Geotechnical study of behaviour of high concentration settled ash slurry

A PROJECT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

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CERTIFICATE

This is to certify that the thesis entitled, "**Geotechnical Study on the behaviour of High Concentrated settled Ash Slurry**" submitted by **SIDDHARTH**
GIRI &PRIYANATH BAIRAGI in partial fulfilment of the requirements for the award of Bachelor of Technology Degree in Civil Engineering at the National Institute of Technology, Rourkela is an authentic work carried out by them under my supervision and guidance.

To the best of my knowledge, the matter embodied in the thesis has not been submitted to any other University/ Institute for the award of any Degree or Diploma.

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ABSTRACT

Electric power generation in India increases to several times in last fifty years the major chunk of power came from the coal based thermal power industries by burning of coal. As result huge quantities of coal ash is produced from the thermal industries. Only little percentage is used for the various productions like cement, bricks, mass concreting and road construction. Rest major portion are lying as a land fill called ash ponds being discharged in the slurry. Traditional ash slurry disposal system like lean slurry disposal pose lot many problems regarding to stability seepage etc. endangering to the stability of thermal power plant. Recently high concentrated ash disposal (HCSD) system is being introduced in some of the industries to overcome those problems. The behaviour of this HCSD disposal system and a comparison with lean slurry will enable a detailed insight to the thermal power industries.

The aim of the project is to geotechnical study on the behaviour of high concentrated ash slurry. From Vedanta Jharsuguda Aluminium plant disturbed and undisturbed sample are collected, field test are also conducted. Experiment such as Modified Proctor test, Standard Proctor Test for determining MDD and OMC, Specific Gravity Test, in-situ density Test, permeability Test, along with Variations of Bulk density, water content and dry density with time at field are done in order to determine the geo-engineering properties high concentrated fly ash slurry.

CONTENTS

CHAPTER 1

INTRODUCTION

High concentration fly ash slurry disposal (HCSD) is a recent method of disposing flyash produced from thermal power plants as obtained by burning of coal. This disposal being prevalent in most of the thermal power industries. This HCSD system is veryexpensive with initial capital investment as well as running maintenance cost. Apartfrom it has some added advantage as compared to traditional lean slurry disposalsystem. In this project, the geotechnical aspects of this advantage will be explored.The laboratory and field study on the geotechnical parameters of HCSD will be done.A comparison of both the methods will be made.

CHAPTER 2

LITERATURE REVIEW

About Flyash

Fly ash disposal is a very environmental sensitive topic in the thermal power plants. Currently India is generating more than 100 million tonnes of coal ash. Fly ash and bottom ash are being mixed together and transported hydraulically to ash ponds. As the properties of fly ash and bottom ash are widely different, their end uses are different. Fly ash is relatively finer as compare to bottom ash, which is extremely coarse. Coal ash is being produced in large quantities at various thermal power plants across the world. Fly ash has to be gainfully utilized and transported as well as stored in an environmentally safe mode. Fly ash is displaced from various locations either hydraulically or pneumatically. Ash is transported to a buffer silo from where it can be given out for utilization, in the Pneumatic method, where as in the hydraulic method ash is transported to a common sump. Centrifugal slurry pumps are used to transport the ash slurry to ash pond. The concentration of ash in the slurry is very low In most of the Thermal power plants, and is of the order of 10-15% by weight. Basically same disposal system is used both for bottom ash as well as fly ash

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TYPES OF ASH GENERATED IN THERMAL POWER PLANTS

Bottom Ash:

This is the ash that gets collected at the ash hoppers in the bottom of the boilers.

They are in the form of lumps and are generally crushed into a coarse form.

Fly ash

These are the finer particles of ash carried away with the flue gases. They get collected at several locations like economiser, air pre-heater, mechanical dust collector,electro-static precipitators (ESP) and chimney. Fly ash is a very fine powder with maximum particle size being of the order of 100 microns.Out of the total ash produced in any thermal power plant approximately 15 –20% is bottom ash and the rest is fly ash.

METHODS OF FLY ASH TRANSPORTATION FROM PLANT TO DISPOSAL AREA:

It classified into two categories:
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1. Low Concentration Slurry Disposal (LCSD) (10%to 30%)
2. High Concentration Slurry Disposal (HCSD) (60% to 70%)

High Concentration Slurry Disposal (HCSD)

The Ash Concentration is in the range 60% by volume.

Reciprocating/ Diaphragm/ progressive cavity etc. are used for transportation.

Extensively not used in India.

Advantages of HCSD System.

Less water consumption, when matched with lean slurry system.

Almost dry disposal system.

No return water system is prerequisite.

Needs less disposal area due to dry piling.

Negates water pollution correlated problem, as it is dry form of disposal.

Stop pollution -Ash solidifies, thus stops ash from flying.

Easy drainage of rainwater.

Does not require Big Ash dyke

No pollution in transporting, as flows through pipeline.

Power consumption is less.

Effectively used in mines void filling and land filling, does not require spreading.

Less wear in pipe.

CHAPTER 3

EXPERIMENTAL SETUP

& PROCEDURES

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3.1 In-situ density Test

Undisturbed fly ash sample is collected from different position of the ash pond with the help of Core cutter of 10 cm internal diameter and 12.5 cm of height each. Before use of core cutter, it is internally greased thoroughly and weight of empty core cutter is measured. Then the weight of core cutter containing undisturbed sample of fly ash is measured. Volume of core cutter is calculated and weight of fly ash is calculated which is got by subtracting weight of empty core cutter from weight of core cutter sample containing fly ash. Then In-situ density is calculated which is the ratio between the weight of the fly ash to the volume of the core cutter.

$\rho = M/V$ g/cm^3

$\rho_d = \rho / (1+W)$ g/cm^3

Where,

ρ =Bulk density of soil (g/cm^3)

ρ_d =Dry density of soil (g/cm^3)

M = mass of wet compacted mould (g)

W = water content ratio.

V= volume of the mould (1000 ml).

3.2 Standard proctor test. IS 2720(VII):1980

Equipment used

Cylindrical metal mould of capacity 1000 cc, with internal diameter of 10 cm and internal effective height of 12.5 cm fitted with a detachable base and a removal extension (collar) of 6 cm height, Metal rammer of weighing 2.6 kg, 5 cm diameter circular face and having drop of 31 cm, Sieves of 20 mm and 4.75 mm, balances, oven, water content containers, mixing equipment, measuring cylinder of glass.

Procedure

At first a clean mould is taken and fixed it to the base. The empty mass of the mould and the base is measured. Then collar is attached to the mould after greasing inside of the mould thoroughly. Then taking out about 2.5 kg of fly ash which is mixed with water of 10% of fly Ash thoroughly and compacted in the mould in three equal layers, each layer being given 25 numbers of uniformly distributed blows over the surface of each layer from the rammer Weighing 2.6 kg dropping from a height of 31 cm.Then the collar removed and the excess fly ash is cut out with the help of a straight edge. The weight of the mould is then measured. The fly ash is ejected out from the mould. From the middle of the mould representative fly ash is kept for water content determination. The above procedure is repeated about five to six times, using a fresh part of the fly ash specimen after adding higher water than the preceding.

$\rho = M/V$ g/cm^3

$\rho_d = \rho / (1+W)$ g/cm^3

Where,

ρ =Bulk density of soil (g/cm^3)

ρ_d =Dry density of soil (g/cm^3)

M= mass of wet compacted mould (g)

W= water content ratio.

V= volume of the mould (1000 ml).

3.3 Modified proctor's Test

IS 2720(VII):1980

Equipment used

Cylindrical metal mould of capacity 1000 cc, with internal diameter of 10 cm and internaleffective height of 12.5 cm fitted with a detachable base and a removal extension (collar) of 6 cm height, Metal rammer of weighing 4.9 kg, 5 cm diameter circular face and having drop of 45 cm, Sieves of 20 mm and 4.75 mm, balances, oven, water content containers, mixing equipment, measuring cylinder of glass.

Procedure

At first a clean mould is taken and fixed it to the base. The empty mass of the mould and the base is measured. Then collar is attached to the mould after greasing inside of the mould thoroughly. Then taking out about 2.5 kg of fly ash which is mixed with water of 10% of fly ash thoroughly and compacted in the mould in five equal layers, each layer being given 25 numbers of uniformly distributed blows over the surface of each layer from the rammer weighing 4.9 kg dropping from a height of 45 cm. Then the collar removed and the excess fly ash is cut out with the help of a straight edge. The weight of the mould is then measured. The fly ash is ejected out from the mould. From the middle of the mould representative fly ash is kept for water content determination. The above procedure is repeated about five to six times, using a fresh part of the fly ash specimen after adding higher water than the preceding.

$$\rho = M/V \text{ g/cm}^3$$

$$\rho_d = \rho / (1+W) \text{ g/cm}^3$$

Where,

ρ =Bulk density of soil (g/cm^3)

ρ_d =Dry density of soil (g/cm^3)

M= mass of wet compacted mould (g)

W= water content ratio.

V= volume of the mould (1000 ml).

3.4 Specific Gravity Test

IS: 2720(part-III/sec-I) 1980

Specific gravity is defined as the ratio of the weight in air of a given volume of a sample at a stated temperature to the weight in air of an equal volume of distilled water at a definite temperature.

At first four no. of pycnometers is taken,cleans it with dry cloth and kept in oven for drying.

The mass (M_1) of the pycnometer is measured.The mass (M_4) of the pcynometers with water is measured and cleans it with dry cloth and kept in oven for further drying. 50 g of oven dried fly ash is taken in each bottle mass of bottle with fly ash is measured (M_2), then water is added up to the mark and mass is taken (M_3).

$G = (M_2-M_1)/ (M_2-M_1) - (M_3-M_4)$

All the masses are in gram, g.

M_1= Mass of bottle

M_2= Mass of bottle + fly ash

M_3=Mass of bottle + fly ash + water

M_4=Mass of bottle + water

G=Specific gravity

3.5 PERMEABILITY TEST ON UNDISTURBED SAMPLE (CONSTANT HEAD)
IS 2720(XVII):1986

The use of this test is to determine the permeability of fly ash by the constant head test method. The undisturbed sample is direct moved from core cutter to the permeameter without disturbing the sample with hammer and plate. Water pipe is attached to it at a constant head. Experiment is repeated for four samples. Permeability denotes the ease with which water can flow through a soil. This property is necessary for the design earth dams or under sheet pile walls, the calculation of the seepage rate from waste storage facilities.

Calculation of permeability,

K_T = VL/Aht

Where:

K_T = coefficient of permeability at temperature T, cm/sec.

L = length of specimen (cm)

t = time for discharge (seconds)

Q = volume of discharge (cm3, assume 1 ml = 1 cm3)

A = cross-sectional area of permeameter –

D= inside diameter of the permeameter)

h = hydraulic head difference across length L, in cm of water.

3.6 Variations of Bulk density, water content and dry density with time at field are done in order to determine the change of moisture content, bulk density and dry density in a course of 48 hours.

Procedure

Three points at different place of the ash pond selected named as A, B, C. Six number of Core cutter are taken and empty weight are noted down and for each point two Core cutters are used. Volume of each core cuter determined. Then undisturbed sample are taken out from each point with help of Core cutter at a time. Then weight of Core cutter containing undisturbed sample for each point are measured, some sample are taken out from core cutter for determination of water content from each point. With the help of empty weight and weight of undisturbed sample containing in core cutter Bulk density is calculated at that time. Sample for water content is collected from core cutter for oven drying. Using water content and bulk density, dry density of each point at a time is calculated. The above procedure is repeated after 2, 6, 18, 24, and 48 hours to calculate bulk density, water content, dry density for every time intervals at each point. After getting Bulk density, dry density, water content for every point at each time intervals, and bulk density-time, water content-time graph is plotted. The bulk density and the resultant dry density for the samples are calculated from theSubsequent relations:

$\rho = M/V$ g/cm^3

$\rho_d = \rho / (1+W)$ g/cm^3

Where,

ρ = Bulk density of soil (g/cm^3)

ρ_d = Dry density of soil (g/cm^3)

M= mass of wet compacted mould (g)

W= water content ratio.

V= volume of the mould (1000 ml).

CHAPTER 4

APPENDIX-I

LIST OF TABLES

TABLE-1: IN-SITU-DENSITY

Mould No.	Mass of ash M (g)	In-situ bulk density γ(gm/cm^3)	Water content w (%)	In-situ dry density γ_d (gm/cm^3)
1	1674	1.421	13.64	1.250
2	1892	1.606	18.09	1.360
3	1782	1.513	17.11	1.292
4	1754	1.489	14.82	1.297

TABLE-2: SPECIFIC GRAVITY TEST

	I	**II**	**III**	**IV**
Mass of bottle (M1) g	106.62	107.09	112.55	94.75
Mass of bottle + fly ash(M2) g	150.03	157.33	162.52	144.56
Mass of bottle+water+flyash(M3) g	378.07	382.71	387.28	370.06
Mass of bottle + Water(M4)g	355.51	356.61	361.78	344.09
Specific Gravity (G)	**2.082**	**2.081**	**2.10**	**2.089**

TABLE-3: PROCTOR TEST 1

Sl.no.	Mass of ash M (g)	Bulk density γ(g/cm^3)	Water content W (%)	Dry density γd (g/cm^3)
1	1405	1.491	16.15	1.284
2	1471	1.561	18.08	1.322
3	1517	1.610	19.30	1.350
4	1577	1.673	20.28	1.391
5	1551	1.646	22.16	1.348
6	1541	1.635	24.34	1.315

TABLE-4: PROCTOR TEST 2:

Sl.no.	Mass of ash M (g)	Bulk density γ (g/cm^3)	Water content W (%)	Dry density γd (gm/cm^3)
1	1380	1.464	14.70	1.276
2	1400	1.485	15.68	1.284
3	1432	1.519	16.15	1.308
4	1448	1.536	16.91	1.314
5	1482	1.572	17.68	1.336
6	1524	1.617	18.43	1.365
7	1540	1.634	18.97	1.373
8	1556	1.651	19.80	1.378
9	1564	1.659	20.56	1.376
10	1556	1.651	21.18	1.362
11	1540	1.634	22.13	1.338

TABLE-5:MODIFIED PROCTOR'S TEST

Sl.no.	Mass of ash M (g)	Bulk density γ (gm/cm^3)	Water content w (%)	Dry density γd (gm/cm^3)
1	1555	1.65	17.4	1.41
2	1634	1.734	18.77	1.460
3	1630	1.729	19.83	1.443
4	1528	1.695	20.08	1.412
5	1596	1.693	20.78	1.402
6	1594	1.691	22.16	1.384
7	1586	1.683	22.91	1.369

TABLE-6: DETERMINATION OF PERMEABILITY OF FLY ASHBY CONSTANT HEAD METHOD.

Test No.	1	2	3	4
Head, h (cm)	202	190	180	196
Length, L (cm)	15	15	15	15
Time, t	600	600	600	600
Quantity of flow, Q (ml)	78.25	56.25	77.33	79.33
Cross-section Area, A (cm$^{2)}$	78.54	78.54	78.54	78.54
Co-efficient of permeability, K cm/sec	1.233×10^{-4}	0.9424×10^{-4}	1.367×10^{-4}	1.288×10^{-4}

TABLE-7: FIELD BULK DENSITY, DRY DENSITY, WATER CONTENT WITH TIME VARIATION.

Site /hour	Bulk density γ (gm/cm^3)	Water content w %	Dry density γ_d (gm/cm^3)
A ,0 hour	1.62	18.4	1.36
	1.60	18.16	1.35
B	1.64	18.24	1.38
	1.65	18.5	1.38
C	1.64	18.9	1.37
	1.63	19.3	1.36
A, 2hour	1.60	17.39	1.36
	1.61	17.32	1.35
B	1.59	17.20	1.35
	1.59	17.33	1.35
C	1.63	18.95	1.37
	1.61	18.6	1.35
A,6hour	1.59	17.25	1.36
	1.60	17.8	1.36
B	1.58	18.04	1.35
	1.59	17.8	1.35
C	1.58	17.5	1.35
	1.59	17.2	1.36
A,18hour	1.56	16.2	1.35
	1.57	16.4	1.35
B	1.59	16.4	1.37
	1.58	16.3	1.36
C	1.56	16.2	1.35
	1.58	16.3	1.36

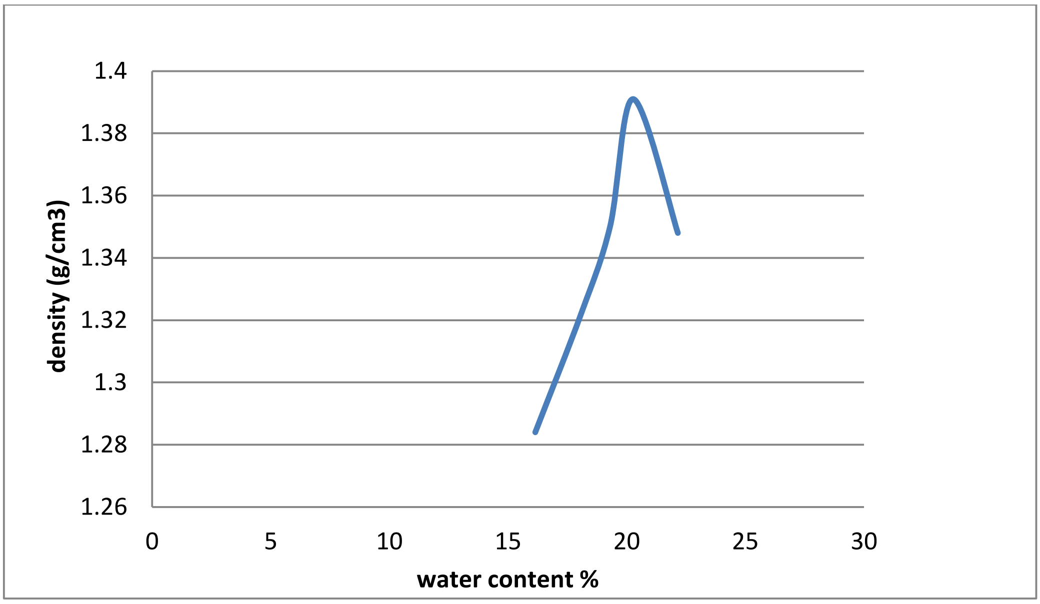
A,24hour	1.48	10.27	1.35
	1.49	10.32	1.36
B	1.48	10.7	1.34
	1.50	10.6	1.36
	1.50	11.01	1.36
A,48hour	1.47	9.60	1.35
	1.46	9.52	1.34
B	1.48	9.33	1.36
	1.47	9.39	1.35
C	1.47	9.58	1.35
	1.47	9.49	1.35

CHAPTER 5

APPENDIX II

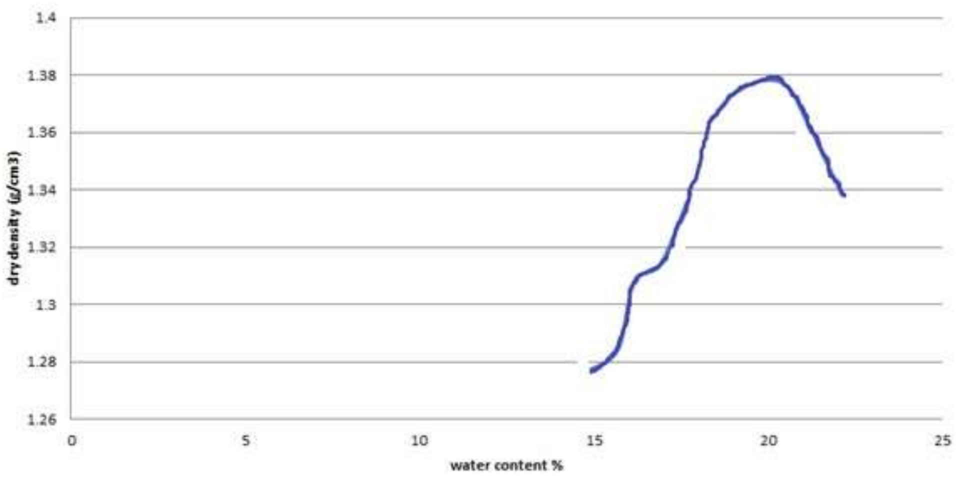
LIST OF FIGURES

FIGURE-1: PROCTOR TEST 1



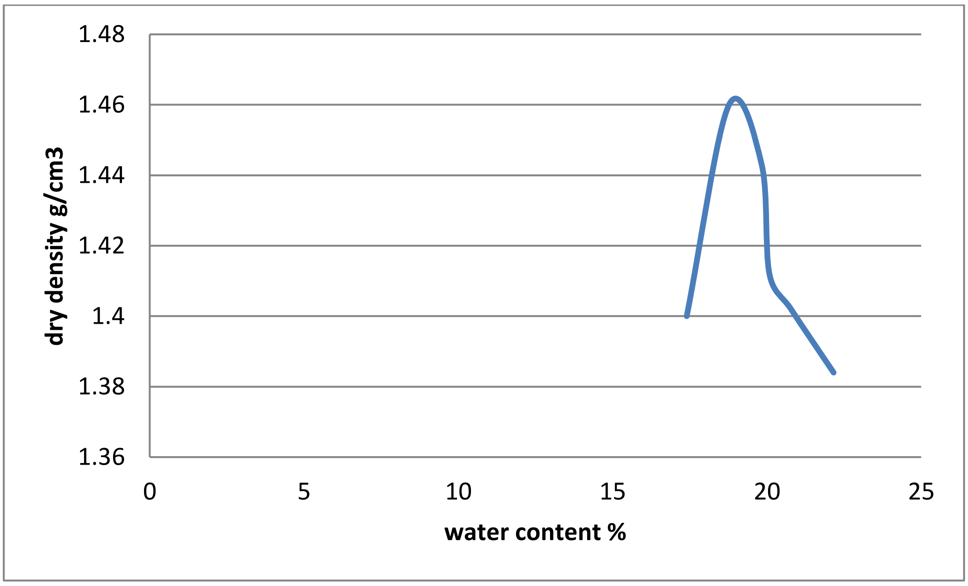
M.D.D=1.39 g/cm^2, O.M.C=20.8%

FIGURE-2:PROCTOR TEST 2



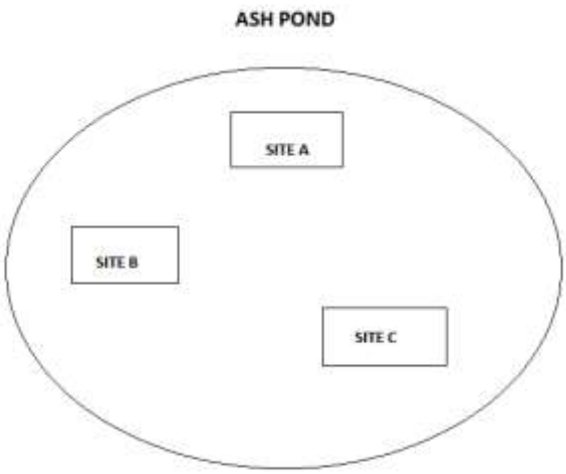
M.D.D=1.37 g/cm^2, O.M.C=19.8%

FIGURE-3: MODIFIED PROCTOR TEST



M.D.D=1.46 g/cm^2, O.M.C=18.44%

FIGURE-4: ASH POND SAMPLE COLLECTION SITE IN TIME VARIATION EXPERIMENT.



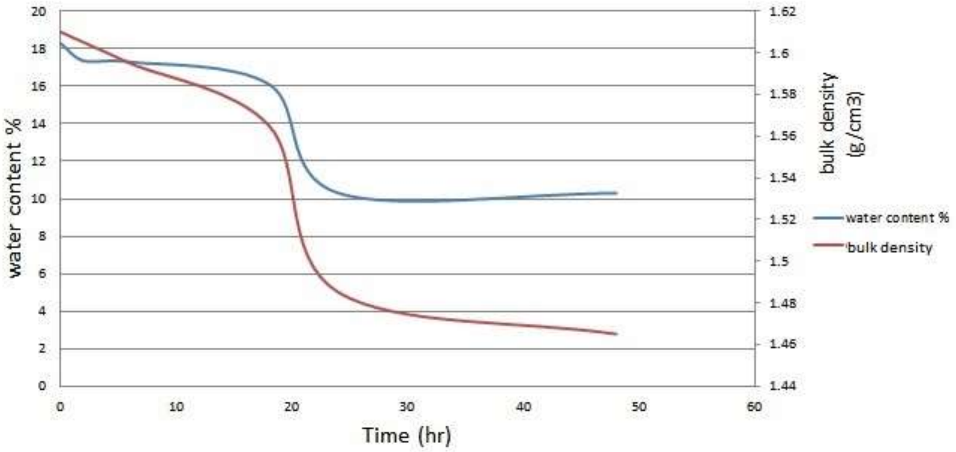


FIGURE-5: FIELD BULK DENSITY, WATER CONTENT WITH TIME VARIATION FOR POINTS A.

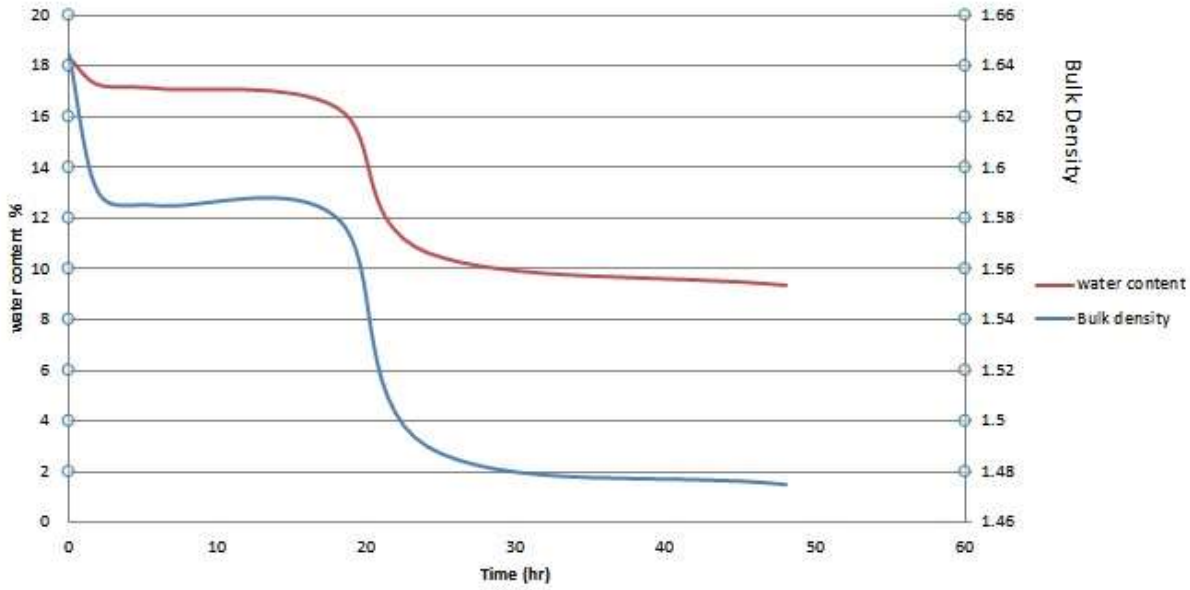


FIGURE-6: FIELD BULK DENSITY, WATER CONTENT WITH TIME VARIATION FOR POINTS B.

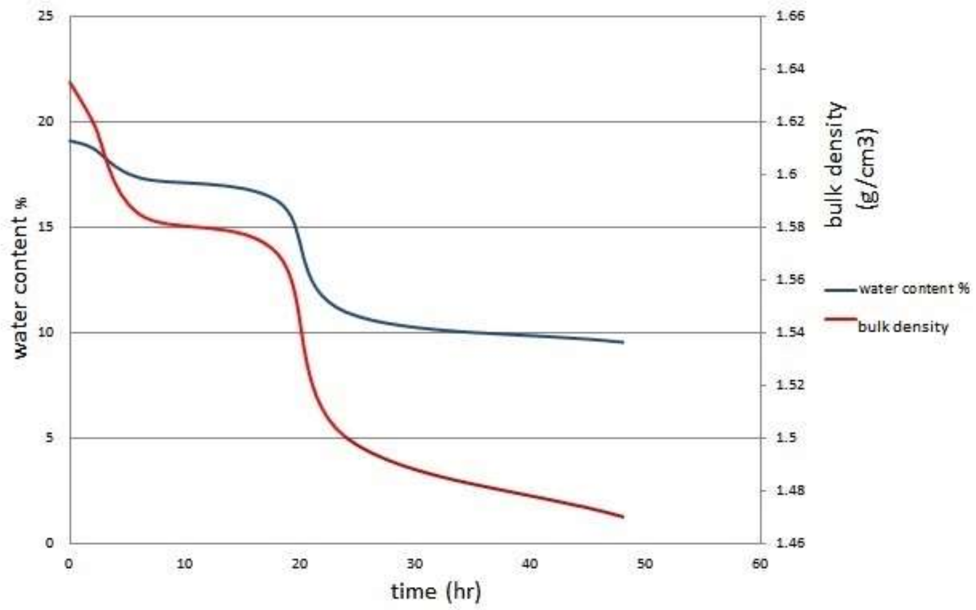


FIGURE-7: FIELD BULK DENSITY, WATER CONTENT WITH TIME VARIATION FOR POINTS C.

CHAPTER 6

RESULTS AND DISCUSSION

Results and Discussion

1. In-situ-density of the fly ash in pond is bulk density 1.5 g/cm^2 and dry density 1.29g/cm^2

2. Maximum dry density (MDD) and corresponding Optimum moisture content (OMC) of the disturbed fly ash collected from the ash pond by Standard proctor compaction test is 1.38 g/cm^2 and 20.04 % respectively.

3. Maximum dry density (MDD) and corresponding Optimum moisture content (OMC) of the disturbed fly ash collected from the ash pond by Modified proctor compaction test is 1.46 g/cm^2 and 18.44% respectively.

4. The specific gravity of fly ash is 2.08.

5. The permeability of fly ash comes to be $1.204*10^{-4}$cm/sec

CHAPTER 7

CONCLUSION

CONCLUSIONS

1. The permeability of high concentrated settled ash in the ash pond collected from ash pond is $1.205*10^{-4}$ cm/sec. This is same as lean slurry settled ash.
2. From the field test it is found that with time variation, water content is reduced to 50% within 48 hours and bulk density decreased by 10% but dry density almost remains same and nearer to its MDD found from proctor test.

CHAPTER 8

IMPORTANT
INDIAN STANDARD
SPECIFICTION

IMPORTANT INDIAN STANDARD SPECIFICATION

1. **Methods of test for soil:** Determination of compaction properties

   IS 2720(VII):1980

2. **Methods of test for soil:** Determination of specific gravity

   IS 2720(III/SEC-I): 1980

3. **Methods of test for soil:** Determination of permeability

   IS 2720(XVII):1986

CHAPTER 9

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