An Experimental Study on Bentonite and Quarry Dust Mixture to Use as a Landfill Liner

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Abstract

Waste management is one of the serious problems in India. The advancements in the field of geotechnics and geosynthetic are associated with growing environmental concern and have enabled the switch from open dumps to landfills. The main objective of the impermeable landfill liners is to reduce the migration of leachate to the ground water and reduces the reasonable amount.

One of the critical parts of a landfill is liner. Generally, the materials used as liner is clay, but later on crack formation and degradation were observed for clay liners. Thereafter researchers began for obtaining a suitable material for landfill which is strong, least permeable, and also economical. For which an attempt was made to determine a mixture of bentonite and quarry dust as a liner it is a waste product from crusher and satisfies all the criteria of a landfill liner.

In this Study the characteristics of mixture are determined with varying percentages of bentonite at 3, 6, 9, 12&15% and 10% quarry dust as liner and finally it was concluded that addition of 15% bentonite clay, behaved as a good barrier for the landfills

Keywords - *Landfill Liner, Bentonite, Quarry dust, Liquid limit, Plastic limit, Permeability.*

I. INTRODUCTION

The fundamental undertaking of the impermeable land fill liners is to diminish the movement of leachate to the ground water and to decrease its rate to sensible sum. The import ants of landfill all through world increments and need of built waste dumps is vital. Land fill liners are presented to different sorts of physical, synthetic and organic procedures and are influenced by filter ate created from the decay of waste dumps. Because of these the significance of Geo-specialized qualities of earth liners are resolved in the research facility. The primary criteria for impermeable liners are their pressure driven conductivity, in show contemplate, the attributes of dirt bentonite and quarry dust is resolved with 3%, 6%, 9%, 12% and 15%. The principle explanation behind utilizing these blenders is to lessen the water driven conductivity, which dispenses with the development of leachate from base of the landfills.

In recent years, number of researchers were determined the interaction of clay with different types of fluids, for landfill liners hydraulic conductivity is one of the important soil characteristics which is always less than or equal to 10^{-7}cm/sec. Fluids are more effect on geotechnical properties of clayey soil.

II. LITERATURE REVIEW

From the literature review it was found that natural clays usually satisfies the specification for liner material; however high plastic dirt's are not ideal in light of the parching of breaks can prompt the spilling of leachate. Taking into account the water driven conductivity mud's containing less sensitive mud minerals, for example, Kaolanite and illite were discovered to be unaffected by chemicals.

Bairwa ramlakhan , Saxena anil kumar (2013) studied on "effect of lime and fly ash on engineering properties of black cotton soil". They added lime and fly ash in the natural soil with varies percentages and concluded that The optimum percentage of mixture obtained at (12%lime +20% fly ash). which gives the CBR value 7.99 that best result for sub grade soil.

J. Jaypal and S. Boobathiraja (2014) attempt made on stabilization of weak soil by admixture like quarry dust fly ash and lime. It his clearly seen that the plastic index values showed a marked decrement 30% replacement of quarry dust and 8% of lime.

V. Srikanth. **A. K. Mishra (2016)** "Laboratory Study On the Geotechnical Characteristics of Sand-Bentonite Mixtures and the Role of Particle Size of Sand" has concluded that the sand is added to bentonite to achieve a higher compaction density and lower desiccation shrinkage. They concluded that the Fine Sand mixes were observed to be more plastic and high Swelling Bentonite with Medium sand exhibited higher MDD as compared to mixture of bentonite with Fine Sand of similar proportion. Finally, swelling characteristics obtained from the tests showed that bentonite content less than 20 % was insufficient in filling the void spaces created by sand matrix.

P.Indiramma, Ch.Sudharani (2016) they use Quarry Dust for Stabilising Expansive Soil A study is carried out to check the improvements in the properties of expansive soil with addition of quarry dust in different percentages. They concluded that the MDD increases from19.14KN/m^3 to 19.58KN/m^3. The UCC increases 130 to 300 KN/m^2 when quarry dust is increased from 0 to 25%.

Ancy, MariyaSkariya, RijaJohny (2017) their work regards experimental study on bentonite and quarry dust in the natural soil with varies percentages and they concluded that the 40% mix has least permeability among the samples the 20% mix has more strength. All the mixes would undergo less consolidation compared to bentonite and with addition of quarry dust.

Lins Paul (2018) attempt was made on Performances of Clay-Bentonite & Bentonite-Quarry Dust Mixture as Landfill Liner. They added 3, 5, 7% of bentonite in only clay and 10, 20 30% of quarry dust in only bentonite for hydraulic conductivity & unconfined compressive strength test. They concluded that the Hydraulic conductivity of the clay when mixed with 3% bentonite was found to be $2.80*10^{-10}$ mm/s and it is the least value among all other clay bentonite samples. Best results of unconfined strength achieved at 20% quarry dust & bentonite mixer.

III.OBJECTIVE OF THE WORK

Clay-Bentonite mixer is used for avoid of leachate produced from mixture of production. At present scenario shows all govt, public and private sectors are interested to constructed engineered landfills for prevention of contamination of ground water. House wastes, hospital wastes, street etc. collected by various trucks and dumped at common place. Such type of dumps is not treated, which tend to pollute the atmosphere. Leachate produced from waste dumps and causes ground water contamination.

For present state of study, soil collected from landfill near Devuni Kadapa dump site, the index properties of clay – bentonite mixers are studied. Tests are carried out on clay alone to determine the amount of bentonite was added. Based on the plasticity character of clay, % of bentonite added is decided. Number of researchers studied on different types of soil mixers. particularly in this paper the optimum percentages was decided by standard proctor test as well as materials percentages and OMC and MDD. From UCC the 9% and 12% of bentonite is changes higher strength points with respect 10% quarry dust in all percentage of bentonite.

IV.MATERIALS AND METHODOLOGY

A. *Materials*

Following materials are used in experimentation work:

1. *Clayey Soil*

In this study, the investigation is carried out on soil samples which are collected at Kadapa district near Devuni Kadapa bypassin a position of dump and which in black in colour with high moistures content. The physical property of soil is shown in table 1.

2. *Bentonite*

The properties of bentonite are shown in table 2, Sodium bentonite, which is often used for the industrial work and it was used into the project work. The particle Size of bentonite is less than 75µ. 75µ Sodium Bentonite is purchased from green field eco solutions Pvt. Ltd Company Jodhpur.

3. *Quarry dust*

Quarry dust is a by product, containing minerals and trace elements, obtained from the crushers, usually processed by mechanical operators. It was procured from a locally available crusher. The oven dried quarry dust was used for the project work. Quarry dust is collected from near railway station krishnapuram. Kadapa.

Fig 1: Bentonite Powder and Quarry Dust

Table 1: Physical Properties of soil

Properties of soil	Values
Specific Gravity	2.48
Atterberg's Limits	
Liquid Limit	65.60%
Plastic Limit	32.40%
Plasticity Index	35.60%
IS Classification	CH
Differential Free Swell Index	59.25%
Standard Proctor Compaction	
OMC	32%
MDD	1.24g/cc
Unconfined compression strength	0.178 kg/cm^2
Permeability	2.18

Table 2: Physical properties of Bentonite

Physical Parameter	Bentonite
Colour	Cream
Shape	Platy
Specific gravity	2.89
Plasticity Index	236

B. Mixed proportion

Samples were prepared by the combination of Clayey Soil, Bentonite and Quarry Dust. The percentage of Bentonite was taken at 3, 6, 9, 12 & 15% and 10% of Quarry dust with OMC. Here 15% of bentonite with 10 % quarry dust exposed optimum percentages in compaction behaviour. So, OMC of 20.5% achieved at 15%B and 10%QD of MDD was 16.4 kN/m^3.

C. Methodology

The following tests were conducted in this investigation as per standard specifications:

1. Index Properties (IS:2720 Part-5-1985)
2. Specific Gravity (IS:2720 Part-3-1980)
3. Differential Free swell Index (IS:2720-Pt-40-1977)
4. Compaction Characteristics (IS:2720-Part-7-1980)
5. UCC Strength (IS:2720 Part-10-1973)

V. RESULTS AND DISCUSSION

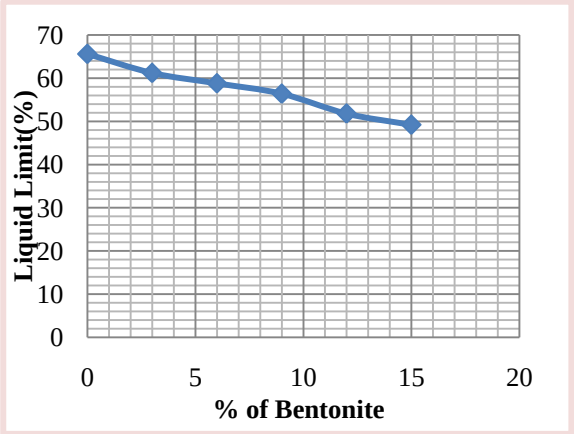
A. PLASTICITY CHARACTERISTICS AND DEFERENTIAL FREE SWELL INDEX

From, table 3 and figure 1. The Liquid limit of all percentages are found to be decrease with increase in content of Quarry dust that is bentonite having maximum liquid limit and 15% mix having the least liquid limit. As the criteria to use as a landfill liner is that the liquid limit should be greater than 90% all the mixes satisfied the criteria.

Table 3: Plasticity characteristics and differential free swell index

Material (%)	Liquid Limit (%)	Shrinkage Limit (%)	Free swell index
CS+ 3%B +10%QD	61.2	0.68	53
CS+ 6%B +10%QD	58.8	0.62	52
CS+ 9%B +10%QD	56.4	0.52	48
CS+ 12%B +10%QD	51.8	0.44	45
CS+ 15%B +10%QD	49.2	0.37	44

Fig 1: Variation of Liquid Limit With Percentage Of Bentonite



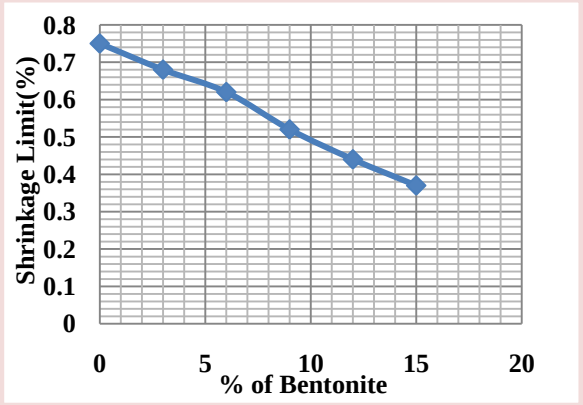


Fig 2: Variation Of Shrinkage Limit With Percentage Of Bentonite

Fig 2 depicts variation Shrinkage limit of all percentages are found to be decrease because of shrinkage limit of bentonite is high when compared to Quarry dust.

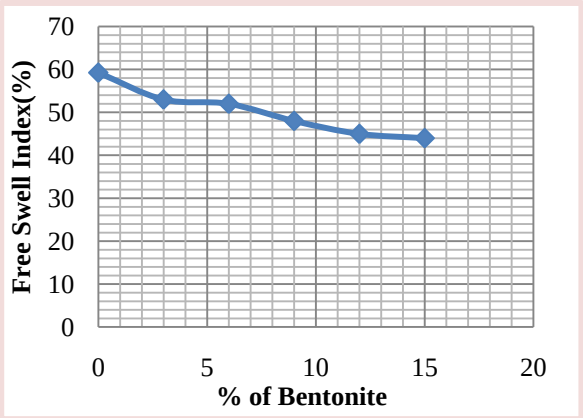


Fig 3: Variation Of Free swell Index With Percentage Of Bentonite

Fig 3 depicts Free Swell Index of all percentages is found to be decreases because of free swell index of quarry dust is high when compared to bentonite.

Variation of Free swell index of bentonite and quarry dust mixed soil shown in table 3.

B. Unconfined compressive strength and co-efficient of permeability

Table 4: Engineering characteristics and co-efficient of permeability for corresponding % of materials in clay soil

Material (%)	Standard Proctor Compaction		UCC (kg/cm^2)	Coefficient of Permeability (mm/sec)
	OMC (%)	MDD (g/cc)		
CS+3%B+10%QD	16.32	1.752	0.185	2.54
CS+6%B+10%QD	17.82	1.724	0.190	3.25
CS+9%B+10%QD	18.50	1.695	0.219	3.50
CS+12%B+10%QD	20.33	1.643	0.240	0.85
CS+15%B+10%QD	20.5	1.640	0.400	0.583

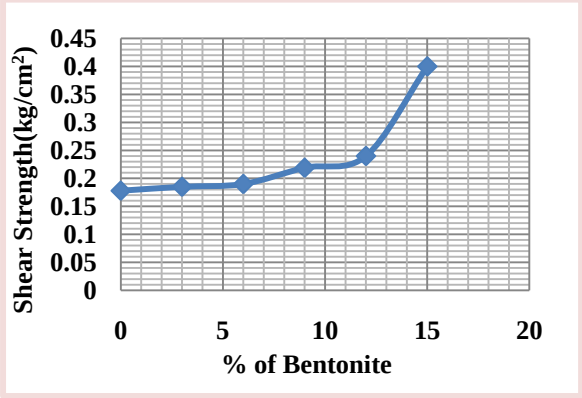


Fig 4: Percentage variation of Shear Strength of Soil with Bentonite:

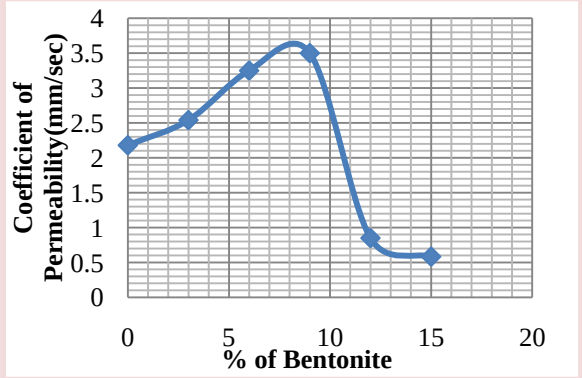


Fig 5: Percentage variation of Co-efficient of permeability of Soil with Bentonite

From table 4 and fig 4 the Shear Strength increases because Bentonite having more strength than Quarry dust. At 15% of mix it was obtained more than remaining all percentages follows 3, 6, 9, 12%.

Thus by Determining the unconfined compressive strength of all the samples, it was seen that the 15% bentonite mixed with 10%quary dust mix exhibited the highest value of compressive strength,ie.,0.4 kg/cm^2.This value was found to be greater than the clay-bentonite mix at 3% proportion and 25% increasing than the 3% bentonite and 10% quarry dust strength.

From table 4 and fig 5 the Hydraulic conductivity of clayey soil was found to be 2.18 x 10^{-6} cm/sec which is not acceptable as per the relevant standards. Hence clayey soil was mixed with bentonite clay. Hence the value of permeability is increases up 9% of bentonite mix and then decreases. Hydraulic conductivity of the clay when mixed with 15% bentonite was found to be $0.583*10^{-10}$mm/s and it is the least value among all other clay-bentonite samples.

Hence bentonite added to 10% quarry dust has been chosen as the best proportion for making the landfill liner and its hydraulic conductivity is $0.583*10^{-10}$mm/s.

VI. CONCLUSIONS

The clayey soil was mixed with different proportions of Bentonite clay and a suitable mix was found at which the desired permeability was achieved. It was found to be addition of 15 % of bentonite clay, clayey soil behaved as a good barrier. Hence further studies were carried out on the clayey soil blended with 15 % bentonite clay, to assess the other properties such as volumetric shrinkage, unconfined compression strength, Atterberg's limits etc.To determine the suitability of the blended soil as a liner material. Based on the studies land fill Design were carried out.

1. With increasing the percentage of Bentonite, the Liquid Limit values are decreased from 65.6% to 49.2 %.
2. With increasing the percentage of Bentonite, the shrinkage Limit values are decreased from 0.68% to 0.37%.
3. With increasing the percentage of Bentonite, the Free Swell Index values are decreased from 59.25% to 44%.
4. With increasing the percentage of Bentonite, the Shear Strength values are increased from 0.178 kg/cm^2 to 0.4 kg/cm^2.
5. With increasing the percentage of Bentonite, the Permeability values are increased from 2.18 mm/sec to 3.5 mm/sec and then decreases to 0.583 mm/sec.

Finally Concluded that:

1. Use of Bentonite increased the Unconfined Compressive Strength of soil.
2. Based on the index properties of the blended soils, it can be concluded that the clayey soil

blended with 15% bentonite clay proves to be a better liner material compared to all mixes.

3. Bentonite and Quarry dust are eco-friendly products, can be effectively used as a liner material

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