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EXPERIMENTAL INVESTIGATION OF HYDRAULIC CONDUCTIVITY OF MUNICIPAL SOLID WASTE

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Abstract: Irrational disposal of municipal solid waste creates an important source of soil pollution to engineered landfills. Leachate is generated in landfill site by hydrolysis process or is the result of water penetration. The leachate from improperly constructed landfill results an extensive contamination of soil beneath and adjacent to the dumping area. Municipal solid waste hydraulic conductivity is important for landfill design. The hydraulic conductivity of any porous media is primarily a function of interconnected void space. Waste density and initial compaction effort may have any significant effect on hydraulic conductivity. In the current study an experimental program was designed constant head permeability meter as per ASTM 2434 to determine the variation of coefficient of permeability of MSW with degradation. Coefficient of permeability of fresh sample, refuse sample, one year old sample, five year old samples are respectively decrease from 1.85× 10-6 to 2.7×10-7,1.68×10-6 to2.93×10-7,1.15×10-6 to 2.42×10-7and 3.94 × 10-7 to1.42 ×10-7. There is an overall decrease in the permeability with increase in density and void ratio is decrease with decrease in permeability.

Keyword: Municipal solid waste, Hydraulic conductivity, Degradation.

I. INTRODUCTION

Landfills are rapidly increasingly becoming for disposal of municipal solid waste (MSW). Permeability of MSW in a bioreactor landfill is an important parameter to determine the recirculation rate and overall performance of landfill. It is also necessary during the design of the containment system. Leachate recirculation plays an important role in successful operation of the bioreactor landfill. [1].

For the design and maintenance of any type of landfills are very importance for geotechnical properties and engineering property of MSW change with degradation. The hydraulic conductivity of municipal solid waste varies significantly and depending on waste composition, compaction overburden pressure and due to degradation of MSW the leachate circulation affected largely due to this phenomena. The increasing confining pressure reduction in permeability causes development of pore water pressure. Due to water pressure the unprotected slopes and MSW fails down or slides down [3].

A) Existing Methods of Hydraulic Conductivity

Hydraulic conductivities were calculated using Plexiglas columns. The columns were set-up as constant head permeameters. Test columns were made of 122 cm long by 38.1 cm outer diameter and 0.6 cm thickness [1]. Large scale rigid wall permeameter was used for measure the hydraulic conductivity of fresh shredded sample. It has inner diameter of 30 cm and a height 95 cm. small scale rigid wall permeameter was designed as per ASTM 2434. The diameter 6.3cm, height varied between 10 to 20 cm [4]. "Alpha cell" is used to perform the hydraulic conductivity test. The diameter is 20 cm and 30 cm long, Polymethyl Methacrylate (PMMA) watertight cylindrical tube [5].

B) Scope

The proposed study aims for studying long term effect of MSW degradation on hydraulic conductivity. The hydraulic conductivity depends on quality of MSW, rate of degradation, temperature confining pressure and it varies

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place to place. No study so for conducted to know the long term effect on permeability and other related parameters.

II. MATERIALS AND METHOD

Municipal solid waste generated within Nasik was selected for this study. Four types of sample collected from landfill such as fresh sample, refuse sample, one year old sample and five year old sample. The refuse sample is the one which has been passed through 100mm sieve, 16 mm sieve and 8mm sieve on the landfill.

A) Municipal soil waste composition

Municipal solid waste samples from different age of Nasik contain approximately the following contain. The below bar graph depicts comparison carried out between fresh sample, refuse sample, one year old sample, and five year old sample.

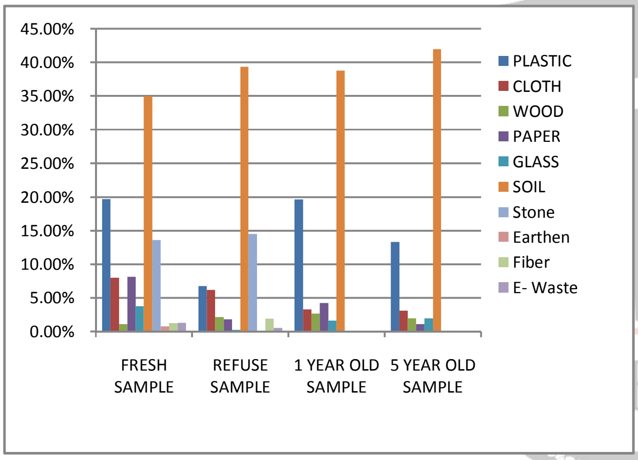

Fig. 1 Comparison of segregation test result carried on fresh, one year old, refuse and five year old sample

B) Experimental Setup

Permeability tests were performing on the constant head per meter design as per ASTM 2434 D 2006. The test setup consist of consist of an acrylic cylinder with inside diameter of 15. cm (6 inches) and a height of 24 cm, porous stones, stand, clamps, silicon grease and a tank maintaining a constant hydraulic head.

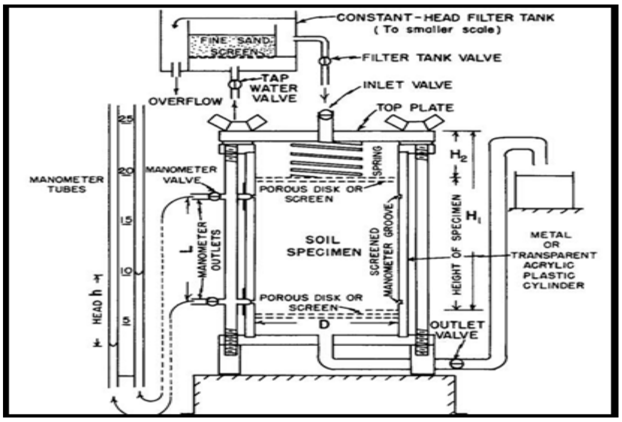

Fig.2 Schematic diagram of hydraulic conductivity mould as per ASTM 2434

III. METHODOLOGY

Various tests carried out on municipal solid waste samples are; moisture content, specific gravity, segregation, particle size distribution, compaction, hydraulic conductivity.

A) Moisture Content

Moisture content of the samples was determined according to standard method (IS: 2720- Part-2 1973). Samples were oven dried at a temperature of 60^{o}C because to avoid combustion of volatile material.

B) Specific Gravity

The specific gravity tests were conducted in accordance with Indian standard test method (IS: 2720- Part-3 sect. 1-1980 and IS: 2720- Part-3 sect.2-1981). Two tests were done on each sample for degradation and an average value was reported.

C) Bulk Unit Weight

The volume weight relationships are in term of bulk unit weight of municipal solid wastes samples. The specific weight is denoted by γ. Bulk unit weight of MSW samples are depend upon on the content present in samples such fresh samples more content of plastic , cloth, vegetable, and which varies with location and degradation.

D) Particle Size Distribution

The particle size distribution of MSW samples were determined using Indian standard, according to part (IS: 2720- Part-4 1975). The test was carried out on the dry basis. Sieves of various sizes ranging from 80mm to 75

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microns were arranged. The sample was passed through a series of sieves. After shaking for 10 min then the particles retained on each sieve were collected and weighed. The percentage passing through each sieve is calculated by dividing the weight of sample retained on each sieve to the total weight of the sample. The sieve size was plotted against the percentage of finer, on semi log scale.

E) Compaction Test

Standard proctor compaction tests were conducted in accordance with (IS: 2720- Part 8 - 1983).Take about 20 kg of air dried MSW sample. Sieve it through 20mm and 4.75mm IS sieves. Calculate percentage retained on 20mm sieve, and 4.75mm sieve. The percentage retained on 4.75mm sieve is greater than 20, use the larger mould of 150mm diameter. Place it in the three equal layers by giving 56 blows of the rammer. Moisture content was plotted against dry density.

F) Hydraulic conductivity

The effects of MSW decomposition on permeability were determined using the constant head permeability method in the laboratory. Hydraulic conductivity test was conducted on four MSW sample. The coefficient of permeability was measured at different type of sample, void ratio and densities. Test was conducted accordance with ASTM 2434 D 2006 .Initial bulk unit weight of each samples were taken at compaction of MSW sample in permeameter cell with tamping rod.

IV. RESULT AND DISCUSSION

A) Moisture Content of MSW sample

The average of value of moisture content of fresh sample, refuse sample, one year old sample, five year old samples are found respectively 66.55%, 12.47%, 28.47%, 12.82%. However, temperature of oven was maintaining 60^0c. Moisture content of waste samples depends upon the waste composition, climate condition and rate of the decomposition. Therefore, higher moisture content expected from fresh sample than old sample because of decrease in pore spaces, enabling the MSW to hold the moisture.

B) Specific Gravity of MSW sample

The average value of specific gravity of the fresh sample, refuse sample, one year old sample, five year old sample are determined respectively 1.041, 1.321, 1.565, 1.802. Value of specific gravity is function of comparative effort, the percentage of soil like material present in MSW and degree of decomposition of waste. So that specific gravity increases with age.

C) Bulk Unit Weight of MSW sample

Sizes of box use for determine the bulk unit weight of MSW samples is 0.24m×0.20m×0.36m. Bulk unit weights for the fresh sample, refuse sample, one year old sample, and five year old sample are respectively 381.3 kg/m^3, 466.61 kg/m^3, 475.3 kg/m^3, 555.9 kg/m^3.

D) Particle Size Distribution of MSW sample

Particle size analysis indicated a decrease in particle size with degradation. This phenomenon can be attributed to the disintegration of the degradable waste like paper food and textile with time fig.3 shows the particle size distribution of the MSW at its various types of sample. The larger particles size of the MSW break down their structure due to the biochemical operation. Particle size of fresh MSW sample is more than other sample.

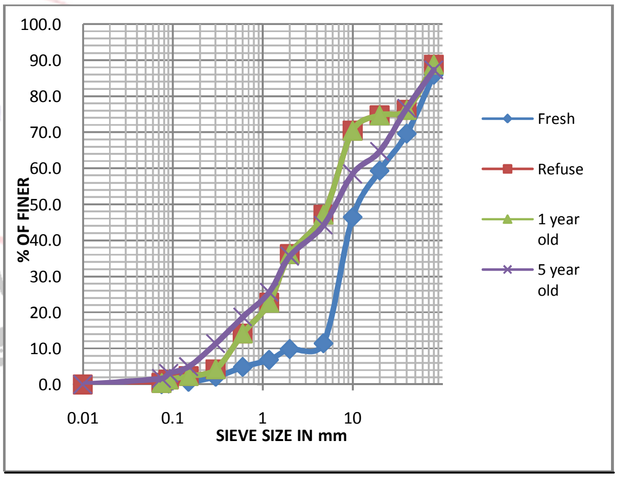

Fig. 3 Particle size distribution of MSW of different types of sample

E) Compaction Test of MSW Sample

Moisture content increase when dry density is decrease. Standard Proctor compaction tests conducted on fresh samples, refuse sample, 1year old sample, 5 year old sample resulted in a maximum dry density of 890 kg/m^3, 1094.5kg/m^3, 1120kg/m^3, 1410kg/m^3 at 38.98%,19.74%,15%, 12% optimum moisture content .however, the decrease in dry unit weight at high moisture content for wastes is not as prominent as that of soils because the relative difference between unit weight of

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water and unit weight of solids is lower for wastes than for soils.

F) Hydraulic Conductivity of MSW Sample

Average values of initial hydraulic conductivity of fresh sample, refuse sample, one year old sample, and five year old sample are respectively 1.96 $\times 10^{-6}$, 1.77×10^{-6}, 7.19×10^{-7} and 3.94 $\times10^{-7}$. The hydraulic conductivity of MSW decreased with the increase in density. Results of change in hydraulic conductivity with increase in density are presented in Fig. 4. The Variation in hydraulic conductivity of the MSW samples at initial stage, running stage, final stage degradation with the calculated void ratio. From Fig.5 it can be understood that permeability decreases with decrease in voids ratio of MSW. Permeability of MSW was in the order of 10^{-6} mm/s the initial stage of degradation and decreased to the order of 10^{-7} mm/s at the final stage of degradation shown Fig 6.

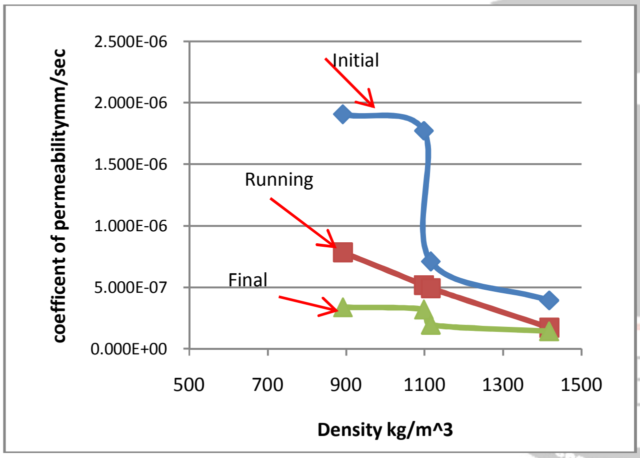

Fig. 4 Hydraulic conductivity with density

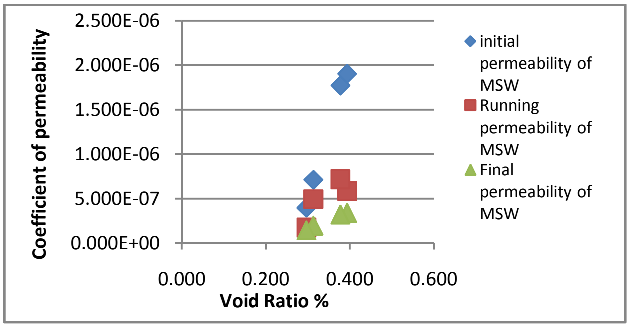

Fig. 5 Hydraulic conductivity of MSW with void ratio

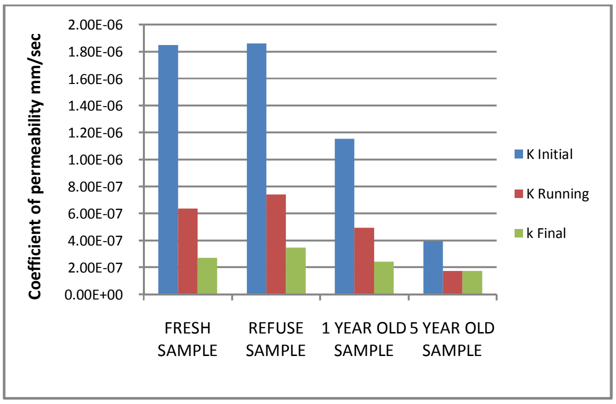

Fig.6 Hydraulic conductivity with degradation of MSW sample

V. CONCLUSION

Hydraulic conductivity in municipal solid waste is mainly dependent on the void ratio geometry and percentage of soil, which in turn varies with the size of particle and shape of the individual particle and density of sample. Hydraulic conductivity of MSW sample decreased with the increase in density.

The possible reason for the decrease might be due to the reduction in pore between particle and change in geometry. There is an increase in density with decrease in voids ratio, thus, resulting in decrease in hydraulic conductivity. There is an increase in percentage soil with overall decrease in hydraulic conductivity of municipal solid waste. The reason might be the increase in finer fraction filling in the void spaces.

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