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Strength and Dispersion Studies in Compacted Liner Soil

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Abstract: ***In the present day scenario of rapid urbanization and industrialization, large quantities of wastes in different physical forms are generated. Despite all efforts to minimize waste and to neutralize it, the requirement for storage or disposal still exists for which landfills form one of the solutions. According to regulations laid down by Environmental Protection Agency, the soil liners shall ensure that the hydraulic conductivity is equal to or less than 10^{-9} m/sec, which obviously is the prime criterion in the selection of liner material. Locally available sundried marine soil and its combination with flyash and polypropylene fibres is included in the study. The influence of the flyash and fibres on the permeability and strength characteristics of the above liner materials is studied. Also the dispersion characteristics of the soil treated with flyash and fibre is analysed and a best proportion for flyash and fibres is selected satisfying the liner requirements and a suitable liner is proposed .***

Keywords: landfills, flyash, polypropylene fibre, permeability, dispersion.

1. Introduction

Environmental pollution is the major problem associated with rapid industrialisation, urbanisation and rise in living standards of people. Despite all efforts, to minimize waste, and to neutralize it, the requirement for storage or disposal still exists. The most frequently used disposal option for solid waste in the land fill because of its low cost and efficiency. The landfill plays a vital role in the whole waste treatment and disposal process. The main components of an engineered landfill is a liner system at the base and sides of the landfill which prevent migration of leachate or gas to the surrounding soil. The most commonly used landfill liner materials are clayey soils of low permeability and low dispersion characteristics.

2. Materials

As per the standards prescribed by Environmental Protection Agency the material for compacted clay liners should necessarily satisfy the following norms for the co-efficient of permeability/hydraulic conductivity, plasticity index, minimum fines content, and maximum gravel content. Obviously, only clayey soils will satisfy the above conditions. The present study aims at investigating the properties of Sundried Cochin Marine Soil with Flyash and Polypropylene Fibres. The materials used are designated as follows:

- **CMS**: Cochin Marine soil was collected at a depth of 0.5m to 2m from Thoppumpady.
- **FA:** Fly ash used was collected from Hindustan Newsprint Limit, Kottayam.
- **PP:** Polypropylene fibres was collected locally from Ernakulam.

Samples are prepared by mixing CMS with FA and PP fibres . CMS with 20% by weight Flyash is mixed and 0 to 1% PP fibres is added. Optimum % PP is selected. Tests are conducted for normal and synthetic leachate water prepared.

Table 1: Properties of Cochin Marine Soil

PROPERTY	*VALUE*
Specific Gravity	2.067
Liquid Limit (%)	46
Plastic Limit (%)	28.12
Plasticity Index (%)	17.88
Shrinkage Limit (%)	17.381
Maximum Dry Density (g/cc)	1.754
Optimum Moisture Content (%)	15.5
Unconfined Compressive Strength (kN/m2)	78.33
CBR Value	1.941
Co-efficient of Permeability (cm/sec)	1.08E-05
Co-efficient of Consolidation (mm2/sec)	1.03E-04
Soil Classification	CL
GRAIN SIZE DISTRIBUTION	
% Sand (0.075 mm - 4.75 mm)	45
% Silt (0.002 mm - 0.075 mm)	23
% Clay (< 0.002 mm)	32

3. Methods and Experimental Results

The sample preparations and conducting experiments are done according to ASTM standards and IS specification as referred under:

- Standard Proctor Test
- Unconfined Compression Test
- Hydraulic Conductivity Test
- Crumb Test
- Double Hydrometer Test

3.1 Standard Proctor Test

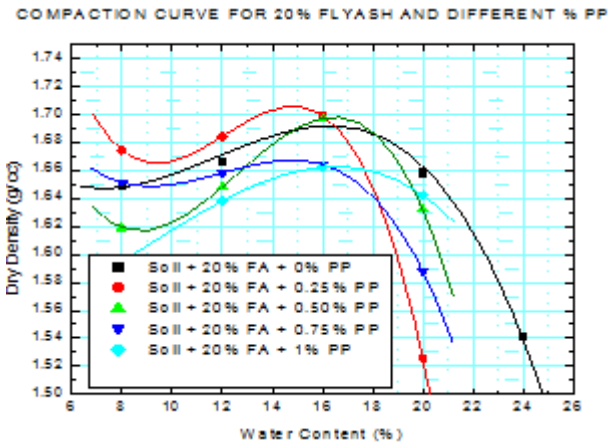

Figure 1: Compaction curve for different PP fibres content

Soil amendment with fibre resulted in changes in both the optimum water content and the maximum dry density. Inclusion of fibres in the soil first increased and then reduced the maximum dry density but the optimum moisture content increased.

3.2 Unconfined Compressive Strength

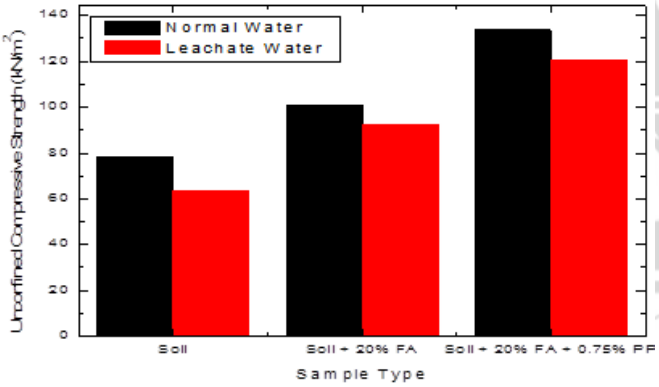

Figure 2: UCS value for Normal and Leachate Water

From the UCS test result it is clear that on addition of FA and PP fibres, strength value increases and maximum value of 133.58 kN/m ^{2} is obtained for a fibre content of 0.75%. Further it is seen that leachate water reduces the strength of fibre added specimen to 120.80 kN/m ^{2} .

3.3 Hydraulic Conductivity Test

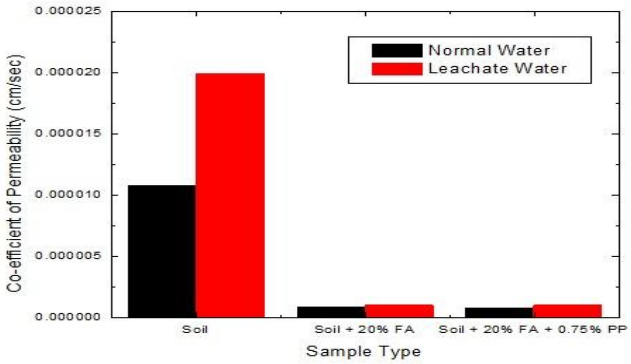

Figure 3: k value for Normal and Leachate Water

From the permeability test result it is clear that on addition of FA and PP fibres reduced the k value and minimum value of 7.710 x 10^{-7} cm/s is obtained for a fibre content of 0.75%. Further it is seen that leachate water increased the permeability value of fibre added specimen to 9.896 x 10^{-7} cm/s.

3.4 Dispersion Characteristics based on Double Hydrometer Test

The double hydrometer test was carried out as per ASTM standards. For this test, 50gm of soil was used. Test was carried out for soil as well as soil - 20% fly ash mix. The percentage dispersion was calculated for each mix and is tabulated below in table 2.

Table 2: Variation of Dispersivity of Various Mixes

Mix	*Dispersivity (%)*	*Classification*
Soil	83.76	Dispersive
Soil + 20% FA	28.187	Non - Dispersive

It can be observed that when 20 % flyash was added to the sample, its dispersivity decreased and changed to non dispersive nature.

3.5 Dispersion Characteristics based on Crumb Test

Crumb test was carried out as it gives a good quick indication of the dispersiveness of soil.. Crumb test were carried out as per the ASTM standard. For the crumb test, sample of 15 mm cubes were prepared. Samples are compacted to its dry density and optimum moisture content. Visual observations are made at 2 minutes, 1 hour, and 6 hour.

Table 3: Variation of Dispersivity of Various Mixes

Sample Type	*Time*	*Grade*	*Dispersivity*
Soil	2min	2	Intermediate
	1hr	3	Dispersive
	6hr	4	Highly dispersive
Soil + 20% FA	2min	1	Non dispersive
	1hr	2	Intermediate
	6hr	2	Intermediate
Soil + 20% FA + 0.75% PP	2min	1	Non dispersive
	1hr	2	Intermediate
	6hr	3	Dispersive

From the crumb test result, it was clearly noted that the addition of FA and PP fibres decreases the dispersion of soil.

4. Conclusions

The strength, permeability, compaction and dispersion characteristics soil amended with flyash and polypropylene fibres was studied. The addition of flyash and PP fibres cause significant decrease in the dispersion and permeability and increase in strength characteristics. The following observations are made in this studies.

1) The optimum percentage of polypropylene fibres was obtained as 0.75%, based on strength and permeability characteristics.
2) Leachate water reduced the strength and increased permeability characteristics of the soil.

3) Dispersivity greatly reduced on addition of flyash.
4) From the crumb test, its concluded that the dispersion of soil can be reduce with the addition of fly ash and PP fibres.
5) Finally, Soil + 20% FA + 0.75% PP mix can sufficiently be used as a liner for a landfill site as it satisfy all the requirements of a liner soil.

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Author Profile

Abishek Kumar A.A received the B.Tech and M.Tech degrees in Civil Engineering from Mahatma Gandhi University in 2012 and 2016, respectively.