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Influence of bottom ash as stabilizing agent on Contaminated Soil

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Abstract: *Waste is a heterogeneous combination of organic and inorganic constituents. Management and disposal of such waste is a complex problem in most of the developing and developed countries. Improper methods of waste disposal may lead to major issues such as pollution of land on which it is disposed, creates health hazards in people living in the vicinity of the dumpsite, contamination of ground water, streams, rivers and other aqua bodies. With the development and expansion of the cities the waste lands and dump yards are acquired for construction of various structures. Construction on a dump site is a challenge, as the disposal of waste deteriorates the strength and stability parameters of the soil. In order to undertake construction on such a site, the soil has to be first tested for the geotechnical properties. Suitable stabilisation method has to be undertaken to improve the strength of the dumpsite soil.*

Background*: Dealing with solid waste is an issue of concern now-a-days all over the world. Due to population explosion and development of cities at a rapid rate, there is large generation of solid waste and hence there is a need for solid waste management to maintain a healthy environment. Municipal waste consists of both organic and inorganic substances which may affect the environment directly and indirectly. Dumping of waste in unscientific manner leads to lots of issues such as ill health of habitant in the surrounding of the dumping, soil pollution, ground water contamination, break out of epidemic diseases. Present study is on the harmful effects on the properties of soil in landfill areas and its stabilization. Presently, samples are collected from accumulated waste of Bangalore, dumped at Seegehalli Bangalore, Karnataka*

Materials and Methods*: The main idea is to compare index, engineering and chemical properties of soil obtained at different places and different depths in dump site and improve the properties of contaminated soil using Bottom ash as an admixture. Impact of Bottom ash on contaminated soil on addition of 10%, 15%, 20%by weight of soil. Change in soil properties is observed.*

Results*: Soil strength characteristics trend to increase with 20% of Bottom ash for direct shear test, and unconfined compressive strength. Compaction characteristics are improved. Atterberg limits show desirable change with decrease in liquid and plastic limit, further, with 20 % of Bottom ash stabilization, permeability characteristics show. The alkalinity, BOD and COD of contaminated soil is high.*

Conclusion: *present investigation revels strength and stability parameters show increase in values, which is desirable change after addition of bottom ash as stabilizing agent for contaminated soil. It can be concluded that bottom ash can be considered as a potential low-cost stabilizing agent for contaminated soil.*

Key Word*: Contaminated soil; landfill; dumpsite; Bottom ash; soil pollution; stabilization.*

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I. Introduction

Soil contamination is a matter of concern in developed and developing nations. Segregation of waste and its disposal in a proper way is still a challenge in many parts of world. Desirable properties of soil are altered due to leachate and soil contamination, such undesirable alteration of soil properties may lead to catastrophic failure of structures. Quality of soil is found to be substandard in vicinity of Landfills, sanitary landfills, biomedical waste treatment, incineration yards. Effects of soil contamination on strength and stability analysis are carried out by researchers since 25 years. Research works associated with improved equipment on field level has made it practical and feasible to stabilize contaminated soil. Soil stabilization is a better option for a Asian subcontinent, tropical country like India where soil washing, soil steaming, chemical washing, is not feasible.

In the Present study the harmful effects on the properties of soil in landfill areas is studied and it's stabilized with bottom ash. Samples are collected from landfill site, and attempts have been made to stabilize it with bottom ash in proportion in 10%, 15% and 20% by weight. Bottom ash is an industrial waste from combustion of coal. It is aimed to stabilize contaminated soil with a waste material i.e. bottom ash. Impact of bottom ash on index properties, permeability, and shears strength is analyzed, which shows considerable improvement towards desirable properties. Use of bottom ash for stabilization of soil makes it cost effective and eco-friendly. Bottom ash is a hazardous material which needs to be disposed in systematic manner.

II. Material And Methods

2.1Contaminated soil:

Samples are collected from accumulated waste of Bangalore, dumped at Seegehallinear Kanahallisite, located in North Bangalore; Karnataka India. Materials from the landfill site were collected from different locations and at different depths Excavation was undertaken just below the landfill area. Contaminated soil was found up to a depth of 0.8m, below it was sand layer up to a depth of 0.3m and the bottom most part was found to be rock, 1.4m below the ground surface index, engineering and chemical properties are given in table 1,2.

Table 1 Index, engineering properties of contaminated soil

Parameter	Values
Natural Moisture Content (%)	18.5
Specific Gravity (g /cc)	1.72
Atterberg limits:	
Liquid Limit (%)	42
Plastic Limit (%)	27
Plasticity Index (%)	15
Flow Index	11.4
Toughness Index	1.31
I.S. classification	MI & SM-SC
Compaction characteristics:	
OMC (%)	17
MDD (kN/m3)	22.1
Permeability Test:	
Constant head method, K (Cm/s)	$3.9X10^{-4}$
Variable head method, K (Cm/s)	$3.78X10^{-4}$
Direct shear test:	
C (kN/m2)	12
ϕ (^{o})	20
Unconfined compressive strength test	
qu (kN/m2)	7.45
Cu (kN/m2)	3.98

Table 2 Chemical properties of contaminated soil

Parameter	values
pH value	7.05 at 24 ^{o}C
Cl %	0.006
Alkalinity, CaCO3 in ppm	19.2
BOD (at 27°C for 4 days)	8.0
Chemical Oxygen Demand	57.2

2.2Bottom ash:

Bottom ash is an incombustible by-product obtained during combustion of coal, in the form of industrial waste. Chemical properties are given in table 3.

Table 3 Chemical properties of bottom ash

Chemical composition	Bottom Ash (%)
SiO_2	54.4
Al_2O_3	28.8
Fe_2O_3	8.52
TiO_2	2.75
MgO	0.44
CaO	4.29
Na_2O	0.10
K_2O	0.55
P_2O_5	0.3
SO3	--

Cl	--
LOI at 1000°C	2.52

2.3 Methodology

Optimum moisture content and Maximum dry density using light compaction

The mould along with base plate is weighed to nearest 1gm. Collar is fixed to the mould. Soil placed in mould is compacted in 3 layers, 25 blows per layer, using a 2.6kg rammer dropping from a height of 310mm. Extension is removed and compacted soil is leveled. Mould containing compacted soil is weighed. Soil is taken from mould and a representative sample kept in oven to determine water content.

Unconfined compressive strength

165gm of soil passing 425µ sieve is taken. It is mixed with water at optimum moisture content. Soil was filled in layers in the mould. Sample dimensions after removing it from mould was 3.8cm diameter and 7.6cm height. The sample was placed in CTM and the readings were noted down. Compressive stress v/s strain is plotted and UCS of soil was found out.

Direct shear test

165gm of soil sample passing 2.36mm sieve is taken. Water at OMC is mixed. Soil is filled in layers into the direct shear box. Load is applied vertically to soil sample which is in the shear mould, different loading conditions were employed and the sample was sheared horizontally and load at which failure occurs is recorded. Graph is plotted and shear parameters are determined.

Permeability tests

Soil sample is filled in the apparatus at specific density and moisture content. By using an adequate connection, overhead tank is connected with inflow. Water is allowed to flow into permeameter and when constant flow is established and entrapped air is eliminated, discharge is measured at a given time. Co-efficient of permeability K was determined using appropriate formula.

III. Result

Table 3.1 Shows Contaminated soil sample test results:

Parameter	Result
Observation	Light brownish color soil
pH value	7.05 at 24 °C
Cl %	0.006
Alkalinity, $CaCO_3$ in ppm	19.2
BOD (at 27°C for 4 days)	8.0
Chemical Oxygen Demand	57.2

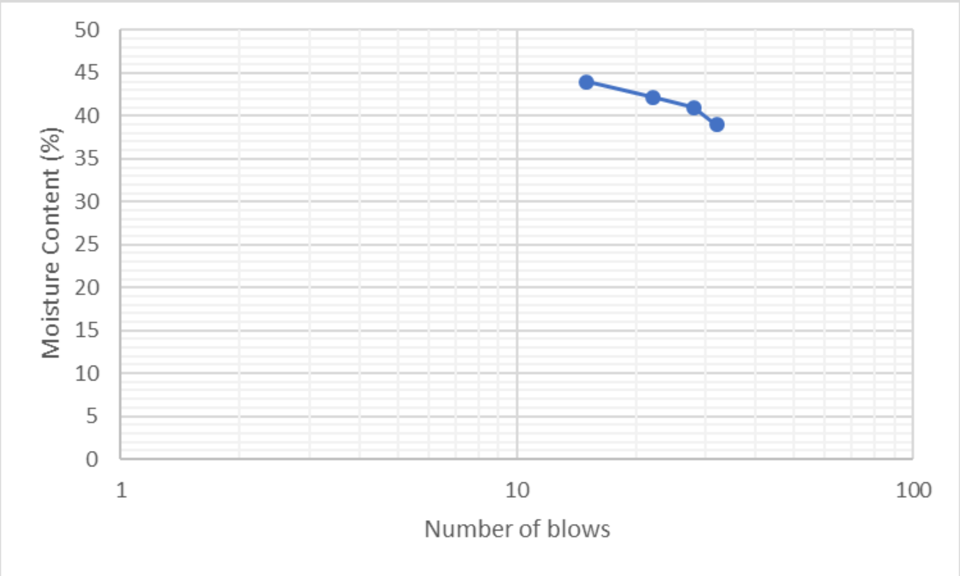

Fig 1. Liquid limit of contaminated and uncontaminated soil

Table 3.2 Shows Liquid limit and Plastic limit of soil sample

Description	Contaminated soil
Liquid Limit (%)	42
Plastic Limit (%)	27
Plasticity Index (%)	15
Flow Index (%)	11.4
Toughness Index	1.31

Table 3.3 Liquid limit for various % of Bottom ash

Liquid limit %	Bottom ash %
0	42.6
10	38.8
15	37.5
20	36.2

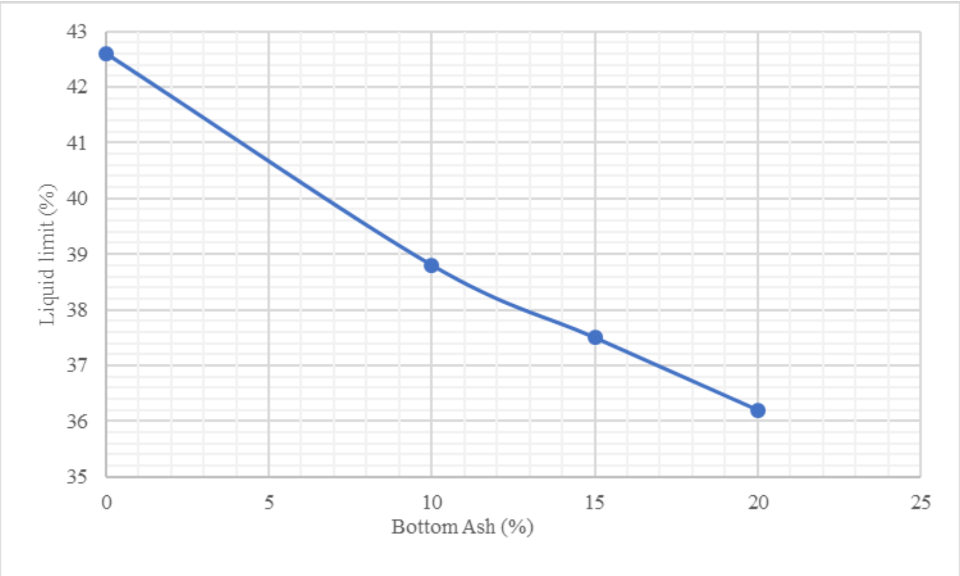

Fig 2 Liquid limit of stabilized soil

Table 3.4 Plastic limit for various % of Bottom ash

Plastic limit %	Bottom ash %
0	27

10	24.2
15	23
20	22.4

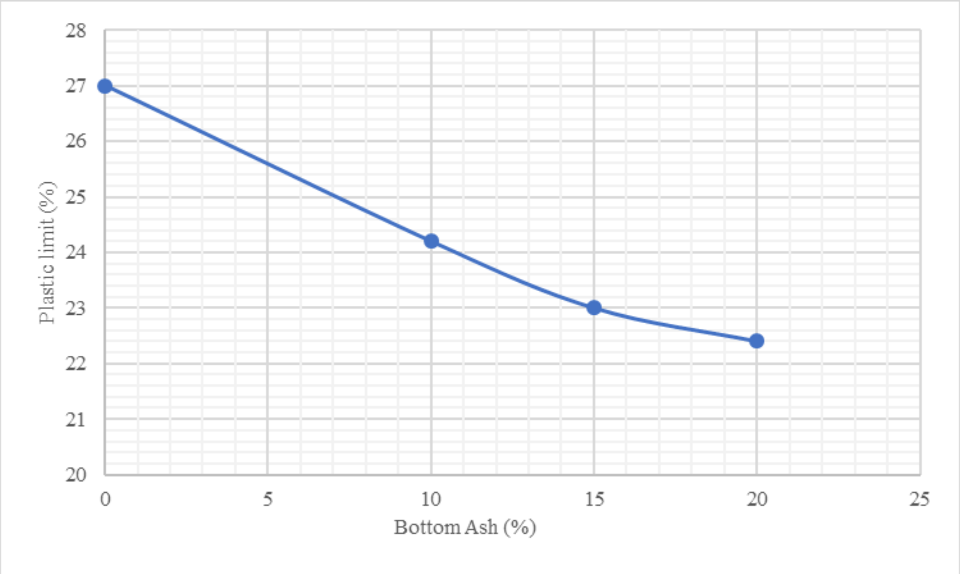

Fig 3 Plastic limit of stabilized soil

Table 3.5 Moisture content values of contaminated soil

Moisture content %	Contaminated soil
4	15.4
8	17.6
12	19.3
16	22
20	18.2

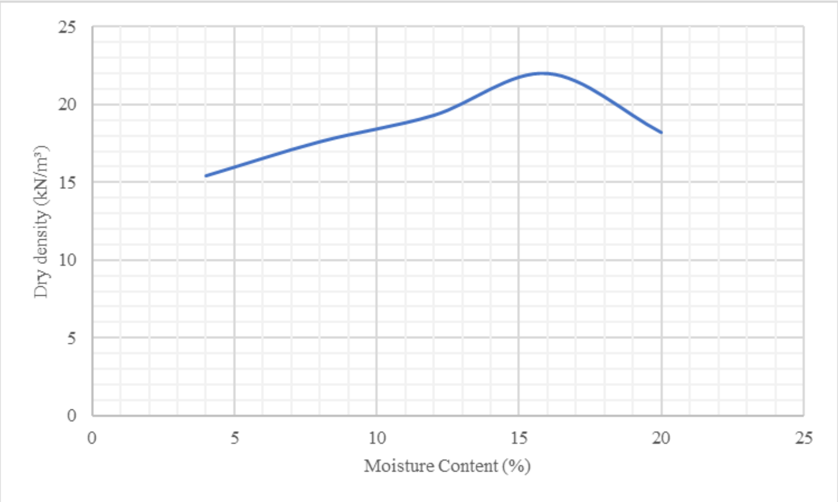

Fig 4 Compaction curve of contaminated soil sample.

Table 3.5 Values of OMC and MDD of contaminated soil

Type of sample	OMC (%)	MDD (kN/m3)
Contaminated soil	17	22.1

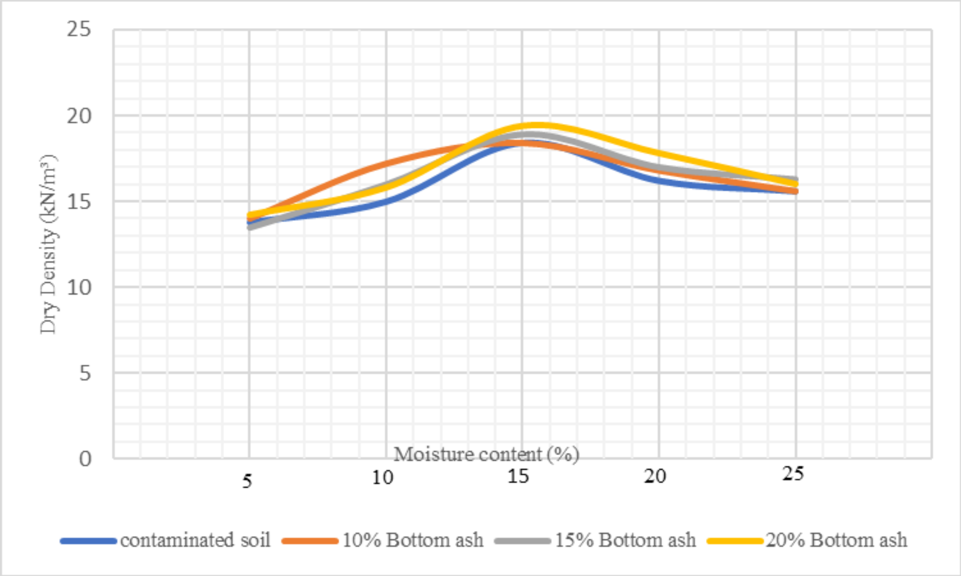

Fig 5 Compaction curves for different percentages of Bottom ash

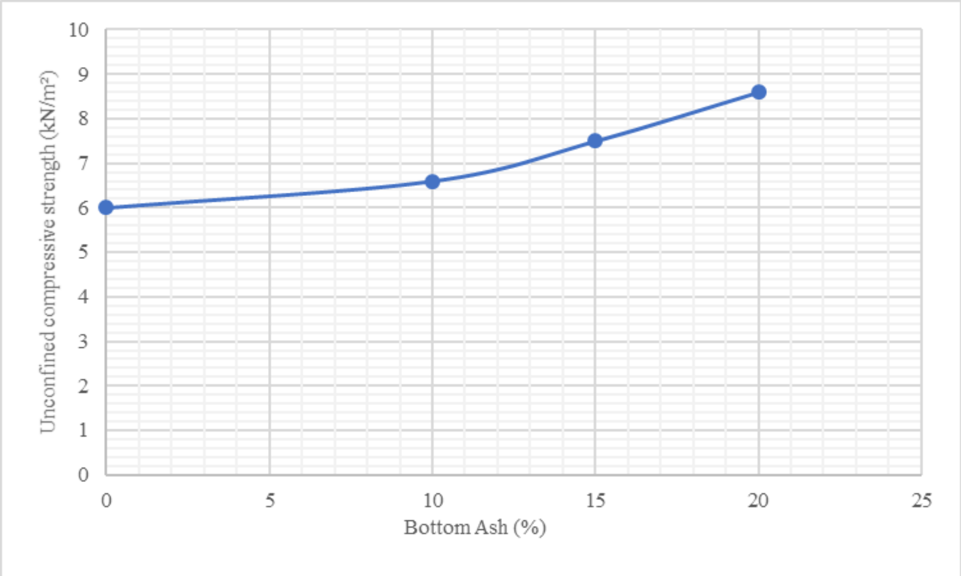

Fig 6 Variation of UCS for different percentages of Bottom ash

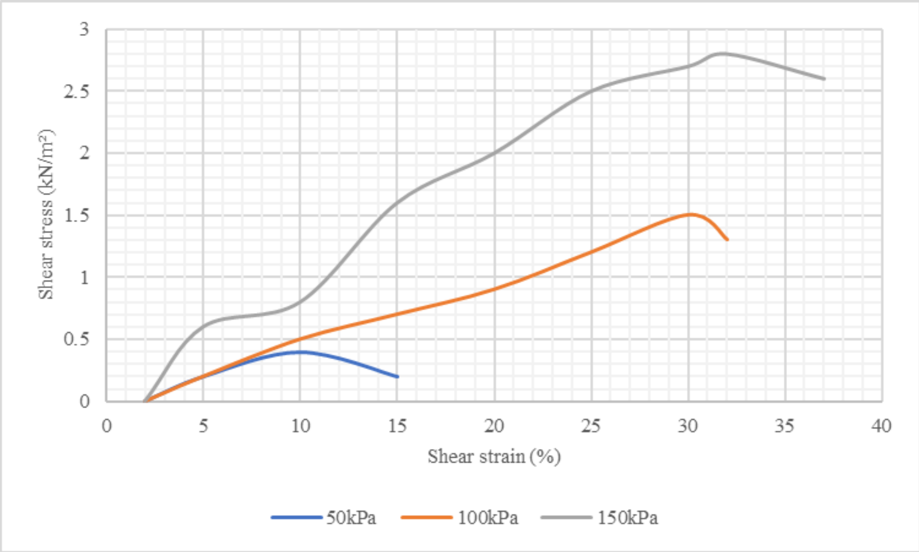

Fig 7 Shear stress v/s shear strain for contaminated soil sample

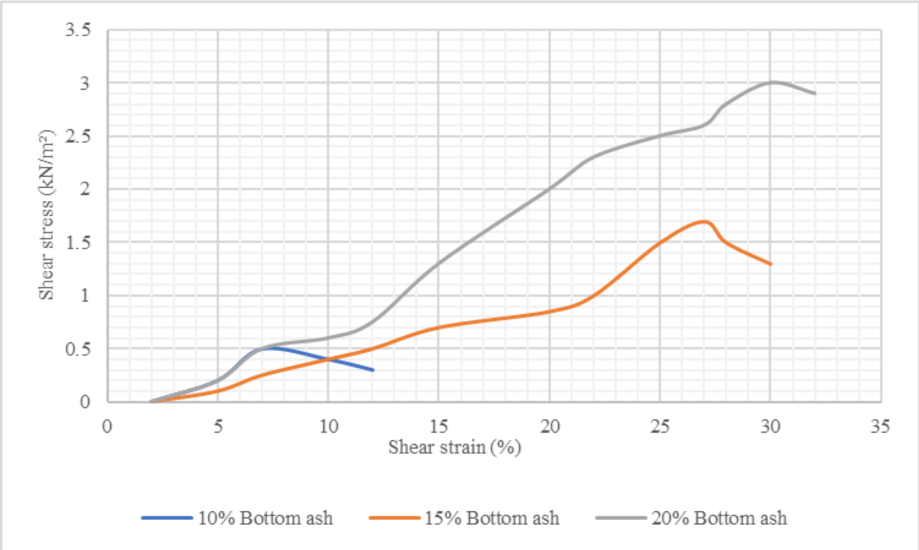

Fig 8 Shear stress v/s shear strain at normal stress of 50kPa

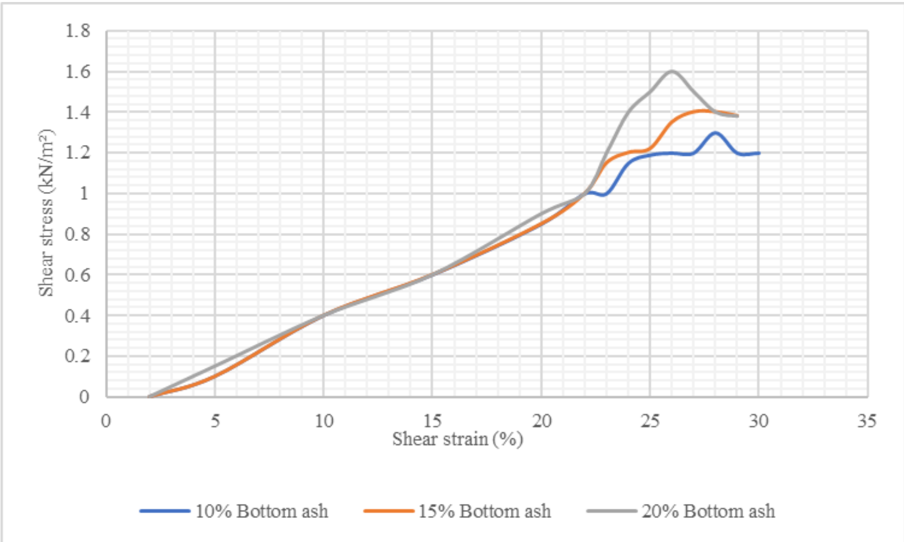

Fig 9 Shear stress v/s shear strain at normal stress of 100kPa

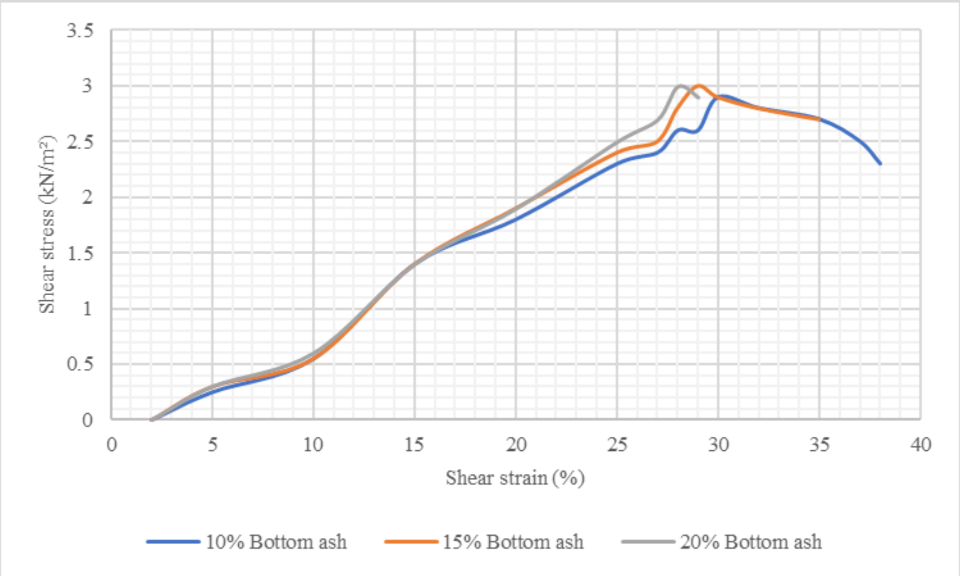

Fig 10 Shear stress v/s shear strain at normal stress of 150kPa

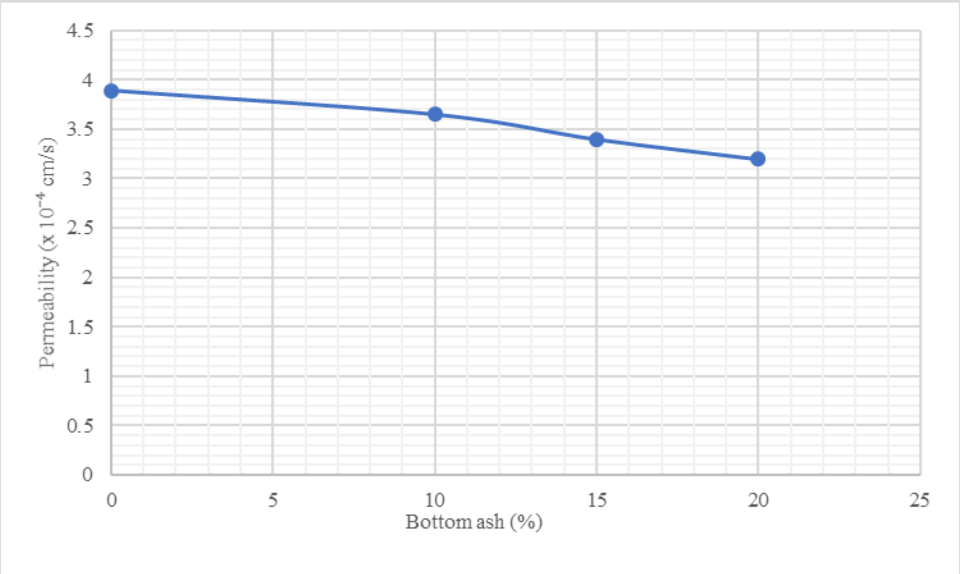

Fig 11 Variation in co-efficient of permeability for different % of Bottom ash

Table 3.6 Overall values after stabilization

Description	**Contaminated Soil**	**Soil +10% Bottom ash**	**Soil + 15% Bottom ash**	**Soil +20% Bottom ash**
Liquid limit (%)	42	38.8	37.6	36.4
Plastic Limit (%)	27	24.2	23	22.4
Plasticity Index (%)	15	14.6	14.6	14
Flow Index (%)	11.4	10.2	9.8	9.5
Toughness Index	1.31	1.43	1.48	1.56
From Plasticity Chart	MI	MI	MI	MI
Compaction Test				
OMC (%)	17	15.2	14.4	13.8
MDD (kN/m^3)	22.1	18.4	19	19.8
Permeability Test				
Constant head method, K (cm/s)	3.9 X 10^{-4}	3.65 X 10^{-4}	3.45 X 10^{-4}	3.3 X 10^{-4}
Variable head method, K (cm/s)	3.78 X 10^{-4}	3.55 X 10^{-4}	3.4 X 10^{-4}	3.26 X 10^{-4}
Direct shear test				

C (kN/m^2)	12	11.8	13.2	14
ϕ (°)	20	22	23	25
Unconfined compressive strength test				
qu (kN/m^2)	7.45	7.8	8.32	8.64
Cu (kN/m^2)	3.98	4.32	4.57	4.89

IV. Discussion

As per graph, we see that liquid limit decreases from 42.5% to 36.4% with increasing percentages of Bottom ash. Liquid limit is least when 20% Bottom ash is mixed with the contaminated soil sample.

From the graph, its seen that plastic limit is decreasing from 27% to 22.4% with increasing percentage of Bottom ash. Plastic limit is least when 20% Bottom ash is mixed with the contaminated soil sample.

The compaction curve shows OMC of contaminated sample as 17% and MDD is 22.1kN/m3. From the curves we can see that as % of Bottom ash increases, MDD increases and OMC decreases. OMC obtained on addition of 20% Bottom ash is 16.5% and MDD is 19.8 kN/m3.

As Bottom ash percentage is increased, the UCS also increases. UCS at 20% Bottom ash is the highest, i.e. 8.7 kN/m2. Constant head permeability and variable head permeability tests were conducted to find the K value of soils. The results indicated that the co-efficient of permeability decreased from 3.9 x10ˉ4 cm/s to 3.3 x 10^{-4}cm/s with increase in % of Bottom ash.

V. Conclusion

pH is nearly same for both contaminated and uncontaminated soil samples. The alkalinity, BOD and COD of contaminated soil is high. Cl % in uncontaminated soil is greater than contaminated soil. Liquid limit and plastic limit were least when 20% Bottom ash is the ratio for stabilization with soil. Soil strength characteristics trend to increase as % of Bottom ash increased from the direct shear test, and unconfined compressive strength.

References

[1]. Ayininuola G M (2014), "Decomposed soil waste impact on soil shear strength and California bearing ratio". IOSR journal of mechanical and civil engineering, volume 11, issue 3, version 7 (may – june 2014).

[2]. Beena K S et al (2011), "Geotechnical characteristics of leachate – contaminated lateritic soil". Proceedings of geotechnical conference, December 15-17,2011, Kochi.

[3]. Chen et al (1995), "Hydraulic conductivity of compacted municipal solid waste, Bioresources technology, vol.51.

[4]. Dr.Krishna M K et al (2016), "Effect of MSW leachate on the quality of soil", International journal of engineering science invention, volume 5, issue 6, june 2016.

[5]. Dr.Solly George et al (2015), "Study on geotechnical properties of diesel oil contaminated soil". International journal of civil and structural engineering research ISSN 2348-7607, volume 2, issue 2, october 2014 – march 2015.

[6]. Dr.Timothy A Adedokun et al (2013), "Geotechnical evaluation of municipal solid waste as an alternate material for land filling". International journal of emerging technology and advanced engineering, volume 3, special issue 4, October 2013.

[7]. Harris M R R (1979), "Geotechnical characteristics of landfilled domestic refuse", The engineering behaviour of industrial and urban fill, held at university of Birmingham, England.

[8]. Korman et al (1987), "Material properties of landfilled primary waste", Environmental conference, april 1987.

[9]. Krishna R Reddy et al (2008), "Compressibility and shear strength of municipal solid waste under short term leachate recirculation operations". Waste management and research 2009:27: 578-587.

[10]. Krishna R Reddy et al (2009), "Geotechnical properties of fresh municipal solid waste at orchard hills landfill, USA". Waste management 29(2009) 952-959.

[11]. Krishna R Reddy et al (2011), "Geotechnical properties on municipal solid waste at different phases of degradation". Waste management 31(2011) 2275-2286.

[12]. Krishna R Reddy et al (2015), "Effect of degradation on geotechnical properties on municipal solid waste from orchard hills landfill, USA". International Journal of geosynthetics and ground engineering (2015) 1:24.

[13]. Musa alhassan (2012), "Effect of municipal solid waste on geotechnical properties of soils". International journal environmental science, management and engineering research volume 1(5), September – October 2012.

[14]. Naveen B P et al (2014), "Compressibility and shear strength of dumped Municipal Solid Waste". Journal of solid waste technology and management, volume 40, no.4, November 2014.

[15]. Olukorede M Osuolale et al (2012), "Effect of pH on geotechnical properties of laterite soil used in highway pavement construction". ISSN 2222-1719, volume 2, no.10, 2012.

[16]. Powrie et al (1995), "Factors affecting hydraulic conductivity of waste", International workshop, LIRIGM Grenoble university of France.

[17]. Rakesh kumarpandey et al (2015), "Physical characterization and geotechnical properties of Municipal Solid Waste". IOSR journal of mechanical and civil engineering, 2278- 1684, volume 12, issue 1, version 2 (January – February 2015).

[18]. Ramakrishnegowda C et al (2011), "Impact of municipal solid waste disposal on geotechnical properties of soil". Proceedings of Indian geotechnical conference, December 15-17, 2011, Kochi.

[19]. Shivaraju R (2016), "Impact of municipal solid waste disposal on compaction characteristics and strength of red soil". Journal of civil engineering and architecture 10(2016) 1168-1172.

[20]. Sivapullaiah P V (2009), "Effects of soil pollution on geotechnical behavior of soils". IGC 2009, Guntur, India.

[21]. Srutipillai et al (2014) , "Soil pollution near a municipal solid waste disposal site in India". International conference on biological, civil and environmental engineering (BCEE-2014) March 17-18, 2014 Dubai (UAE).