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RESEARCH ARTICLE

EXPANSIVE SOIL STABILIZATION USING IRON ORE TAILINGS

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Abstract

The foundation of the natural world is the soil, which is prevalent in many parts of India and has a high silt content, low strength, and weak bearing ability. The loads placed on these soils during construction or during the structure's useful life are too great for them to bear. In India, expansive soil covers 20 percent of the land. To enhance the functionality of expansive soils, soil stabilization is used.In this research work, an attempt has been made to use Iron Ore Tailings (IOT) an industrial by-product as stabilizing agent for expansive soil. In this study, expansive soil is replaced with IOT from 0% to 30% at 5% interval. It was found from the experimental observations that the values of Liquid limit and Plastic limit decreased with increase in percentage of IOT. Free swell index shows a total decrement of 55% at 30% IOT content. MDD of standard and modified compaction increased with higher percentage of IOT whereas the OMC decreased accordingly. CBR values of un-soaked condition yielded whereas no penetration resistance was observed in soaked condition. Swelling pressure effectively decreased to a total of 50% at 30% IOT content. Hence, it can be concluded that IOT will help in improving the mechanical properties of expansive soil.

Introduction:-

In recent years, steel production has increased significantly to meet the construction industry demands. This has resulted in the generation of huge amount of iron ore tailings (IOT) which are disposed of as waste in landfills, quarries, oceans, etc. after the extraction of iron concentrate from the ore. For production of 1 ton of iron ore 3.5 - 4.0 tonnes of iron ore tailing is discharged. At present India is the 4th largest country after China (1.5 billion), Australia (774 million) and Brazil (411 million) to produce iron ore every year (around 150 million metric tonnes/year). These tailings pose serious environmental problems besides occupying large area of landfill sites. Disposal of large quantities of industrial by-products as fills on disposal sites adjacent to industries not only requires large space but also create a lot of geo-environment problems such as releasing toxic metals, contamination of ground water and surface water etc..

On the other hand, Engineers have often faced the problem of constructing facilities on or with soils, which do not possess sufficient strength to support the loads imposed on them either during construction or during the service life

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of the structure. Many areas in India have soil with high silt content, low strength and tend to have poor bearing capacity. Around 20%[4] (5.4 lakh sq. km) of the land is covered with expansive soil in India. Expansive soil (Black cotton soil) is a clayey soil and is black in color. It contains clay mineral in which montmorillonite is predominant mineral and has expansive characteristics. This soil possesses high shrinkage limit and high optimum moisture content when it is exposed to water. These soils occur in the states of Madhya Pradesh, Gujarat, Maharashtra, Karnataka, Andhra Pradesh and Tamilnadu.

The inspiration behind this research work is to improve the engineering performance of expansive soil by utilization of industrial by-products or wastes. Various methods can be used to improve the performance of poor quality of soils. The choice of a particular method depends mainly on the type of soil to be improved, its characteristics, the type and the degree of improvement desired for a particular application. Stabilization of soil is an effective method to improve the strength properties of soil. In this research work, an attempt has been made to use iron ore tailings as stabilizing agent for expansive soil.

Materials And Methodology:-

Materials

The materials and methodology adopted in this research work confines to various Indian standard specifications. The materials used are listed below.

a. Expansive soil

The soil sample used in this study was obtained from Thorenoor village, Somwarpet taluk, Kodagu district, Karnataka. It was collected as disturbed sample, excavated from depth not less than 0.5 m, to avoid any organic material. The samples were packaged in sealed plastic bags for use in laboratory. The collected soil sample was air-dried and pulverized into particles passing IS sieve No 04 (4.75 mm aperture) sieve (Plate 2.1) before laboratory tests were carried out. The properties of Expansive soil are tabulated in table 2.1.

Plate 2.1:-Expansive soil sample of 4.75mm passing.

Table 1:- Physical properties of Expansive soil.

Parameters	**Results**
Specific gravity	2.62
Liquid Limit (%)	63
Plastic Limit (%)	36.98
Plasticity Index (%)	26.02
Optimum moisture content (%)	18.26
Maximum Dry Density (g/cc)	1.56
Free Swell index	45

2 days curing period UCS (kN/m^2)	283.03
5 days curing period UCS (kN/m^2)	306.09
CBR (%) 2.5mm	0.20
CBR (%) 5mm	0.18
Swell pressure (kg/cm^2)	0.134

b. Iron ore tailings

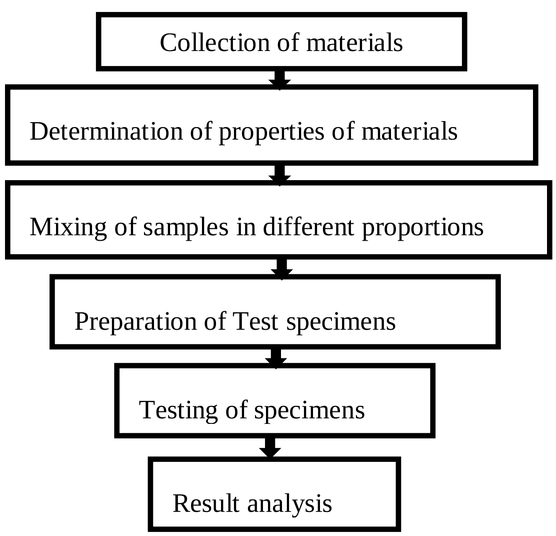
Iron ore tailing was obtained from the Jindal southwest company (JSW) waste deposit in Sandur, Bellary district Karnataka. The iron ore tailing sample (Plate 2.2) was passed through IS sieve No 04 (4.75 mm aperture) sieve before laboratory tests were carried out.

Table 2.2:- Properties of Iron ore tailing.

Parameters	**Results**
Specific gravity	4.03
Effective water absorption (%)	1.41
Total water absorption (%)	5.67
Moisture content (%)	3

Plate 2.2:- Iron Ore Tailings sample of 4.75mm passing.

Methodology:-



Tests Performed
The tests which were conducted on different proportions of expansive soil and iron ore tailings i.e, 0%, 5%, 10%, 15%, 20%, 25% and 30% are as follows

1. Liquid limit
2. Plastic limit
3. Standard and Modified proctor test
4. Swell index
5. Unconfined compression test
6. California Bearing ratio and
7. Swell pressure

Results:-

Liquid limit and Plastic limit test

Table 4.1:- Liquid limit and plastic limit of soil and IOT mixes.

Ratio of ES and IOT	Liquid limit (%)	Plastic limit (%)
Expansive Soil (ES)	63	36.98
95%ES+5% IOT	62	27.71
90%ES+10%IOT	58	27.22
85%ES+15%IOT	52	26.31
80%ES+20%IOT	49	28.86
75%ES+25%IOT	47	21.26
70%ES+30%IOT	44	19.86

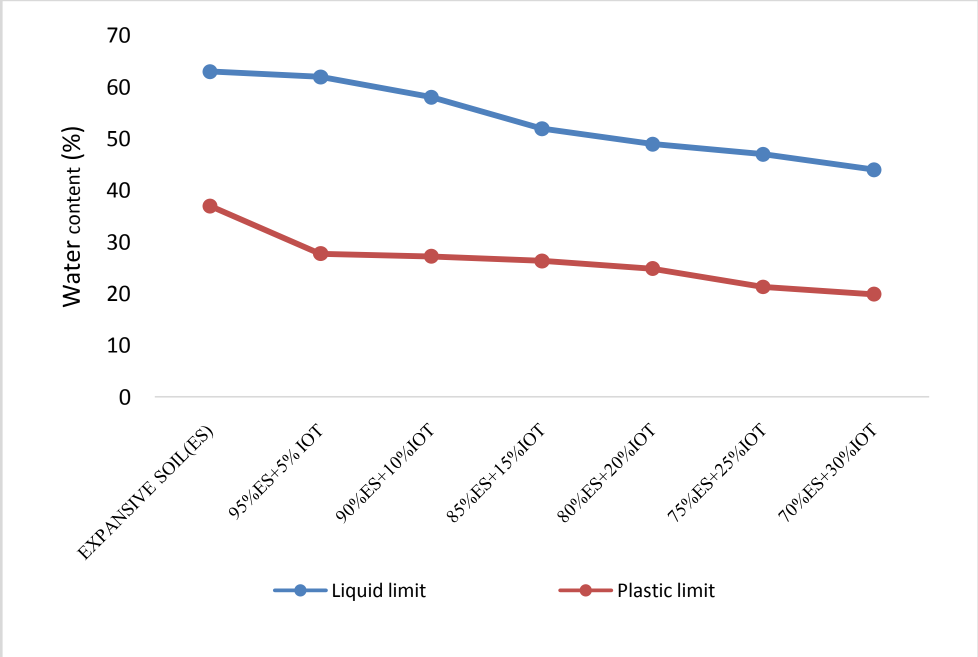


Figure 4.1:- Variation of Plastic limit and Liquid limit.

Standard (Light) Compaction

Table 4.2:- MDD and OMC of soil and IOT mixes.

Ratio of ES and IOT	MDD (g/cc)	OMC (%)
Expansive soil(ES)	1.56	18.26
95%ES+5% IOT	1.5	20.23
90%ES+10%IOT	1.57	20.19
85%ES+15%IOT	1.64	17.21
80%ES+20%IOT	1.79	16.92

75%ES+25%IOT	1.8	16.08
70%ES+30%IOT	1.86	15.98

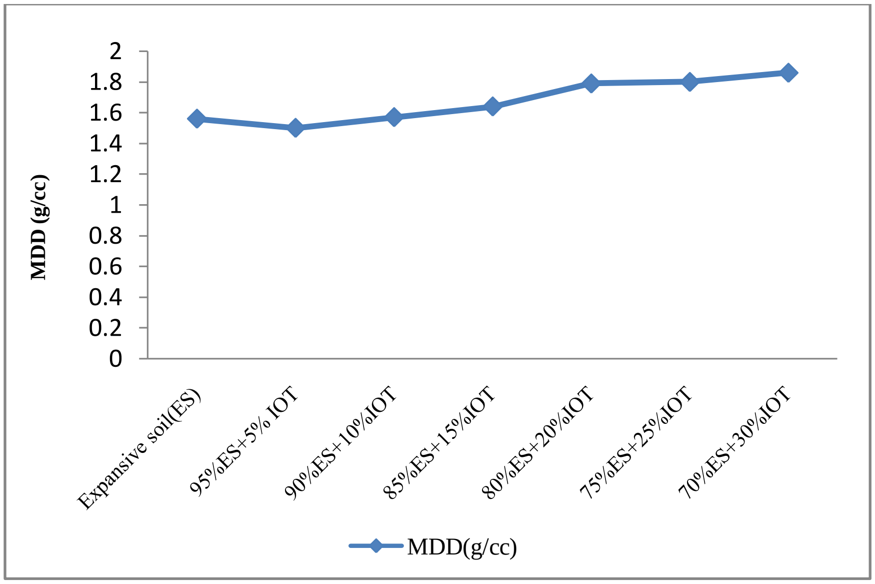


Figure 4.2:- Variation of MDD.

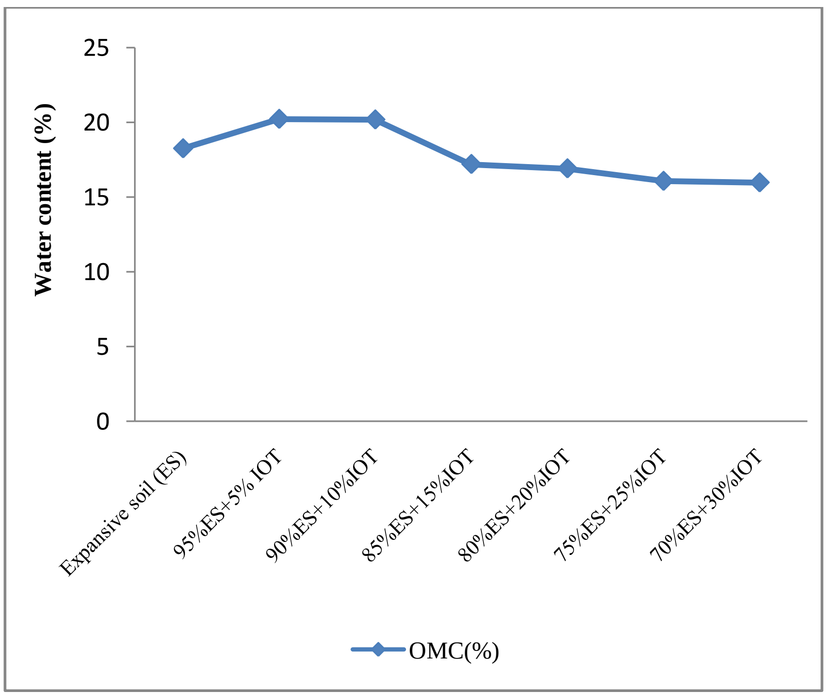


Figure 4.3:- Variation of OMC.

Modified (Heavy) Compaction

Table 4.3:- MDD and OMC of soil and IOT mixes.

Ratio of ES and IOT	MDD (g/cc)	OMC (%)
Expansive soil(ES)	1.67	20.68
95%ES+5% IOT	1.69	19.5
90%ES+10%IOT	1.72	18.32
85%ES+15%IOT	1.78	17.37

80%ES+20%IOT	1.86	16.42
75%ES+25%IOT	2.01	15.8
70%ES+30%IOT	2.33	15.18

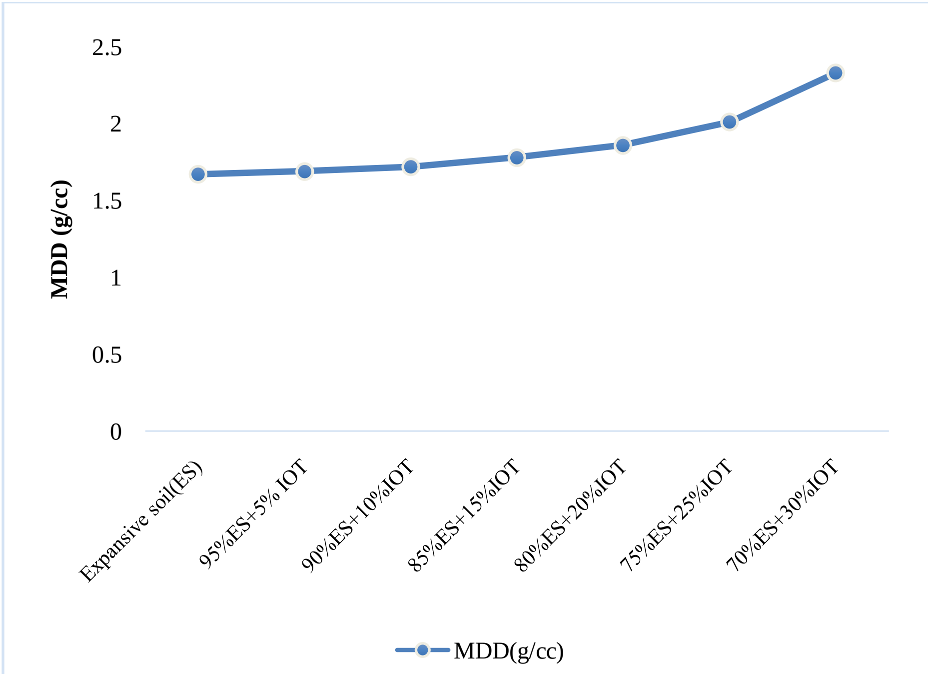


Figure 4.4:- Variation of MDD.

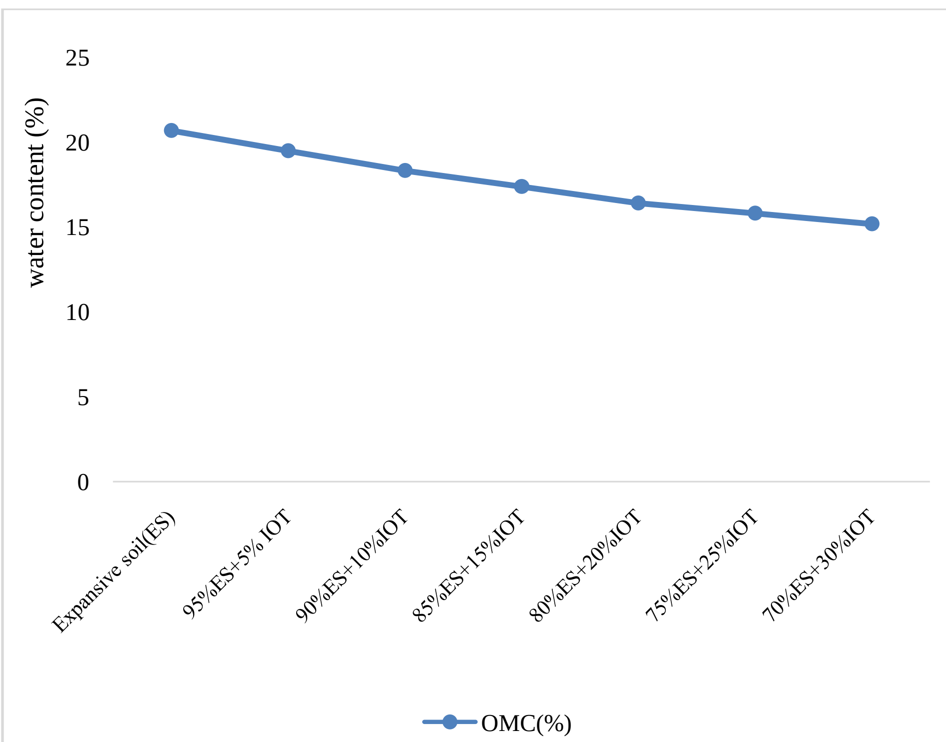


Figure 4.5:- Variation of OMC.

Free Swell Index

Table 4.4:- Free swell index of soil and IOT mixes.

Ratio of ES and IOT	Swell index (%)
Expansive soil (ES)	45
95%ES+5% IOT	39.72
90%ES+10%IOT	33.33
85%ES+15%IOT	29.16
80%ES+20%IOT	27.21
75%ES+25%IOT	22.5
70%ES+30%IOT	20.45

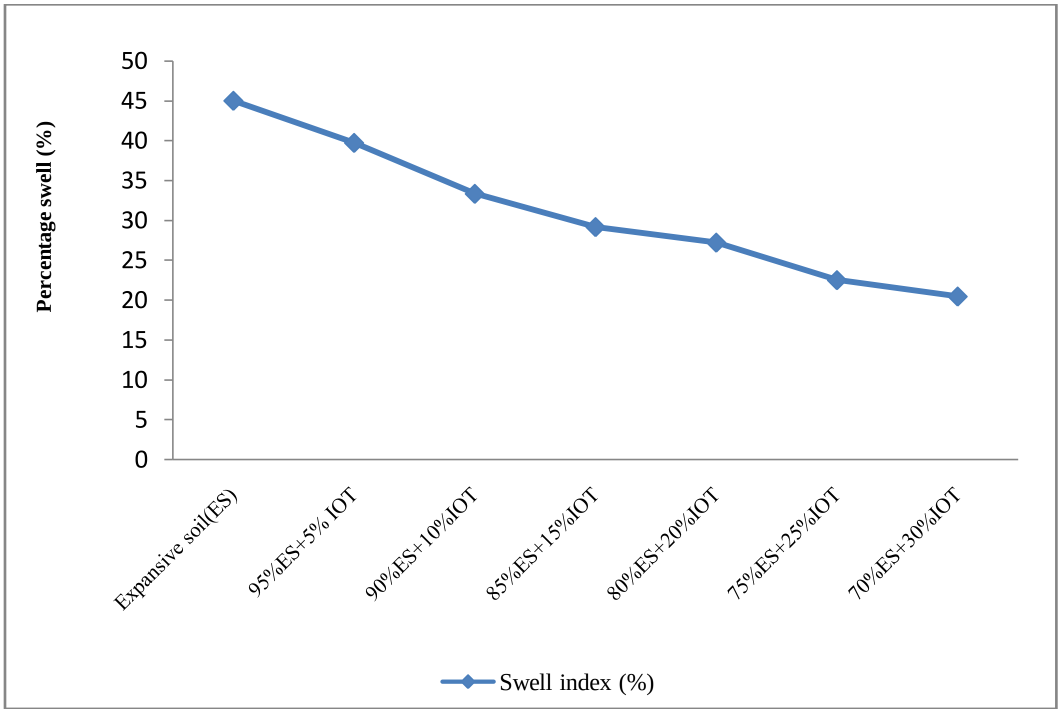


Figure 4.6:- Variation of Free Swell index.

Unconfined Compression Test (UCS)

Table 4.5:- Unconfined compression test of soil and IOT mixes.

Ratios of ES and IOT	UCS (kN/m^2)	
	2 days curing	**5 days curing**
Expansive soil(ES)	283.03	306.09
95%ES+5%IOT	304.11	387.44
90%ES+10%IOT	325.19	468.79
85%ES+15%IOT	381.42	552.35
80%ES+20%IOT	437.65	635.91
75%ES+25%IOT	509.13	709.25
70%ES+30%IOT	580.61	782.60

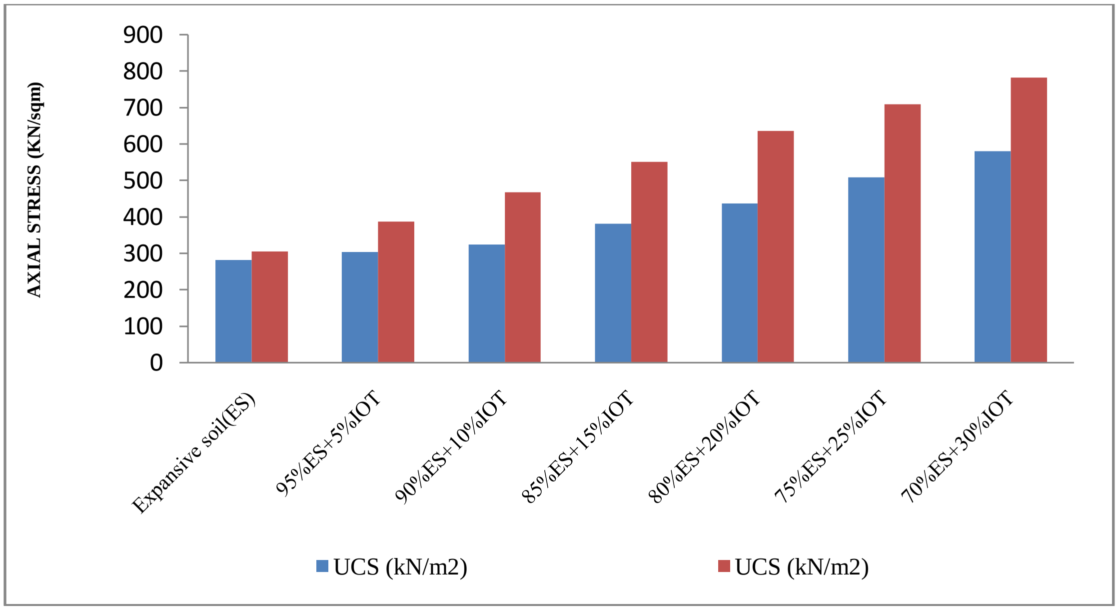


Figure 4.7:- Variation of UCS.

California Bearing Ratio (CBR)

Table 4.6:- CBR test for soil and IOT mixes.

Ratios of ES and IOT	CBR (%)			
	Unsoaked		Soaked	
	2.5mm	5mm	2.5mm	5mm
Expansive soil(ES)	0.20	0.18	-	-
95%ES+5%IOT	0.28	0.29	-	-
90%ES+10%IOT	0.37	0.40	-	-
85%ES+15%IOT	0.46	0.46	-	-
80%ES+20%IOT	0.55	0.53	-	-
75%ES+25%IOT	0.65	0.60	-	-
70%ES+30%IOT	0.75	0.68	-	-

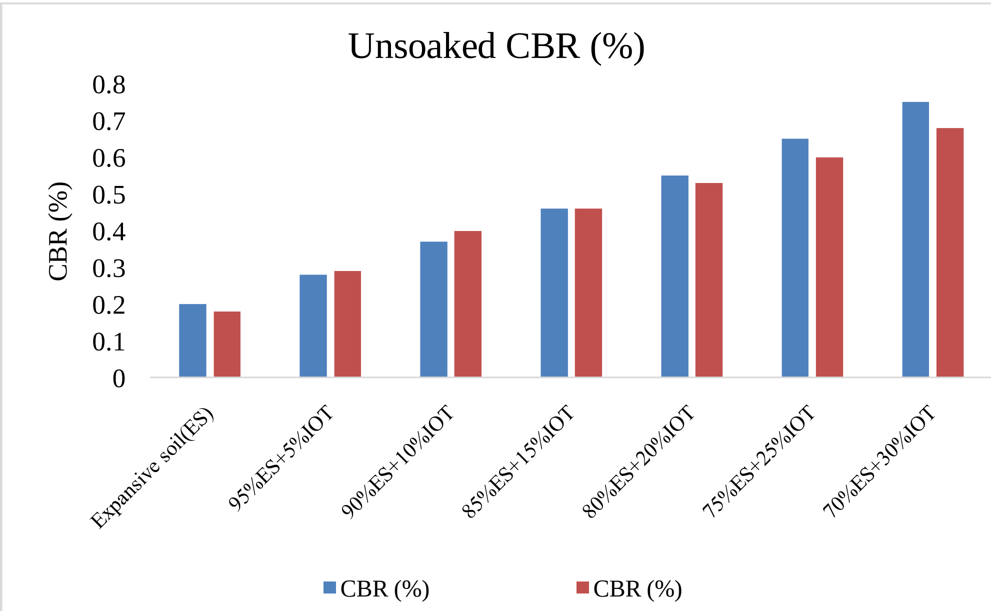


Figure 4.8:- Variation of CBR values.

Swell Pressure Test

Table 4.7:- Swelling pressure test for soil and IOT mixes.

Ratio of ES and IOT	Swell pressure (kg/cm^2)
Expansive soil (ES)	0.134
95%ES+5% IOT	0.117
90%ES+10%IOT	0.100
85%ES+15%IOT	0.092
80%ES+20%IOT	0.085
75%ES+25%IOT	0.076
70%ES+30%IOT	0.067

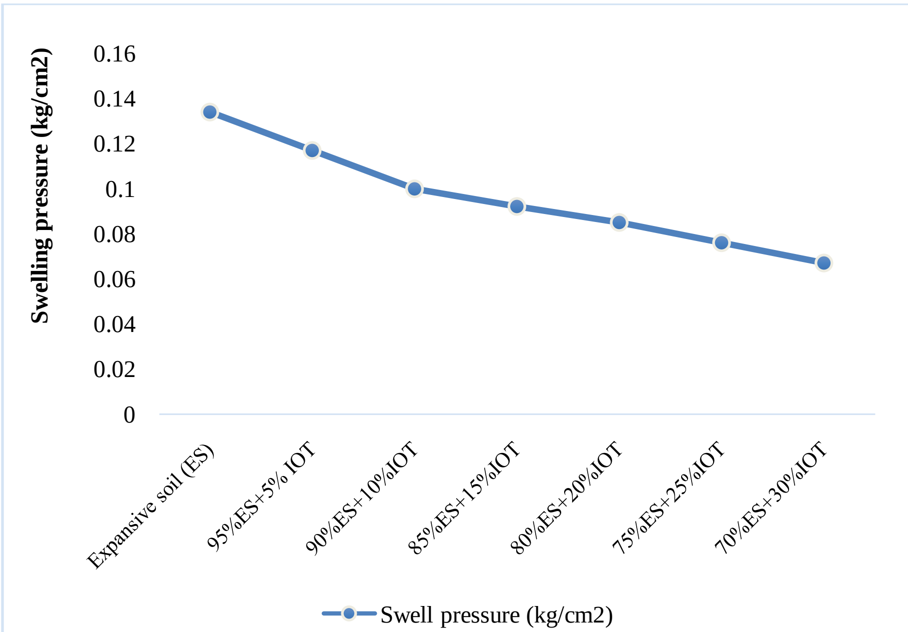


Figure 4.8:- Variation of swelling pressure.

Conclusions:-

Based on the literature cited, analysis made and results obtained, the following conclusions are drawn.

1. The Atterberg limits showed that the liquid limit decreased from 63% of the control soil to 44% water content at 30 % replacement of IOT. Therefore total percent reduction in liquid limit is 30.15%
2. The Plastic limit decreased from a control soil value of 36.98 % to a lowest value of 19.86 % at 30 % IOT content. Therefore total percent reduction in plastic limit is 46.29%
3. The MDD value of standard compaction decreased initially from 1.56 g/cc to 1.50 g/cc at 5% IOT content and further it was steadily increased up to 1.86 g/cc at 30% IOT content. Whereas in modified compaction test, value of MDD increased from 1.67 g/cc to maximum of 2.33 g/cc at 30% replacement of IOT
4. The OMC of standard compaction increased from 18.26% to 20.23% at 5% replacement of IOT, Further it is decreased to lowest of 15.98% at 30% IOT replacement. wherein modified compaction, OMC decreased with increase in percentage of IOT
5. The value of free swell index decreased from 45% for control soil to 20.45% at 30% replacement of IOT. Therefore total percent reduction of free swell index is 54.55%
6. For 2 days curing period, the value of UCS steadily increased from 283.03 kN/m^2 for control soil to maximum of 580.61 kN/m^2 at 30% IOT content. For 5 days curing period, the value of UCS increased from 306.09 kN/m^2 to 782.60 kN/m^2 at 30% IOT.
7. For unsoaked condition, the value of CBR effectively increased with increasing the percentage of IOT for both 2.5mm and 5mm penetration. But for soaked condition, No penetration resistance was observed
8. The swelling pressure decreased linearly from 0.134 kg/cm^2 to lowest of 0.067 kg/cm^2 at maximum of 30% IOT content. Therefore, total percent reduction of swelling pressure is 50%

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