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Demonstrating of Desiccation Crack Improvement in Clay Soils

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Abstract – Many constructions work done by using fine grained soils; are affected by the changes in the mechanical properties of the soil because of cracking Hydraulic conductivity is also affected by the Desiccation cracking in the clayey soils. Compacted clay liners are considered as very important part of waste landfills. The leakage tends to take place if less hydraulic conductivity is found. It is observed that the hydraulic conductivity tends to rise in the wet soil after cracking.

The overall performance of the landfills gets affected by the Desiccation of landfill clay liners. Shrinkage in the cracks also takes place because of the desiccation process. Moisture tends to migrate into the landfill through cracks which ultimately increases the efficiency of the soil and ground water contamination. Some of the studies suggest that above the clay liner, the surface moisture should be used. It is observed that the repeated cycles tend to form the desiccation cracks.

It is also noticed that the desiccation cracking in compacted clay can be reduced by using fibres. An attempt is therefore done to study the formation of cracks in clay liner materials and to control the desiccation cracks by using arbitrarily dispersed distinct fibres.

Keywords:- Clay, Soil, Desiccation, Crack

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INTRODUCTION

Many activities are performed by the engineers in order to secure the environment from the liquid which is known as leachate. This liquid penetrates into the ground and remains there for decades. The main thing which is considered while selecting any material to be used as a liner is that, it should have low permeability and should be adopted with leachate.

There are many other standards as well which should be followed while selecting a liner soil. Firstly, a soil should be used having at least 20% of fines.

The bentonite is used at very large scale. It is not permeable. It is also observed that it has suspectible behavior as the volume changes. It is used liner material to enhance the volume stability and volume.

Mostly, sand is mixed with bentonite. The quantity of sand and the bentonite is decided according to the specified hydraulic conductivity. It is observed that the ideal bentonite-sand mixture is that in which there is 80% sand and 20% bentonite. This liner soil is termed as bentonite enhanced sand mixture (BES).

The selection of liner material to be used also depends on the materials which can be easily found in the nearby areas. If the supporting materials are found in nearby places then it naturally reduces the cost margin. On the other hand, if the material is brought from a place which is very far away from the source place then the cost gets increased.

It is observed that a lot of changes take place in marine clay because of drying of the soil. It is clear from the table that Atterberg limits tend to reduce by sun drying. Also, the liquid limit of clay tends to decrease as a result of air-drying. Since the finer particles tend to aggregate with coarser particles so the variations in limits are observed by air-drying.

At the end of each compaction-dry cycle, the photographs were taken for all the four samples used. The cracks were noticed only in BSMC out of all samples. In the BSMC sample, the hair line cracks were observed. The samples were mixed with water after the compaction dry cycle. The samples were entirely soaked at the end of the wetting period.

The plastic index was observed to be reduced to 23%. According to EPA standards, the plasticity index should be greater than 10% and there should be at

least 20% fines in the soil to satisfy the hydraulic conductivity criteria.

It is observed that the marine clay performs better than the sand mixed with bentonite. It is also observed that 80% sun dried marine clay is applicable to add bentonite. In this research work, 20% of bentonite is mixed with 80% of sun dried marine clay.

The main objective of using kaolinite soil is that it is used to maintain the continuity in the behavior of the soil in wetting and drying conditions. The hydraulic conductivity of the soil liner is reduced by using the compaction method. There are many factors which are considered for the installation of clay liners. Some of these factors are water content, dry unit weight, energy level etc. The hydraulic properties of the liner soils are deeply affected by the water content at the compaction. The main thing before construction is concerned that the range of water content should not cross the limit of optimum water content beyond 4% and the minimum dry unit weight should be 95% of the highest dry unit weight.

For the current study, the moulds having size 30 cm in diameter and 10 cm in height were used to carry out desiccation tests. It is observed that the variation in the saturation of clay is found by wet or dry cycles. The first cycle of compaction-drying ended when the compressed soil was kept in drier for drying for 5 days.

At the end of each compaction-dry cycle, the photographs were taken for all the four samples used. The cracks were noticed only in BSMC out of all samples. In the BSMC sample, the hair line cracks were observed. The samples were mixed with water after the compaction dry cycle. The samples were entirely soaked at the end of the wetting period.

The desiccation cracks were formed because of the shrinking of BES during the drying periods. At the end of the first wet/dry cycle, the photographs were taken and analyzed by using MATLAB, for determination of the CIF and length of cracks.

The colored snap of the desiccated sample was transformed into black and white frame by using MATLAB function. Marine clay was used for the study in relation with three types of fibres used. The procedure of wetting or dry cycles was used that was of two cycles.

SMC tests were conducted for these three cycles of wet and drying. For a particular fibre content, samples of SMC were taken to perform various tests to check the repeatability of results. The effect of fibre content was also observed in controlling the cracks.

MATLAB was used in order to analyze the photographs of the samples used. Table shows the CIF values. It is observed that fibre content and CIF are indirectly proportional to each other as CIF tends to increase on decreasing the percemtage of fibre content.

The variation in optimum moisture was also observed between 0.6% below and 0.3% above OMC. Similarly, the variations were observed in the unit weights between 0.2kN/m^3 to 0.1kN/m^3, which again is less than 1.5% of that of unamended SMC. It was also observed that the compaction behavior had no effect on the compaction properties of the fibre nylon as both of these tend to variate the values of the admixture so as to maintain the optimum moisture content of the soil.

REVIEW OF RELATED LITERATURE

Kalteziotes et al. 1994 described that since 1970, the trend of depositing the waste products into the landfill has increased. People have got aware about the environment and they try to keep everything clean. Besides, throwing the waste products here and there, they try to adopt the technology of placing the waste products into the landfill.

According to Mehta et al. 2010, the disposal of waste products has become a challenging task. Now a days, various techniques are used in order to dispose the waste products. Some of these techniques are deep well injection, landfills etc. Among these, the methodology of landfill is used at very broad level due to its low cost and efficiency.

Agarwal et al. 2012 described that the process of landfill is very important for the treatment of the waste products as many kinds of wastes like ashes and many sludges penetrate into the land through this method. So the technology of landfill has proven very beneficial for the society and environment.

Jain et al. 2010 investigated that clayey soil is widely used as landfill lining material because of its low permeability. Somewhere, man-made artificial lining materials are also used. Nearly all geo membranes used in landfills are thin sheets of flexible thermoplastic or thermo set polymeric materials.

According to Shiva et al. 2010, the landfill liners are made from a number of materials. They are classified as rigid liners and flexible liners. Rigid liner is considered as the mixture of cement, sand and water. This technique has high cracking potential so it is not used widely. It can be used for most rigid of foundations like landfill on rock.

Umer et al. 2010 described that stone and sand are mixed to form concrete liners. After that some cement and water is added to prepare the final product. The strength of this mixture is very high but the limitation is that sometimes, leakage is noticed due to expansion of joints. So it is considered that it is not suitable for the leachate.

Khan et al. 2010 mentioned that soil-cement liners are prepared by using on site materials and various methods of construction. The bigger drawback of this type of liner is the final homogeneity of the material.

Shah et al. 2009 described that asphalt can also be used for landfill liners. Here, the same technology is used which is used in highway engineering and construction. The more intention is given on the factor of permeability. Also, the compatibility of the chemicals is also considered. This is used at very large scale.

Kumar et al. 2008 described that fine grained soil can also be used for the liner under some specific conditions. For that, the permeability of the soil is also checked. Bentonite is very good example for this type of liner which has low permeability.

Malhotra et al. 2008 investigated that the behavior of the soils can be changed by using various types of chemicals. This process can be less costly if the chemicals of cheaper quality are used. These materials are put into the void place to fill them and a layer on the crust surface is created which is very helpful.

Sodha et al. 2007 reported that Bentonite is a very complex material. Its resulting particles are flake etc. In its structure, a sharing of oxygen atoms is found which is used to form sheets. Water can easily be gone through the sheets.

Sahil et al. 2009 described that bentonite is anionic and it carries a negative electrical charge. When water is mixed in soil void then the water tends to move to the surface of clay. This forms the adsorbed water layer, which protrudes, into the soil voids drastically affecting the soils permeability.

Shobha et al. 2012 described that flexible membrane liners (FML) and pure clay are combined to form composite liners. Leachate moves down from the top and controls the hydraulic conductivity of the liner and its whole area. The FML does not spread out because of movement of water.

Mahi et al. 2009 reported that a less leakage is observed from the composite liner system as compared to a clay liner alone because it is considered that the area of flow is much smaller through the clay liner. The lamellar arrangement of the liner materials prevent the direct permeation of the leachate from the top even in case of an accidental leakage.

Singh et al. 2009 described that the compressed clay liners are used widely. The cost also tends to reduce by using clayey soils for the treatment. There are many types of liner materials which can be used for the construction work. Some of these are fine grained soils, admixtures, membranes etc.

Anand et al. 2007 reported that natural clay deposit can also be used for the effective disposal of waste products and many times for the harmful products like poison chemicals and harmful gases from factories.

Agnihotri et al. described that there should be enough thickness in the surface so that transfer of waste products can be done easily. So to achieve this objective, compacted clay is used as liner materials. Clay mineral and soil are mixed together to form the clay material. Its thickness is observed to be from 0.3 to 1.2 m.

RESEARCH METHODOLOGY

Compressed clay liner soil was used in the current research work. According to a report of Environmental Protection Agency, liner soil is the better option as it possesses all the standards like plasticity index, hydraulic conductivity and quantity of fines etc.

Therefore, clay liner soil was used as it contains all the necessary materials to be a part of our research work. Also, the soil having a group of kaolinite was used in the current research work. The specimen of soil were chosen randomly. It was observed that the selected samples were dried and stored in bags which were airtight.

Polypropylene is very famous material used in various civil engineering activities. It is an artificial fabric whose cost is supposed to be very less as compared to the other fibres used in the market. The main benefit of Polypropylene is that it can easily mix up with the soil.

The other property of Polypropylene is that it has a very moderate melting point. Due to its this feature, it can be easily stored in oven and can be used in several tests which can be used to evaluate the percentage of moisture. It is also observed that Polypropylene is hydrophobic in nature.

It is greatly influenced on adding some amount of salt in the soil with the help of ultraviolet dilapidation. These kinds of its characteristics make it to be an extra ordinary fiber which can be easily mixed in the soil. It is noticed that it survives for around 100 years.

The monofilament fibre was also used in the current research work. It is made up of strands which are single. The samples of fibres were also used which helped a lot in making a three dimensional structure. It was observed that a high increase in bonding was generated because of the factor of stress.

To make a compaction factor, soil was used which was made air dried. It was highlighted that soil showed less hydraulic conductivity when it was compressed with dry content of water as compared to that was compressed with wet content of water, which showed a higher hydraulic conductivity.

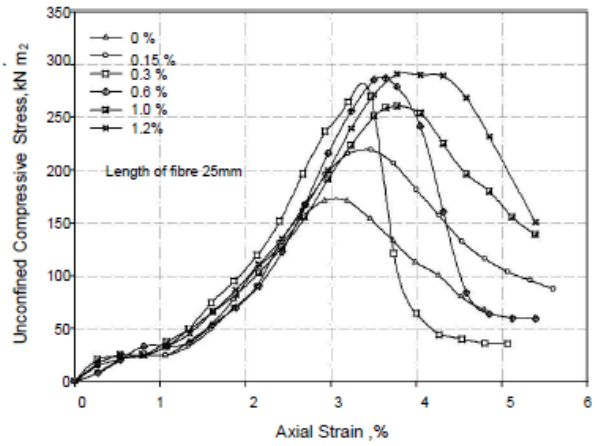
Hot air is injected into the system and moved throughout the system via stacks. Heating coils were used so as to produce the hot air. Three layers of stacks were used in the system. A lattice was placed whose responsibility was to share the amount of hot air in equivalent manner.

A pulley system was used to increase or decrease the temperature. Integration of two heating systems was also done so that same amount of heating energy can be produced in the system.

ANALYSIS

One of the significant parameter to identify the clay water electrolyte system is shrinkage limit which is supposed to be the lowest water content at which the sample can remain in a saturated state. The procedure used for the shrinkage limit of soil having amended fibers was same as that was considered in the case of unamended fibers.

The dry density was kept at 95% and optimum moisture was kept at above 3% to prepare the soil samples for the research purpose. Nylon and polypropylene were also used in several levels. Table gives the shrinkage limit of BES mixture amended with nylon and polypropylene monofilament fibres.



Fibre content (%)	Unconfined compressive strength (qu)kN/m^2	Strain at failure (%)	Percentage increase in strength (%)
0.3	171.28	2.9	0
0.15	218.99	3.45	27.86
0.3	270.05	3.3	57.67
0.6	287.41	3.6	67.80
0.8	231.09	3.49	31.92
1.0	260.7	3.77	52.21
1.2	291.0	3.77	69.9

It is noticed that a compressive strength of 270.5 kN/m^2 can be obtained by using the fibre content of only 0.3%. If fibre content is enhanced to 1.2 then the strength is observe to be 291 kN/m^2. If the percentage of increase in strength is found to be higher than 0.6% for the fibre content then it is not considered as much effective.

It is also found that the percentage of fibre content and compressive strength of BES are directly proportional to each other as if the percentage of fibre is increased then the compressive strength of BES also tends to increase or vice-versa.

CONCLUSION

The differential percentage of fibre contents were used for the research work to study BES amended with nylon and polypropylene monofilaments. These percentages taken were 0.15%, 0.3%, 0.6%, 1.0% and 1.2%.

If the percentage of fibre is increased above 1% then balling of fibres take place because of the mixing of polypropylene monofilament fibres and hence, uniform soil was hard to get. Similarly, the percentage of Polypropylene cannot be taken beyond 0.8% due to balling effect and problems arose while adding with higher percentage of fibres.

It is also found out that the hydraulic conductivity and fibre content are indirectly proportional to each other as the fibre tends to increase on decreasing the hydraulic conductivity or vice-versa.

Similarly, it was noticed that the consolidation pressure tends to increase on decreasing the hydraulic conductivity as both are indirectly proportional to each other. The experiments were conducted till 25kPa. The Figure shows the level of hydraulic conductivity on increasing the fibre content.

Table shows the results obtained from hydraulic conductivity tests for nylon fibre amended BES. It is quite clear from the results that hydraulic conductivity values vary according to the permissible limits. A curvy trend was observed in the case of polypropylene monofilament.

Marine clay was used for the study in relation with three types of fibres used. The procedure of wetting or dry cycles was used that was of two cycles. After the completion of each and every dry or wet cycle, the photographs of the samples were taken. SMC tests were conducted for these three cycles of wet and drying. For particular fibre content, samples of SMC were taken to perform various tests to check the repeatability of results. The effect of fibre content was also observed in controlling the cracks.

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