Scientific Journal of Impact Factor (SJIF): 4.72

e-ISSN : 2348-4470
p-ISSN : 2348-6406

International Journal of Advance Engineering and Research Development

Volume 4, Issue 7, July -2017

Study of Shear Strength Parameters of Yamuna Sand Mixed with Pond Ash and Lime

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Abstract — *This study is to investigate the possibility of using pond ash in varying percentage as fine aggregate substitute in Yamuna sand. In India, Thermal power plants are the main source for production of energy and mainly coal is used to achieve this energy. Combustion of coal leads to production of fly ash, bottom ash and Pond ash as a waste product. Pond ash for this study is collected from NTPC Badarpur, Delhi. From the construction point of view, there are many problems associated with Yamuna sand. So it is important to stabilize Yamuna sand. The shear strength of the soil is one of the important aspects to be considered in any geotechnical activity. Bearing capacity, Slope stability of earthen embankment and design of retaining wall, all are related with shear strength characteristics of soil. Previously in many places Pond ash is used as a stabilizing material. Pond ash with lime shows increase in the stability of mix by forming cementious compound. There are several work carried out for the stability of Yamuna sand. In this study, Geotechnical properties of Yamuna sand and Pond ash is find out. Pond ash in various proportions is blended with Yamuna sand and shear strength parameters of mix are find out. For this various UU Triaxial tests, Direct shear tests are performed and MDD variation is studied. Various tests are performed for lime content determination. All the above analyses were carried on every mix to acquire an optimum mix. The outcomes are gathered in graphical form to observe the patterns in the different parameters.*

Keywords- *Yamuna sand, pond ash, shear strength, shear strength parameters, direct shear test, standard proctor test.*

I. INTRODUCTION

1.1. General

Because of population growth, rapid urban and industrial growth, more land is required for further development. In order to meet this demand, utilization of land has been taking place. At that land, Soil may have less load carrying capacity or subjected to more settlement, for this purpose various ground improvement techniques, ground reinforcement techniques, and ground treatment techniques are used. For our project, Yamuna sand is collected from Yamuna bank, Delhi. Yamuna sand is located on the bank of Yamuna which is located at Indo-Gangetic plain. Yamuna sand in Delhi is in seismic active zone, which is located in zone 4.Yamuna sand has low bearing capacity, and susceptible to erosion. We may use Pond ash mixed with lime for improvement of its bearing capacity and shear behavior.

1.2. Scope of the study

In India, Thermal power plants are the main source for production of energy. We use 70-75% of total coal production in thermal power plants. Study shows, 30% of residue is generated from coal combustion. In 2010-12, about 408 Million tons/year was used by 88 thermal plants in India. Presently 116 thermal plants are running across the India, and approx. 90,000 acres of valuable land is used to collect this ash. This residue includes Fly ash, Bottom ash and Pond ash and also called as Coal Combustion Residue or CCR. We are recycling about 28-30% of total CCR produced. Fly ash is collected by mechanical or electrostatic precipitators, Bottom ash is collected from the bottom of boilers. When this Bottom ash mixed with dry Fly ash are transported in the form of slurry and disposed-off in the ash pond located few kilometers distance from thermal plant, this ash is called Pond ash.

This large volume of Pond ash causes various environmental and significant economic problems. To solve this problem, Pond ash uses in various applications

- Pond ash can is used as fine aggregate in concrete works.
- It is suitable for backfilling of low lying areas.
- It is suitable for saline land reclamation.
- Appropriate quantity of Pond ash can increases the production of agriculture, horticulture and forestry.
- It is suitable for filling as Reinforced Earth, Wall pavements and Flyover construction.
- It can be used for stabilization of soil with appropriate amount of lime or cement and decrease the cost of pavement and foundations.
- Pond ash mixed with residue of integrated steel plants can be used for brick manufacturing.
- It can also be used as a stowing material in underground mines.

There should be more study or research should be done to make more utilization of Pond ash and to reduce consumption of natural resources. In my study, Pond ash is collected from Badarpur thermal power station, Delhi. In this

study Pond ash is mixed with Yamuna sand and their shear strength parameter variation by increasing Pond ash content is carried out.

II. MATERIALS USED AND METHODOLOGY

2.1. Materials Used in Present Study

2.1.1. Yamuna sand

Yamuna sand was brought from a dealer in Rohini, Delhi. The sand is cohesionless with fine grain particles and is dark grey in colour.

Table 2.1.Geotechnical Properties of Yamuna Sand

Properties	Values
Sand content (4.75-0.075mm),%	92.6
Fine soil fraction (<75µ),%	7.4
Coefficient of uniformity, C_u	1.37
Coefficient of curvature, C_c	2.87
Effective size of particle,D_{10} (mm)	0.0846
Soil classification	SP-SM
Specific Gravity	2.65
Maximum dry density (MDD) kN/ m^3	16.94
Optimum moisture content (OMC),%	11.2

2.1.2. Pond Ash

Pond ash used in the study was procured from Badarpur Thermal Power Station is located at Badarpur area in NCT Delhi.

Table2.2. Geotechnical properties of Pond Ash

Properties	Values
Sand content (4.75-0.075mm),%	78
Fine soil fraction (<75µ),%	22
Coefficient of uniformity, C_u	4.8
Coefficient of curvature, C_c	1.05
Effective size of particle,D_{10} (mm)	0.049
Soil classification	SP-SM
Specific Gravity	2.20
Maximum dry density (MDD) kN/m^3	12
Optimum moisture content (OMC),%	32

2.1.3. Lime

Lime used in the study was taken from a dealer in Delhi.

Table2.3. Chemical properties of Lime

Chemical Composition	Content (%)
Minimum array(Acidimetric)	95
Chloride(Cl)	0.1
Sulphate	0.5
Iron(Fe)	0.1
Lead(Pb)	0.2
Loss on Ignition	10

2.2. Laboratory Experiments Conducted

The particle morphology of Yamuna sand, pond ash and lime was analyzed using scanning electron microscope in Nano Science Laboratory of DTU Delhi. Particle size analysis of Yamuna sand, Pond ash and Lime was carried out as per IS: 2720 (Part IV)- 1985. The specific gravity is determined as per IS: 2720 (Part III/Sec I)-1980. MDD and OMC of Yamuna sand, Pond ash, Lime and sample mixes is determined as per IS: 2720 (Part VII) 1980. Direct shear test was conducted on sample mixes as per IS: 2720 (Part XIII)-1986 and UU Tri-axial test was conducted on various soil mixes as per procedure lay down in IS: 2720 (Part XI)-1993.

III. RESULTS AND DISCUSSIONS

3.1. Scanning Electron Microscope (SEM) Test

3.1.1. Yamuna Sand

SEM test on Yamuna sand shows that particles are little bit angular and rounded both, sand particles can be seen with sharp edges and particles are formed by weathering of rocks and showing silica content.

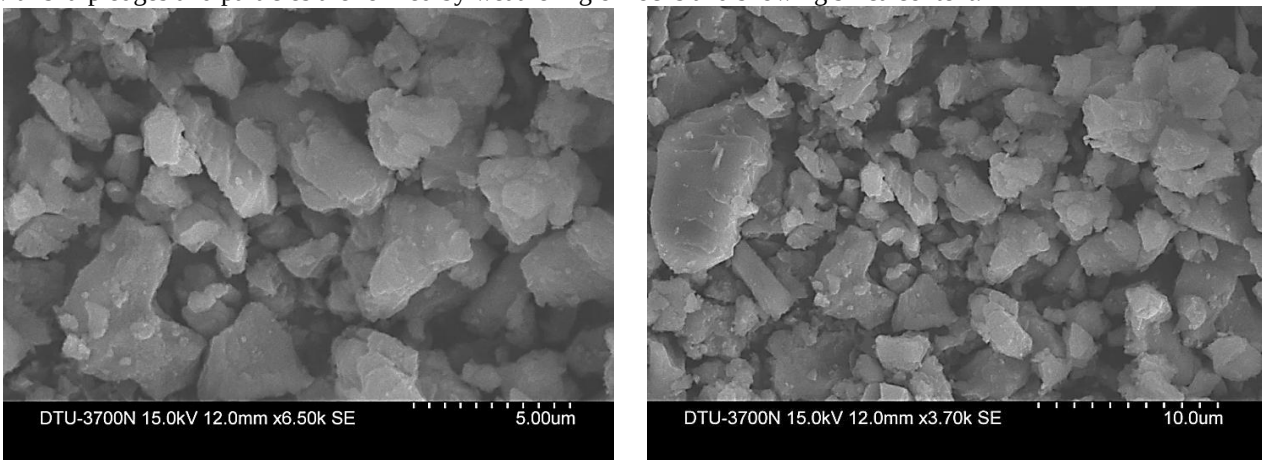

Fig. 3.1. Particle morphology of Yamuna Sand

3.1.2. Pond Ash

SEM Test on Pond ash shows presence of alumina silicates and dark matter present shows magnetite.

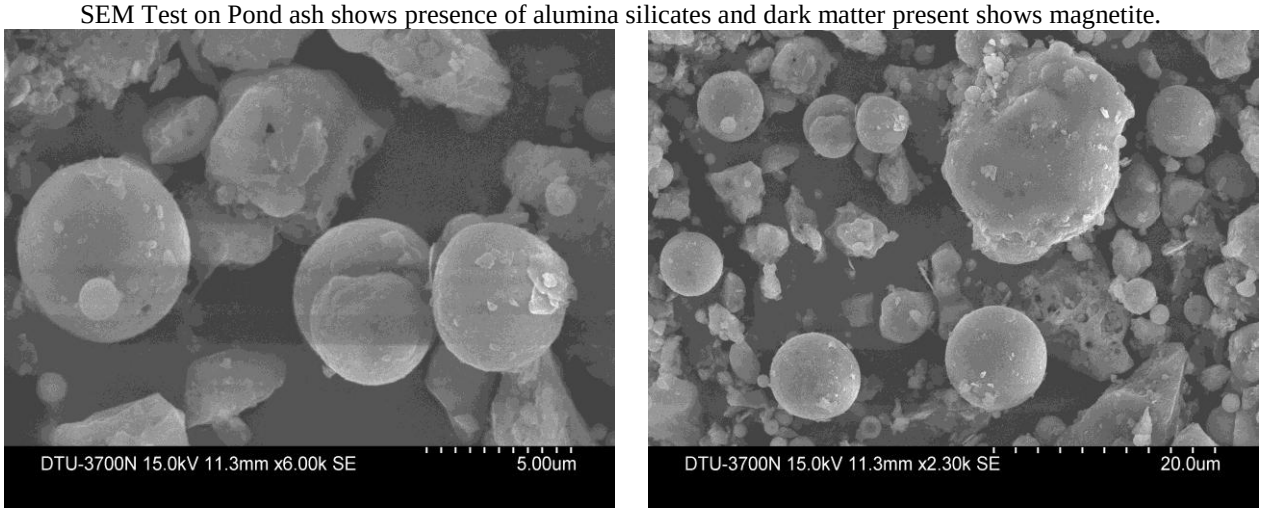

Fig 3.2.Particle morphology of Pond ash

3.1.3. Lime

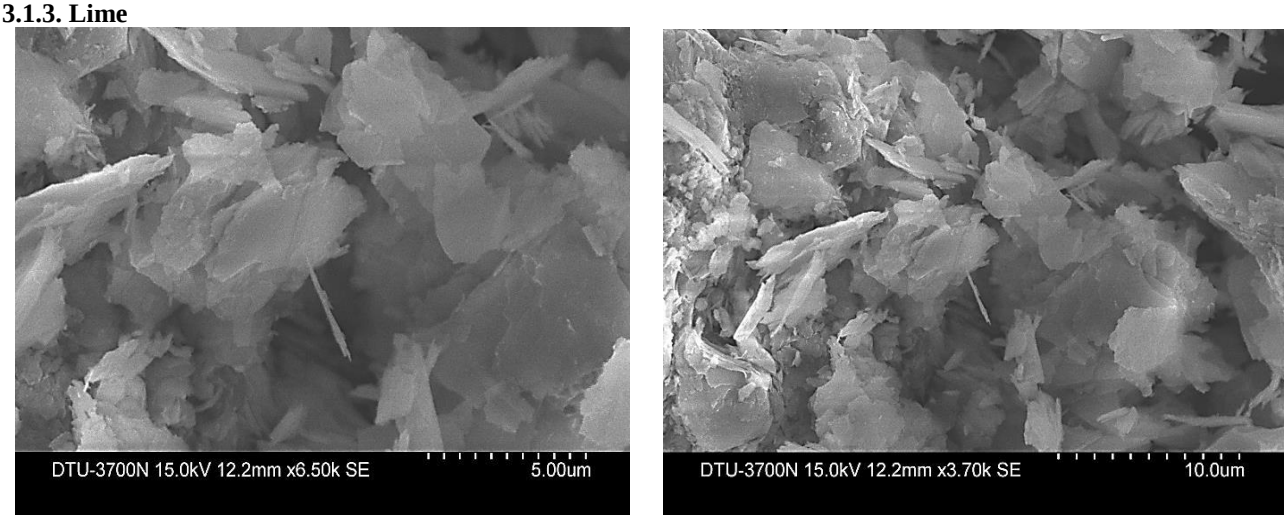

Fig 3.3.Particle morphology of lime

3.2. Standard Proctor Test

3.2.1. Standard Proctor Test to determine the optimum lime content when Yamuna sand is mixed with lime

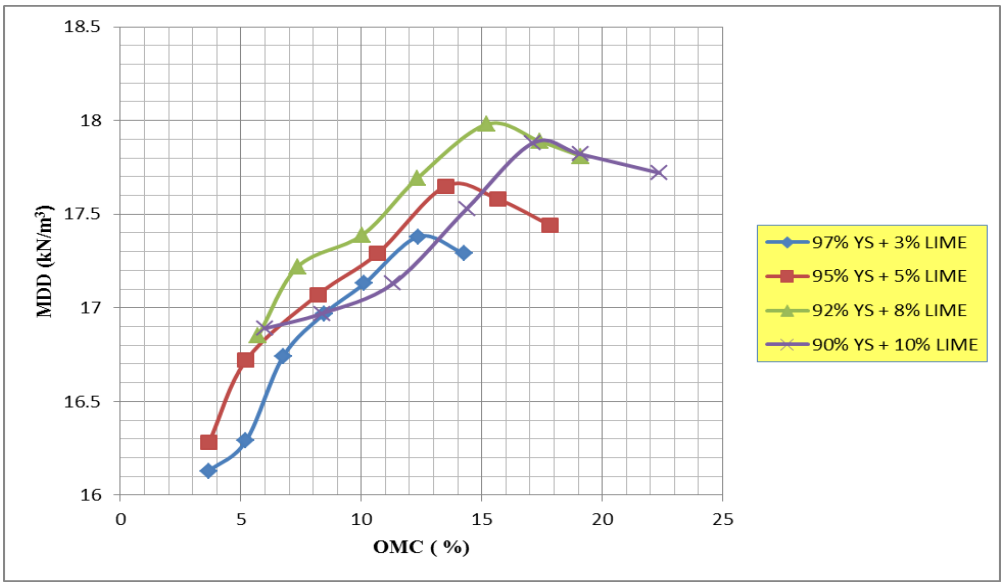

Fig.3.4. Compaction curve for Yamuna sand mixed with lime

Table 3.1. Variation of OMC and MDD for Yamuna sand mixed with lime

Sample Mix	MDD(KN/m^3)	OMC (%)
97% YS + 3% Lime	17.38	12.36
95% YS + 5% Lime	17.65	13.54
92% YS + 8% Lime	17.98	15.23
90% YS + 10% Lime	17.89	16.78

3.2.2. Standard Proctor test for determination of optimum lime content when pond ash is mixed with lime

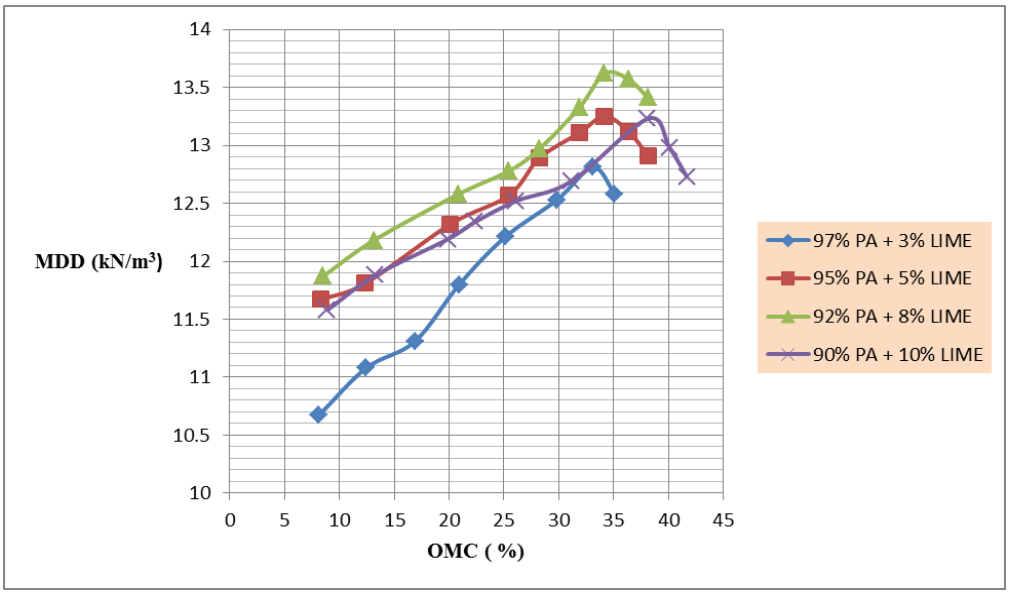

Fig.3.5. Compaction curve for pond ash mixed with lime

Table 3.2.Variation of OMC and MDD for Yamuna sand mixed with lime

Sample Mix	MDD(KN/m$^{3)}$	OMC(%)
97% PA + 3% Lime	17.32	12.42
95% PA + 5% Lime	17.68	13.67
92% PA + 8% Lime	18.24	14.51
90% PA + 10% Lime	18.42	15.23

It has been found that the optimum value of lime is 8%.

3.2.3. Determination of MDD and OMC for Yamuna sand mixed with pond ash and lime

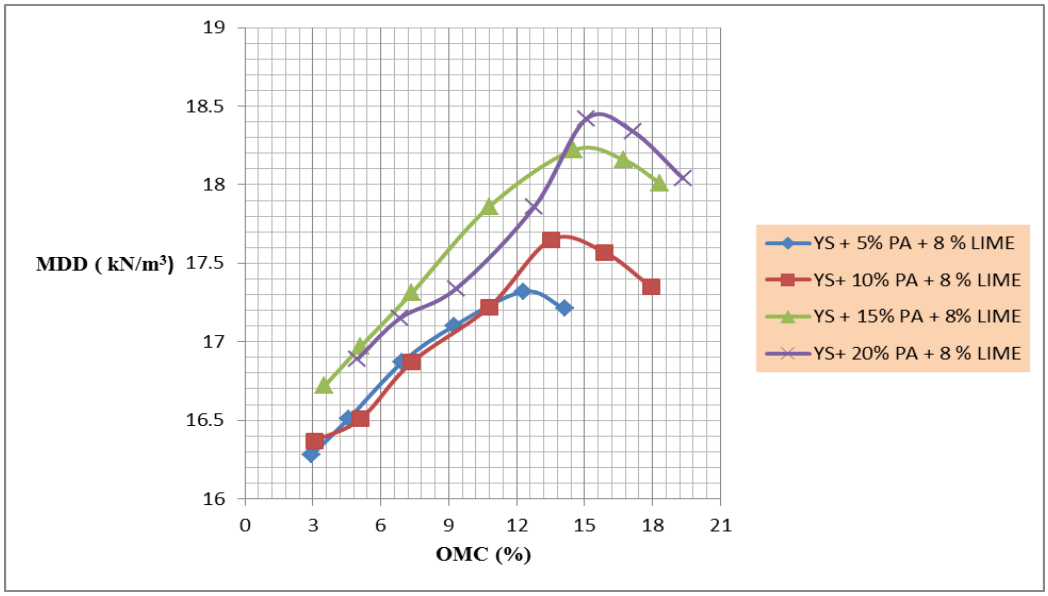

Fig.3.6. Compaction curve for Yamuna sand mixed with pond ash with lime

Table 3.3.Variation of OMC and MDD for Yamuna sand mixed with pond ash and lime

Sample Mix	MDD(KN/m$^{3)}$	OMC(%)
87%YS + 5% PA + 8% Lime	17.24	12.13
82%YS + 10% PA + 8% Lime	17.91	13.25
77%YS + 15% PA + 8% Lime	18.39	14.18
72%YS+20% PA + 10% Lime	18.64	15.01

3.3. Direct Shear Test

Shear behavior of different sample mixes is shown in the following figures:

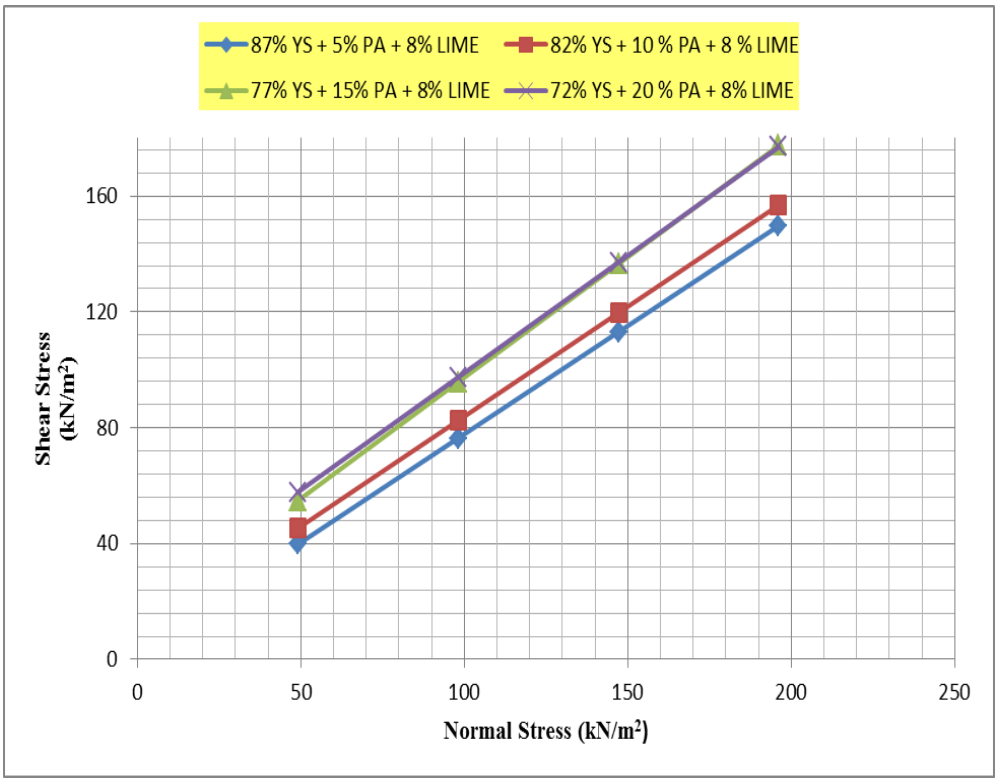

Fig.3.7. Shear behavior of various mixes

Table 3.4.Variation of various mixes of Yamuna sand, Pond ash and Lime

Sample Mix	Shear Strength Parameters	
	Cohesion, c (kPa)	ϕ (Degrees)
Yamuna sand	0	34
87 % YS + 5 % PA+8% Lime	3.2	36.8
82 % YS + 10% PA+8% Lime	7.6	37.2
77 % YS + 15 % PA+8% Lime	13.4	39.8
72 % YS + 20 % PA+8% Lime	17.7	39.1

3.4. Unconsolidated Undrained Triaxial Test

UU Test was performed on Yamuna sand mixed with varying proportions of pond ash and lime. Following results were obtained:

Table 3.5.Variation of shear strength parameter (c-ϕ) for various Yamuna sand, Pond ash and Lime mixes

Sample Mix	Shear Strength Parameters	
	Cohesion, c (kPa)	ϕ (Degrees)
Yamuna sand	1.02	35.2
87 % YS + 5 % PA+8% Lime	8.83	37.1
82 % YS + 10% PA+8% Lime	13.73	37.9
77 % YS + 15 % PA+8% Lime	16.64	40.7
72 % YS + 20 % PA+8% Lime	20.59	39.2

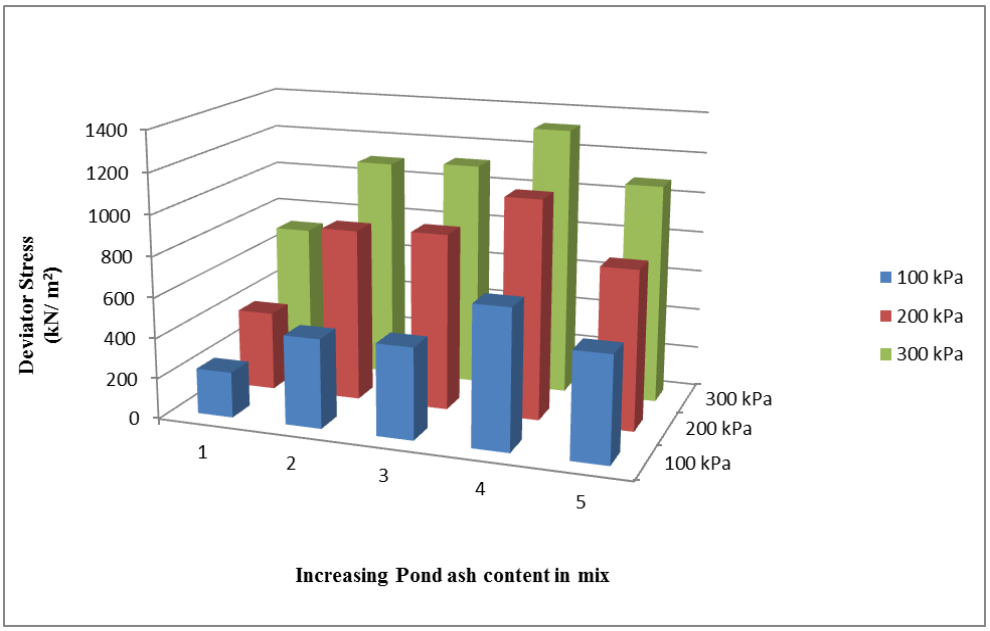

Fig.3.8. Deviator Stress v/s Axial strain variation when Pond ash is added on different proportions

IV. CONCLUSIONS

As a result of present work Pond Ash and lime is used to stabilize Yamuna sand, Geotechnical properties mainly shear behaviour and compaction behaviour of the individual and mix have found out. Following conclusions are drawn from this work

- Since Pond ash is a waste material obtained from thermal power station, which is present on large amount, is a major constituent in mix, in the mix its finer size leads to larger surface area than Yamuna sand and leads to increase the MDD of mix as Pond ash increases.
- Pond ash alone does not provide binding or stabilizing action, since it does not provide cohesion, so we need such material which forms some binding action in the mix. In our study lime was taken.
- Lime is not a waste material or freely available, so it is important to determine lime content. In our case direct shear test and standard proctor test were performed when lime was mixed with pond ash and when lime was mixed with Yamuna sand. Results shows optimum lime content taken for mix is 8%.
- Pond ash content is taken 5%, 10%, 15% and 20% of sample mix; keeping lime fixed as 8 % and remaining content is Yamuna sand. Compaction result shows, As Pond ash content is increasing, OMC & MDD both are increasing.
- Shear behaviour study is done by both Direct shear test and Triaxial test. Shear strength tests on virgin Yamuna sand and fresh pond ash compacted on OMC and MDD show that shear strength is mainly due to internal friction.
- Shear strength tests on mix show that increase in the 'c' parameters is little, 'Ø' parameter mobilized more and up to Pond ash content 15% and after that internal friction decreases.
- Deviator stress v/s axial strain behavior also show that deviator stress increases up to 15% Pond ash content for same confining pressure and for 20 % Pond ash deviator stress decreases suddenly.
- Hence by studying shear behavior and compaction behavior, Optimum replaceable amount of Pond ash should be 15%.
- This work shows by utilizing Pond ash, we not only use this waste material but can reduce the load of it on environment also.

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