil stabilized with polyolefin materials (Electrical insulation wire).**

Keywords: **Influence of effluent, CBR test, Standard proctor compaction test, stabilization, polyolefin fibre.**

1. INTRODUCTION.

The engineering property of the soil aroung the industrial plant gets modified because of the disposal of wastewater. An investigation made by Yaji et al. (1996) influence of sugar mill liquid waste. It decrease the shear strength of the soil. An investigation made by Ghosh et al. (1998) reported that soil property get deteriorate due to tannery effluent. The industrial effluent contains various types if nutrient which may increase or decrease the strength of subgrade soil. Stabilization is the process of improving the strength of the soil. Polyolefin is the synthetic material made from simple olefin as a monomer. Polyolefin available in different forms like crocs shoes, seat cushion, tennis racket, heat shrink tubes etc.

Principles of soil stabilization are,

- ❖ Evaluating the soil property of selected soil.
- ❖ Deciding the lacking property of soil and choose effective and economical method of soil stabilization.
- ❖ Designing the stabilized soil mix for intended stability and durability value.

2. LITERATURE REVIEW

MallikarjunaRao et al., (2008) studied the influence of spent orange dye effluent from a Textile industry on a clayey soil. The soil was mixed with spent orange dye effluent and tested for Index properties and Engineering properties after varying curing periods. The dye effluent and its constituents were found to induce cementation/bonding and flocculation to the soil resulting in improved engineering properties.

Narasimha Rao and Chittaranjan (2012) investigated the effect of Textile, Tannery and Battery effluents on Compaction characteristics of expansive clayey soil and showed that when soil is treated with Textile and Battery effluents separately an increase in Optimum moisture content and decrease in maximum dry density is observed. But when it is treated with Tannery effluent opposite trend is observed. Hence the Strength Characteristics such as California Bearing Ratio, Unconfined Compressive Strength, Triaxial shear Strength Parameters which are obtained at Optimum Pore fluid Content and Maximum Dry Unit Weight are strongly influenced by these three industrial effluents.

Pandey,(2014) Hydrocarbon induces varying in the engineering characteristics and performance of soils. This variation consist an extreme comprise on current and planned constructions that will be based on the contaminated soil. It may be caused a structural or functional failure of current constructions, at the time of the contamination produces a serious rise in the soil's plasticity; loss of its bearing capacity; rise its settlement, and prevent drainage of water or other liquid .

Rao, (2008) It was actually confirmed that the geotechnical characteristics of such soil are significantly varied and created unacceptable for constructing structures. Sulphur elements present in contaminated soils effect on the concrete and hydrocarbons from oil negatively affect the hydration of fresh concrete.

Dr. A. I. Dhatrak , 2015 after reviewing performance of plastic waste mixed soil as a geotechnical material. It was observed that for construction of flexible pavement to improve the sub grade soil of pavement using waste plastic bottles chips is an alternative method.

Akshat malhotra & Hadi ghasemain , 2014 studied the effect of HDPE plastic waste on the UCS of soil. In a proportion of 1.5%, 3%, 4.5% and 6% of the weight of dry soil, HDPE plastic waste was added. They concluded that the UCS of black cotton soil increased on addition of plastic waste.

Choudhary, Jha & Gill , 2010 demonstrated the potential of HDPE to convert as soil reinforcement by improving engineering properties of sub grade soil.

Rajkumar nagle, 2014 performed CBR studied for improving engineering performance of sub grade soil. They mixed polyethylene, bottles, food packaging and shopping bags etc., as reinforcement within black cotton soil, yellow soil and sandy soil.

Mercy joseph poweth , 2013 investigated on safe and productive disposal of quarry dust, type of waste and wastes-plastic by using them in the pavements sub grade. In their paper, a series of CBR and SPT test were carried out for finding the optimum percentages of waste plastics, quarry dust in soil sample.
Achmad fauzi , 2016 calculated the engineering properties by mixing waste plastic High Density Polyethylene (HDPE) and waste crushed glass as reinforcement for sub grade improvement.
Chebet , 2014 did laboratory investigations to determine the increase in shear strength and bearing capacity of locally available sand due to random mixing of strips of HDPE (high density polyethylene)
Kalantari et al ,2012 were experiments on use of cement, polypropylene fibres and optimum moisture content values to strengthen peat. From their laboratory study it was observed that peat with cement and fibres can be used as the base course in the pavement construction. It appears that the fibres prevent the formation and the development of the cracks upon loading and thus increasing the strength of the samples.
Firoozi et al , 2014 were investigated on Influence of Fibre and Cement on Stabilisation of Silty Clay. They were stabilized The UKM soil with 10% of Portland cement and varying percentages (0, 0.5, 0.75 and 1) polypropylene fibres, and concluded that both compressive strength and tensile strength increased with the increase in polypropylene fibres.

3. EXPERIMENTAL INVESTIGATION

3.1 Materials used.

- Soil samples
- Effluent samples

3.1.1Soil samples.

The soil samples collected from the surrounding area of industries such as sugar mill industry (sample 1), textile industry (sample 2), printing industry(sample 3), mining industry(sample 4).The soil samples are passing through the IS 4.25mm are taken for study. The properties of soil sample shown in table 1.

Table.1. Properties of soil sample taken for study

SI. NO	Property of soil samples	Value sample 1	Value Sample 2	Value sample 3	Value sample 4
1	Grain size distribution				
	(i)Gravel(%)	4	3	8	3
	(ii) sand(%)	23	32	41	17
	(iii) silt ,clay(%)	73	65	52	80
2	Atterbeg limits				
	(i)Liquid limit(%)	55	75	40	65
	(ii)Plastic limit(%)	27	32	23	28
3	Specific gravity	2.68	2.55	2.59	2.71
4	Proctor compactor test				
	(i)Maximum dry density(KN/m^3)	14.7	18.12	11.2	19.57
	(ii)Optimum moisture content(%)	8	14	12	9.5
5	California bearing ratio value (%)				
	(i) 2.5mm penetration	9.83	14.5	10.2	12.5
	(ii)5.0mm penetration	9.58	13.3	9.98	10.3

3.1.2. Effluent samples

3.1.2.1. Sugar mill effluent.

The sugar mill effluent is greenish black in color. It has a small amount of sludge itself. The properties of sugar mill effluent shown in table 2.

Figure 1. Flame photometer

Table.2. Properties of sugar mill effluent

SI.NO	PARAMETERS	SUGAR MILL EFFLUENT
1	Ph	7.7
2	Total solids(mg/L)	1150
3	Total dissolved solids(mg/L)	690
4	Total suspended solids(mg/L)	520
5	calcium(mg/L)	35.07
6	Magnesium(mg/L)	19.48
7	Total alkalinity(mg/L)	400
8	Dissolved oxygen(mg/L)	2.07
9	BOD(mg/L)	96
10	COD(mg/L)	45.2

3.1.2.2.Textile effluent

Textile effluent is coloured liquid and soluble in water. The properties of textile effluent shown in table 3.

Figure 2 Textile effluent

Table.3. properties of textile effluent

SI.NO	PARAMETERS	TEXTILE EFFLUENT
1	Ph	7.9
2	Total solids(mg/L)	4520
3	Total dissolved solids(mg/L)	3560
4	Total suspended solids(mg/L)	960
5	Hardness(mg/L)	120
6	Chloride	980
7	Nitrate	442
8	Copper	0.061
9	BOD(mg/L)	640
10	COD(mg/L)	1830

3.1.2.3. Printing effluent

Printing effluent is a dark coloured liquid. Properties of printing effluent shown in table 4.

Table.4 . Properties of printing effluent

SI.NO	PARAMETERS	PRINTING EFFLUENT
1	Ph	8.66
2	Total solids(mg/L)	5216
3	Total dissolved solids(mg/L)	2100
4	Total suspended solids(mg/L)	3116
5	Hardness(mg/L)	970
6	Oil , grease (mg/L)	18
7	Calcium (mg/l)	1723
8	Iron (mg/l)	0.16
9	BOD(mg/L)	970
10	COD(mg/L)	3080

3.1.2.4. Mining effluent

Mining effluent is the pale yellow colour and it has a small amount of sludge itself. The properties of mining effluent shown in table 5

Table.5. Properties of mining effluent

SI.NO	PARAMETERS	MINING EFFLUENT
1	Ph	7.4
2	Total solids(mg/L)	1448
3	Total dissolved solids(mg/L)	466
4	Total suspended solids(mg/L)	982
5	Hardness(mg/L)	230
6	Oil , grease (mg/L)	11
7	Total alkalinity(mg/L)	86
8	Ca(mg/l)	122.4
9	BOD(mg/L)	30
10	COD(mg/L)	250

3.3.Preparation of soil sample mixed with effluent.

The soil from the site is dried and hand sorted to remove the pebbles and vegetative matter if any. It is further dried and pulverized and sieved through a sieve of 4.75mm to eliminate gravel fraction if any. The dried and sieved soil is stored in air tight containers and ready to use for mixing with effluents. The soil sample so prepared is then mixed with solutions of different concentrations of

Sugar mill, Textile, Mining and Printing effluent. The percentage varied from 0% to 100% in increment of 25%. The soil - effluent mixtures are mixed thoroughly before testing.

3.4. Tests conducted on soil mixed with effluent.

(a). California Bearing Ratio(CBR).

Un soaked CBR of soil is found for soil with various percentage of effluent and the variation of CBR with percentage Sugar mill, Printing, Textile and Mining effluent. CBR value increases with the addition of Textile effluent and decreases with the addition of Sugar mill effluent, Printing effluent and Mining effluent. Improvement of CBR value will help in increasing the suitability of soil for pavement. Decrease in CBR value is need of stabilization of soil. The test results of CBR value 2.5 mm penetration shown in table 6. The test results of CBR value 5.0 mm penetration shown in table 7.

Figure 3 : CBR test apparatus

Table.6. CBR value 2.5mm penetration

EFFLUENT IN %	C.B.R VALUE 2.5mm PENETRATION			
	SUGAR MILL	TEXTILE	PRINTING	MINING
0	9.83	11.50	10.20	12.50
25	9.50	11.85	9.98	12.26
50	9.11	12.38	9.54	11.92
75	8.76	12.89	9.23	11.66
100	8.52	13.78	8.89	11.37

Table.7. CBR value 5.0mm penetration

EFFLUENT IN %	C.B.R VALUE 5.0mm PENETRATION			
	SUGAR MILL	TEXTILE	PRINTING	MINING
0	9.83	11.50	10.20	12.50
25	9.54	11.98	9.75	11.89
50	9.18	12.48	9.12	11.28
75	8.78	12.99	8.87	10.86
100	8.42	13.33	8.32	10.33

The test result shows increase in textile effluent treated soil and decrease in sugar mill effluent, printing effluent and mining effluent treated soil.

(b). Standard proctor compacted test

The compaction parameters i.e. optimum moisture content and Maximum dry unit weight play a vital role in changing the strength characteristics of an expansive soil. Hence in this investigation Standard Proctor's compaction tests are carried out on expansive soil treated with Sugar mill effluent , Printing effluent, Textile effluent and Mining effluent at various percentages of the soil. The test result for optimum moisture content shown in table 8. The test results of maximum dry density shown in table 9.

Table.8. Optimum moisture content

EFFLUENT IN %	OPTIMUM MOISTURE CONTENT IN %			
	SUGAR MILL	TEXTILE	PRINTING	MINING
0	15.2	12.8	13.6	12.4
25	14.8	13.4	13.1	12.8
50	14.2	13.8	12.9	13.5
75	13.5	14.3	12.4	13.9
100	13.0	14.7	12.1	14.3

The test result shows increase in optimum moisture content while adding textile effluent and mining effluent. There is a decrease in optimum moisture content while adding sugar mill effluent and printing effluent.

Table.9. Maximum dry density

EFFLUENT IN %	MAXIMUM DRY DENSITY (KN/m³)			
	SUGAR MILL	TEXTILE	PRINTING	MINING
0	18.5	18.8	17.9	17.5
25	18.8	18.4	18.2	17.1
50	19.2	17.9	18.7	16.7
75	19.6	17.5	19.3	16.2
100	20.2	17.1	19.8	15.5

The test result shows decrease in maximum dry density while adding textile effluent and mining effluent. There is a increase in maximum dry density while adding sugar mill effluent and printing effluenttt

3.5. Comparison graph

(a) CBR Test

3.5.1. Comparison of CBR value 2.5mm penetration is shown in figure 4.

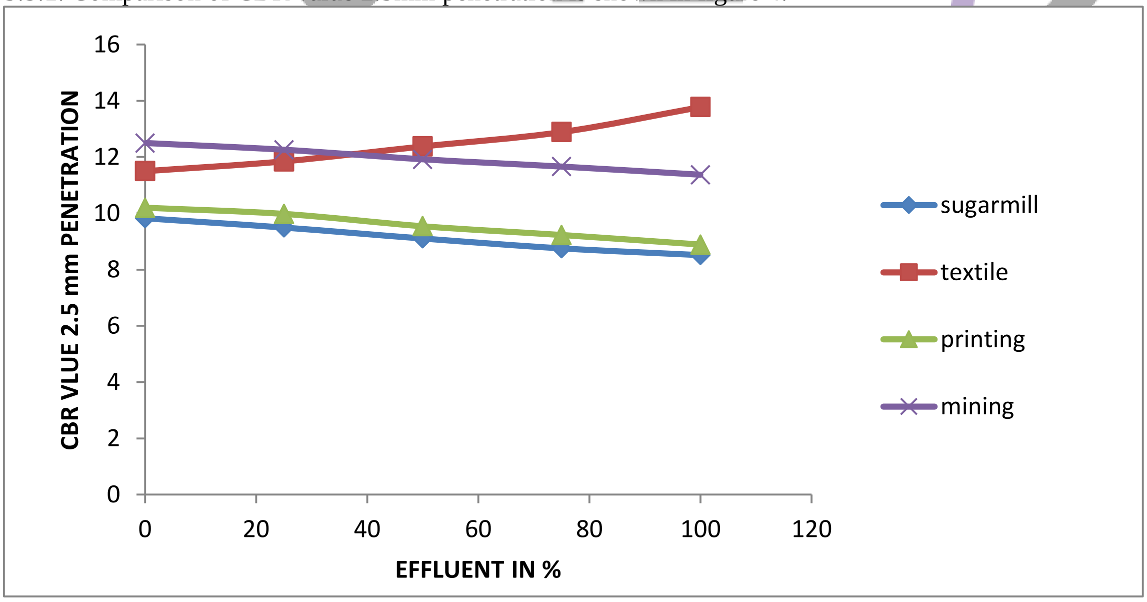

Figure.4

3.5.2. Comparison of CBR value 5.0mm penetration is shown in figure **5**

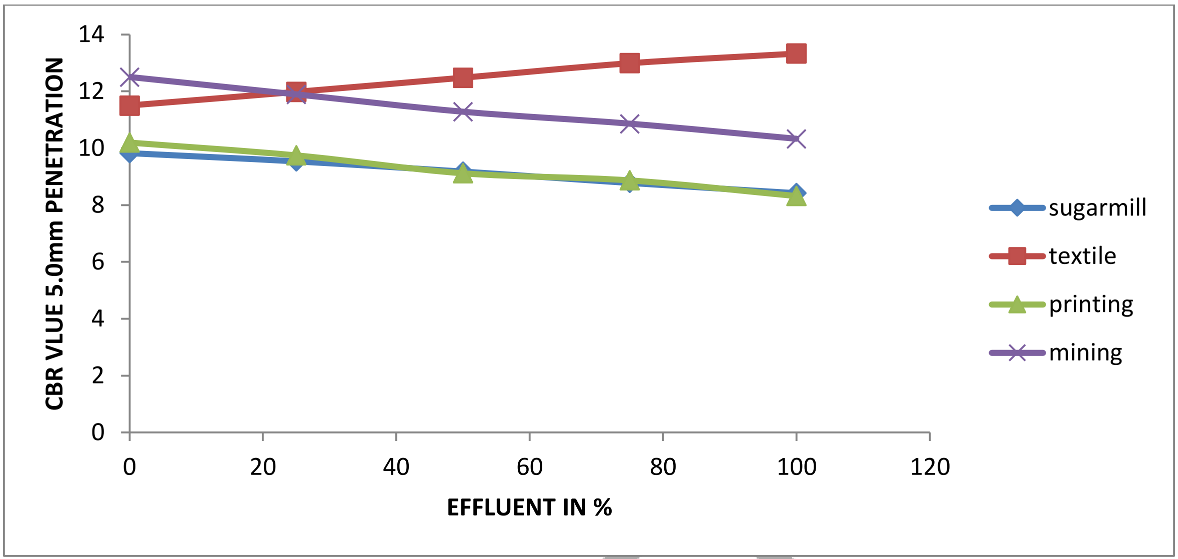

Figure.5

The test result shows increase in textle effluent treated soil and decrease in sugar mill effluent, printing effluent and mining effluent treated soil.

(b)Standard proctor compactors test

3.5.3. Comparison graph of optimum moisture content shown in figure 6.

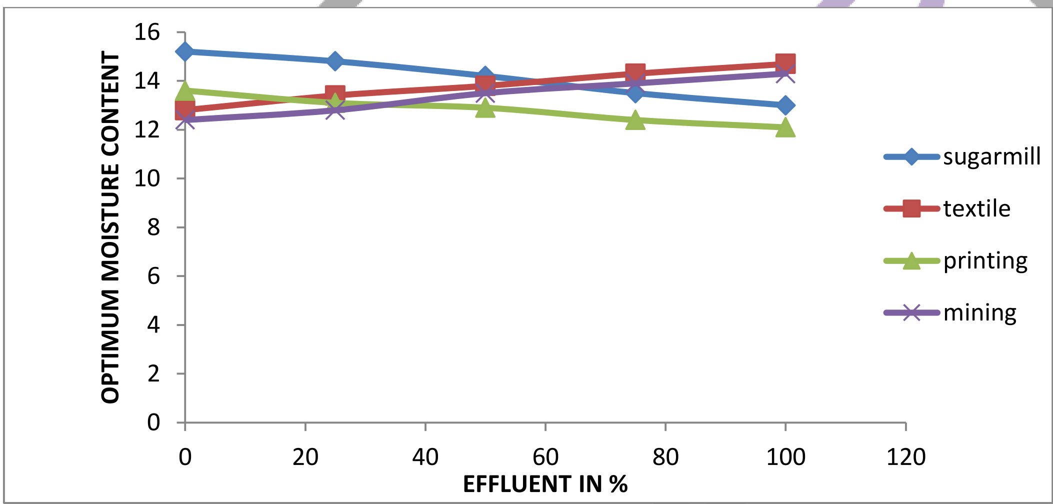

Figure.6

The test result shows increase in optimum moisture content while adding textile effluent and mining effluent. There is a decrease in optimum moisture content while adding sugar mill effluent and printing effluent.

3.5.4. Comparison graph of maximum dry density shown in figure 7.

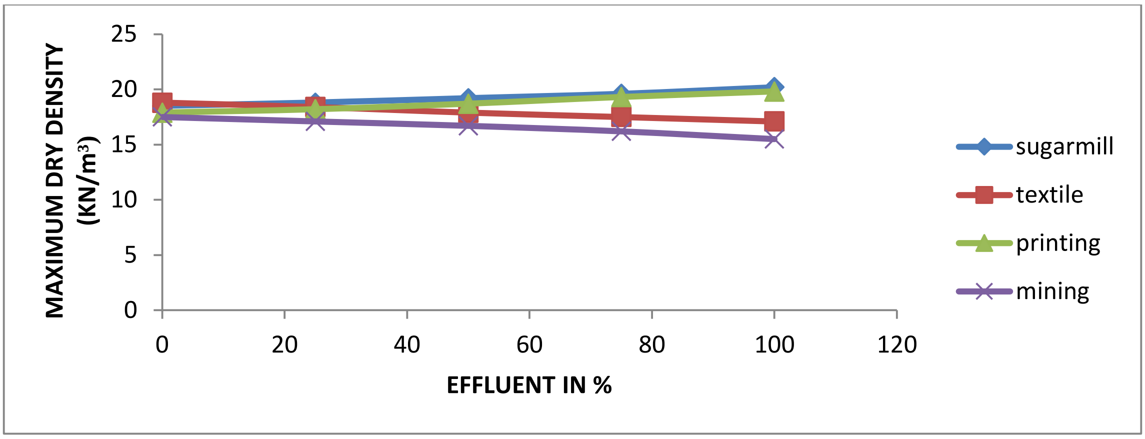

Figure 7

4. SOIL STABILIZATION BY USING POLYOLEFIN MATERIALS

4.1. Properties of polyolefin.

- High tensile strength
- Impactt resistant
- Brittleness
- High compressive strength
- Creep resistance
- Low permeability
- Orientation factor
- Abrasion resistance
- Puncture resistance
- Hardness

Figure 8 : polyolefin fiber

4.2. Types of polyolefin

SI.NO	TYPE	USES
1	High density polyethylene(HDPE)	Fuel tank, bottle caps, plastic bottles..
2	Low density polethylene(LDPE)	Liquid container, tubing, plastic wrap…
3	Polypropylene	Piping, carpet, auto parts, hinges…
4	Ethylene propylene diane monomer (EPDM) rubber	Seals, electrical insulation, roofing…

4.3. Polyolefin material.

Polyolefin is a type of polymer consists huge range of synthetic organic. It's a very huge issue to whole world as it degrades very slowly to earth. In this project we use the ***electrical insulation wire*** as the reinforcing medium in the soil.

4.4. Mixing of polyolefin fibre with soil.

The polyolefin fibre randomly mixed with the soil. We had cut wires of plain surface whose dimension is almost length 20mm and width4mm.

This arrangement has discrete fibres distributed randomly in the soil mass. The mixing is done until the soil and the reinforcement form a more or less homogeneous mixture. Randomly distributed fibres have some advantages over the systematically distributed fibres. Somehow this way of reinforcement is similar to addition of admixtures such as cement, lime etc. Besides being easy to add and mix, this method also offers strength isotropy, decreases chance of potential weak planes which occur in the other case and provides ductility to the soil.

3.6.5. Test conducted on reinforced soil

3.6.5.1. CBR Test

The number of test specimen are prepared. Then required amount of the strips in their appropriate sizes were cut and weighed according to required percentage. The experimental study involved performing a series of laboratory CBR tests on unreinforced and randomly oriented plastic strip reinforced soil specimen

Required amount of strips as well as soil was first weighed and then the strips randomly mixed with dry soil at

obtained moisture content. The soil mass formed must be a homogeneous specimen. The load is applied through the penetration reading of deflection are taken with help of dial gauges of sensitivity 0.01mmfor 0.0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 4.0, 4.5, 7.5, 10.0 and 15.0mm. The CBR value of soil reinforcing with 0.25% polyolefin fibre test result shown in table 10. The CBR value of soil reinforcing with 5.0% polyolefin fibre shown in table 11.

Table.10. CBR value of soil with 0.25% polyolefin fibre

Aspect ratio	CBR values of soil reinforcing with 0.25 % polyolefin fibre		
	Sugar mill	Printing	Mining
0	8.52	8.89	11.37
1	18.62	15.98	19.80
2	22.76	20.56	24.76
3	29.55	26.89	29.11
4	35.65	32.21	34.56

Table.11. CBR value with 0.50% of polyolefin fibre

Aspect ratio	CBR values of 2.5mm penetration reinforcing with 0.50% polyolefin fibre		
	Sugar mill	Printing	Mining
0	8.42	8.32	10.33
1	17.55	19.66	20.14
2	28.77	24.45	28.79
3	35.50	30.91	34.52
4	42.81	37.72	40.61

The tests results shows the randomly increase in the bearing capacity of the soil while reinforcing with polyolefin fibre. The increase in strength with the in percentage of polyolefin fibre.

4.6. Result and discussion

The test result of CBR value reinforcing with 0.25% of polyolefin fibre shown in figure 9 and CBR value reinforcing with 0.50% of polyolefin fibre shown in figure 10.

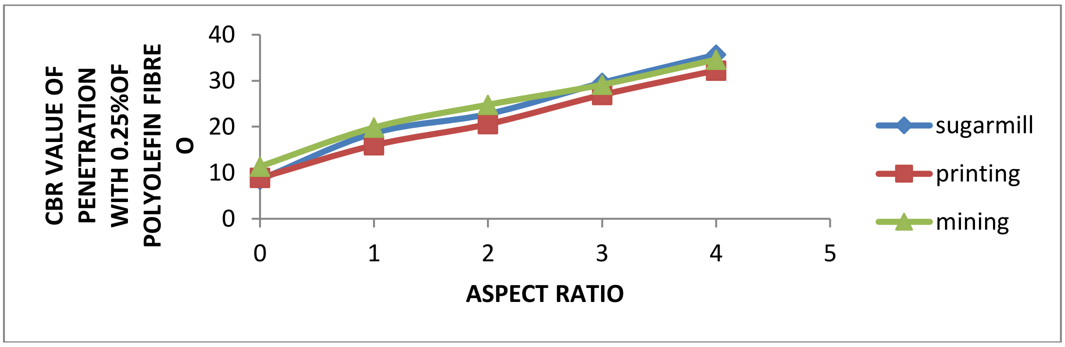

Figure.9

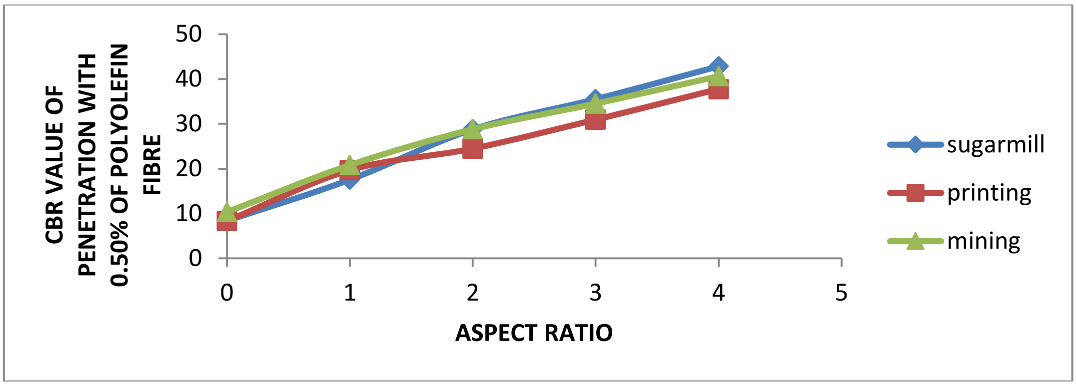

Figure.10

The tests results shows the randomly increase in the bearing capacity of the soil while reinforcing with polyolefin fibre. The increase in strength with the increase in percentage of polyolefin fibre.

5. CONCLUSION

- The bearing capacity of the soil decreases with the addition of the sugar mill effluent, Printing effluent and Mining effluent.
- The bearing capacity of the soil increases with the addition of textile effluent.
- This is because of the mineral content present in the industrial effluent.
- The increase in the bearing capacity of the soil is the addition factor to the strength of the pavement.
- But decrease in bearing capacity of the soil affect the strength and construction of the pavement.
- Hence there is a need of reinforcing soil to increase the strength.
- The addition of polyolefin fibre increases the bearing capacity of the soil.
- Polyolefin is mostly in the form of plastic and use of electrical insulation wire fibre decreases the environmental pollution.
- The waste electrical insulation wire is used for this project hence it is cost effective.

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