BEARING CAPACITY OF POND ASH OVERLAIN BY SAND BED

A THESIS SUBMITTED IN PARTIAL FULFILMENT

OF THE REQUIREMENTS FOR THE DEGREE OF

Bachelor of Technology

In

Civil Engineering

By

OM PRITAM PRIYADARSHEE

Roll No-109CE0455

DEPARTMENT OF CIVIL ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY, ROURKELA

ODISHA-769008

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Under the guidance of

Dr. S.P. Singh

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Rourkela

CERTIFICATE

This is to certify that the thesis entitled "**BEARING CAPACITY OF POND ASH OVERLAIN BY SAND BED**" submitted by **Mr. OM PRITAM PRIYADARSHEE** in partial fulfillment of the requirements for the award of **Bachelor of Technology** Degree in **Civil Engineering** at the National Institute of Technology, Rourkela (Deemed University) is an authentic work carried out by him 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.

DATE:

Dr. S.P. Singh

Department of Civil Engineering

National Institute of Technology

Rourkela – 769008

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I would like to articulate my deep gratitude to my project guide **Dr. S.P. Singh** for providing me an opportunity to work under his supervision and guidance. He has always been my motivation for carrying out the project. His constant encouragement at every step was an invaluable asset to me during my work.

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The help and support received from Mr. **Jajati Keshari Naik**, M.Tech, Civil Engineering was vital for the successful of the project.

Last but not the least; I am thankful to ALMIGHTY, who kept me for the necessary hard work during my thesis work

Date: 13-05-2013

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ABSTARCT

In the recent past large amount of Pond ash are generated by the thermal power plants. It is a major reason of concern for the people living around the power plants. Statistical observation shows that the current rate of deposition of Pond ash in India has reached 170 million tons/annum. About 90,000 acres of precious cultivable land is used for the storage of abandoned ash. But the current rate of utilization of ash is only about 35-40%.The unused ash leads to an increasing ponding area for storing of ash and related environmental problems for the people who live around the power plants.

Besides this, over the last few years, due to development the construction of skyscrapers, highways and roads has taken a boost. This requires a large amount of natural soil and aggregates to excavated or to be deposited. Hence this is a both environmental and economic issue. These are some issues now-a-days which motivates in development of alternative methods to overcome those environmental and also the economic issues which leads to the reuse of suitable industrial waste products which can fix those issues and also fulfill the specifications.

During this work, the effect of moisture content, degree of compaction, dry densities etc. on various geotechnical properties of pond ash are studied. Specific gravity test, grain size distribution test by mechanical sieve analysis etc. are performed to obtain some physical properties of the pond ash. A series of tests such as light compaction as well as heavy compaction test, Direct shear test, Footing load test are done to estimate the strength characteristics of suitably compacted pond ash. The footing load test of saturated pond ash sample over lain by some thickness of sand bed is done and increase in the strength of pond ash is observed. These results will be very much helpful for the successful application of pond ash in different fields as well as the disposal of pond ash in an ecofriendly manner.

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CHAPTER 1

INTRODUCTION

1. INTRODUCTION

Over the last few years, environmental and economic issues have large interest in the development of alternative materials and reuse of industrial waste or by-products. Thermal power plants release waste materials as by-products which are threat to environment. Disposal of them is a major concern now-a-days. It consumes a large area and also has many environmental hazards. A material such as pond ash is a residue collected from ash pond near thermal power plants. These micron-sized earth elements primarily consist of silica, alumina and iron. The current rate of generation of coal ash in India has reached 130 million tons per annum with about 75,000 acres of precious land under the cover of abandoned ash ponds. The current rate of utilization of ash is about 35%. This leads to an ever increasing ponding area for storing ash and related environmental problems. On the other hand, the construction of highways and roads embankments, abutments, earthen dams and other retaining structures in India which requires a huge amount of natural soil and aggregates and to meet this demand huge amount of exploitation of fertile soil and natural aggregate is being adopted. Due to rapid industrialization and the scarcity of availability of natural soil the scientists thought to utilize the waste products of power plants as a replacement to the natural soil. This will reduce the scarcity of natural soil and also solve the environmental issues due to the deposition of the by-products. However, due to lack of sufficient knowledge due to insufficient research, its use has not taken momentum. But till now the basic and essential parameters of pond ash, to be used either as structural fill or embankment material. Some special type of pond ash is used for manufacturing of building materials like lime fly ash bricks/ blocks etc.

The strength of the pond ash is less as compared to the conventional earth material because of less angle of friction and interlocking between the particles as the shape of pond ash particles is sub rounded. Past studies and researches are dealt with the improvement of bearing capacity of pond ash by reinforcing it with different fibers, geo-grids and geo-synthetics. But now-a-days, due to the less availability of sand in different construction works as filling material, pond ash can be used as a replacement of sand and the bearing capacity can be improved by providing a layer of sand over it. As compared to the natural soil or sand, the weight of pond ash is very less and it has self-drainage capability. And before its successful application in various fields it is necessary to know the strength characteristics and different geo-technical properties of suitably compacted pond ash.

CHAPTER 2

LITERATURE REVIEW

2. LITERATURE REVIEW

2.1 Pond ash

Pond ash is the by-product of thermal power plants, whose disposal is a major problem from an environmental point of view and also it requires a lot of disposal areas. There are three types of ash produced by thermal power plants, viz. (1) fly ash, (2) bottom ash, and (3) pond ash. Fly ash is collected by mechanical or electrostatic precipitators from the flue gases of power plant. It is used in the manufacture of PCC, Concrete & Cement mortar, Lime fly ash bricks, Building blocks, Aerated concrete blocks etc. Whereas the bottom ash is collected from the bottom of the boilers and it is characterized by better geotechnical properties. It is a good material for fill, road and embankment construction. These two types of ash are mixed together and transported in the form of slurry. It is stored in the lagoons. In ash pond area, ash gets settled and excess water is removed and the deposit is called pond ash. This is used as filling materials in the construction of roads and embankments. Some selected pond ash can be used for manufacturer of building products like lime fly ash bricks/ blocks etc.

2.1.1 Source of Fly Ash

Ash Content in Indian Coal

The quality of coal depends upon its rank and grade. The coal rank arranged in an ascending order of carbon contents is:

Lignite --> sub-bituminous coal --> bituminous coal --> anthracite

Indian coal is of mostly sub-bituminous rank, followed by bituminous and lignite (brown coal). The ash content in Indian coal ranges from 35% to 50%. The coal properties including calorific values differ depending upon the colliery. The calorific value of the Indian coal (~15 MJ/kg) is less than the normal range of 21 to 33MJ/Kg (gross). According to ***National Thermal***

Power Corporation (*NTPC),* coal is used for approximately 62.3% of electric power generation in India, oil and gas accounts for 10.2%, hydro's share is 24.1%, nuclear, wind, and other contribute remaining 3.4%.

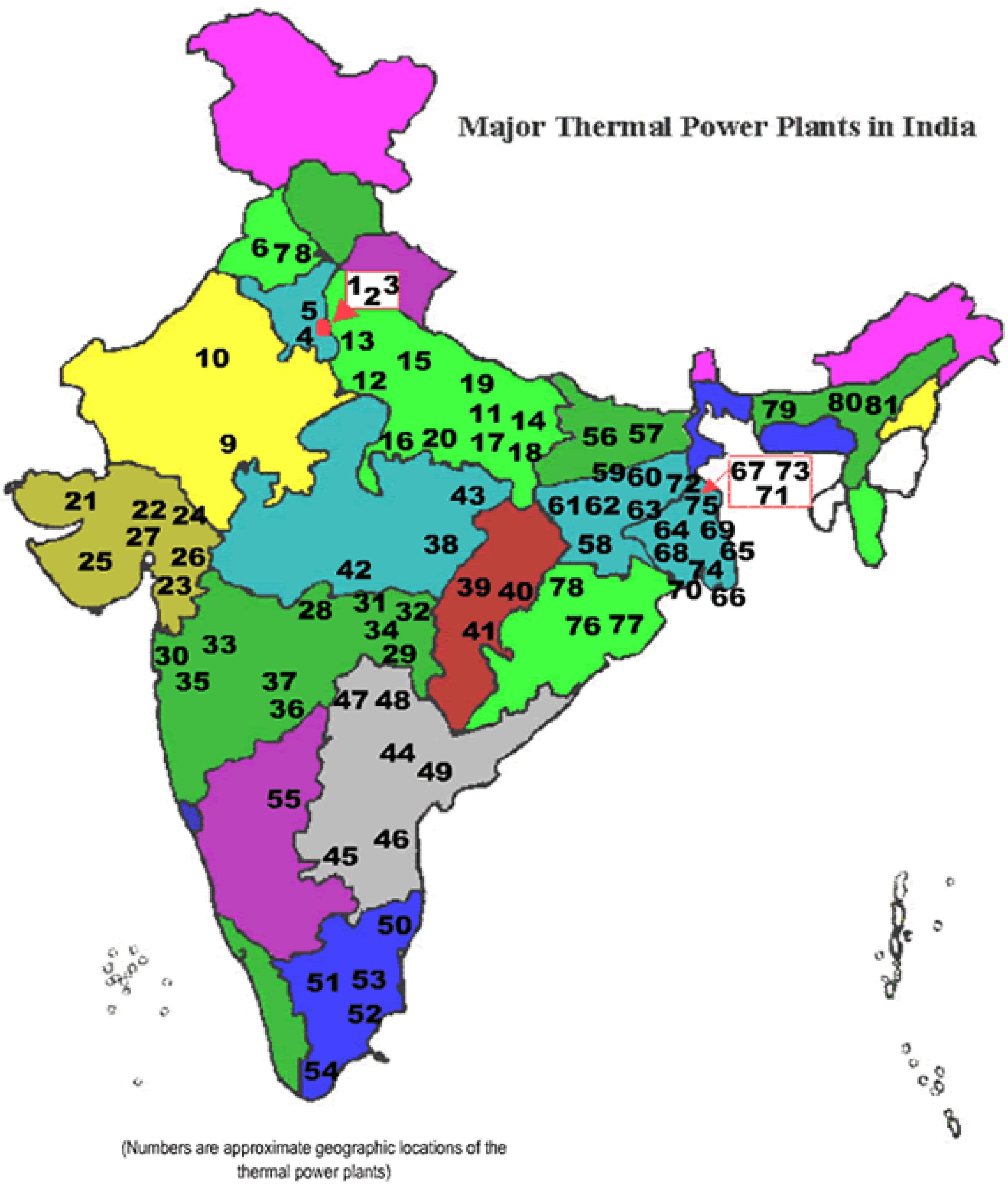


Fig 2.1 Geographical location of major thermal power plants in India [11]

2.1.2 Current coal Ash Generation in India

The current electricity generation (as on March 31, 2004) in India is about 1,12,058 MW, 65- 70% of which is thermal (mostly coal based). According to an estimate 100,000 MW capacity or more would be required in the next 10 years due to continually increasing demand for electricity. In India fly ash generation is around 110 million tonnes / year and is set to continue at a high rate into the foreseeable future. Presently majority of the coal ash generated is being handled in wet form and disposed of in ash ponds which is harmful for the environment and moreover ash remains unutilized for gainful applications. India has sufficient coal reserves. In India almost 65-70% of electricity production is dependent on coal which produces a huge quantity of Fly Ash as residue which is allegedly a waste product in Thermal Power Stations. Fly Ash has a vast potential for use in High Volume fly ash concrete especially due its physic-chemical properties. A good amount of research has already been done in India and abroad on its strength and other requisite parameters. Current fly ash generation and utilization in six major states; Gujarat, Maharashtra, Tamil Nadu, Rajasthan, Andhra Pradesh and Uttar Pradesh is presented in the present report. Presently, out of 110 million tonnes of total ash generated, about (30%) is being utilized.

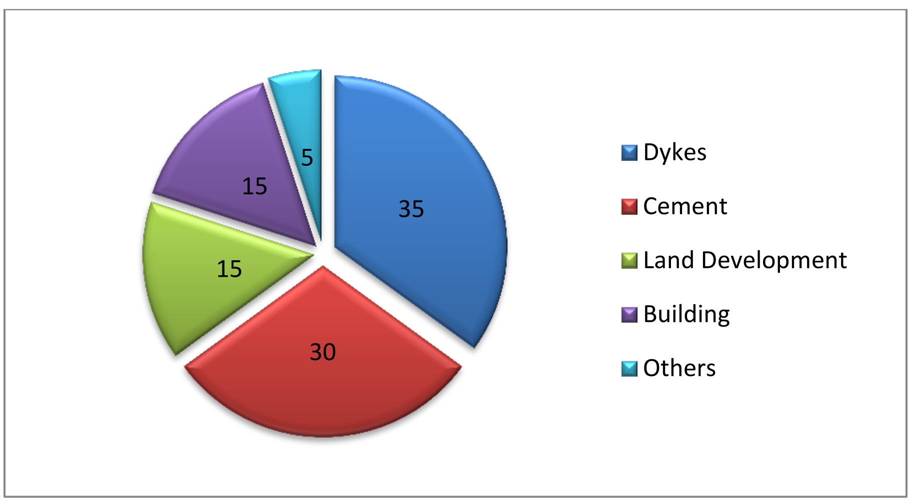


Fig2.2 Current ash utilization in India

2.1.3Chemical composition of pond ash

The chemical composition of pond ash is described in the following table

Table 2.1 Chemical composition of pond ash

PARAMETRE	VALUE IN %
SiO_2	59-61
Al_2O_3	28-28.8
Fe_2O_3	2.7-5.52
Na_2O	0.24-0.5
K_2O	1.26-1.76
CaO	0.7-1
MgO	1.4-1.9
LOI	0.5-2.5

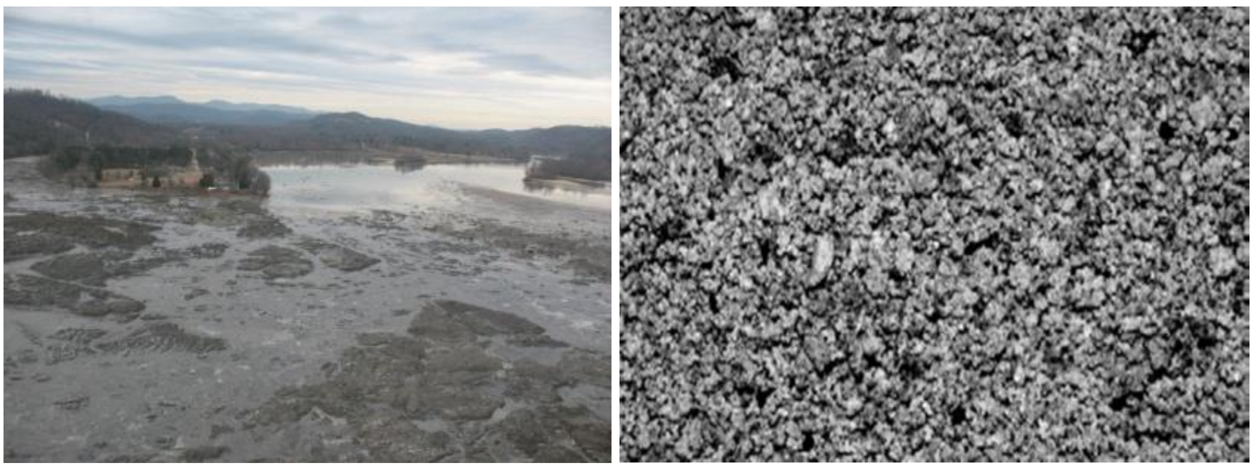
The pH value of the pond ash was 7.28 which is determined according to Indian Standard, IS: 2720 (Part 26)-1987.

Chemical composition suggests the possible applications for coal ash. Roode reported that loss on ignition is generally equal to the carbon content. Throne and Watt observed that the amount of SiO_2 or SiO_2 + Al_2O_3 in fly ash influences the pozzolonic activity. Minnick has reported that a relatively high percentage of carbon decreases the pozzolanic activity.

Pond ash may find potential application in bulk amount as foundation medium. Studies on the bearing capacity of square footing on fly ash have been reported by DiGioia and Nuzzo (1972). They proposed some correction factors, based on the model tests to be applied in the

Terzaghi's bearing capacity equation. A correction factor of 1.25 is suggested to be applied to Nc and a factor of 0.90 to Nc, but no correction factor to Nq is necessary. The resultant expression is as follows:

$$q = 1.25cN_c + qD_fN_q + 0.45B\gamma N_\gamma$$



(A) (B)

Fig 2.3 (A) Ash pond, (B) magnified view of pond ash

2.1.4 Factors affecting properties of pond ash

Meyer (1976) and Despande (1982) represent that the chemical and physical composition of a pond ash is a function of several variables, i.e.

(1) Design of boiler unit

(2) Coal source

(3) Degree of coal pulverization

(4) Handling and storage methods

(5) Loading and firing conditions.

Thus, it is not surprising that a high degree of variability can occur in pond ash not only between power plants but single power plants. A change in any of the above factors can result in detectable changes in the pond ash produced.

2.1.5 Uses of pond ash

It can be used for multifarious applications, some of them are mentioned below;

- In Land fill and dyke rising.
- In Structural fill for reclaiming low areas.
- Manufacture of Portland cement
- Lime – Fly ash Soil Stabilizing in Pavement and Sub-base
- In Soil Conditioning
- Manufacture of Bricks
- Part replacement in mortar and concrete.
- Stowing materials for mines.

2.2 Past studies on Pond ash

Pond ash is an industrial waste having low bearing capacity and high settlement. Previously some of scientists researched about the project. They tried to improve the characteristics of pond ash by lime stabilization process or by reinforcing it by various geo-textiles.

Sudeep Kumar Chand et.al.[3] have attempted in-place stabilisation of pond ash deposit by hydrated lime columns and concluded that, this technique was effective in increasing the unconfined compressive strength and decreasing the permeability. In addition, the contamination potential of the ash leachates was reduced. Ambarish Ghosh et.al.[4] have attempted stabilization of pond ash using lime and phosphor-gypsum and found that, the content of stabilizers and the curing period are influential on the bearing ratio values.

Goutham Kumar Pothal et.al. [5], have carried out triaxial and load tests on reinforced pond ash and reported improvement in bearing capacity. Bera et.al. [6-7], have reported conducting laboratory load tests on pond ash at its MDD, reinforced with one type of jute geotextile and three types of polypropylene geotextiles. They reported that, ideal depth of placement was 0.255B, where B is width of the model footing that resulted in a maximum improvement of 34% in the bearing capacity of reinforced pond ash. The change in strength due to different compaction, controlling parameters, such as layer thickness, compaction energy, tank size, moisture content, mould area, and specific gravity on the dry unit weight of pond ash are obtained.

Kumar, R et.al. [8], Temel Yetimoglu et.al. [9] have studied the behavior of pond ash reinforced with randomly distributed fibers. Kolay, P.K. et.al. [9] have used pond ash as a stabilizer of Peaty soil. Jakka et al. studied the geotechnical characteristics of pond ash samples, which was sampled from the outflow and inflow points of two ash pond areas in India. The strength characteristics were obtained using CD (consolidated drained) and CU (consolidated undrained) triaxial tests with pore water pressure measurements; conducted on loose and compacted specimens of pond ash samples under different outer confining pressures. The ash samples collected from the inflow point of pond ash area exhibited similar behavior to sandy soils in many aspects. Their strength was higher than the reference material (Yamuna river bank sand), although their specific gravity and MDDs are significantly lower than that of sands.

The ash samples from the outflow point of ash pond area exhibited significant differences in their values and properties as compared to the samples from the inflow point of the ash pond area. Ash samples taken from the outflow point had low shear strength particularly in loose state in which case static liquefaction is observed. Sharan A.[2] conducted various tests on pond ash and found that a linear relationship was found to exist in between the unconfined compressive strength and the compaction energy of suitably compacted pond ash. When pond ash is reinforced with fiber, its ductility is increased to a required optimum level.

Chapter 3

EXPERIMENTAL WORK

3. EXPERIMENTAL WORKS

3.1 Introduction

Experiments were done to determine various properties like specific gravity, grain size analysis and geotechnical characteristics like maximum dry density, optimum moisture content, cohesion value, internal angle of friction of pond ash. Then the bearing capacity of pond ash was determined by performing footing load test for both saturated and unsaturated condition. Then the same procedure was repeated on saturated ash sample overlain by a sand layer and change in behavior of the saturated pond ash is observed. Following experiments were performed serially to observe the change in behavior of pond ash in different conditions.

3.2 Material used

POND ASH: Pond ash sample was collected from Rourkela Steel Plant. The sample passing through the sieve of 2mm diameter was used in experiments.

3.3 Specific gravity test (IS 2720(III/SEC-I): 1980

The experiment is performed according to the above IS code procedure. The specific gravity of pond ash was determined by density bottle and illustrated in table 3.1.

Table 3.1 Specific gravity test result

	Sample 1	**Sample 2**	**Sample 3**
Mass of bottle (gm)	117.3	119.60	120.90
Mass of bottle + soil (gm)	167.13	169.60	170.90
Mass of bottle + soil + water (gm)	394.20	396.50	397.90
Mass of bottle + water (gm)	365.86	368.40	369.95
Specific gravity	2.308	2.283	2.275

3.4 Determination of grain size distribution (IS 2720(IV):1985)

For determination of grain size distribution, the pond ash was passed through test sieve having an opening size 75µ. Sieve analysis was conducted for coarse particles as per IS: 2720 part (IV), 1975 and hydrometer analysis was conducted for finer particles as per IS: 2720 part (IV). The percentage of pond ash passing through 75µ sieve was found to be 36.28%. Hence the particle size of pond ash ranges from fine sand to silt size. Coefficient of uniformity (Cu) and coefficient of curvature (Cc) for pond ash was found to be 1.95 and 1.61 respectively and indicating uniform gradation of samples. The grain size distribution curve of pond ash is presented in Fig. 4.1. Coefficient of uniformity and co-efficient of curvature were found out using the following formula.

Coefficient of uniformity, $C_u = D_{60} / D_{10}$

Coefficient of curvature, $C_c = (D_{30})2 / (D_{60} * D_{10})$

3.5 Determination of engineering properties

3.5.1 Compaction test (IS: 2720 (Part VII) 1980)

The moisture content, dry density relationships were found by using compaction tests as per IS: 2720 (Part 7) 1980. For this test, pond ash was mixed with required amount of water and the wet sample was compacted in proctor mould either in three or five equal layers using standard proctor rammer of 2.6 kg or modified proctor rammer of 4.5 kg respectively. The moisture content of the compacted mixture was determined as per IS: 2720 (Part II) 1973. From the dry density and moisture content relationship (graph), optimum moisture content (OMC) and maximum dry density (MDD) were determined. Similar compaction tests were conducted with varying compactive energy and the corresponding OMC and MDD were determined. This was done to study the effect of compactive energy on OMC and MDD. The compactive energies used in this test procedure were 357, 595, 1604, 2674, and 3209 kJ/m^3 of compacted volume. The test results are presented in Table 4.1 and graphs were plotted.

3.5.2 Direct shear test (IS 2720 (XIII): 1986)

This test is performed to determine the consolidated-drained shear strength of a sandy to silty soil. The shear strength is one of the most important engineering properties of a soil as it is required whenever a structure is dependent on the soil's shearing resistance. The shear strength is needed for engineering situations such as determining the stability of slopes or cuts, finding the bearing capacity for foundations, and calculating the pressure exerted by a soil on a retaining wall.

The c and Φ values of pond ash were found out by direct shear test. It consisted of a box with a dimension of 60 x 60 x 50 mm depth. Specimen of size 60 x 60 x 25 mm was prepared at MDD and OMC and also at saturated condition and sheared with a constant strain for different normal stress. A graph is plotted between shear stress vs normal stress from which c and Φ values are found out. Direct shear test was conducted for the soil samples at light compaction density and heavy compaction density are shown in table 4.2.

Fig 3.1 Direct shear test machine and different parts of shear box

3.6 Determination of bearing capacity by Footing Load test

Footing load test was performed to determine the ultimate bearing capacity of the soil sample. A cylindrical vessel with 30 cm depth and 25.5 cm diameter is used. The pond ash samples were prepared at different maximum dry densities and moisture content those determined from compaction test and also at saturation condition. Then the samples were placed over the testing machine and the dial gauge and proving ring reading were noted down. From the above data graph was plotted between stress and strain (shown in fig 4.12 and 4.13). The final result of footing load test is shown in table 4.3. The diameter of the sample footing used was 5cm.

Then the same test is performed over two saturated pond ash sample of compactive energy 595kJ/m^3 and 1604kJ/m^3 overlain by sand bed of 2 different thickness i.e. 5cm (B=diameter of sample footing) and 2.5cm (1/2 B) in different cases.

Fig 3.2 Footing Load test machine

Fig 3.3 Failed pond ash sample

Chapter 4

RESULTS AND GRAPHS

4. RESULTS AND GRAPHS

4.1 Introduction

Pond ash is the waste-product or by-product of thermal power plants, contains grains of fine sand and silt size. It is a lightweight and self-draining material compared to natural soil. A conventional way of determining the compaction characteristics, shear parameters and compression strength is by proctor tests, direct shear test and footing load tests respectively. Under this work a number of experiments have been done to study the above. In this section the experimental results of pond ash are presented. The effects of different compaction and shear controlling parameters, i.e. compaction energy, moisture content, dry density are highlighted herein. The discussion on the results obtained from the experiments has been made in this section, highlighting the effects of different parameters item-wise and also with reference to relevant figures.

4.2 Index properties

4.2.1 Specific gravity

The specific gravity of fly ash was determined as per IS: 2720 (Part III section 1) 1980 and was obtained to be 2.288.

4.2.2 Grain Size Distribution

Grain size distribution curve was determined by sieving analysis. Grain size distribution curve is represented in figure 4.1. The coefficient of uniformity and coefficient of curvature were found to be 1.95 and 1.61 respectively. The grain size distribution of fly ash mostly depends upon the degree of pulverization of coal and the firing temperature in boiling units**.**

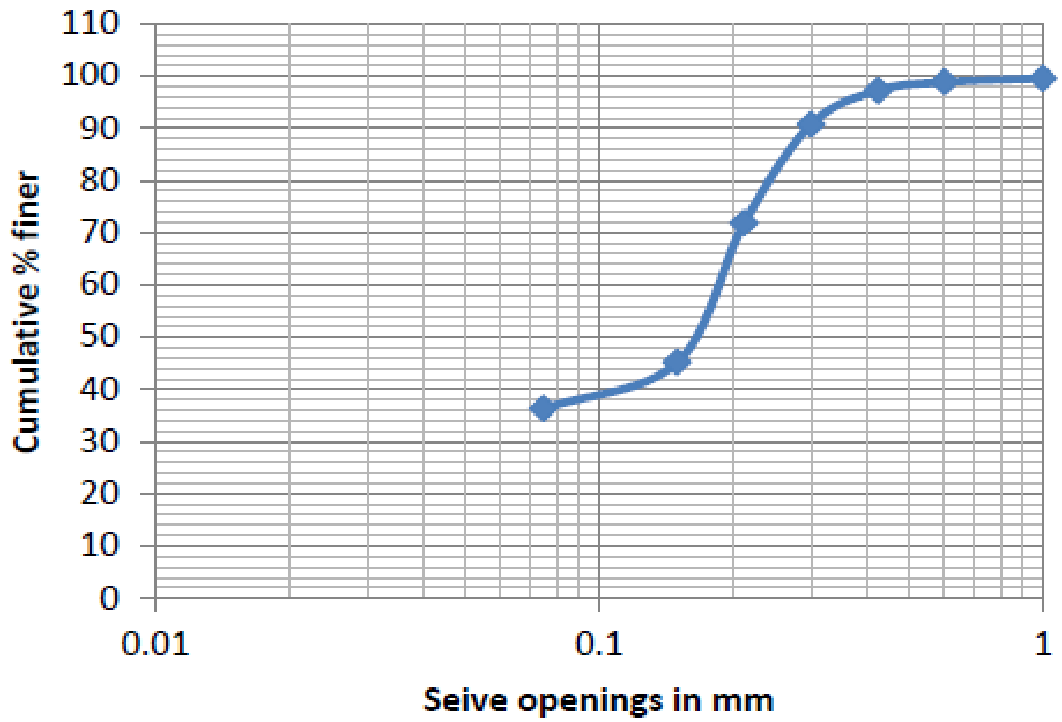


Fig. 4.1 Grain size distribution curve

4.2.3 Atterburg limits

It was not possible to find out the liquid limit and plastic limit of pond ash indicating that pond ash is non-plastic in nature.

4.3 Engineering characteristics

4.3.1 Compaction characteristics

The moisture content, dry density relationships were found by using compaction tests as per IS: 2720 (part VII). For this test pond ash was mixed with water and the mixture was compacted in proctor mould. Compactive energy used was in the range from $357 kJ/m^3$ to $3209 kJ/m^{3.}$ Fig 4.2 to 4.7 shows the effect of compactive energy on compaction characteristics.

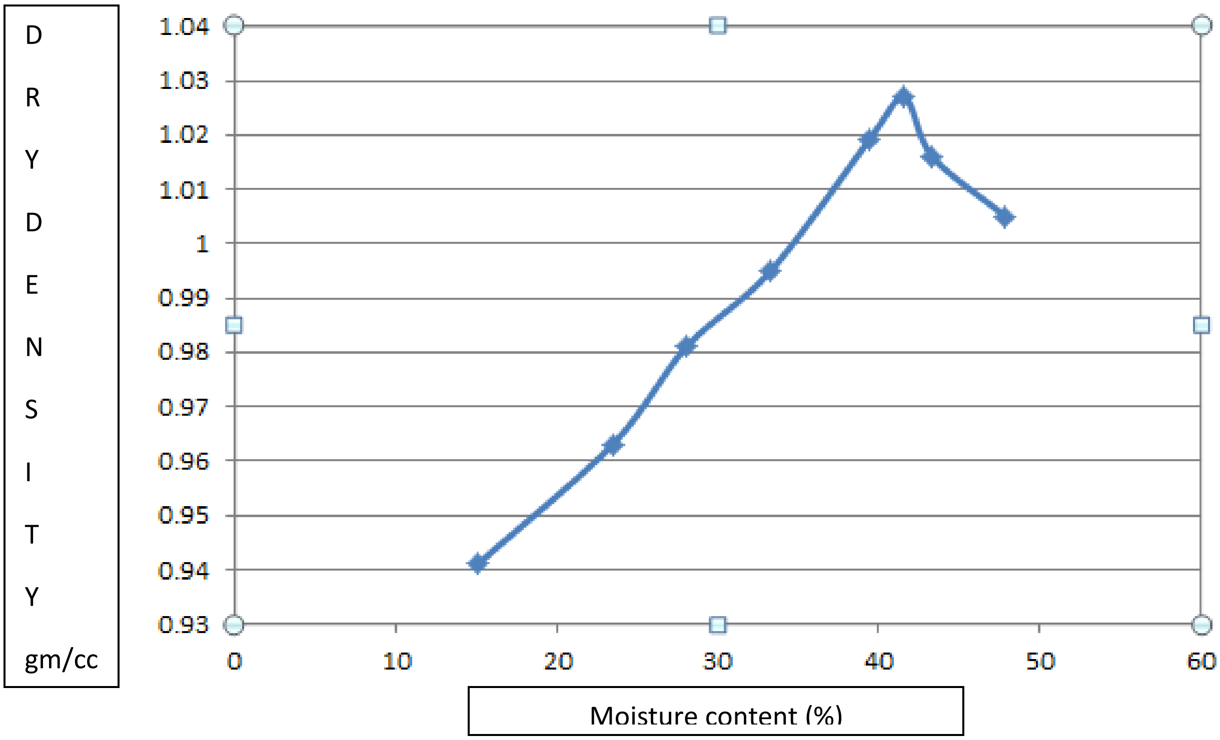


Fig. 4.2 Variation of dry density with moisture content at compaction energy 357 kJ/m3

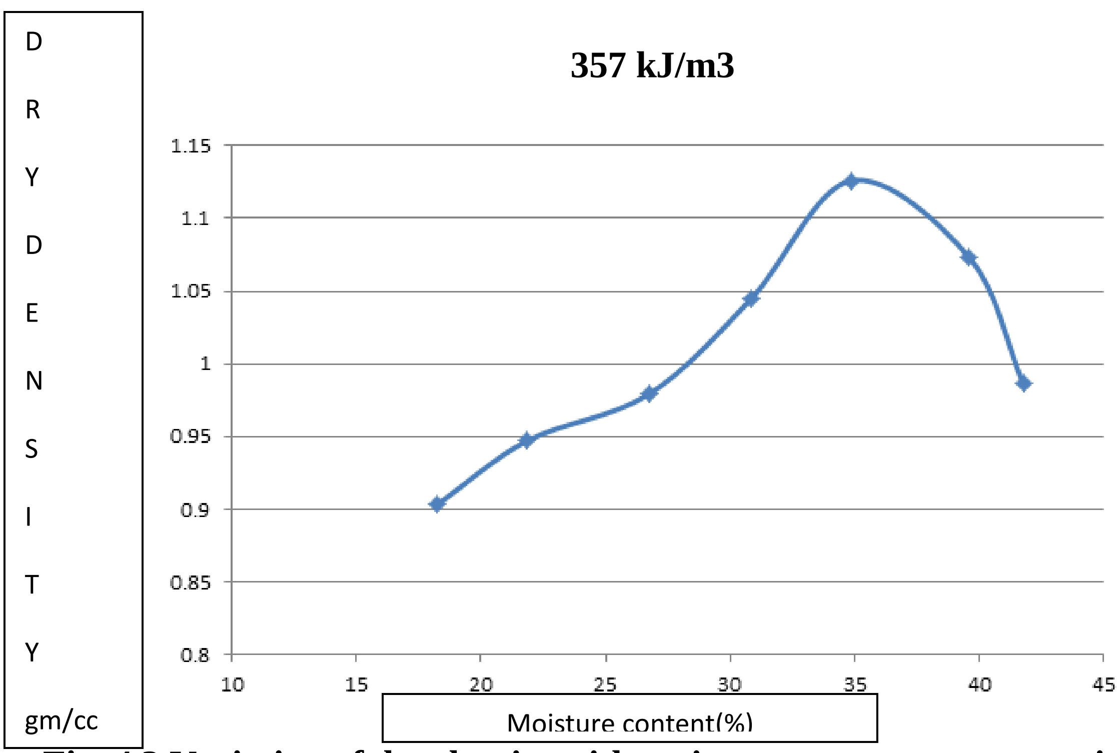


Fig. 4.3 Variation of dry density with moisture content at compaction energy 595 kJ/m^3

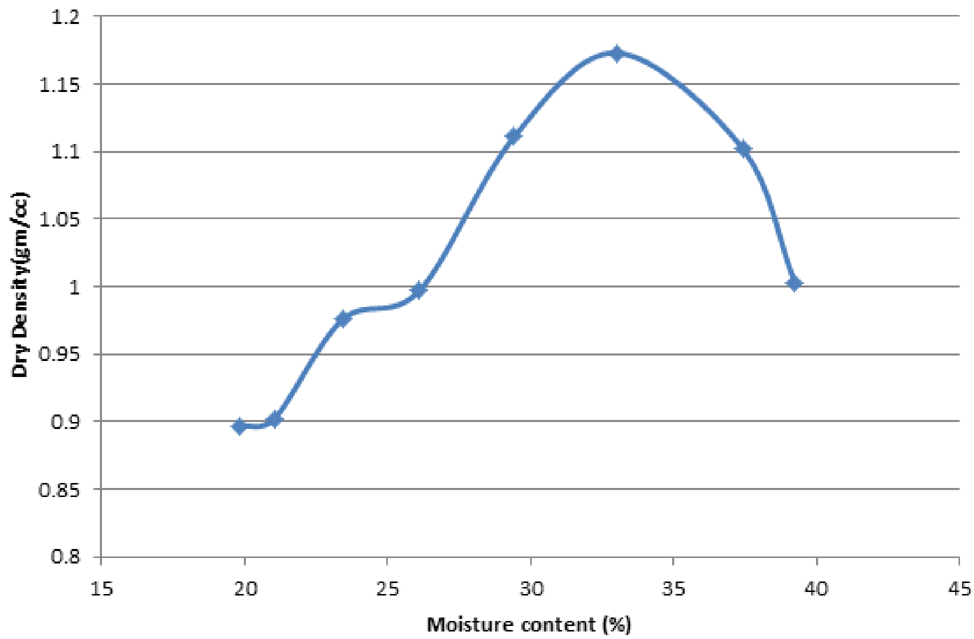


Fig. 4.4 Variation of dry density with moisture content at compaction energy 1604 kJ/m^3

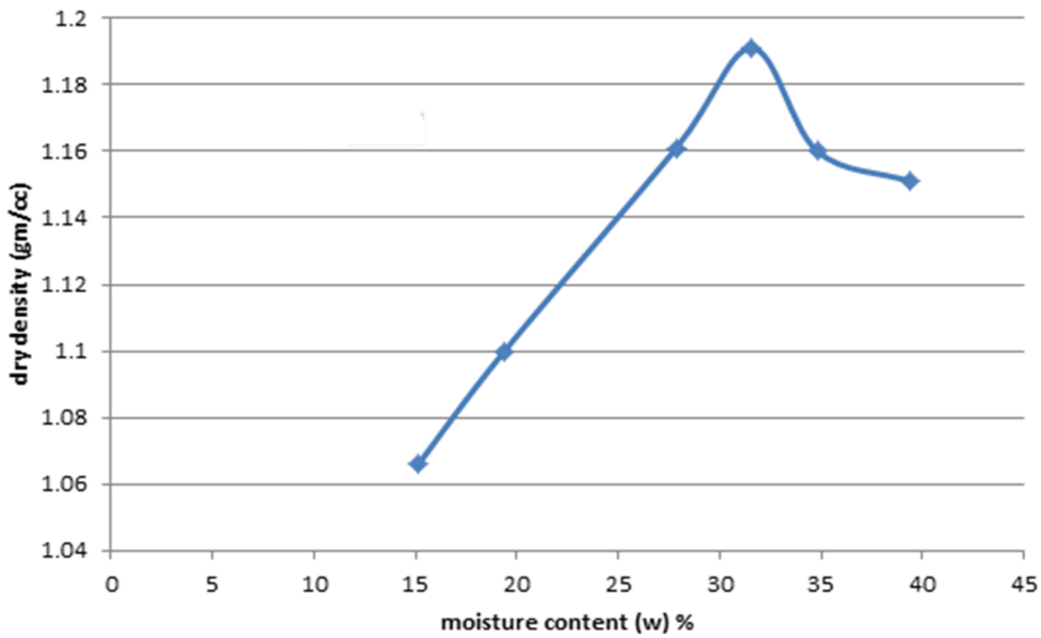


Fig. 4.5 Variation of dry density with moisture content at compaction energy 2674 kJ/m^3

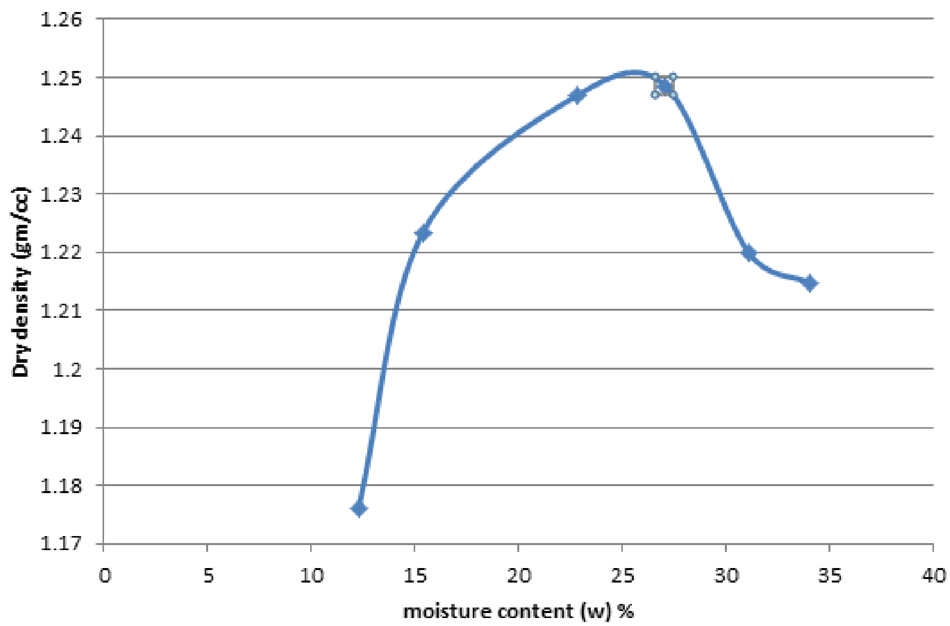


Fig. 4.6 Variation of dry density with moisture content at compaction energy 3209 kJ/m^3

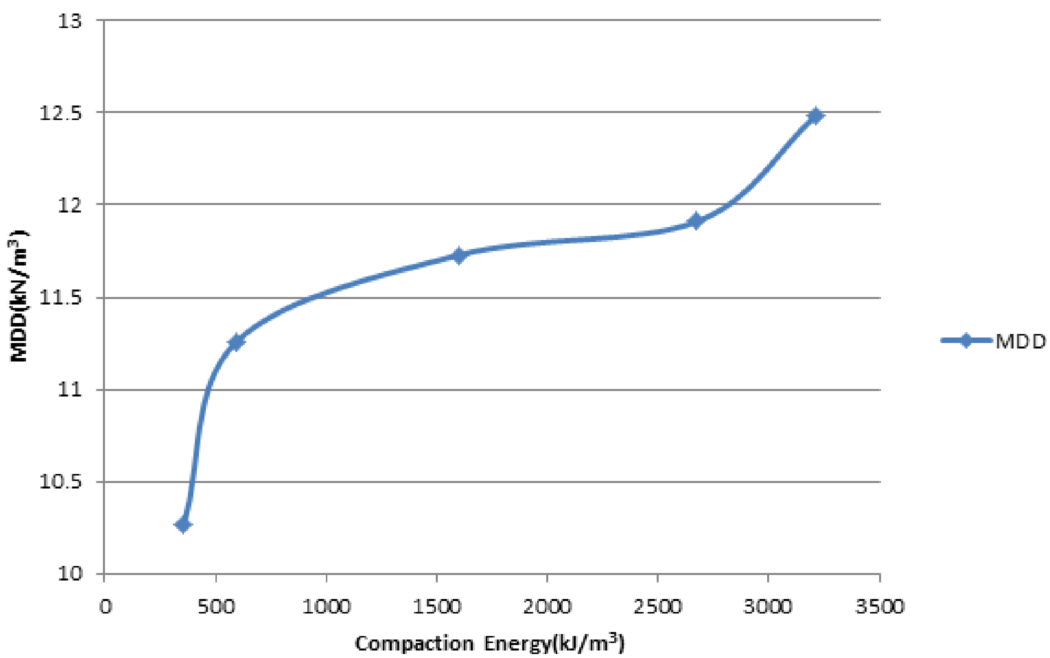


Fig. 4.7 Variation of maximum dry density with compaction energy

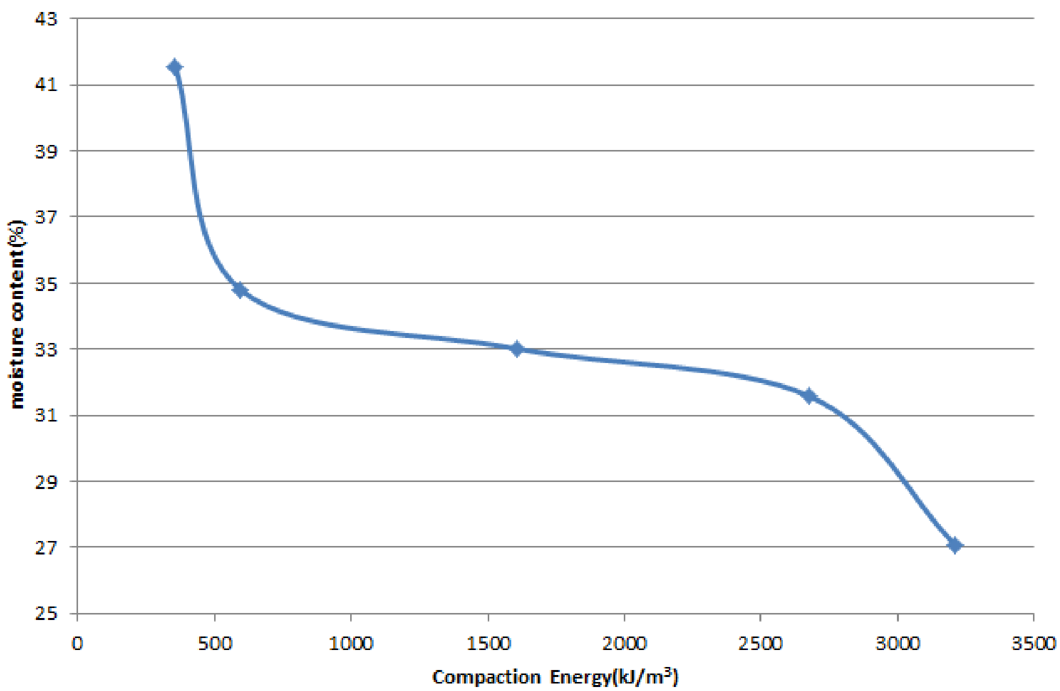


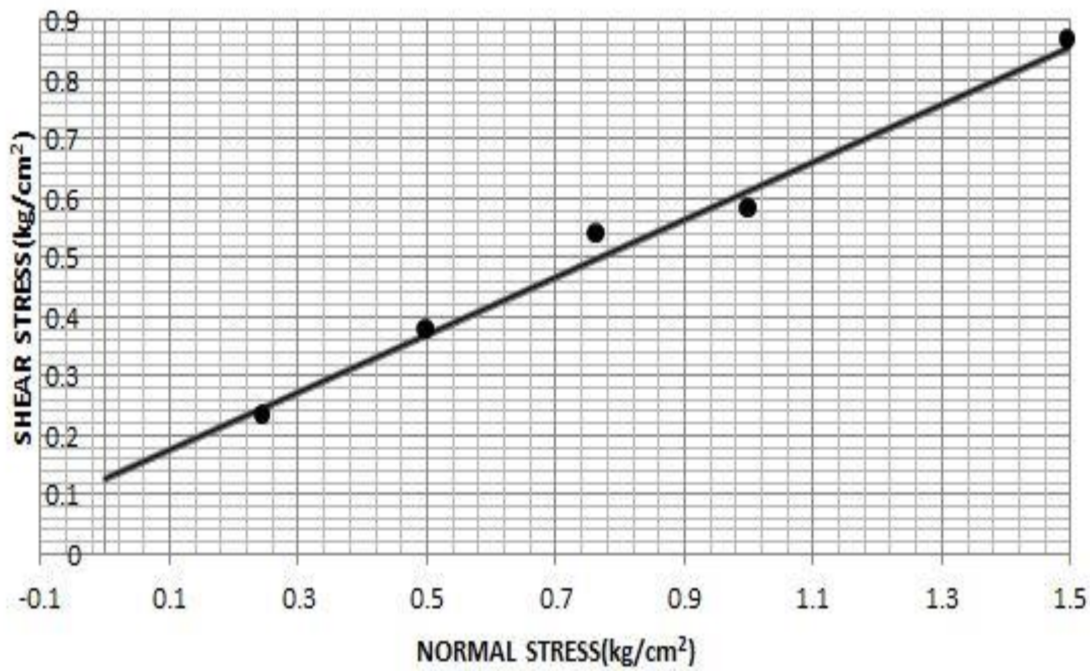
Fig. 4.8 Variation of optimum moisture content with compaction energy

Table 4.1 Compaction test results

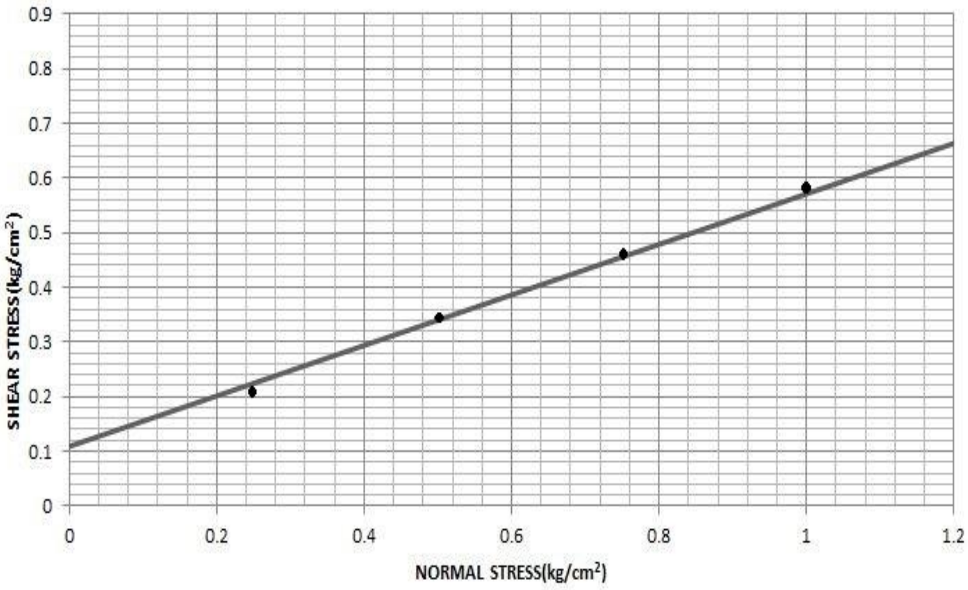
Energy accumulated(kJ/m^3)	MDD (kN/m^3)	OMC (%)
357	10.27	41.53
595	11.26	34.8
1604	11.73	33.02
2674	11.91	31.59
3209	12.48	27.08

4.3.2 Direct shear test

Specimens were tested in a 60 mm square and 50 mm deep shear box which is divided into two parts horizontally , with suitable spacing screws at normal stresses of 25 to 100 kPa and sheared at a rate of 1.25 mm/minute according to IS:2720 (Part XIII). The resulting peak friction angle and cohesion values were found. Graphs are plotted in fig 4.8 to fig 4.11 and result is shown in the table 4.2.

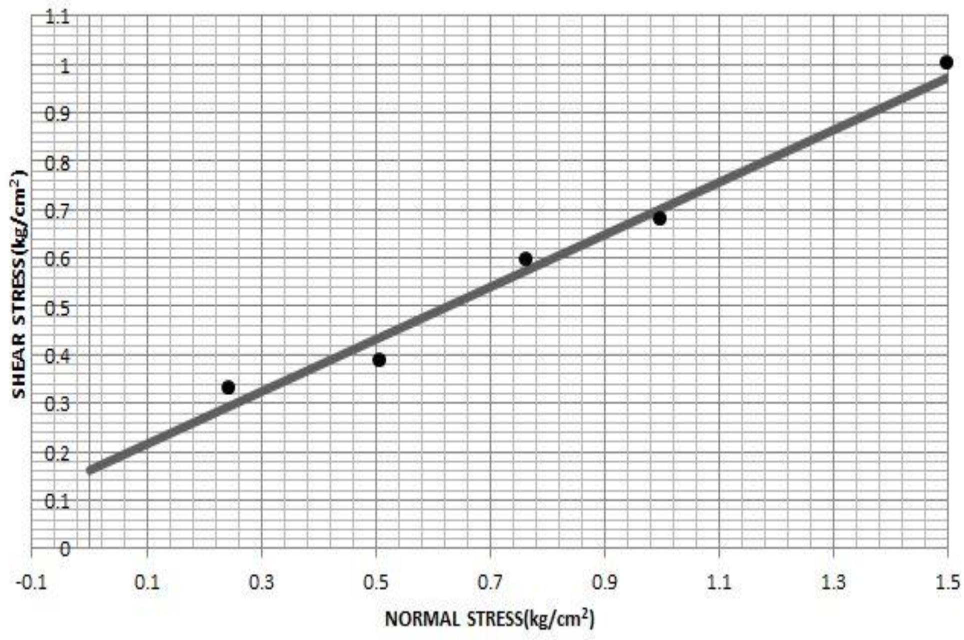


(A) Unsaturated condition

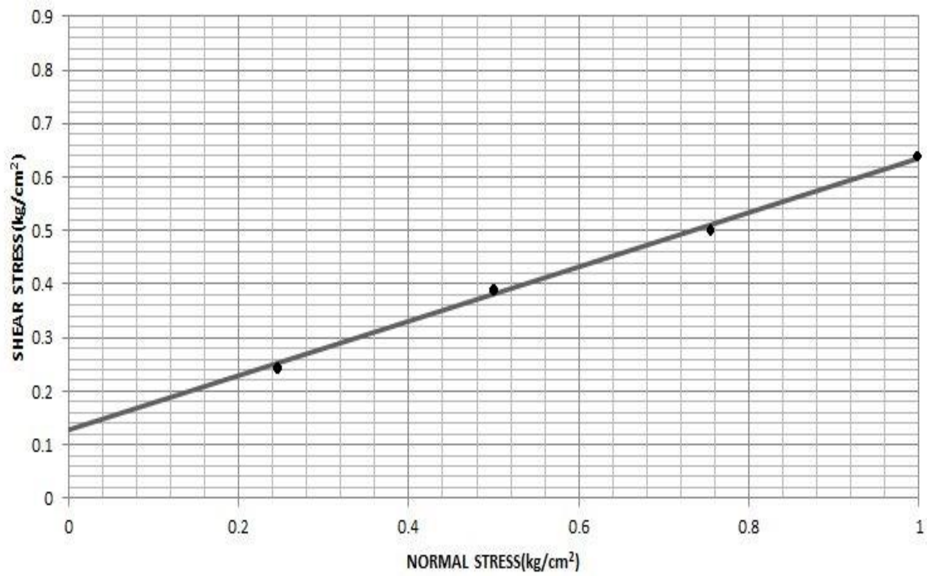


(B) Saturated condition

Fig 4.9 (A), (B) COMPACTION ENERGY=357kJ/m^3 SAMPLE PREPARED WITH γ_d =10.27kN/m^3, O.M.C=41.53%

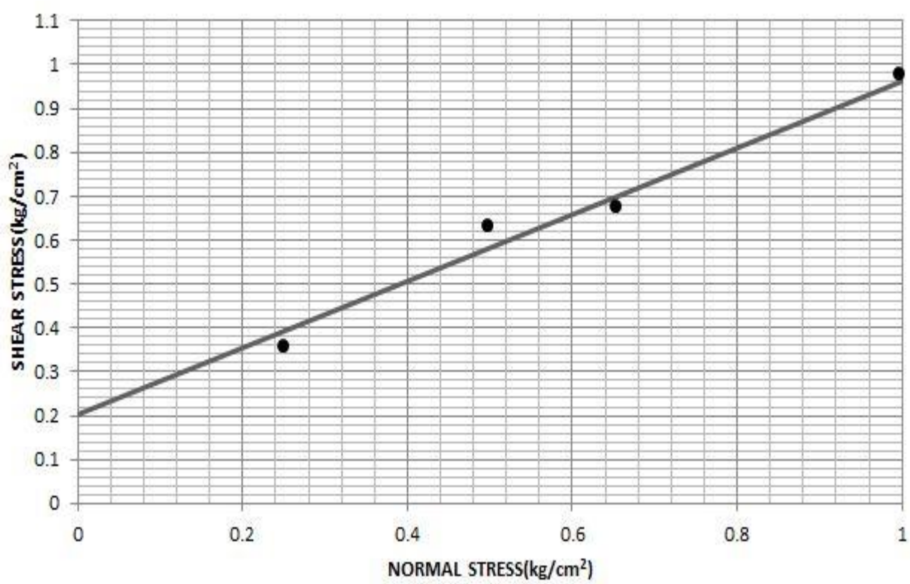


(A) Unsaturated condition

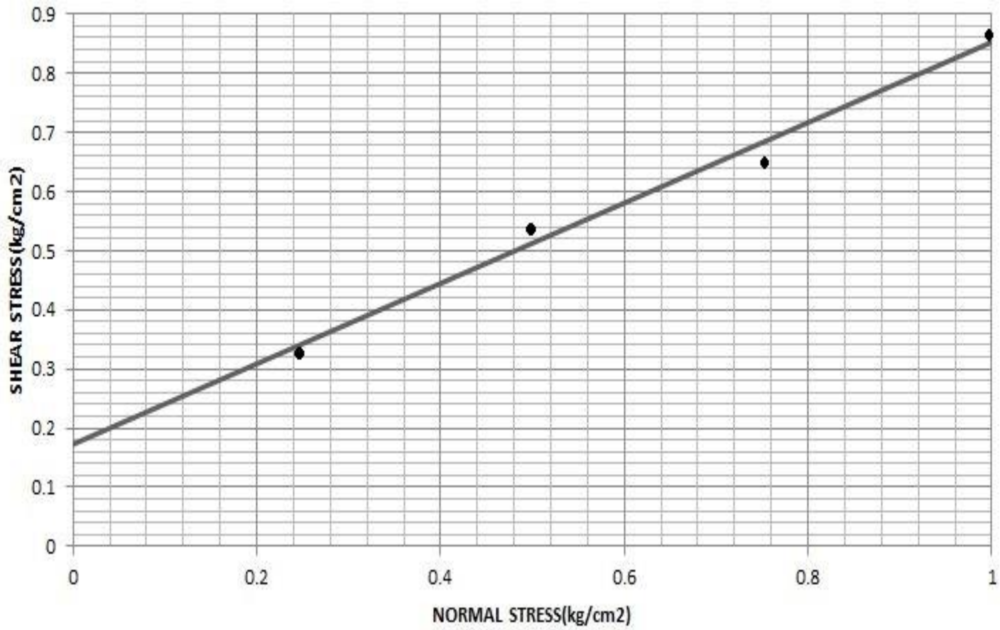


(B) Saturated condition

Fig 4.10 (A), (B) COMPACTION ENERGY= 595 kJ/m^3 SAMPLE PREPARED WITH γ_d=11.26kN/m^3, O.M.C=34.8%

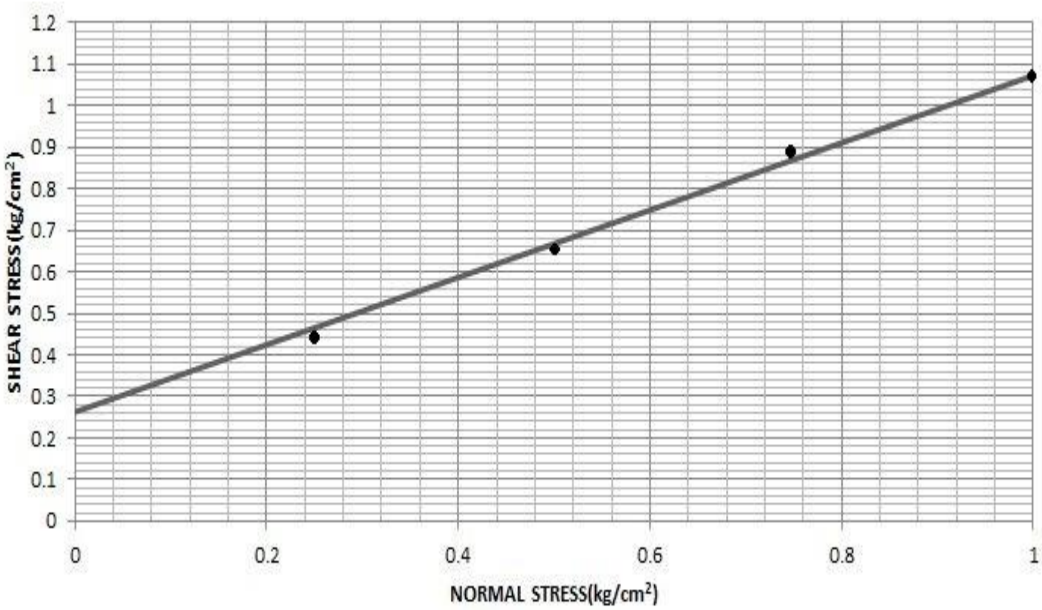


(A)Unsaturated condition

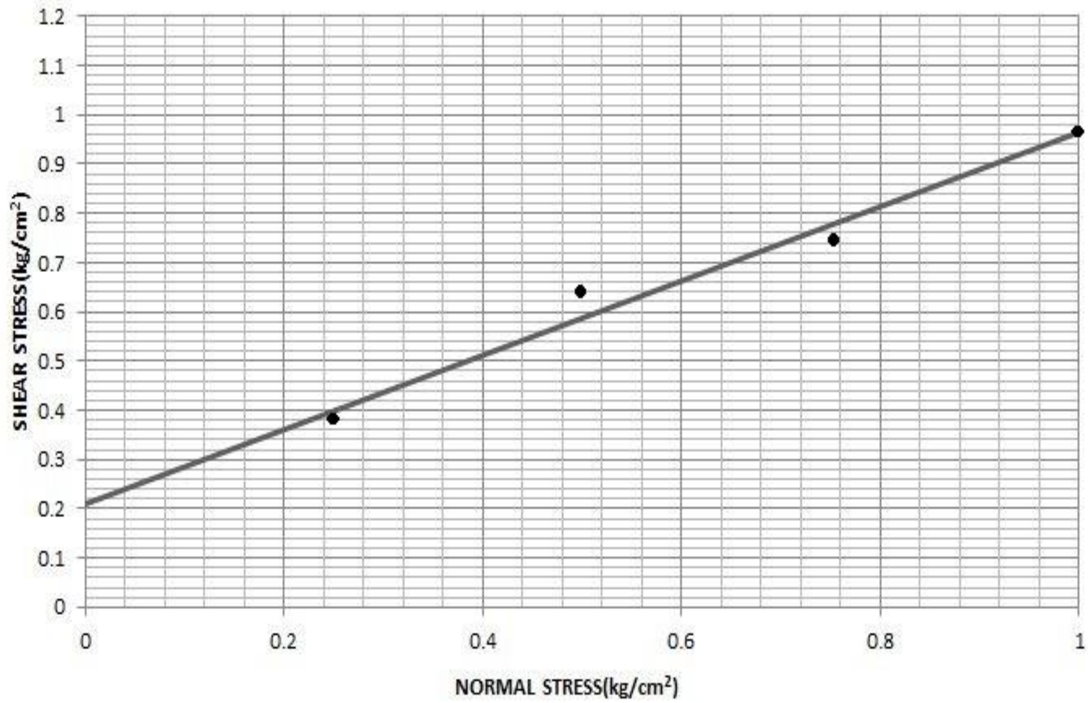


(B)Saturated condition

Fig 4.11 (A), (B) COMPACTION ENERGY=1604kJ/m^3 SAMPLE PREPARED WITH γ_d=11.73kN/m^3, O.M.C=33.02%

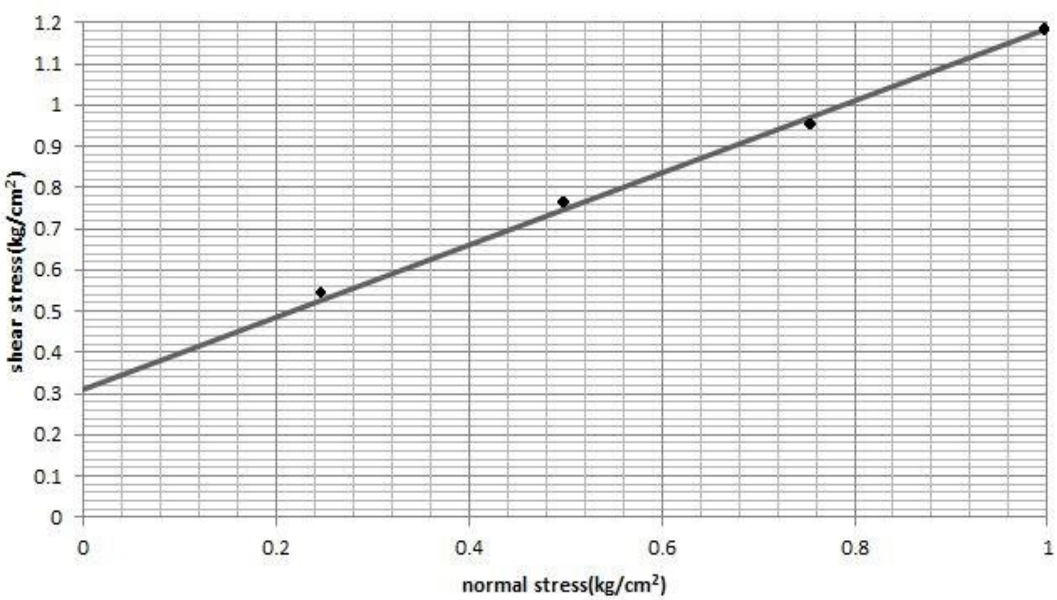


(A)Unsaturated condition

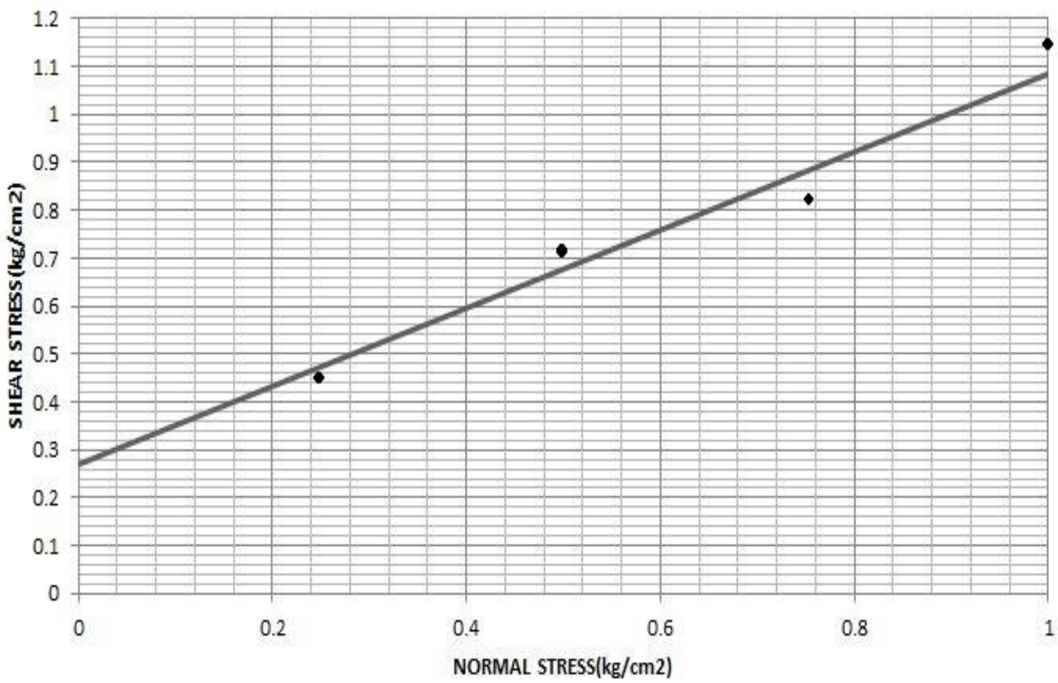


(B)Saturated condition

Fig 4.12 (A), (B) COMPACTION ENERGY=2674kJ/m^3 SAMPLE PREPARED WITH γ_d=11.91kN/m^3, O.M.C=31.59%



(A)Unsaturated condition



(B) Saturated condition

Fig 4.13 COMPACTION ENERGY=3209kJ/m^3 SAMPLE PREPARED WITH γ_d=12.48kN/m^3, O.M.C=27.08%

Table 4.2 Direct shear test result

Compaction Energy (kJ/m^3)	MDD (kN/m^3)	OMC (%)	C (Unsaturated) (kg/cm^2)	Ø (Unsaturated) (in degree)	C (Saturated) (kg/cm^2)	Ø (Saturated) (in degree)
357	10.27	41.53	0.127	25.92	0.109	24.82
595	11.26	34.8	0.162	28.43	0.128	26.92
1604	11.73	33.02	0.203	37.22	0.173	34.23
2674	11.91	31.59	0.263	39.02	0.21	37.07
3209	12.48	27.08	0.310	41.23	0.27	39.2

4.4 Footing Load Test

4.4.1 Footing load test on the pond ash sample

In this test samples were prepared at different dry densities and respective moisture contents and also at saturation condition. The sample was prepared in a cylindrical tank of 30 cm height and 25.5 cm diameter of volume 15321.15 cm^3. Then the cylinder was placed on the footing load test machine. A circular footing of 5 cm diameter is placed over the sample and the test is performed. The strain due to loading in the sample is observed from dial gauge reading and stress was observed from proving ring reading (4 types of proving ring was used in total test procedure: 2.5kN (constant-3.3956N), 5kN (constant-6.65N), 10kN (constant-12.121N), 20kN (24.845N)). Graph was plotted between stress and strain observations in the fig 4.22 to fig 4.23 and maximum bearing capacity is observed. The results are shown in the table 4.3.

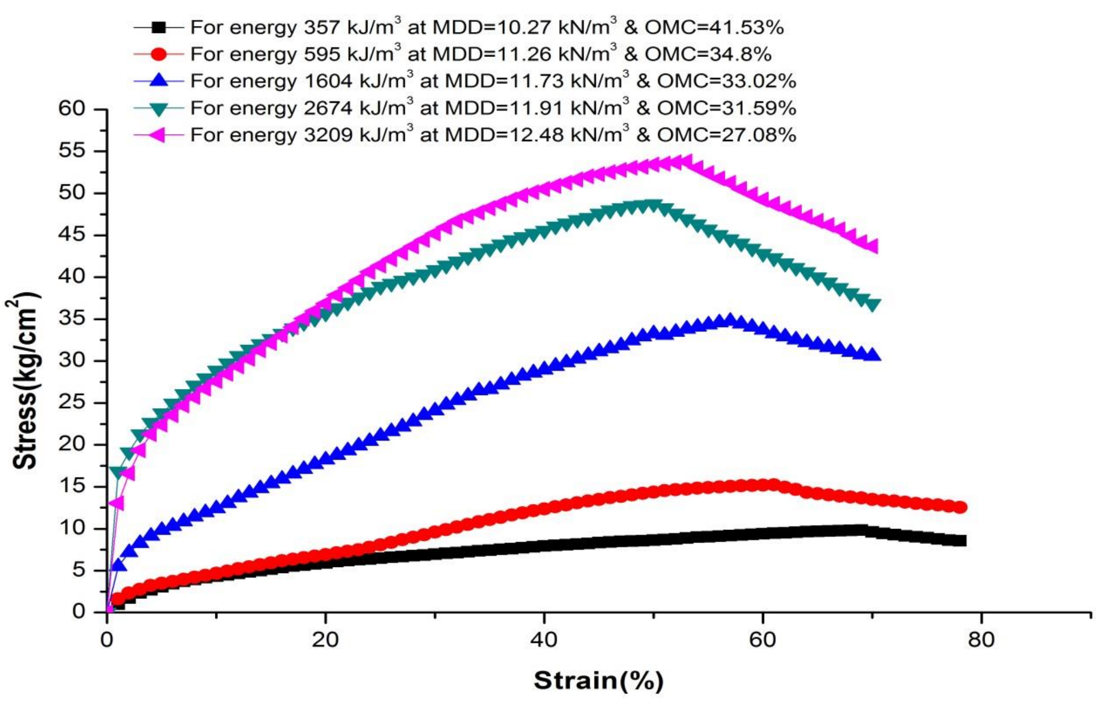


Fig 4.14 Footing load test (stress vs strain graph) in unsaturated graph

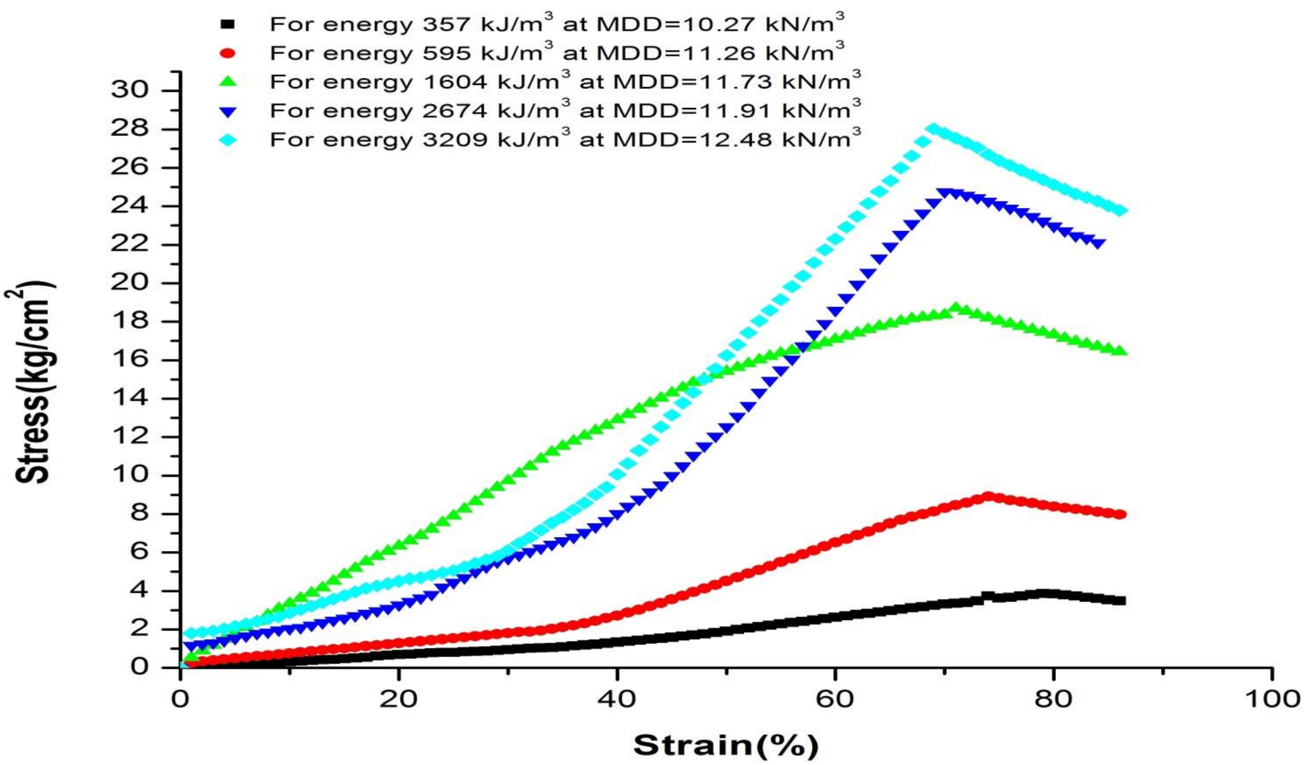


Fig 4.15 Footing load test (stress vs strain graph) in saturated graph

Table 4.3 Footing load test result for unsaturation and saturation condition

Compaction Energy (kJ/m^3)	MDD (kN/m^3)	OMC (%)	Bearing capacity (N/cm^2) (for unsaturation condition)	Bearing capacity (N/cm^2) (for saturation condition)
357	10.27	41.53	98.26	38.75
595	11.26	34.8	152.14	89.1
1604	11.73	33.02	377.72	187.04
2674	11.91	31.59	487.4	247.66
3209	12.48	27.08	538.04	280.4

4.4.2 Footing load test on the pond ash sample overlain by sand bed

In this case a layer of sand bed of thickness B (=5cm) and ½ B (=2.5cm) was over laid on the sample. The sand used in this experiment had minimum density of 1.445 and maximum density 1.62. The over lain sand bed was compacted to its maximum density by tamping. The test was effective over *saturated sample* only. Hence the compacted sample having energy 595kJ/m^3 (MDD=11.26kN/m^3) and 1604kJ/m^3 (MDD=11.73kN/m^3) was used in this experiment. The test was performed and graph was plotted in both cases between stress and strain observed from proving ring reading and dial gauge reading respectively in fig 4.14 and fig 4.15. Comparison of bearing capacity of pond ash without sand bed and with sand bed for saturation condition is provided in the table 4.4.

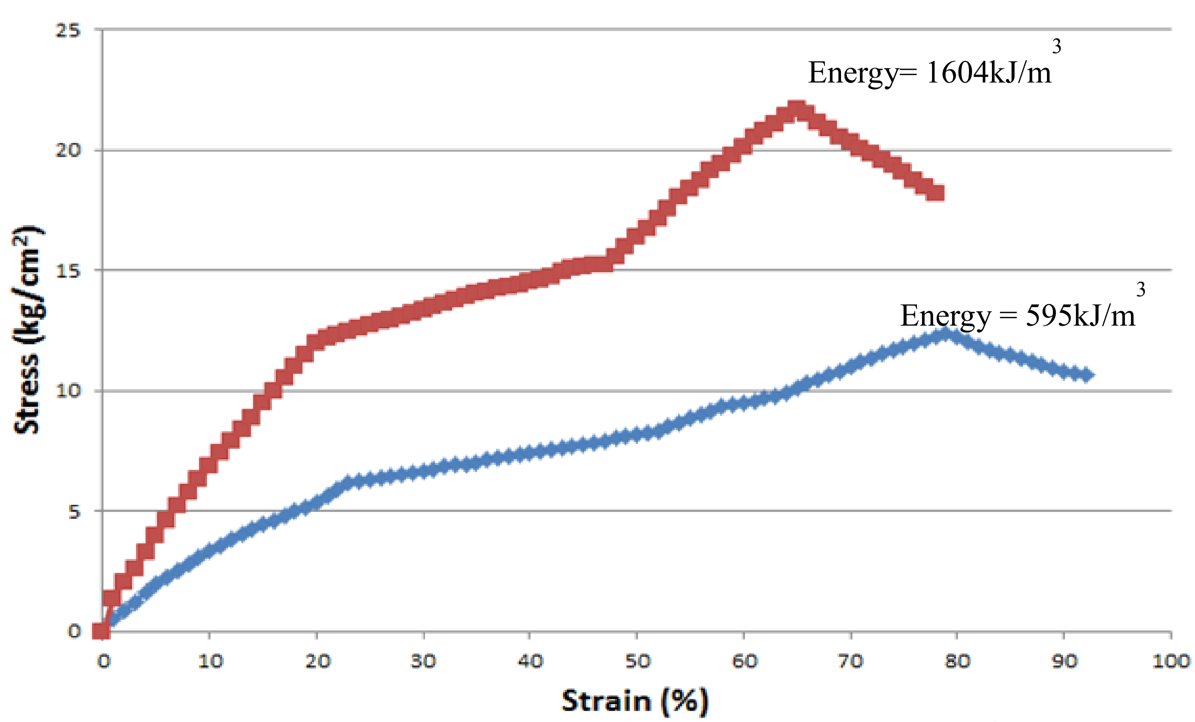


Fig 4.16 Footing load test (stress vs strain graph) on the pond ash sample overlain by 5cm thick sand bed

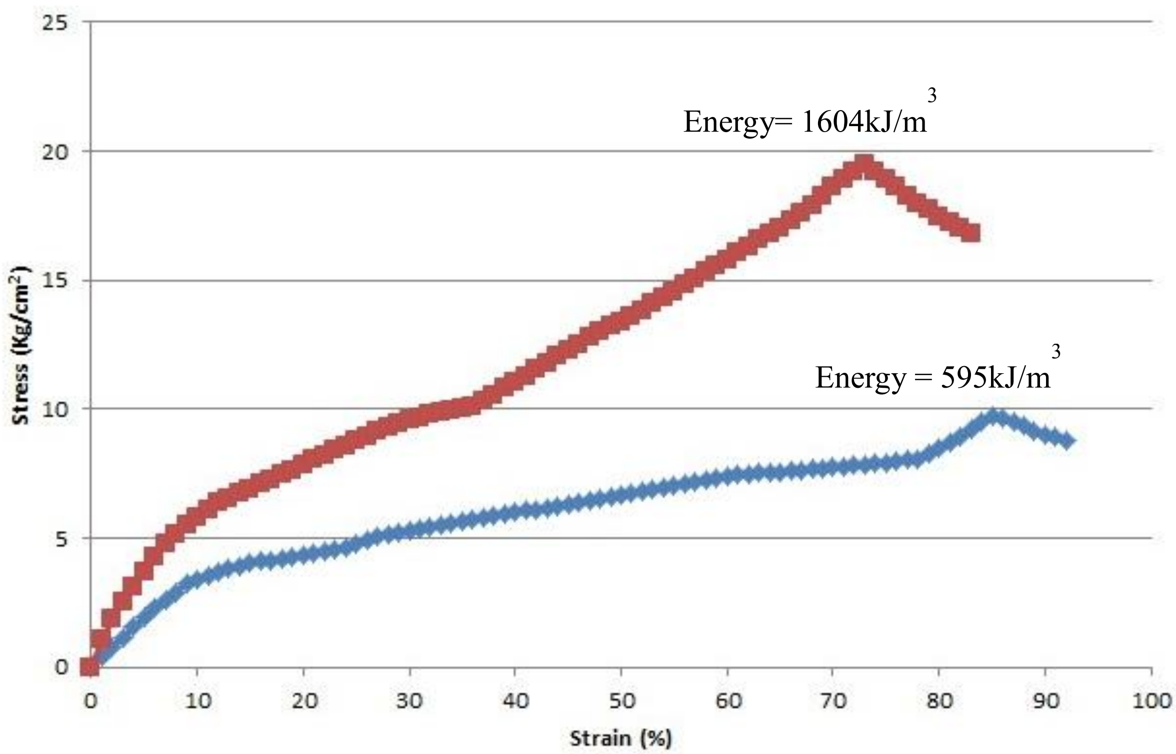


Fig 4.17 Footing load test (stress vs strain graph) on the pond ash sample overlain by 2.5cm thick sand bed

Table 4.4 Footing load test result comparison between pond ash and pond ash overlain by sand bed

Compaction Energy (kJ/m^3)	MDD (kN/m^3)	OMC (%)	Bearing capacity (N/cm^2) (for unsaturation condition)	Bearing capacity (N/cm^2) (for saturation condition)	Bearing capacity (N/cm^2) (for saturation condition) (using sand bed of 5cm thickness)	Bearing capacity (N/cm^2) (for saturation condition) (using sand bed of 2.5cm thickness)
595	11.26	34.8	152.14	89.1	123.68	97.25
1604	11.73	33.02	377.72	187.04	217.4	195.17

The use of sand bed on the unsaturated pond ash sample was not so effective to observe. Hence sand bed is used on the saturated ash sample of 2 densities of 11.26kN/m^3 and 11.73kN/m^3. The increase in the bearing capacity was clearly observed. The experimental results showed that the bearing capacity of saturated pond ash is more in case of sand bed of (B) 5 cm than case with sand bed of (1/2 B) 2.5 cm was provided.

Chapter 5

CONCLUSION

5. CONCLUSIONS

- The pond ash consists of grains mostly from fine sand to silt size with uniform gradation of particles. The specific gravity of particles is lower than that of the conventional earth materials and it was found to be 2.288.
- Particle size distribution curve represents a well graded soil. Generally contains fine sand particles and silt particles of generally round shape.
- It was not possible to find out the Atterburg units like liquid limit and plastic limit of pond ash indicating that pond ash is non-plastic in nature.
- An increase in compaction energy results in closer packing of particles which leads to an increase in dry density whereas the optimum moisture content decreases.
- Maximum dry density varies from 10.27kN/m^3 to 12.48kN/m^3 and optimum moisture content varies from 41.53% to 27.08% with change in compactive effort from 595kJ/m^3 to 3209kJ/m^3.
- From the results it was observed that with increase in compaction energy, optimum moisture content decreases.
- The shear parameters also increase in both saturated and unsaturated condition with increase in compactive effort. The value of unit cohesion increases with degree of saturation up to the OMC and thereafter the same decreases. Hence the highest value of unit cohesion occurs at OMC for samples compacted both at standard and modified densities. However, there is a continuous decrease of angle of internal friction value with increase in degree of saturation. It was observed, initially there is a sharp decrease which gets stabilized at moisture contents higher than OMC.

- The bearing capacity of pond ash increases from 98.26N/cm^2 to 538.04N/cm^2 for unsaturated condition and from 38.75N/cm^2 to 280.4N/cm^2 for saturated condition with increase in compactive effort from 595kJ/m^3 to 3209kJ/m^3.
- The sand bed acts effectively in case of saturated pond ash sample in increasing bearing capacity. The bearing capacity of saturated pond ash overlain by a layer of sand bed increases with the increase in the thickness of sand bed
- In case of saturated sample with increase in the layer of sand bed the bearing capacity increases. It is due to higher the thickness of sand bed higher will be the surcharge load for the pond ash and higher will be the amount of drained pore water which increases the closeness of particles and leads to the increase in the bearing capacity of the ash sample.

Chapter 6

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6. REFERENCES

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