“THE IMPACT OF MUNICIPAL SOLID WASTE ON SOIL”

A PROJECT

Submitted in partial fulfillment of the requirements for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

Under the supervision of

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By

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to

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ACKWNOLEDGEMENT

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CERTIFICATE

This is to certify that the work which is being presented in the project report titled **"THE IMPACT OF MUNICIPAL SOLID WASTE ON SOIL"** in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology in Civil Engineering and submitted to the Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat is an authentic record of work carried out by Raghav Gupta (141640) and Adarsh Chandra (141655) during a period from August 2017 to May 2018 under the supervision of Prof. Ashok Kumar Gupta, Head of Department, Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat.

The above statement made is correct to the best of our knowledge.

Date: - 18-05-2018

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1. Introduction

India is a fast-developing nation, due to the rapid urbanization there is an exponential growth in the amount and density of the urban population. Because of this rapid population there is also a growth in the solid waste generation. As the urbanizations is spreading quickly it arises a problem for collection and disposal of Municipal Solid Waste(MSW). Already the solid waste generation is very high and it keeps on increasing every year. 50,000 tons of waste is generated per day by Class 1 cities and about 30,000 tons per day by metro cities. It has been studied by NEERI that the per capita waste generation rate varies between 0.3 to 0.6 kg/capita/day depending upon the size of the city. Approximately there is 1.33 % increase in per capita waste generation in India per year.

The Municipal Solid Waste generated usually includes commercial, residential, industrial waste. They contain both biodegradable and non-biodegradable materials. In Indian cities per capita solid waste generated is calculated by number of trips and quantity transported per day. Due to the expansion of cities lines this has put a huge pressure on the availability of the land which can be used for dumping waste. This has become major problem in the fast-growing cities. Reclaiming the land for the future development of dumpsite is also a problem faced. Due to this shortage of land area for dumping there is dumping on the outskirts of the cities. This can result in environmental and public health hazard. These are the major problems that has made solid waste management difficult are the insufficiency of land, high quantity of generated waste, and the pollution cause to the environment.

Municipal bodies of India have spent a significant amount of money on solid waste management. Despite such high budget allocation, the service provided is often inadequate. The control of pollution by contamination in soil and groundwater, depends largely on the geotechnical properties of the soil where the solid waste is dumped. Many writers have worked to characterize the contents of Municipal Solid Waste(MSW) and pollution in the ground water but a very few have done research on geotechnical characteristics of this problem. This study shows the geotechnical properties of soil in dumpsite located in Shogi, Solan.

1.1 Solid Waste

Any type of unwanted material that is of no need to the other person i.e., useless material from any industry, residential areas, treatment plants and other sources are referred to as solid waste.

1.2 Types of solid waste

1.2.1 Municipal Solid Waste

The items that are thrown out by the people from houses, from construction sites or waste collected from the streets is known as Municipal Solid Waste. The amount of waste generated is increasing every year at a high rate. The landfills that are now in use are not properly lined neither they are equipped to protect from contamination.

In the last years, a huge amount of damage has been done on the environment because of the non-biodegradable items that are present in the waste. Plastics, aluminum foils are some main materials that are causing problems. The use of biodegradable items and proper handling of waste is to be taken care of.

1.2.2 Hazardous Waste

The waste containing toxic substances that can harm human health or environment is categorized as hazardous waste. It can be found in hospital waste like phenol and formaldehyde used as disinfectants or even in houses like in batteries. This type of waste can be explosive in nature can be highly corrosive and even toxic to humans.

1.2.3 Biomedical Waste

Waste generated from the refuse of research activities or treatment of any biomedical process is known as biomedical waste. It can be seen in the form of bandages, syringes, fluid excreting from body, etc. This waste can be highly infectious to the human body so proper disposal methods are to be adopted for its disposal.

1.3 Generation of MSW – Indian Scenario

Industrialization has become very significant in developing countries and India is no far from it this has now increased the load of E-waste and the plastic wastes on the waste collection and disposal process. As with increasing population the waste generation also tends to increase at a high rate. Nuclear waste is one of the other waste streams that require attention due to fast growing nuclear sector nowadays. Solid waste management is required to ensure the proper disposal of such kind of waste.

1,27,496 TPD (tons per day) (CPCB, 2012) of municipal solid waste is being generated due to domestic and commercial activities. While in the year 2000 it was about 1,00,000 TPD. CPCB estimated 39,031 TPD MSW generation in 2004-05. Survey was conducted again in year 2010-11 and estimated 50.592 MSW generation. This shows the increase in waste generation w.r.t. time. Table 1 below shows waste collected per day in different states and union territories (CPCB 2011).

Table 1 showing waste collected per day in different states and union territories (CPCB 2011).

State	**Quantity Generated (TPD)**	**Collected (TPD)**
Andaman & Nicobar	50	43
Andhra Pradesh	11500	10655
Arunachal Pradesh	94	NA
Assam	1146	807
Bihar	1670	1670
Chandigarh	380	370
Chhattisgarh	1167	1069
Daman Diu & Dadra	28+13=41	NA
Delhi	7384	6796
Goa	193	NA
Gujarat	7379	6744
Haryana	537	NA
Himachal Pradesh	304	275
Jammu & Kashmir	1792	1322
Karnataka	6500	2100
Kerala	8338	1739
Lakshadweep	21	21
Madhya Pradesh	4500	2700
Maharashtra	19204	19204
Manipur	113	93
Meghalaya	285	238
Mizoram	4742	3122
Nagaland	188	140
Orissa	2239	1837
Puducherry	380	NA
Punjab	2794	NA
Rajasthan	5037	NA
Sikkim	40 (capital)	32
Tamil Nadu	12504	11626

Tripura	360	246
Uttar Pradesh	11585	10563
Uttrakhand	752	NA
West Bengal	12557	5054
34 States	127486	89334

1.4 Scenario of waste generation - Himachal Pradesh

The Municipal Solid Waste generated in Himachal Pradesh is estimated to be 304 tons per day (CPCB, 2012). According to the CPCB the generation of waste is approximately 0.412 kg/day per capita. As India still uses unscientific manner of disposing waste it can cause lead to the uncontrolled emission of methane gas because of the anaerobic conditions created at the dump site. As 60% of the generated waste is thrown in the landfills it becomes a bigger problem.

Table 2 shows the MSW to be generated in the years to come. This is based on the increase of both the population and waste generation rate, it is estimated that annual increase in waste generation rate per capita is 1-1.33% annually. The estimates for the population growth are also given in the Table 2. On multiplication this gives the estimates for waste generated in the years 2021, 2031, 2041.

Table 2 showing total MSW generated in Himachal Pradesh

Year	**Per capita waste generated (kg/day)**	**Urban Population (x1000)**	**Waste generated (T/day)**
2011	0.413	736.3369	304.3
2021	0.472	883.3212	416.6
2031	0.538	1023.429	550.9
2041	0.614	1155.249	709.6

2. Literature Review

1) Aziz S.Q. and Maulood Y.I.,” Contamination valuation of soil and groundwater source at anaerobic municipal solid waste landfill site.”

The authors worked to determine the risks on the ground water and to determine the properties of the dumpsite soil. They found out that the soil and the ground water were contaminated. Also, the nearby places were affected due to stabilized leachate formed. It was also seen that the leachate that was formed is already in its acid formation phase. The soil there was found to be having low permeability.

2) Journal of Environment and Earth Science. “Geologic and Geotechnical Evaluation of An Open Landfill for Sanitary Landfill Construction in Ilorin, Southwestern Nigeria.”

This study focused on the geological and geotechnical properties of an open landfill and using the derived results for converting it into a landfill. The indices properties like liquid limit, plastic limit, activity all satisfied the required limits to be used for barrier materials in the landfill. The soil determined was inactive clayey soils.

3) Srigirisetty S., Jayasri T., Netaji C.,” Open dumping of municipal solid waste- “Impact on Ground water and soil”.

The report starts with various approaches to manage municipal solid waste and a plan to implement solid waste management technique for a town. The study focuses to find the soil contamination and ground water pollution due to the dumping of waste. The results of their study showed that there was a variation in the composition of soil from dumpsite than the control sample. Groundwater also showed certain pollution levels. A landfill was designed as the waste management technique.

4) Kanmani S. and Gandhimathi R., “Assessment of heavy metal contamination in soil due to leachate migration from an open dumping site.”

This research was carried out to find the concentration heavy metals from the soil samples collected from a dumping site. It was observed that at different depths and different locations in the dumping yard the composition of waste shows huge variation. Also, the presence of leachate tells about the anaerobic conditions there.

5) Nanda H.S., Shivaraju R. and Ramakrishnegowda C.,”Impact of municipal solid waste disposal on geotechnical properties of soil.”

This study aims to find the geotechnical properties of soil and also characterizing the municipal solid waste at the dumping site. It was observed that there was a high leachate formation in the dumping site due to the large variety of the wastes. Also the effect of leachate was seen too a greater depth than expected, continuous use of this site can have environmental problems in the future.

3. Objectives

- Assessment of geotechnical properties of dumpsite soil.
- Assessment of geotechnical properties of natural soil outside the dumpsite.
- Comparison of the geotechnical properties of the dumpsite soil and natural soil.

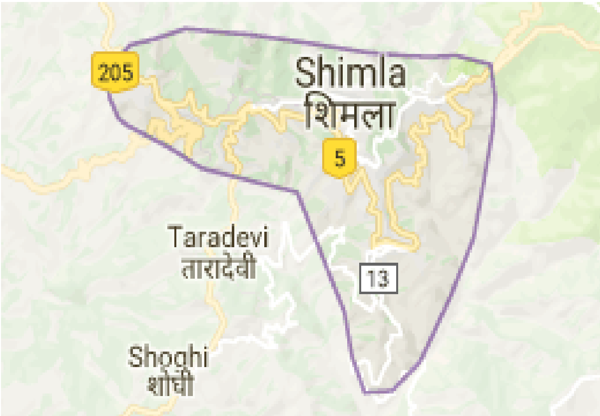
4. Site Description

In the foothills of Himalayan range Shimla is the capital of the northern Indian state of Himachal Pradesh. It once served as the summer capital of British India. With the city area of only 35.34 km^2 it still attracts a lot of tourists because of the cool weather here. This in turn increases the load of generated waste in the city.

Shimla lies at 31.61°N 77.10°E, south-western to ranges of the Himalayas. Its average altitude is about 2,208 metres (7,248 ft) above mean sea level. As of increasing population the problem of waste management is also increasing. We took the shogi dumpsite located on the airport road, 60% of the waste from Shimla is transported to this site.

Fig 1 shows the location of chosen site.

Figure 1: Location of site



5. Experiments & Methodology

The following tests were performed on the control sample and the soil containing MSW.

5.1. Specific Gravity

The specific gravity test is conducted on soil samples as per IS 2720: Part 3-1980.

5.2. Grain Size Analysis

This test is performed to determine the percentage of grain sizes present in the soil. The grain size distribution curve is found out by sieve analysis as per IS 2720: Part 4-1980.

5.3. Atterberg Limits Test

These tests are done to find out the liquid limit and plastic limit of soil samples as per IS 2720: Part 5-1980. These limits are also used to classify fine grained soils.

5.4. Compaction Test

Light compaction test is to be carried out on the soil samples as per IS 2720: Part-7-1980. This test is done to find the maximum dry density of the soil sample along with its optimum moisture content.

5.5. Permeability Test

The soil samples were compacted at respective optimum moisture content and falling head permeability test is carried out as per IS 2720: Part 17-1980.

5.6. Direct Shear Test

Direct shear test is used to predict angle of internal friction and cohesion of soil. This test was conducted as per IS 2720: Part 13-1980.

6. Result & Discussion

6.1. Specific Gravity

The specific gravity of the dump site samples ranged from 2.14 to 2.41 and that for the clean soil sample was 2.58. The specific gravity of the dumpsite soil is less than the clean soil due to the presence of organic content in the dump site soil.

Table 3: Specific gravity of different soil samples.

Sample	Specific Gravity
Sample 1	2.14
Sample 2	2.28
Sample 3	2.41
Clean Soil	2.58

6.2. Grain Size Analysis (Sieve Analysis)

The distribution of different grain sizes affects the engineering properties of soil. Grain size analysis provides the grain size distribution, and it is required in classifying the soil.

Table 4, 5, 6 shows observations of sample 1, 2, 3, respectively.

Table 7 shows observations for clean soil sample.

Table 4: Observations for sample 1.

Sieve Size(mm)	Mass Retained (g)	Cumulative Mass Retained (g)	Percent Cumulative Retained (%)	Percent Cumulative Finer (%)
10	40.5	40.5	8.1	91.9
4.75	142.1	182.6	36.52	63.48
2	127.8	310.4	62.08	37.92
1	71.5	381.9	76.8	23.2
0.6	31.1	413	82.6	17.4
0.3	24	437	87.4	12.6
0.212	14.7	451.7	90.2	9.8

0.1	11.4	463.1	92.6	7.4
0.75	21.1	484.1	96.82	3.18

Table 5: Observations for sample 2.

Sieve Size (mm)	**Mass Retained (g)**	**Cumulative Mass Retained (g)**	**Percent Cumulative Retained (%)**	**Percent Cumulative Finer (%)**
10	41.6	41.6	8.32	91.68
4.75	129.3	170.9	34.18	65.82
2	131.4	302.3	60.46	39.54
1	69.8	372.1	74.42	25.58
0.6	32.7	404.8	80.96	19.04
0.3	26.5	431.3	86.26	13.74
0.212	15.3	446.6	89.32	10.68
0.1	13.6	460.2	92.04	7.96
0.075	27.6	487.8	97.56	2.44

Table 6: Observations for sample 3.

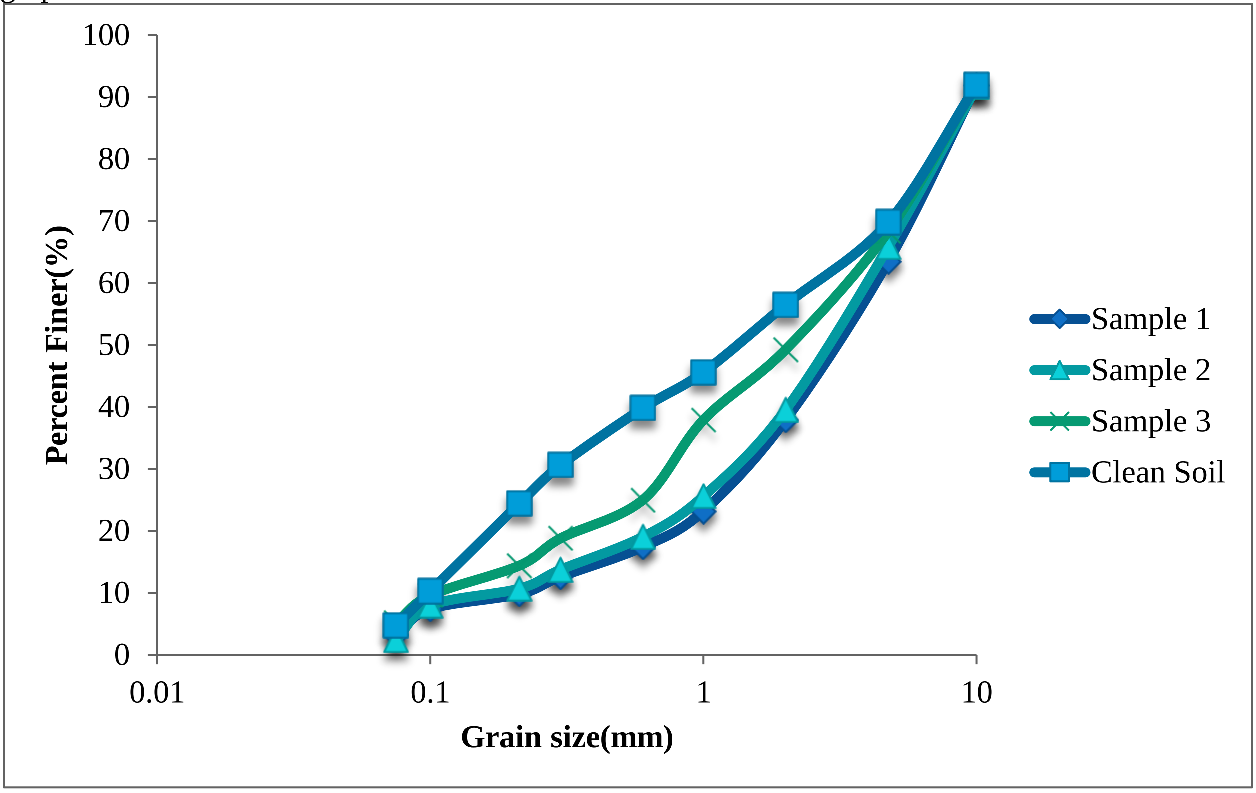
Sieve Size (mm)	Mass Retained (g)	Cumulative Mass Retained (g)	Percent Cumulative Retained (%)	Percent Cumulative Finer (%)
10	39.8	39.8	7.96	92.04
4.75	118.6	158.4	31.68	68.32
2	95.3	253.7	50.74	49.26
1	56.8	310.5	62.1	37.9
0.6	29.5	340	75	25
0.3	28.2	368.2	81.2	18.8
0.212	20.4	369.6	85.6	14.4
0.1	16.6	406.2	90.4	9.6
0.075	37.6	443.8	94.8	5.2

Table 7: Observations for clean sample.

Sieve Size (mm)	Mass Retained (g)	Cumulative Mass Retained (g)	Percent Cumulative Retained (%)	Percent Cumulative Finer (%)
10	40.3	40.3	8.06	91.94
4.75	110.7	151	30.2	69.8
2	66.5	217.5	43.5	56.5
1	54.5	272	54.4	45.6
0.6	26.4	298.4	59.68	39.8
0.3	38.6	337	67.4	30.6
0.212	40.9	377.9	75.58	24.42
0.1	25.9	403.8	80.76	10.24
0.075	72.6	476.4	95.28	4.72

The following Grain Size Distribution curve (Fig 4.) is obtained from the above observations of percent finer passing and sieve size.

Figure 2: Plot between grain size and percent finer of the different soil samples on a semi-log graph



The soil is classified using this graph and using the equations for Cu and Cc.

$Cu = D_{60}/D_{10}$ & $Cc = (D_{30})^2/D_{10}*D_{60}$

For soil containing MSW avg. values of Cu and Cc are 8.75 and 1.73, respectively. And the soil is classified as well graded sand. Whereas for clean soil sample Cu and Cc are 9.36 and 0.83, respectively and is classified as poorly graded sand.

6.3. Atterbergs Limit Test

The Atterberg limits test were tried to test on the soil samples but proper readings cannot be recorded this confirms our belief that the soil sample tested on is in fact sandy soil with very few quantities of silt or clay.

6.4. Compaction Test

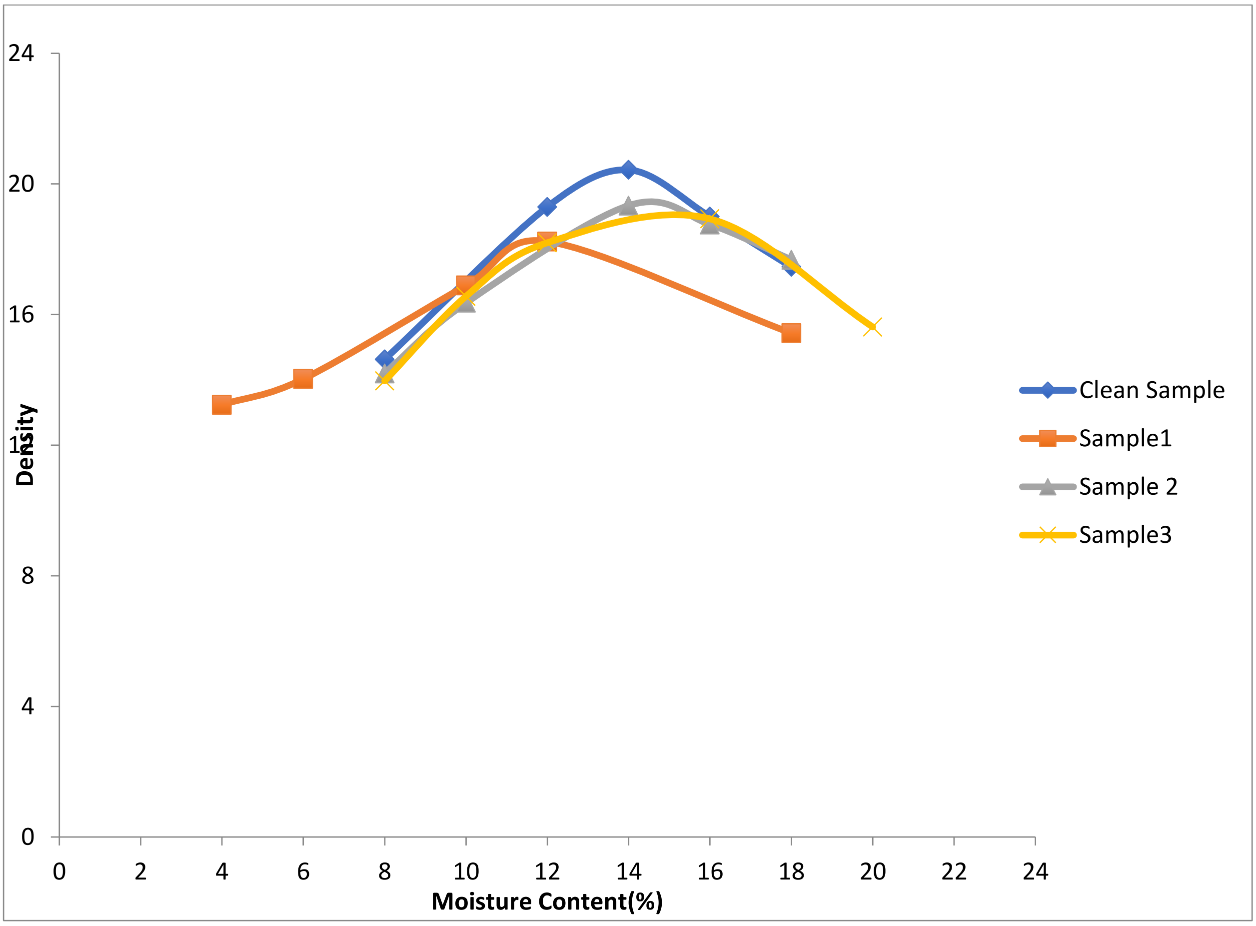
The soil sample collected from MSW dumping yard and the control sample is compacted using standard proctor compaction test. The maximum dry density of the MSW dump site samples tested varies from 18.24 kN/m^3 to 19.5 kN/m^3 and optimum moisture content varies from 14.28 % to 16.66 % whereas the maximum dry density of the control sample is 20kN/m^3 and the optimum moisture content for the same is 14 %. Figure shows the compaction characteristics of the various samples collected. It is observed that the compaction curve shifts to the right as samples collected from the dump site have maximum dry density at higher optimum moisture content. This shows that the soil structure changes from flocculated to dispersed. Also, the soil has increased permeability and lower shear strength at higher strain.

Table 8: Moisture content and density from compaction test

Sample	Moisture Content (%)	Density (kg/m^3)
Clean Soil	8	14.63
	12	19.3
	14	20.43
	16	19.2
	18	17.46
Sample 1	4	13.24
	6	14.03
	10	16.89
	12	18.24
	18	15.43
Sample 2	8	14.2

	10	16.36
	14	19.34
	16	18.76
	18	17.68
Sample 3	8	13.97
	10	16.56
	12	18.2
	16	18.93
	20	15.62

Figure 3: Plot between the density and moisture content of different soil samples.



6.5. Permeability Test

The results suggested that the coefficient of permeability ranged from 6.16 x 10^{-3} cm/sec to 5.30 x 10^{-3} cm/sec and that for the control sample is 2.56x10^{-3} cm/s. It is observed that the contaminated soil has higher value of coefficient of permeability than the uncontaminated soils. These results in some way challenge the fact that the contaminated soil particles are loosely arranged. This irregularity may be due to flocculation of soil particles as a result of contamination with MSW.

Table 9: Permeability of different soil samples.

	Clean soil	**Sample 1**	**Sample 2**	**Sample 3**
Coeff. Of Permeability(cm/sec)	2.56x10^{-3}	6.16x10^{-3}	5.30x10^{-3}	5.86x10^{-3}

6.6. Direct Shear Test

The following observations were taken from the direct shear test on the control sample and unclean soil sample.

Table 10: Sample 1 @ 1.75kg loading

Dial Gauge	**Displacement(x10^{-4})**	**Dial Gauge**	**Load KN (x10^{-5})**	**Shear kg/m^3 Stress (10^{-3})**
0.2	4	14	2.9	8.1
0.4	8	25	5.1	14.2
0.6	12	34	6.9	19.2
0.8	16	41	8.4	20.4
1.0	20	44	9.0	22.1
1.2	24	50	10.2	23.3
1.4	28	55	11.2	24.6
1.6	32	59	12.0	25.4
1.8	36	63	12.9	26.5

2.0	40	65	13.3	28.3
2.2	44	67	13.7	29.3
2.4	48	69	14.1	30.8
2.6	52	70	14.3	32.7
2.8	56	70	14.3	32.7
3.0	60	70	14.3	32.7
3.2	64	70	14.3	32.7

Table 11: Sample @ 2.5kg loading

Dial Gauge	**Displacement ($x10^{-4}$)**	**Dial Gauge**	**Load KN ($x10^{-5}$)**	**Shear kg/m^3 Stress (10^{-3})**
0.2	4	20	4.1	11.4
0.4	8	32	6.5	18.1
0.6	12	28	5.7	26
0.8	16	60	12.2	33.9
1.0	20	71	14.5	36.8
1.2	24	82	16.7	40.3
1.4	28	92	18.8	42.9
1.6	32	97	19.8	45.3
1.8	36	100	20.4	46.8
2.0	40	102	20.8	46.8
2.2	44	102	20.8	46.8
2.4	48	102	20.8	46.8
2.6	52	102	20.8	46.8

Table 12: Sample 3 @ 3.25kg loading

Dial Gauge	**Displacement ($x10^{-4}$)**	**Dial Gauge**	**Load KN ($x10^{-5}$)**	**Shear kg/m^3 Stress (10^{-3})**
0.2	4	28	5.7	15.8
0.4	8	47	9.6	26.7
0.6	12	64	13.1	36.4
0.8	16	88	17.9	40.7
1.0	20	102	20.8	44.3
1.2	24	115	23.5	49.7
1.4	28	121	24.7	52.6
1.6	32	127	25.9	54.8
1.8	36	134	27.3	55.8
2.0	40	135	27.5	56.31
2.2	44	137	27.9	57.2
2.4	48	138	28.2	58
2.6	52	138	28.2	58
2.8	56	138	28.2	58
3.0	60	138	28.2	58

The below tables 13, 14, 15 show the readings for clean soil sample. On the same parameters as the unclean soil sample.

Table 13: Clean Sample @ 1.75kg loading

Dial Gauge	Displacement(x10^{-4})	Dial Gauge	Load KN (x10^{-5})	Shear kg/m^3 Stress (10^{-3})
0.2	4	8	4.1	20.6
0.4	8	16	5.1	22.1
0.6	12	20	5.6	24.3
0.8	16	32	6.5	25.4
1	20	28	5.7	27.6
1.2	24	60	12.2	28.9
1.4	28	71	14.5	30.4
1.6	32	82	16.7	31.4
1.8	36	92	18.8	36.2
2	40	97	19.8	38.2
2.2	44	100	20.4	40.7
2.4	48	102	20.8	28.3
2.6	52	105	21	42.3
2.8	56	107	21.3	43.9
3	60	109	21.4	45
3.2	64	109	21.4	45

Table 14: Clean Sample @ 2.5kg loading

Dial Gauge	Displacement(x10^{-4})	Dial Gauge	Load KN (x10^{-5})	Shear kg/m^3 Stress (10^{-3})
0.2	4	27	6.7	24.3
0.4	8	46	10.6	26.7
0.6	12	65	13.2	29.8
0.8	16	87	17.9	34.4
1	20	103	20.8	41.3
1.2	24	116	23.5	45.9
1.4	28	123	24.7	47.5
1.6	32	127	25.9	52.3
1.8	36	134	27.3	55.1
2	40	135	27.5	57.6
2.2	44	138	28.6	58.7
2.4	48	140	30.6	59.4
2.6	52	140	30.6	59.4

Dial Gauge	Displacement($x10^{-4}$)	Dial Gauge	Load KN ($x10^{-5}$)	Shear kg/m^3 Stress (10^{-3})
0.2	4	30	6.3	30.2
0.4	8	51	10.6	37.5
0.6	12	67	14.2	41.5
0.8	16	89	15.8	48.6
1	20	105	17.8	52.4
1.2	24	117	20.6	55.4
1.4	28	126	22.4	58.3
1.6	32	128	24.6	60.5
1.8	36	132	26.7	62.6
2	40	134	27.5	64.2
2.2	44	135	28.4	65.1
2.4	48	137	29.7	66.3
2.6	52	137	30.4	67.2
2.8	56	138	31.6	68.2
3	60	138	31.6	68.2

Table 15: Clean Sample @ 3.25kg loading

It can be seen that on increasing the normal stress on the sample the shear strength is increased. The stress strain curve becomes constant after the failure, and there existed a cohesion for the soil sample.

Table 16: Shear stress value corresponding to the normal stress

	Shear Stress (Kg/cm^2)	
Normal Stress(Kg/cm^2)	**Unclean soil**	**Clean Soil**
1.75	0.32	0.45
2.5	0.46	0.59
3.25	0.58	0.68

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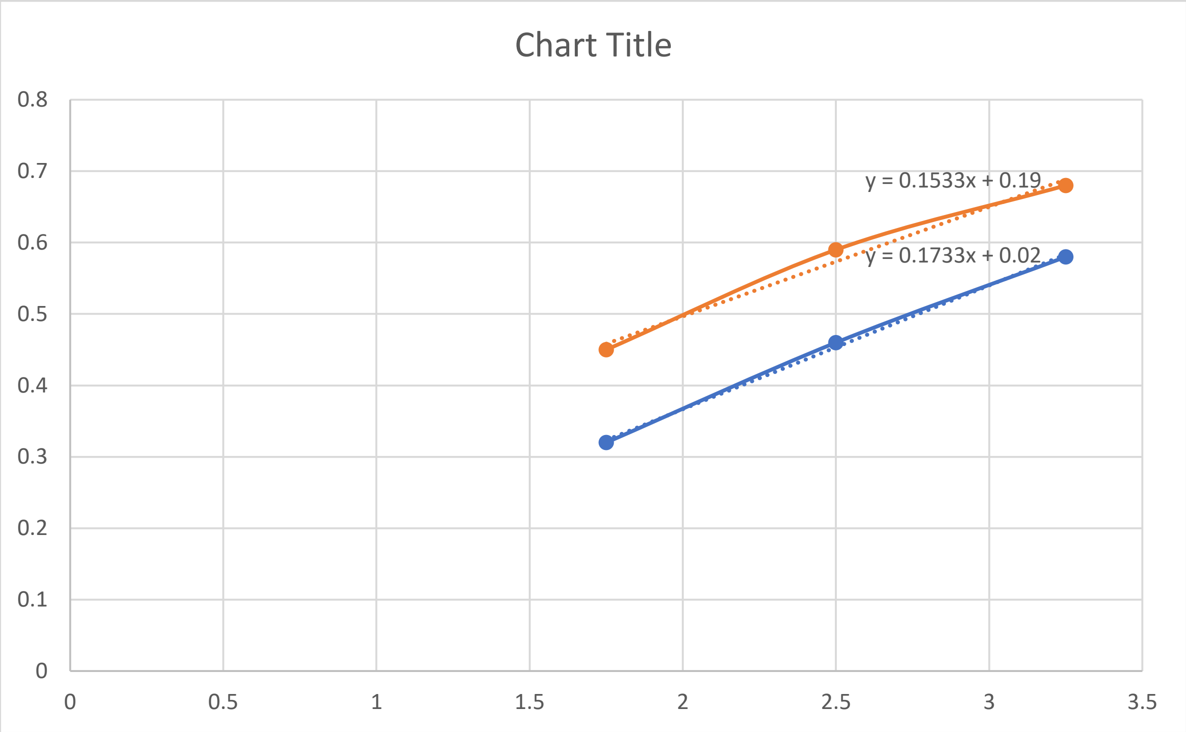
Fig 4 gives relationship between shear stress and normal stress for both clean and unclean soil samples.

Figure 4: Plot between the normal stress and shear stress of the soil samples



The cohesion is found to be 0.02 Kg/cm^2 from general values discussion our soil is found to be loamy sand, sandy silt, silty clay. Angle of Internal friction came to be around to be 9 degrees for the unclean soil. Where as for the clean soil sample cohesion as found to be 0.19 Kg/cm^2 and angle of internal friction to be 8 degrees.

7. Conclusion

The above-mentioned experiments were conducted on the soil samples to determine the characteristics of soil. We have arrived to the following based on the experimental work on municipal solid waste collected from the Shogi dumping yard, Solan.

- The specific gravity of the samples is slightly lower than that of the control sample showing the presence of organic content in the soil.

- Dumping has caused the compaction curves to shift towards the right (i.e) maximum dry density increased with the increase in optimum moisture content. Also, the clean sample shows higher dry density than the sample at optimum moisture content.

- The coefficient of permeability of the contaminated soil has higher value than that of uncontaminated soil. These results somehow contradict the fact that the contaminated soil has less fine soil particles are loosely arranged. The high value recorded for contaminated soil samples than clean sample maybe due to the pseudo-cohesion, because of the leachate action from the decomposing Municipal Solid Waste(MSW).

8. References

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