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

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***Abstract*-A landfill is a carefully engineered depression in the ground into which wastes are put. One of the critical parts of a landfill is liner. Generally, the materials used as liner was clay. But later on crack formation and degradation were observed for clay liners. Thus researches began for obtaining a suitable material for landfill which is strong, least permeable, and also economical. Through this project, an attempt is made to determine a mixture of bentonite and quarry dust, which is a waste product in crusher, which satisfies all the criteria of a landfill liner.**

***Index Terms*- Landfill Liner, Bentonite, Quarry dust, mix**

1) INTRODUCTION

Nowadays, environmental problems have grown as a major concern in the minds of people, especially the disposal of harmful wastes. The industrial units produce lot of harmful waste materials of which most are disposed in landfills[4]. A landfill is a carefully engineered depression in the ground into which wastes are put. There are four critical elements in a secure landfill- a bottom liner, a leachate collection system, a cover, and the natural hydro geologic setting. Out of these, landfill liner is the component that determines the efficiency and durability of a landfill. A landfill liner is intended to be a low a permeable barrier, which is laid down under engineered landfill sites[2].But as the time propagates, crack formation had been observed in the liners which resulted in low permeability.

Various materials such as clay, high density polyethylene (HDPE), geomembranes, etc. have been adopted to create landfill liners. But these may not be either efficient to function as a liner or economical[6]. Therefore this work aims at mixing the bentonite and quarry dust in various proportions so as to achieve a liner which is efficient in function, durable and also economical.

The bentonite is absorbent aluminium phyllosilicate clay consisting mostly of montmorillonite. and the quarry dust is the waste product obtained from crusher. Both the materials being fine in nature will have low permeability[1]. The quarry dust being a waste product, its partial replacement with bentonite will be economical too. The material used for the liners should satisfy the following criteria.

- Coefficient of permeability ≤ 1 X 10^{-6}mm/s
- Minimum layer thickness of 1m
- Minimum clay content of 10%
- Minimum Fines (clay & silt) content of 30%
- Maximum particle size of 75 microns

2) MATERIALS AND METHODS

Bentonite: Sodium bentonite, which is often used for the industrial work, is used for the project work. The particle size of bentonite is less than 75μ.

Quarry dust: Quarry dust is the by product containing minerals and trace elements, obtained from the crushing operation of stones, usually processed by natural or mechanical means. It was obtained in a locally available crusher. The oven dried quarry dust was used for the project work.

Methodology

The project has been divided into 2 phases. In the first phase, the basic properties of both the materials were studied. This includes the specific gravity, grain size distribution, liquid limit, shrinkage limit, etc. In the second phase, different mix proportions of bentonite and quarry dust passing through 425μ sieve was tested for its strength and permeability to determine the optimum one.

3) EXPERIMENTS AND RESULTS

The work was completed in two phases.

In the first phase, the basic properties of bentonite and quarry dust were determined. The basic tests conducted include

1. Specific gravity - IS 2720 part 3, 1980
2. Grain size analysis –IS 2720 part 4, 1985
3. Standard Proctor test –IS 2720 part 8, 1983
4. Liquid limit–IS2720 part 5, 1985
5. Unconfinedcompression test (UCC)–IS 2720, part 10, 1991.

In the second phase, different mix proportions varying from 10% to 50% of bentonite replaced by quarry dust were prepared and following tests were conducted.

1. Standard Proctor test
2. Unconfined Compression test
3. Consolidation test - IS 2720 part 15, 1965

Results

1. Specific Gravity: The specific gravity was determined using density bottle.

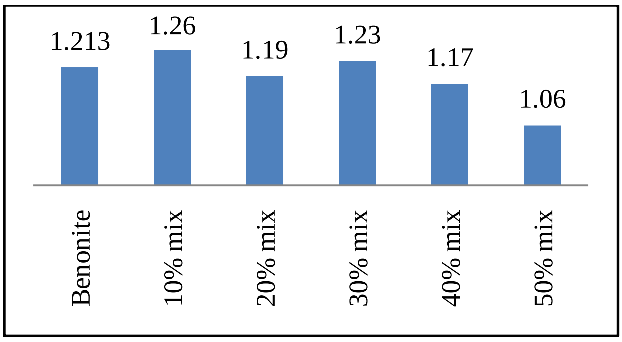

Figure 1: Specific gravity of all samples

The specific gravity of the mixes didn't follow any pattern.

2. Grain size distribution: The grain size distribution of quarry dust was found out by sieving and that of bentonite by sedimentation analysis. It was observed that the particle size of bentonite as well other mixes satisfied the corresponding the criteria for bentonite.

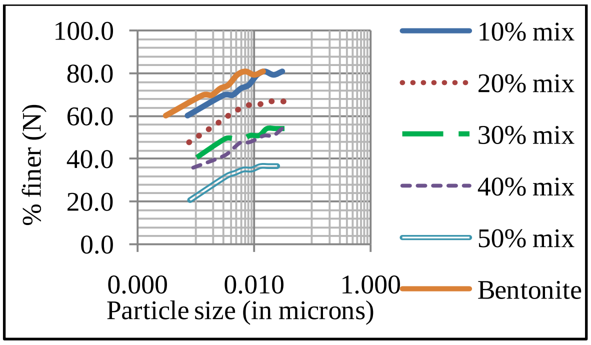

Figure 2: GSD of all samples

From the graph, it was observed that the clay content of all the mixes were above 30%. So all the mixes satisfied the criteria for clay content and fine content.

3. Liquid Limit:The liquid limit of bentonite and quarry dust was determined using cone penetrometer.

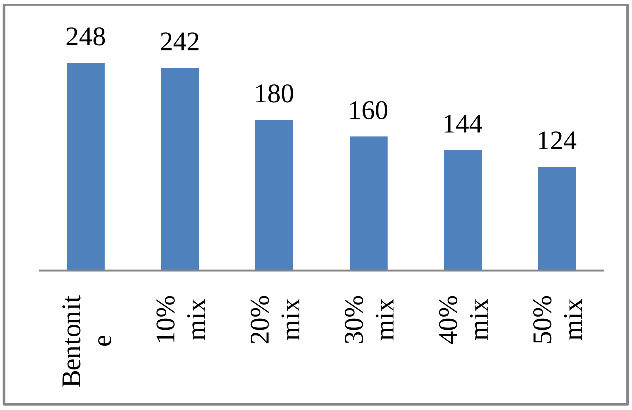

Figure 3: Liquid limit of all samples

Liquid limit of the mixes was found to decrease with increase in the content of quarry dust. .i.e., bentonite is having maximum liquid limit and 50% mix is 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.

4. Shrinkage limit: shrinkage limit was determined as specified in IS 2720 Part 6 1972

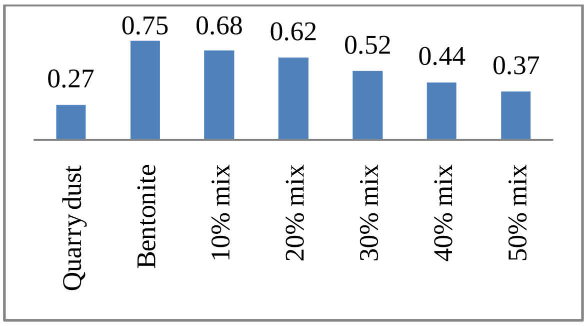

Figure 4:Shrinkage Limit of all samples

Shrinkage limit is found to be maximum for bentonite. Shrinking of the mixes reduced with increase in the quarry dust content as the shrinkage limit of quarry dust is much less than that of bentonite.

5. Unconfined Compressive Strength (UCS): The UCS (kN/m^2) was determined at its OMC.

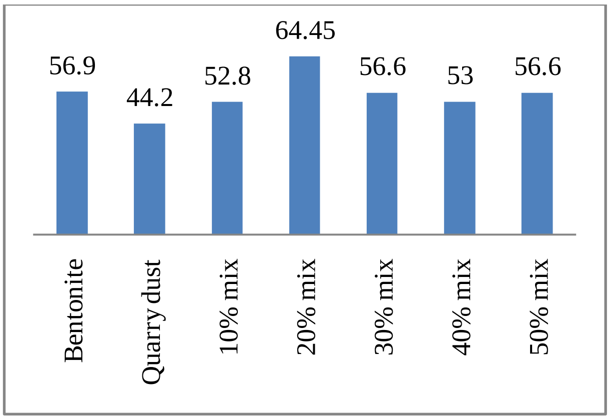

Figure 5: UCS of all samples

UCS of the mixes does not follow any pattern. It was observed that 20% mix is having the maximum strength among all the mixes.

6. Consolidation: The consolidation tests were carried out in all the samples. After a seating load of $5kN/m^2$, further loads were incremented to $10kN/m^2$, $20kN/m^2$ and $40kN/m^2$. The coefficient of consolidation (C_v) (in mm^2/s) was determined using square root time fitting method.

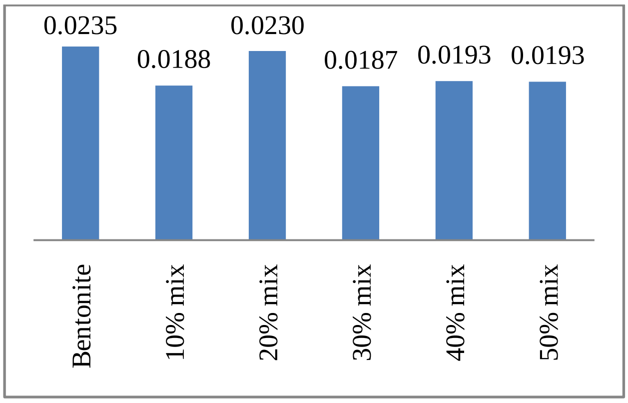

Figure 6: Coefficient of consolidation of all samples

From the void ratio v/s load (e v/s p) graph, the coefficient of compressibility (a_v) was determined. From the e v/s log(p) graph, it was observed that the steepness of the curves reduces with addition of quarry dust.

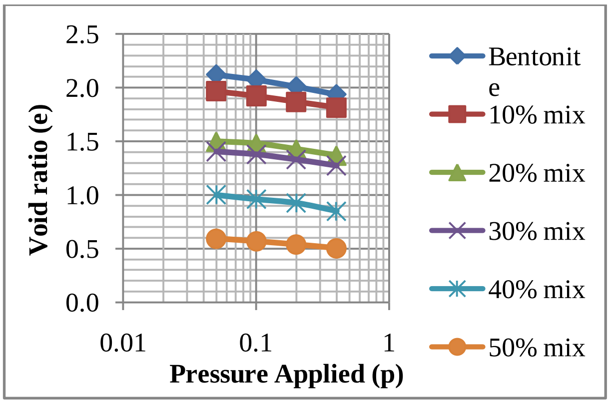

Figure 7: e v/s log (P) graph of all samples

7. Permeability: These values of C_v and m_v obtained were used to determine the coefficient of permeability (k) by the Eq.1

$$k= m_v*C_v*\gamma_w \quad (1)$$

where,
m_v – volumetric strain = $a_v/(1+e_0)$
e_0 – initial void ratio
γ_w – unit weight of water = 9.81kN/m^3

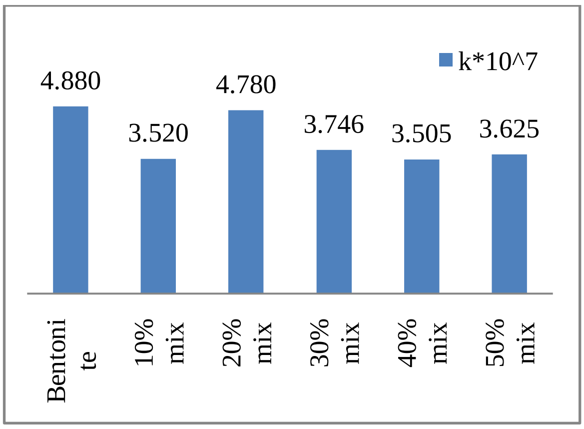

Figure 8: Coefficient of permeability (k)in mm/s

It was observed that the permeability of the mixes do not follow any pattern. The 40% mix is found to have lowest permeability among the samples.

4) CONCLUSION

Considering all the factors such as permeability, which is prioritized, strength, and consolidation, it can be concluded that the optimum mix is that of 20%, in which 20% of bentoniteis replaced with quarry dust. Other conclusions that can be drawn from the interpretation of the results are as follows:

1. The 40% mix has least permeability among the samples
2. The 20% mix has more strength.
3. All the mixes would undergo less consolidation compared to bentonite.
4. With addition in quarry dust, the compressibility of the sample is reduced.

REFERENCES

[1] Naranagowda M J et al. (2016) 'An Experimental Study on Stabilization of Black Cotton Soil by Using Quarry Dust and Lime Mixture', *International Journal of Engineering Research*, Vol. 5, Issue No.8, pp: 654-656

[2] Hasibul et al. (2013), 'Evaluating cracking behavior of composite clay as liner in landfill using extensive software' *International Journal of Engineering Research*, Vol.1.Issue.1.2013

[3] J.H. Li et al. (2016), 'Cracking and vertical preferential flow through landfill clay liners', *Journal of Engineering Geology*, Vol. 206 33–41

[4] DilipSrivastava, A.K.Singhai, and R.K.Yadav (2014), 'Effect of Lime and Rice Husk Ash on Index Properties of Black Cotton Soil', *International Journal of Engineering Sciences &ResearchTechnology*, Volume 1, Issue 3, pp: 2019-217

[5] Karthik et al. (2014) ,'Effect of fly ash in the stabilization of soft fine-grained red soils', *Journal of Mechanical and Civil Engineering,*Vol. 10, Issue 6, pp: 20-26

[6] Ramlakhan et al. (2013),'Effect of lime and fly ash on Engineering Properties of BlackCotton soil', *International Journal of Emerging Technology and Advanced Engineering,*Vol. 3, Issue 11, pp: 535-541

[7] Hakari et al. (2012),' Stabilization of black cotton soils by using fly ash', *Global Journal of researches in engineering Civil and Structural engineering*, Vol. 12 Issue 2, pp: 21-29

[8] V.Giridhar et al. (2015), 'Experimental Studies on Clay, Bentonite and LeachateMixer as Liner Material', *International Journal of Innovative Research in Advanced Engineering*, Vol. 2 Issue 1, pp:274-280

[9] Ajanta Kalita and Baleshwar Singh, 'Experimental Studies on Clay, Bentonite and Leachate Mixer as Liner Material', *Indian Geotechnical Society*, pp: 379-383

[10] David E. Daniel (1993), 'Case histories of compacted clay liners and Covers for waste disposal facilities', *Third International Conference on Case Histories in Geotechnical Engineering*, pp: 1407-1425

IS Codes

i. *IS: 2720 (Part 3) (1980). Methods of Test for Soils: Determination of Specific Gravity, Bureau of Indian Standards, New Delhi, India*

ii. *IS: 2720 (Part 4) (1985). Methods of Test for Soils: Determination of Grain Size Analysis, Bureau of Indian Standards, New Delhi, India*

iii. *IS: 2720 (Part 5) (1985). Methods of Test for Soils: Determination of Liquid and Plastic Limit, Bureau of Indian Standards, New Delhi, India.*

iv. *IS: 2720 (Part 7) (1980). Methods of Test for Soils: Determination of Water Content-Dry Density Relation Using Light Compaction, Bureau of Indian Standards, New Delhi, India*

v. *IS: 2720 (Part 3) (1980). Methods of Test for Soils: Determination of Unconfined Compression Strength, Bureau of Indian Standards, New Delhi, India.*

vi. *IS: 2720 (Part 15) (1986). Methods of Test for Soils:Determination of Consolidation Properties, Bureau of Indian Standards, New Delhi, India.*