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A Study On Permeability Properties Of Soil Using E-Waste

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Abstract : Soil is considered by the engineer as a complex material and is formed by the disintegration of rocks due to physical, chemical and biological weathering .Soil particles consists of a mixture of mineral particles , organic matters ,air and liquids . Soils are different types based on the colour, profile, texture, composition and properties. Based on the properties of the soil it is classified as coarse gravel, fine gravel sand silt and clay [1]. This Classification helps to identify the types of soil and its properties in regard to construction purpose. E-waste represent the discarded electrical electronic waste which have reached their end- of- life period. India has generated 0.6 million tons of e-waste in 2014 which may increases to 1.85 million tons by 2015- 2016[2]. Just 2.5% of total e-waste is recycled and the remaining wastes are disposed either by incineration or dumping. Permeability is the property of soil which represents ability to transmit the fluid through the porous medium. It is the soil characteristics that governs the rate of air and water movement. The objective of present study is to find the feasibility of using e-waste in soil to enhance the permeability. The properties of low permeability soils are replaced by non-recycle able e-waste through various percentage up to 20%.

Keywords : Soil, E-waste, Permeability.

1.0 Introduction:

Soil is a solid material on the earth's surface that results from the interaction of weathering and biological activity on the parent material. Parent material can influence the soil in number of ways such as colour, texture, minerals, composition and permeability/drainage. The system of classification of soil helps to identify the engineering purposes. There are three basic types of soil namely sand, silt and clay. Sand is small particles of weathered rocks and it is fairly coarse and loose, so water is able to drain through it easily and it range from .075 to 4.75mm [1].Silt is a fine sand and it will hold water better than sand, its range from 0.002 to 0.075mm .Clay is a very fine-grained soil and it particles are even smaller than silt, ranges from less than 0.002mm [1]. The electronic industry is the world's largest and fastest growing manufacturing industry in the world. Discarded electronic and electrical equipment with all of their peripherals at the end of life is termed e-waste. E-waste is a generic term encompassing various forms of electrical and electronic equipment that are old, end of life of electronic appliances and have ceased to be of any value to their owners. e-waste is an emerging problem given the volumes of e-waste being generated and the content of both toxic and valuable materials in them[2].This fast growing waste stream is accelerating because the global market for personal computers(pc) is far from saturation and the average life span of pc is decreasing rapidly. The life span of central processing unit had reduced from 4-6 years in 1997 to 2 years in 2005[3]over the past two decades, the global market of electrical and electronic equipment(EEE)continues to grow exponentially, while the life span of those products becomes shorter and shorter. The dumping of e-waste particularly computer waste into land will cause issue of environmental and health concern. Of the total e-waste generated in our country, western India accounts for the

largest volume at 35%,while the southern, northern and eastern regions account for 30,21 and 14% respectively[2].For instance, Mumbai alone throws away 19000 to 20000 tons of electronic waste a month, excluding the large e-waste it imports from developing nations through its port[4]. The permeability of soil is to measure the capacity of soil to allow fluids to pass through it. Water flowing through the soil exerts considerable seepage forces which has direct effect on the safety of hydraulic structures. The rate of settlement of foundation depends on the permeability properties. Higher the permeability of soil, higher the rate of settlement[5].The permeability gives the solution of many engineering problems involving flow of water through soils such as dewatering and drainage of excavations, back fills and subgrades, determining yield of water bearing strata, assessing seepage through the body of earth dams and computing losses from canals[11].

M.D.Jalal Uddin have collected data of disposal materials percentage in Mahbubnagar on 2011 and which is causing harm to environment and for reducing this they have explained some techniques from which it can be controlled without causing any effects to environment. Santhanam Needhidasan,

Melvin Samuel, Ramalingam Chidambaram's article provides concise overview of India's current e-waste scenario namely magnitude of the problem environmental and health hazards, current disposal recycling operations and mechanism to improve the condition for better environment [2]. Creu Obrer improve clays softness by stabilizing with cement. One of the sub-tasks of the project concerns permeability. The aim of his report is to study the permeability of the cement stabilized clays of Finland in order to collaborate with a three years project (2006-2008) carried out by the Soil Mechanics and Foundation Laboratory of the Helsinki University of Technology (HUT). Balakrishnan Ramesh Babu, Parande AK, Ahmed Basha C offers an overview of electrical and e-waste recycling including a description of how it is generated and classified and technologies for recovering materials and new scientific developments related to these activities and they discussed about recycling industries for e-waste in India[3].

The main objective of this research work is (i) to find out the feasibility of using E-waste in soil (ii) To find the properties of E-waste (iii) To analyse the permeability behaviour of soil with the usage of E-waste.

2.0 Experimental Program:

2.1. Preparation of Sample:

Soil samples are taken from the field and it is oven dried. The clods present in the soil is broken with the help of hand tool and the organic matters present in the soil are removed. The required amount of sample for the proposed test is taken from the oven dried soil [7] kept at a temperature of 110^{o}C for a specified duration as per the procedure of IS 2720 part 1.Table shows that the replaceable percentage of E-waste with soil.

Table 1: Replaceable Percentage of E-waste with soil

S.No	Description	SOIL PER KG AS%	E-WASTE PER KG AS %
1	EW0.0	100	0
2	EW2.5	97.5	2.5
3	EW5.0	95	5
4	EW7.5	92.5	7.5
5	EW10	90	10
6	EW20	80	20

2.2. Description of Mixtures

In order to identify the various proportions, the proportions are named as EW0, where EW0 is the soil with a mixture of 0% E-Waste (EW0). The other proportions are named as EW2.5, EW5, EW7.5, EW10 and EW20

3.0 Test Methodology

All the test methodology are carried as per Indian Standards.

3.3.1. Specific gravity

Pycnometer has been dried and weighed by using the weighing balance with an accuracy of 0.2gm. 200 gm of oven dried soil taken for the test. The soil is oven dried for a duration of 24 hours at 105-110^{0}C. Specific gravity for the soil [8] and e-waste is computed as per table 1 of IS 2270 part 1[9].

3.3.2. Gradation

Gradation of soil and e-waste is carried out by sieve analysis method and its results are used to find the particle size distribution of a sample, uniformity coefficient and coefficient of gradation. The set of sieves used for the test are less than 4.75mm are 4.75mm, 3mm, 2.36mm,1.18mm, 1mm, 0.6mm, 0.3mm, 0.15mm, 0.075mm sieves and for the materials that are greater than 4.75mm are 45mm, 40mm, 25mm, 20mm, 12.5mm, 6.3mm, 4.75mm sieves as per IS 2720 Part 4 [10].

3.3.3. Permeability

The permeability of the soil is determined by using permeability apparatus. The coefficient of permeability can be determined by two methods, constant head and falling head method as per IS 2720 Part 17 . In constant head method the head loss is kept constant and steady flow is maintained. The quantity of water is collected from the outlet of soil sample for the convenient time interval . In falling head method the time interval taken to fall of the water level from initial head to final head is noted [11].The resultant coefficient of permeability for different proportion of mix is found out and compared with the conventional mix.

4. Results and Discussions:

4.1. Specific gravity:

The definition of specific gravity is the ratio of density of substance to the density of reference substance is water. Pycnometer is used for calculating specific gravity. Specific gravity on normal soil and e-waste has been done using pycnometer as per IS: 2720, Part 3; 1980 discussed in the test methodology. The table 1 shows the experimental results specific gravity (G).from the table it is found that the specific gravity of the soil is more when compared to the specific gravity of e-waste. This infers that the E-waste are less dense than water.

Table 2: Test results for Specific Gravity

S.No.	Material	G
1	Soil	2.202
2	E-waste	1.204

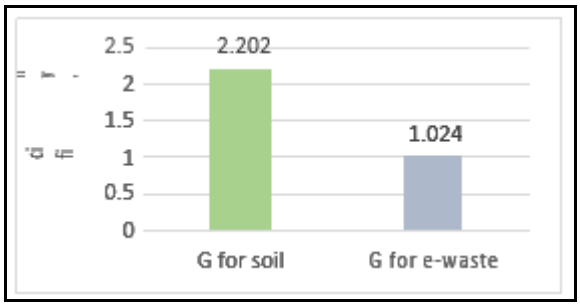

Figure 1: Comparative of Specific Gravity

4.2. Sieve analysis:

Sieve for normal soil:

The experiment has been done to determine the fineness modulus, uniformity coefficient and gradation coefficient. The test has been done as per the IS 2720 part4 1985. The results of the sieve analysis for normal soil are shown in Table 3.

Table 3: Sieve size Distribution for normal soil

Sieve Size (mm)	Weight Retained (gm)	Cumulative weight retained	Cumulative percentage weight retained	% of passing	Remarks
4.75	24	24	4.8	95.2	Fineness Modulus = 2.658
3	15	39	7.8	92.2	
2.36	11	50	10	90	
1.18	58	108	21.6	78.4	
1	12	120	24	76	
0.6	88	208	41.6	58.4	
0.3	114	322	64.4	35.6	
0.15	136	458	91.6	8.4	
0.75	31	489	97.8	2.2	

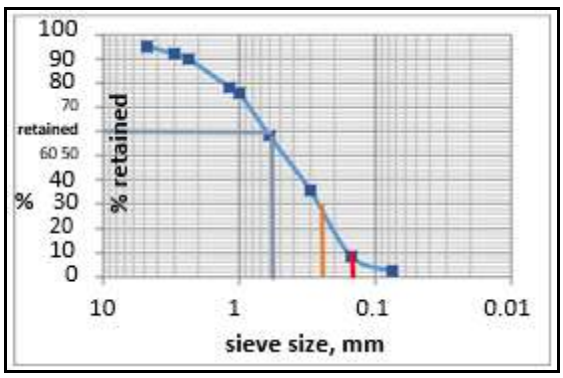

Figure 2: Graphical representation of gradation

Uniformity Coefficient (Cu) = 3.53
Coefficient of curvature (Cc) = 0.66
Type of soil is well graded sand

Sieve for e-waste:

The experiment has been done to determine the fineness modulus. The results of the sieve analysis for normal soil are shown in Table 4.

Table 4: Sieve size Distribution for e-waste

Sieve Size (mm)	Weight Retained (gm)	Cumulative weight retained	Cumulative percentage weight retained	% of passing	Remarks
45	0	0	0	100	Fineness Modulus = 3.349
40	0	0	0	100	
25	14	14	.7	99.3	
20	58	72	3.6	96.4	
12.5	996	1068	53.4	46.6	
6.3	745	1813	90.65	9.35	
4.75	98	1911	95.55	4.45	
Pan	89	2000	100	0	

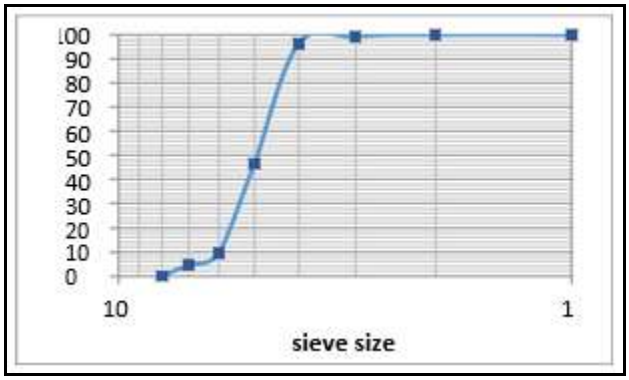

Figure 3: Graphical representation of gradation

Uniformity coefficient (cu) = 0.76
Coefficient of curvature (cc) = 1.10

Table 5: Test results on fineness modulus

S.No.	Material	Fineness modulus
1	Soil	2.658
2	E-waste	3.439

Fineness modulus of sand is an index number which represents the mean size of particles in sand. The test result shows that the fineness modulus of E-waste is more than the fineness modulus of soil which highlights the presence of large size particles when compared to soil.

4.3. Permeability:

4.3.1 Falling Head Test:

For a falling head test arrangement the specimen shall be connected through the top inlet to selected stand-pipe. The bottom outlet shall be opened and the time interval required for the water level to fall from a

known initial head to a known final head as measured above the centre of the outlet shall be recorded. The stand-pipe shall be refilled with water and the test repeated till three successive observations give nearly same time interval; the time intervals being recorded for the drop in head from the same initial to final values, as in the first determination [11]. The test has been done by adding various percentages (0, 2.5, 5, 7.5, 10, and 20%) of e-waste are replaced for the soil. Table 5 shows the test results to find the coefficient of permeability. The results highlights an increases in the permeability of soil with the addition of E-waste. The higher permeability will decreases the voids ratio which may affect the mechanical properties of the soil.

Hence the addition of 10% E-waste can be adopted as the optimum percentage of replacement.

Table 6: Test results on coefficient of permeability of falling head method

S.NO	DESCRIPTION	COEFFICIENT OF PERMEABILITY k (cm/sec)
1	EW0.0	0.83 x 10-3
2	EW2.5	1.28 x 10-3
3	EW5.0	5.04 x 10-3
4	EW7.5	6.70 x 10-3
5	EW10	9.95 x 10-3
6	EW20	10.7 x 10-3

Constant Head Test:

For a constant head test arrangement, the specimen shall be connected through the top inlet to the constant head water reservoir. The bottom outlet shall be opened and when the steady state of flow has been established, the quantity of flow for a convenient time interval shall be collected and weighed or measured. The collection of the quantity of flow for the same time interval shall be repeated thrice. The linearity (of Darcy's law) between the hydraulic gradient and the average velocity of flow for the soil under test should be established by performing the test over a range of hydraulic gradients and any deviation from linearity observed should be noted [11]. The test has been done by adding various percentages (0, 2.5, 5, 7.5, 10, and 20%) of e-waste are replaced for the soil. The results of the constant head method are shown in Table 6. It shows the test results to find the coefficient of permeability. The results highlights an increases in the permeability of soil with the addition of E-waste. The higher permeability will decreases the voids ratio which may affect the mechanical properties of the soil.

Hence the addition of 10% E-waste can be adopted as the optimum percentage of replacement.

Table 7: Test results on coefficient of permeability of constant head method

S.NO	DESCRIPTION	COEFFICIENT OF PERMEABILITY k (cm/sec)
1	EW0.0	0.75 x 10-3
2	EW2.5	1.08 x 10-3
3	EW5.0	3.41 x 10-3
4	EW7.5	4.04 x 10-3
5	EW10	6.93 x 10-3
6	EW20	7.31 x 10-3

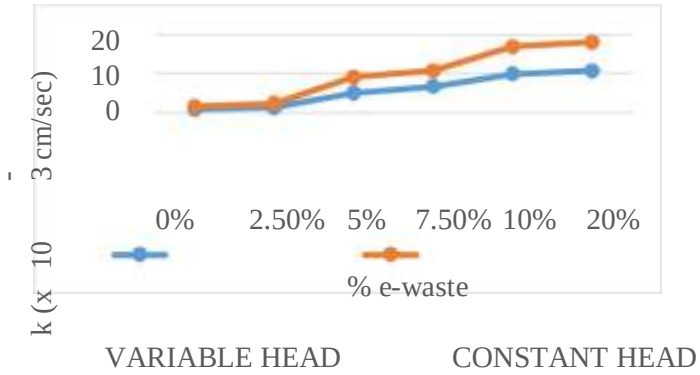

Figure 4: Comparison of k by falling and constant head method

5.0 Conclusion:

1. The specific gravity of E-waste is lower which shows the soil is denser than E-waste.
2. From the sieve analysis, fineness modulus of E-waste is more than the fineness modulus of soil.
3. From the constant head method, it is found that the optimum percentage of E-waste is 10%
4. From the falling head method, it is found that the optimum percentage of E-waste is 10%
5. The experiment shows that E-waste can be used in an optimum percentage of replacement

6.0 Reference:

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