Major Project-II

STRENGTH CHARACTERISTICS OF POND-ASH USING SYNTHETIC FIBRE AS REINFORCEMENT

Submitted in Partial Fulfillment For the Award of the Degree of

MASTERS OF TECHNOLOGY

IN

CIVIL ENGINERING

With Specialization In

GEOTECHNICAL ENGINEERING

By

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ABSTRACT

We can see since last decades economy of our country has been increasing. Hence various constructions work, construction of roads,highways is also increasing and these project requires an excavation and deposition of natural soil and aggregates in huge amount and so it is an environmental and economical issue. These are the issues which encourage us to find another method to overcome these environmental and economical issues which leads us to find reusability of industrial by-products which helps to overcome those issues and fullfill the specifications too. Pond-ash is one of them which is non-plastic and light weight material. The core objective is to create a material-system that can fit under the conditions of design use and for the design period of engineering construction projects.

Earth reinforcement with the help of fibrous materials is an old technique and has been shown in nature by action of roots of trees, animals, shrubs, birds.This reinforcement produce resistance against tensile stress developed in pond ash thereby restricting shear failure.In this investigation, Recron 3S polypropylene fibre manufactured by Reliance India Ltd., has been used. Polypropylene Fibres are engineered micro fibers with a unique "Triangular" Cross-section shape and are widely used in construction, mining, agricultural, textile and automotive industry.

An experimental investigation was undertaken to analyse the impact of polypropylene fibre inclusion on shear strength parameters of Pond ash. Test specimens prepared with varying percentages of 6 mm PP fibre (non-reinforced, Pf= 0.25%and 0.50% where, Pf is percentage of fibre of total weight of pond Ash)by the weight of dry Pond ash. Direct Shear Tests & California Bearing Ratio tests conducted on fibre reinforced Pond Ash and the effect of various proportions of polypropylene fibre on the properties of Pond ash were noted. The Pond ash was obtained from a Rajghat Power plant site in Delhi. Measurement of shear strength parameters were done by performing Direct shear test(DST) of standard size (6cm×6cm).

DST were conducted on three different normal stress i.e. 0.1, 0.2 & 0.3 N/mm^2 and cohesion intercept values and angle of friction were obtained by drawing a straight line through the graph of normal stress versus the shear stress.There was increase in the compressive strength & shear strength value of Pond ash on the addition of fibre. Also the cohesion intercept of the reinforced soil increased slightly. But the angle of internal friction reduced for the fiber reinforced soil. Scanning Electron Micrographs indicated that the obtained results were due to the special cross-section of the polypropylene fibre. CBR test were also conducted on different content of fibre in pond ash.

These results will help us in utilization and applicability of pond ash in many fields of construction works like sub-base and road base construction, construction of embankment, retaining walls designing and disposal of pond ash in eco friendly way.

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CHAPTER-1

INTRODUCTION

1.1 INTRODUCTION

Pond ash is a industrial by-product of coal based Thermal power plants which uses large area of land for dumping. From the economic and environmental point of view it is used in sub-base materials, material for dams, roads, embankment, basically it is used as filler material.The rate of utilization of pond-ash in present is not very high and various constructions work, construction of roads,highways is also increasing and these project requires an excavation and deposition of natural soil and aggregates in huge amount and so it is an environmental and economical issue. These are the issues which encourage us to find another method to overcome these environmental and economical issues which leads us to find reusability of industrial by-products which helps to overcome those issues and fullfill the specifications too

Pond-ash is produced from thermal power plant and it is non-plastic and light in weight. Due to the fast growth of human population and the need of good quality of life, there have been an exponential increase in the constructional activity. Due to this fast expansion and restriction of land, different civil engineering structures have to be constructed even where the soil cannot sufficiently bear the load of the superstructure. Thus the need arises for use of Pond ash.

Pond ash is good in compression, but very weak in tension.weakness of the Pond ash restricts its use in certain civil engineering applications. Thus arises the need for the modification of Pond ash strength parameters for its improved performance in desired areas. This deficiency of Pond ash strength can be eradicated by reinforcing the Pond ash; i.e. the introduction of an external material into the Pond ash materials can be defined as those materials which combine the strength of two or more materials in a supplementary way. These composite materials are widely used in various fields of engineering. The core objective is to create a material-system that can fit under the conditions of design use and for the design period of engineering construction projects. Pond ash reinforcement basically means the introduction of an external material into the Pond ash, in a manner that the overall behavior of Pond ash is significantly improved.

1.2 POND-ASH .

Pond-ash is basically product of combination of coal, Bottom ash, and fly-ash which are produced from coal based thermal power plant. All these are mixed together with water which forms slurry and that is pumped to the ash pond in which ash settles as residue and excess water is removed and final final residual of ash is called pond-ash, it is used as a filling material in various construction like roads , embankment, dams etc

Manufacturing of various building materials is also done with the help of Pond-ash like-lime, fly-ash bricks,blocks etc. Mostly Pond-ash is produced from power plants but alumimium, steel and copper plants also produced huge amount of Pond-ash.

1.3 REINFORCING FIBRES

Fibres are the basic constituents of composites which acts as a load carrier and also occupies large volume and space in composite laminate. Strength of fibres is lowest in radial or transverse direction and highest in longitudinal direction. It can be continuos and dis-continuos. The modulous and strength of composites produced from discontinuous fibres is lesser than those produced from continous fibres. A single unit of continous fibre is known as filament which has very small diameter, hence it's difficult to handle it as a practical purpose. To solve this problem many filaments are grouped together into a bundle to use it in a commercial way .The single filament have higher average modulous and tensile strength than of fibre strands.

Even to produce reinforcement element in many forms strands can be bundled together, like uni-axial reinforcements(prestressing strands and reinforcing bars) and fabrics. Strength requirements in many direction can also be meet by using these fabrics. Here as a reinforcement we are using Recron-3S fibre which is a polyester fibre. This recron-3s fibre is also used to increase strength in various application like filtration fabrics, cement based precast products. This fibre also provides resistance to abrasion , impact, and also improves the quality of construction in foundation construction reataining wall designing, it also decrease permeability of water helps in controlling cracking, easy to use.

1.4 FIBRE REINFORCED POND ASH

1.4.1 INTRODUCTION

RDFPA (Randomly distributed fibre reinforced pond-ash) is used in modern ground improvement techniques , in this technique pond-ash is mixed with desired quantity and type of fibres and mixed and laid in random way after compaction. RDFPA is different from other types of pond ash reinforcement methods in its orientation. In earth reinforcement, sheets, strips is put in horizontal direction and at a specific interval while in RDFPA fibres mixed in pond ash in random way and makes a homogenous mass and also maintain the strength isotropy RDFPA fibres are mixed randomly in pond ash thus making a homogeneous mass and maintain the isotropy in strength. Now-a-days geotechnical engineers are focusing on use of planar reinforcement(sheet , strips etc). But reinforcement of pond-ash with randomly distributed discrete fibres is a new technique in various geotechnical engineering project and construction.

1.4.2ADVANTAGES OF FIBRE-REINFORCED POND ASH

Randomly distributed fibre reinforced pond ash (RDFPA) offers many advantages as listed below:

- Beneficial for all and every type of soil,pond ash (i.e. clay, sand, silt).
- Increases shear strength with the maintenance of strength isotropy.
- Increases ductility
- Decreases loss in post peak strength
- Increases seismic performance
- Use of waste materials like shredded fibres, coir fibres also maintain economy in construction.
- Reduces shrinkage and swell pressure of expansive soil.
- Helps in development of vegetation and in controlling soil erosion.
- Fibre reinforcement is not substantively affected by weather conditions, unlike, lime , cement , chemical stabilization.

1.5 POLYPROPYLENE FIBRE

1.5.1 INTRODUCTION

Polypropylene fibre was first produced back in 1951 and is the second most important plastic. The sales of this material are forecast to grow every year.Fibre found its first use in the civil industry in the year 1965 as an admixture in concrete by the U.S. Corps of Engineers.

Polypropylene fibre is a synthetic fibre which is derived from petroleum , water, air, coal. It is developed in laboratory of 20th century, it is a product of chemical reaction of alcohol and acid in which two or more molecule combines together and resulting in a large molecule whose repetation of structure is done through the process of polymerization.

1.5.2 SHAPE OF POLYPROPYLENE FIBRES

Polypropylene fibres have a unique triangular cross-section, which provides 30-50% more surface area hence provides extra bonding in comparison to other shape. Its designing is in specific way so that fibres stays dimensionally straight and uniformly dispersed for prevention against bunching, balling, and curling.

1.5.3 WORKING OF POLYPROPYLENE FIBRES

Polypropylene fibre when mixed with cement during concrete preparation, these fibres spread in concrete thoroughly which gives extra 3-dimensional reinforcement. It is also used to improve workability. Due to expansion, shrinkage before and after hardening process and due to heat of hydration micro cracks developed which are avoided by the presence of polypropylene fibre, and these fibres also acts as a barrier for further propagation of cracks.

1.5.4 APPLICATIONS OF POLYPROPYLENE FIBRE IN CONSTRUCTION

- Tiles, tanks, manhole.
- PCC and RCC, Wall plastering, flooring, colum, beam, lintel
- Pavements and Roads
- Foundations

1.5.5 ROLE OF POLYPROPYLENE FIBRE IN CONSTRUCTION INDUSTRY

On addition of polypropylene fibre in small amount of 0.25% in the weight of cement helps us in various ways to imrove labour, time , money, improving quality of construction as well as raw material.

- Controlling micro-cracks
- Decreases permeability of water
- Decreases rebound loss
- Helps in rising ductility and flexibility
- Rises resistance of abrasion

1.5.6 USE OF POLYPROPYLENE FIBRE IN PLASTERING

- Acts as a barrier for plastic and dry shrinkage cracks and checks plastic settlement cracks.
- It protects iron bar from rust and corrosion by reducing water seepage through micro cracks developed in plaster.
- It also improves aesthetics by making plaster free from micro cracks and hence avoid the extra cost and expenses on frequent repair work and repainting..

1.5.7 ROLE OF POLYPROPYLENE FIBRE IN CONCRETE

- Its natural if cracks develops in concrete. Polypropylene fibres helps in avoiding micro cracks, hence improves the longevity of the structure.
- The development of micro-cracks are arrested by presence of fibres in 3-dimensions through out the structure, which are formed in plastic stage and cement curing stage.
- It avoids the micro cracks hence reduce the seepage and protect primary reinforcement from rust and corrosion added quality to the construction.

- Polypropylene fibre by improving resistance impact and abrasion also improves flooring , life and durability of roads etc.
- Other improvements seen in fibre reinforced concrete :-
    - Improved flexural strength
    - Better abrasion than plain concrete.

1.6 NECESSITY OF STUDY

- Higher subgrade strength lowers the thickness of overlying layers hence makes the road construction economical.
- Large types of synthetic fibres are available in market easily at an economical price.
- Placing randomly distributed fibres in pond ash are easy as compared to the reinforced pond ash in which the added material (the geosynthetics sheet, etc.) is layered at a specific direction and position, which may keep the pond ash(subgrade material)weaken in some other direction.

1.7 OBJECTIVES OF THE STUDY

- To study the effect of content of polypropylene fibre addition on the shear strength of pond ash by conducting Direct Shear Tests[IS 2720(XIII):1986 Methods of Test for Soils, direct shear test].
- To study the effect of content of polypropylene fibre addition on the CBR value of pond ash[IS 2720(XVI):1987 Methods of Test for Soils, determination of CBR].
- To draw a comparison between shear strength parameters of both unreinforced and fibre reinforced pond ash[Bera et al. (2007)].
- To notice the pond ash particles-fibre abrasion effect by conducting SEM (Scanning Electron Microscope) tests

CHAPTER-2

LITERATURE REVIEW

2.1 LITERATURE REVIEW ON REINFORCED POND-ASH

2.1.1 INTRODUCTION

Pond ash is a industrial by-productof coal based Thermal power plants which uses large area of land for dumping. From the economic and environmental point of view it is used in sub-base materials, material for dams, roads, embankment, basically it is used as filler material and it is good in compression and weak in tension. So, To increase its utility in various civil engineering application, there is a need for modification of pond ash strength parameter, for this fibre is helpful and it can increase the shear parameters, its suitability for the use in sub-base and base-course material. For this study, literature of some authors studied which is given below.

[**Kumar et al. (1999)]** presented results of tests performed on pond-ash & silty-sand with polypropylene fibres. The results suggested the use offibre as reinforcement on pond ash which increases the peak compressive strength, peak friction angle, CBR value and ductile nature of specimen. These test reports shows that the optimum content of fibre should be used for both pond-ash and silty-sand is 0.3%- 0.4% of dry density.

[**Bera at al. (2007)]** reported the impact of compaction on strength parameters of pond-ash. Variation in strength due to different compaction energies, controlling parameters like size of tank, compaction, layer thickness,mould area, moisture content and specific gravity on dry unit weight of pond-ash are obtained. Test results showed that Maximum dry density(MDD) of pond-ash changed in the range of 8.41-12.24kN/m^3 and Optimum moisture content(OMC) changed between 29-46% where degree of saturation varies**sa**me tests were carried out for three different types of pond ash. These tests showed that the MDD of pond ash varied within the range of 8.40–12.25 kN/m^3 and the OMC of pond ash varied within the range of 29–46% where as the degree of saturation at OMC founded to varied between 63-89%. By using method of analysis through multiple regression,Prediction of dry density of pond-ash in terms of specific gravity,moisture cintent , compaction energies can be easily done by using empirical model analysis.These model analysis can help us in the field for estimation of OMC and MDD and for planning of field compaction control.

[**Singh et al.(2015)]** This apper shows the strength characteristics of compacted pond-ash reinforced with polyester fibres. Sample of pond-ash collected from Rourkela Steel Plant(RSP) pond, subjected to varying energies of compaction from 356 to 3489 KJm^{-3}. And OMC and MDD corresponding to these energies of compaction determined by compaction tests. The parameters of shear-strength, UCS of pond-ash specimens subjected under modified and standard proctor densities with 6mm and 12 mm legth fibres and variation of fibre content as 0, 0.1, 0.2, 0.3, 0.5, 0.75, 1 % were estimated and analyzed , These estimations showed us that on inclusion of polyester fibres the peak friction angle, peak compressive strength, ductility also increases. For a given compaction density and fiber content, higher strength is given by 12mm fibres rather than 6mm fibres.

[Kumar A, Gupta D,(2016)] The Maximum dry Density of pond-ash stabilized by cement reduces from 1.79 to 1.63 g/cc and Optimum moisture content(OMC) rises from 18.46 to 21.14 %, when we increases content of cement from 0 to 6 %. The stabilization of pond-ash with cement alone or in addition with fibres is fruitful in increasing the CBR and UCS values.

2.1.2 CONCLUSION.

Study of these literature suggest the inclusion of fibre in pond ash which affect the shear parameters of pond ash which will be shown by performing DST(IS 2720(XIII):1986 Methods of Test for Soils,(DST) direct shear test) on different % of fibre values, and similarly impact of fibre inclusion in pond ash for suitability of the use in sub-base and base-course material, which will be shown by performing CBR test(IS 2720(XVI):1987)].

CHAPTER-3

MATERIAL USED

3.0 INTRODUCTION

In the following chapter description of the materials used in the current investigation has been given. The properties of the pond ash used and the type and source of the fibre is given.

3.1 POLYPROPYLENE FIBRE AS REINFORCEMENT

Polypropylene Fibres are engineered micro fibres with a unique “Triangular” Cross-section, used in Secondary Reinforcement of Concrete. It increases the concrete’s resistance to shrinkage cracking by complementing structural steel and also improves Flexural transverse and tensile strengths of concrete and in parallel it also increasesabrasion and impact strength.

The product(polypropylene fibre) under the brand name of “RECRON-3S” has launched by the Reliance Industries Limited(RIL) with the aim of improving quality of concrete and plaster. Reliance is 4th largest polymer player in the world and our experience and research in Polymer field supports Polypropylene fibre as better polymer for concrete than polypropylene. Polypropylene fibres have a unique triangular cross-section, which provides 30-50% more surface area hence provides extra bonding in comparison to other shape. Its designing is in specific way so that fibres stays dimensionally straight and uniformly dispersed for prevention against bunching, balling, and curling

This triangular unique shape of polypropylene fibre also improves the quality of adhesion in the cement matrix. Which also helps us in better dispersion and operability, and this is a key of performance of secondary reinforcement.

The Polypropylene fibre we used in the experiments is made from reliance group of industries hence properties of fibre given by reliance group is given on next page.

3.2 PROPERTIES OF POLYPROPYLENE FIBRE

Table 1: Properties of Recron-3S Fibre bought from RIL office Delhi. [Indian concrete jounal, (2003): “Properties of Recron-3s fibre” by Reliance industries .Ltd. *website- www.icjonline.com/products/pdfs/2003_03_Recron.pdf*]

Material	Polypropylene
Shape/ Cross Section	Triangular
Effective Diameter	10-40 Microns
Length	6 / 12 mm
Specific Gravity	1.31-1.39
Melting Point	>250°C
Tensile strength	4-6 MPa
Young`s Modulus	>5000 MPa

Figure 1: Recron-3S Fibre (6mm) used in the following experimental programme

3.3 POND ASH

In the current investigation following sample of Pond Ash has been used.

- Pond-Ash – Silty (SP) obtained from a Rajghat Thermal Power plant site in Delhi.

Following are the results of various test carried out on the pond ash.

- **SPECIFIC GRAVITY TEST**.
- According to the method(IS-2720(III/SEC-I):1980 Methods of Test for Soils, Determination of specific gravity)

- **SIEVE ANALYSIS.**
- According to the method(IS-2720(IV):1985 Methods of Test for Soils, determination of grain size analysis)

- **MAXIMUM DRY DENSITY.**
- According to the method(IS-2720(VII):1980 Methods of test for soils, determination of water content dry density relation using light compaction)

- **OPTIMUM MOISTURE CONTENT.**

- According to the method(Is-2720(Part 2), 1973 Methods of tests for soil, Determination of water content)

Table 2: Summary of the test results performed on pond-ash

PROPERTY OF THE SOIL	**RESULT**
Specific Gravity	2.38
I.S. Classification	Silty (SP)
Maximum Dry Density	11.42 kN/m^3
Optimum Moisture Content	33.1 %
Effective size, D_{10}	0.088 mm
D_{30}	0.185 mm
D_{60}	0.345 mm
Coefficient of Uniformity, C_u	3.92
Coefficient of curvature, C_c	1.127

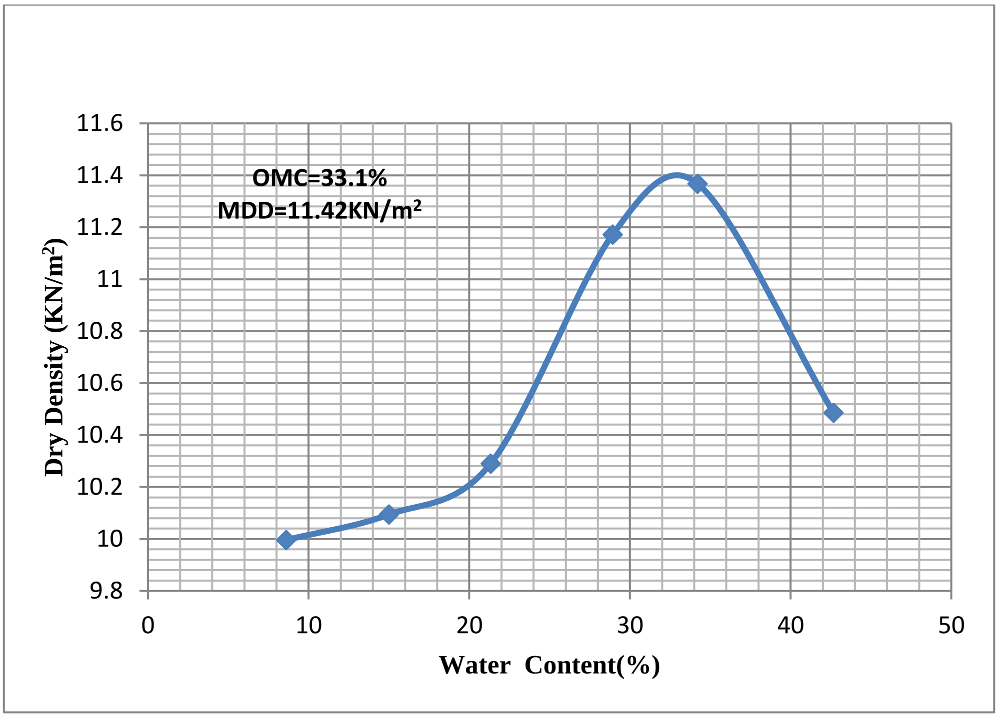

Fig 2 :Dry density v/s water content

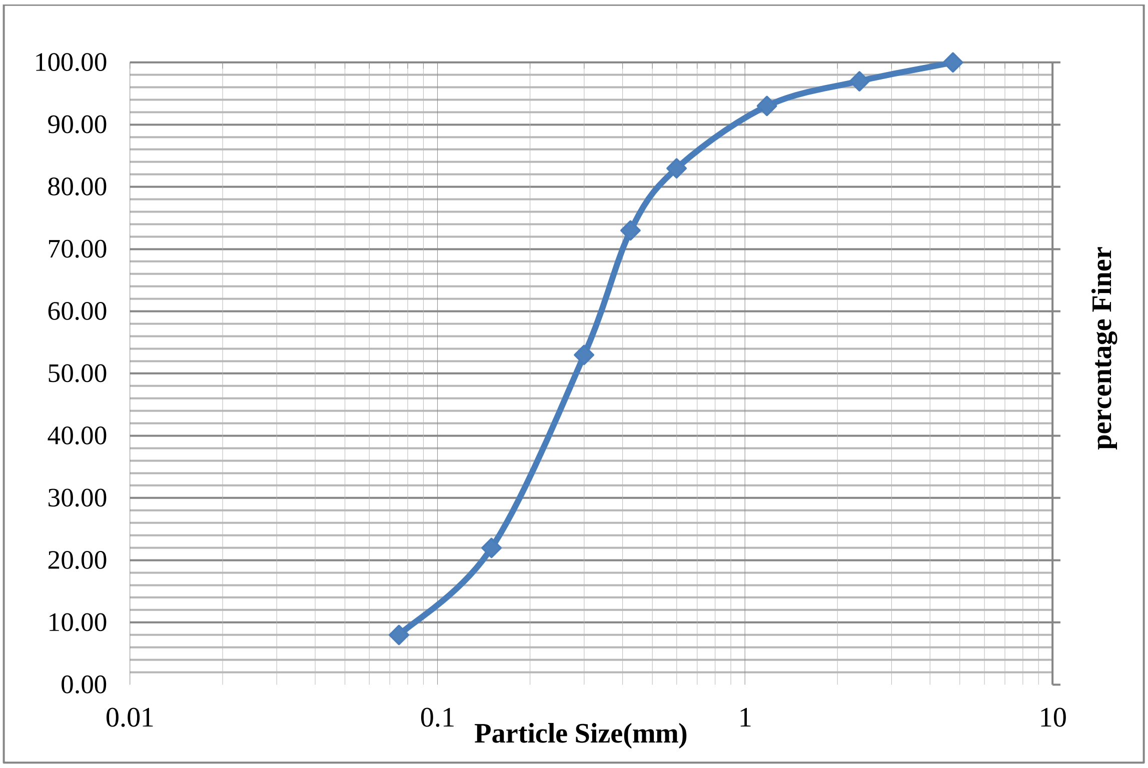

Fig 3: Particle size distribution curve.

CHAPTER-4

EXPERIMENTAL PROGRAMME

4.0 INTRODUCTION

In the following chapter description of methodology and experimental programme has been given. Description of the procedure of the various tests has been stated.

4.1 TESTS CARRIED OUT FOR THE INVESTIGATION

Following test have been performedon both reinforced and unreinforced Pond ash with different percentage of fibre addition.

- Direct Shear Test
- California Bearing Ratio(CBR TEST)

4.2 METHODOLOGY

Direct Shear Test(IS 2720(XIII):1986)

- This test is performed on Pond-ash estimate the shear parameters of Pond-ash, by using Direct shear box of standard size for the investigation(IS-2720(XIII):1986 Methods of test for soils, Direct shear test).
- The test is carried out on sample for different normal stress(0.1, 0.2, 0.3 N/mm^2) and cohesion intercept value and angle of friction obtained by drawing straight line through the graph of Normal stress versus Shear stress.
- DST were conducted according to IS-2720: Part-13:1986).

Unsoaked CBR TEST(IS-2720(XVI):1987)

- Unsoaked CBR test were done for the evaluation of subgrade strength of pond ash.
- Sample was prepared at optimum moisture content and max dry density(MDD) and then compacted in a mould of 17.5 cm height and 15 cm diameter.
- The whole system with the surcharge load was kept for penetration test. Loads readings were recorded for different values of penetration and then unsoaked CBR values were determined corresponding 2.5mm and 5mm penetration

value(Kumar A, Gupta D,(2016))

- Tests were performed for samples at light compaction density at light compaction with varying content of fibre [Bera et al. (2007)].

DIRECT SHEAR TESTS

Table 3: Load Displacement Response of Unreinforced pond ash.

LOAD			
displacement(mm)	**σ_n=0.1N/mm^2**	**σ_n =0.2N/mm^2**	**σ_n =0.3N/mm^2**
0	0	0	0
0.1	49.05	123.61	64.75
0.25	92.21	188.35	204.05
0.5	125.57	274.68	310
0.75	147.15	321.77	382.59
1	162.82	361.99	436.55
1.25	176.58	392.4	481.6
1.5	185.41	412.02	515.13
1.75	193.26	433.6	545.45
2	200.12	447.34	567.03
2.25	205.03	457.15	575.87
2.5	210.92	464.99	594.49
3	217.78	474.18	606.26
3.5	222.69	480.61	607.24
4	226.61	476.7	609.2
4.5	231.52	471.52	616.07
5	235.44	470.88	623.98
5.5	235.44	471.85	620.98
6	236.42	472.83	614.11
6.5	236.42	471.84	602.33
7	236.42	471.86	596.45
7.5	236.42	471.87	586.64
8	238.38	471.87	585.65
9	236.42	471.87	574.85
10	235.44	472.84	562.11
11	233.48	474.81	542.47
12	233.48	475.79	514.03

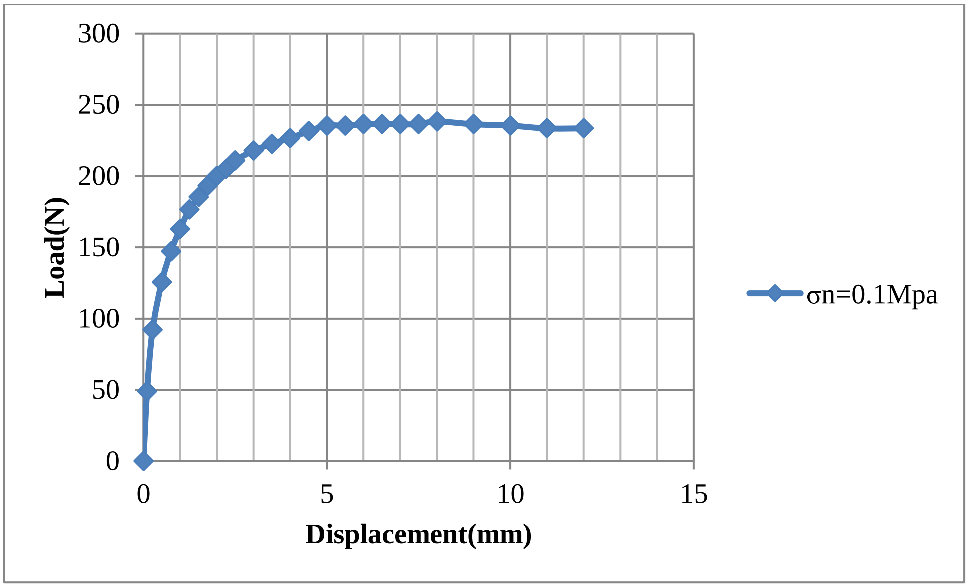

Fig-4: Load-Displacement response of unreinforced pond ash (P_f=0%) at Normal stress 0.1N/mm^2

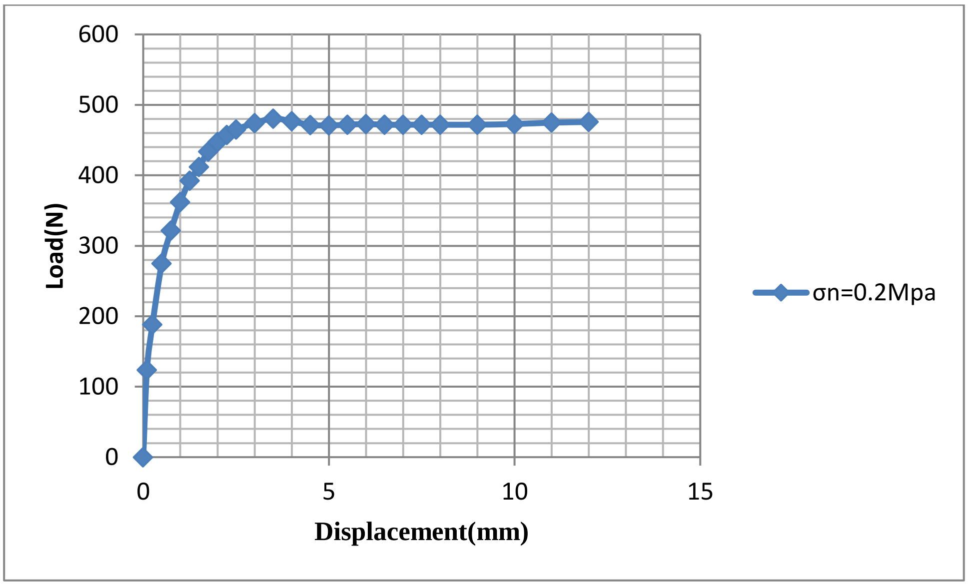

Fig-5 : Load-Displacement response of unreinforced pond ash (P_f=0%) at Normal stress= 0.2N/mm^2

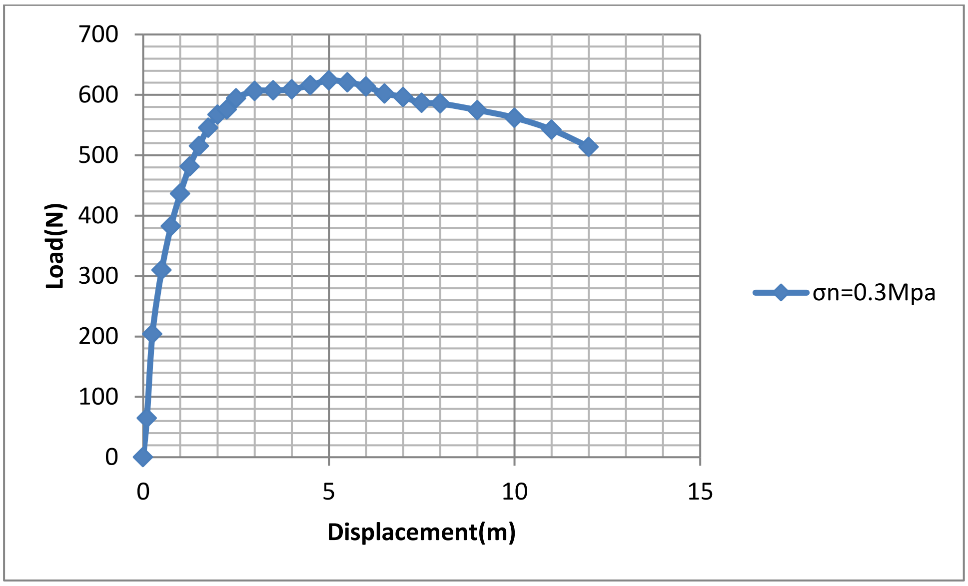

Fig 6: Load Displacement response of unreinforced pond ash (P_f=0%) at Normal stress= 0.3N/mm^2

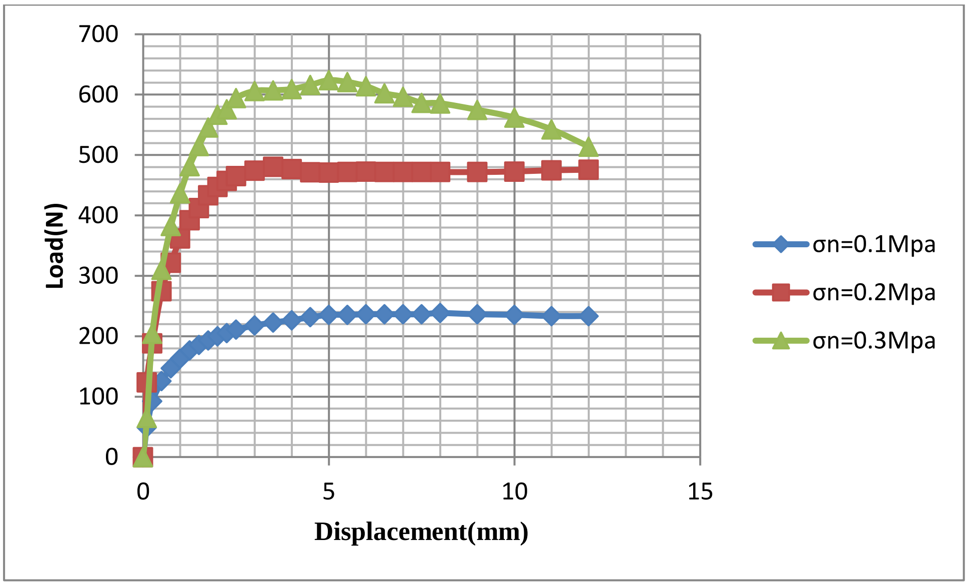

Fig-7: Load-Displacement response of unreinforced pond ash (P_f=0%).

Table 4: Load-Displacement Response of Reinforced Pond ash (P_f =0.25%).

Horizontal Displacement(mm)	Load		
	σ_n=0.1N/mm^2	σ_n=0.2N/mm^2	σ_n=0.3N/mm^2
0	0	0	0
0.1	59.84	72.59	127.23
0.25	103.02	173.64	208.29
0.5	149.12	217.58	300.56
0.75	177.54	257.32	356.32
1	195.25	290.36	398.56
1.25	210.58	317.59	436.95
1.5	218.52	338.65	469.32
1.75	225.62	360.59	499.85
2	232.54	376.95	531.29
2.25	237.58	389.36	558.46
2.5	242.56	400.25	583.34
3	248.95	420.63	632.23
3.5	254.23	434.12	669.86
4	261.85	443.25	695.39
4.5	269.45	450.89	725.2
5	273.85	454.32	742.56
5.5	276.96	459.98	762.58
6	278.25	468.23	782.12
6.5	282.65	483.69	795.96
7	284.94	496.32	807.36
7.5	285.36	507.61	815.36
8	289.57	515.03	824.65
9	293.68	533.69	843.29
10	294.3	546.26	866.33
11	296.26	552.3	886.82
12	296.26	559.17	901.54

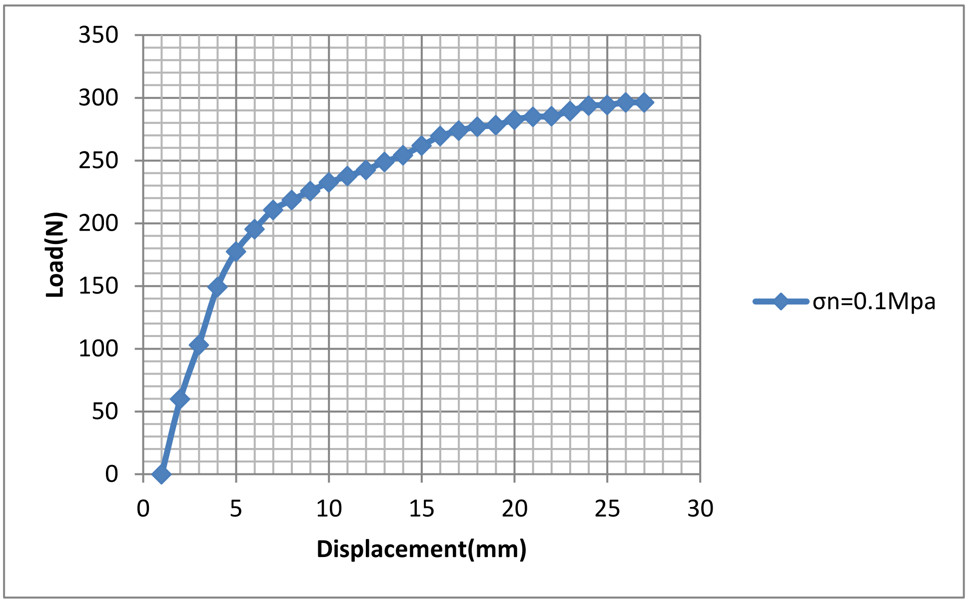

Fig 8: Load Displacement response of unreinforced pond ash (P_f=0.25%) at Normal stress= 0.1N/mm^2

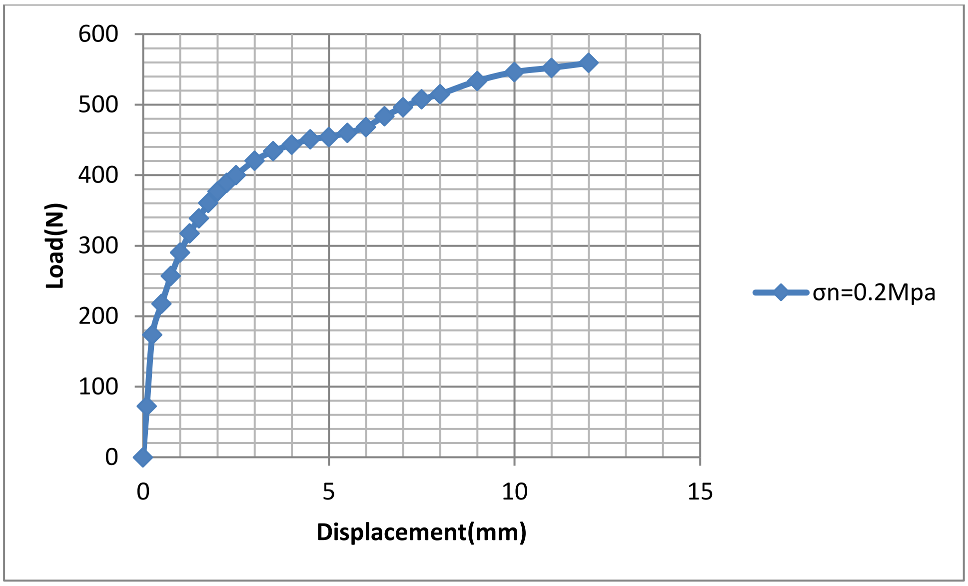

Fig-9: Load-Displacement response of unreinforced pond ash (P_f=0.25%) at Normal stress= 0.2N/mm^2

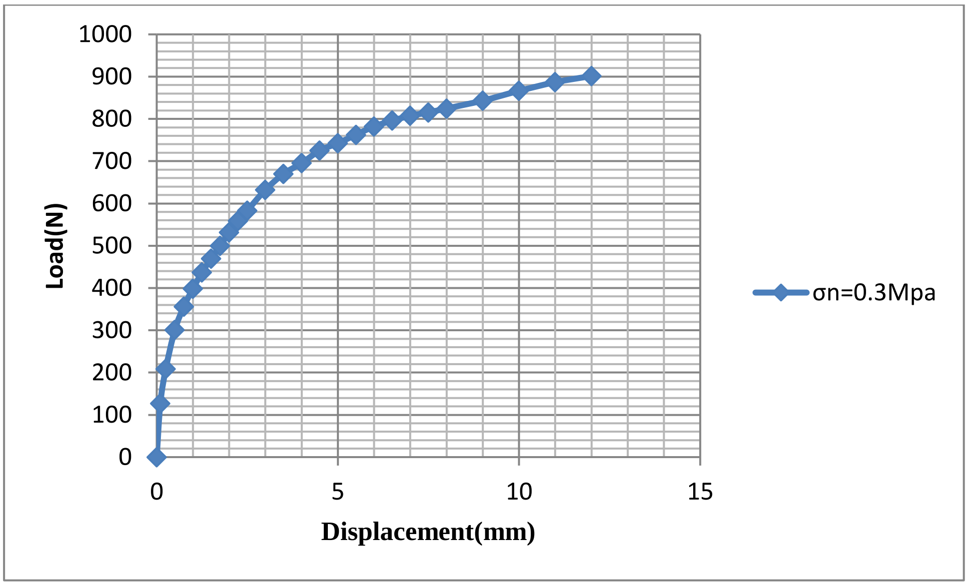

Fig-10: Load-Displacement response of unreinforced pond ash (P_f=0.25%) at Normal stress= 0.3N/mm^2

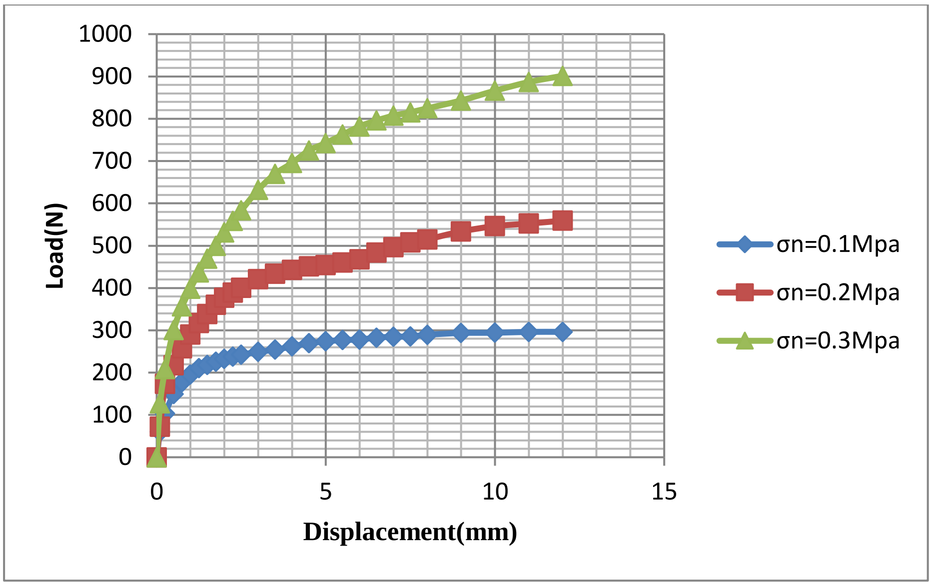

Fig-11: Load-Displacement response of unreinforced pond ash (P_f=0.25%).

Table 5: Load-Displacement Response of Reinforced Pond Ash(P_f =0.50%)

Horizontal Displacment (mm)	**Load (N)**		
	σ_n=0.1N/mm^2	**σ_n=0.2N/mm^2**	**σ_n=0.3N/mm^2**
0	0	0	0
0.1	108.23	88.56	68.94
0.25	142.85	186.69	135.62
0.5	179.95	245.23	232.56
0.75	204.56	274.62	284.69
1	227.59	294.36	336.59
1.25	245.25	323.85	386.59
1.5	257.89	362.56	426.83
1.75	267.81	372.58	461.89
2	277.62	382.69	501.87
2.25	285.95	402.21	522.26
2.5	293.69	412.02	548.36
3	305.23	431.29	587.29
3.5	314.54	451.69	619.27
4	323.65	461.13	642.59
4.5	328.96	470.38	662.18
5	334.13	480.39	684.56
5.5	338.16	490.26	715.58
6	342.93	500.35	747.59
6.5	346.37	510.23	773.89
7	350.63	519.3	791.15
7.5	353.12	529.89	816.59
8	356.95	539.87	838.29
9	362.26	549.35	869.58
10	367.76	559.29	894.56
11	371.59	568.19	924.25
12	374.73	568.94	948.25

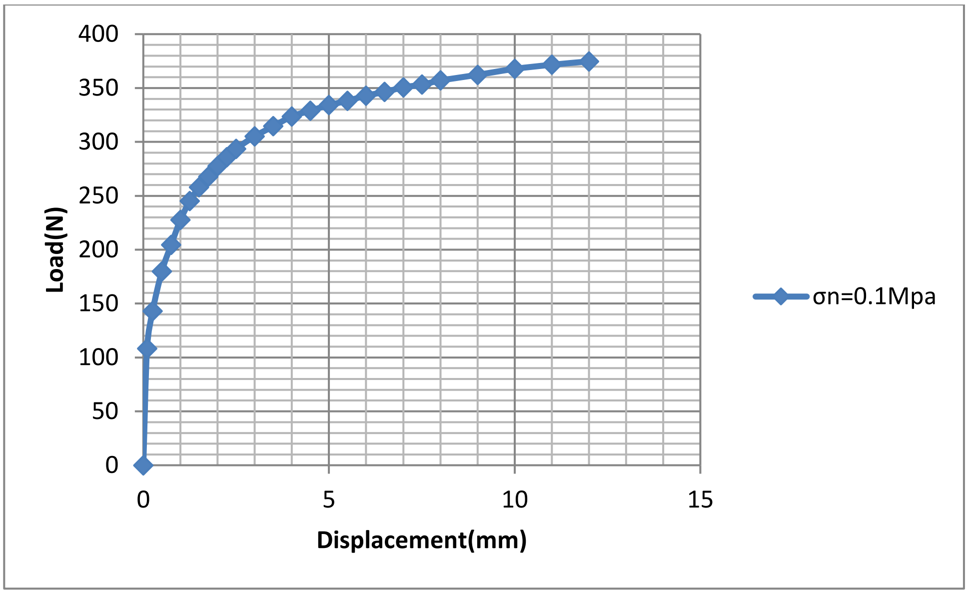

Fig 12: Load Displacement response of unreinforced pond ash (P_f=0.5%) at Normal stress= 0.1N/mm^2

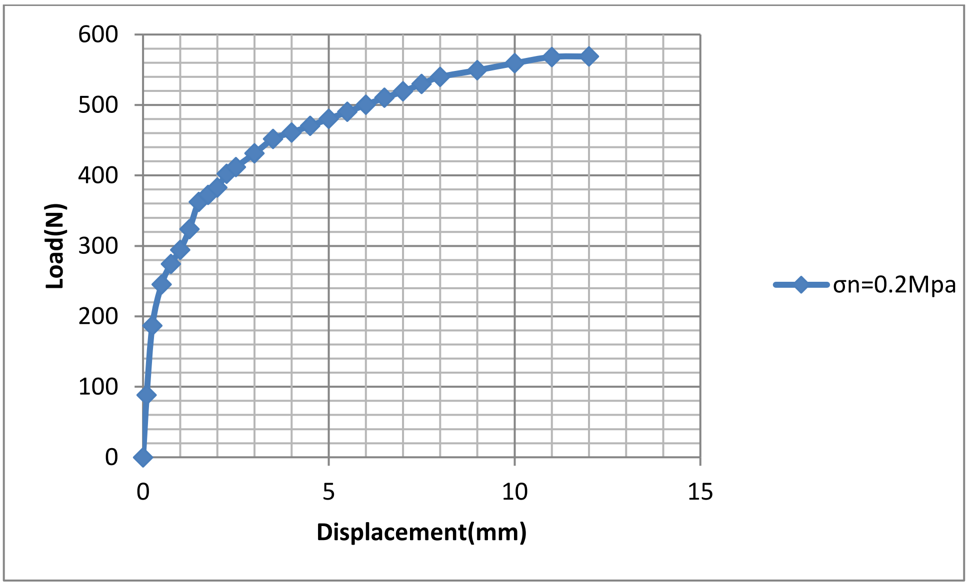

Fig 13: Load Displacement response of unreinforced pond ash (P_f=0.5%) at Normal stress= 0.2N/mm^2

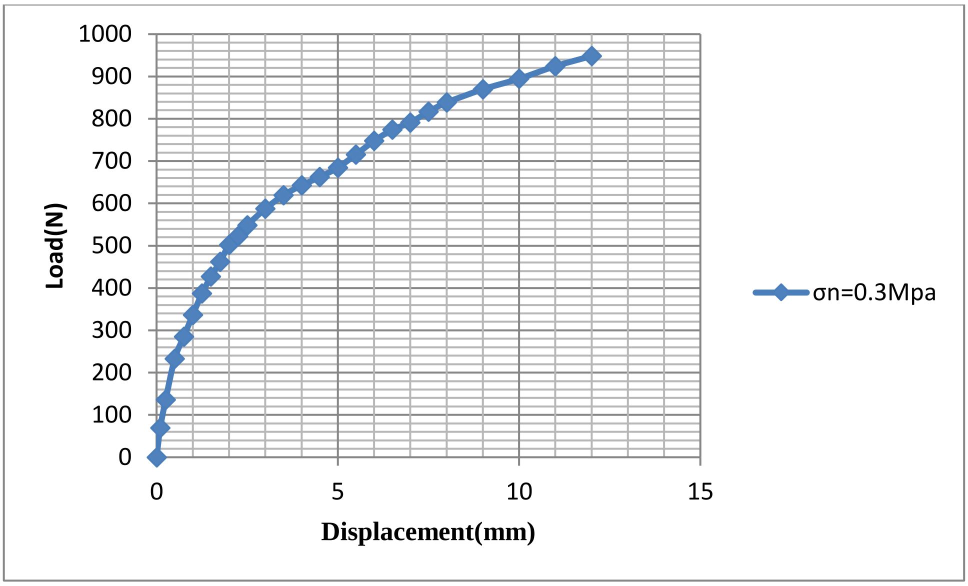

Fig-14: Load-Displacement response of unreinforced pond ash (P_f=0.5%) at Normal stress= 0.3N/mm^2

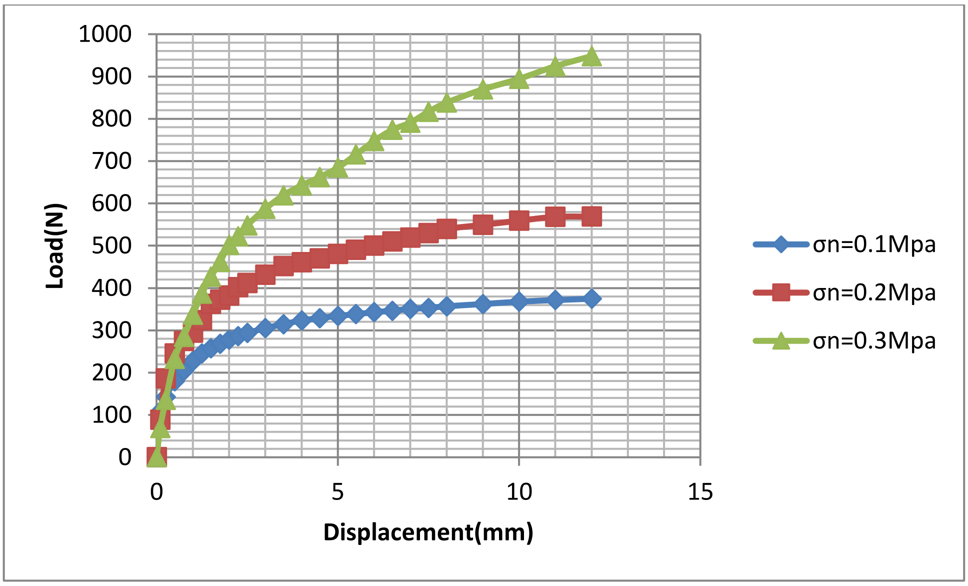

Fig-15: Load-Displacement response of unreinforced pond ash

CBR TEST

Table 6: Load-Penetration Response of unreinforced Pondash (P_f =0.0%)

Penetration of plunger (mm)	**Load dial reading . (N/mm^2)**	**Load(N)**
0	0	0
0.5	0.2401	471.4213
1	0.5096	1000.568
1.5	0.784	1539.335
2	1.0241	2010.756
2.5	1.2544	2462.936
3	1.47	2886.253
3.5	1.6464	3232.604
4	1.7836	3501.987
4.5	1.9208	3771.371
5	2.0384	4002.271
5.5	2.1756	4271.655
6	2.2932	4502.555
6.5	2.4304	4771.939
7	2.5284	4964.355
7.5	2.6264	5156.772
8	2.7636	5426.156
8.5	2.9008	5695.54
9	2.9204	5734.023
9.5	2.94	5772.506
10	3.0576	6003.407
10.5	3.1164	6118.857
11	3.136	6157.34

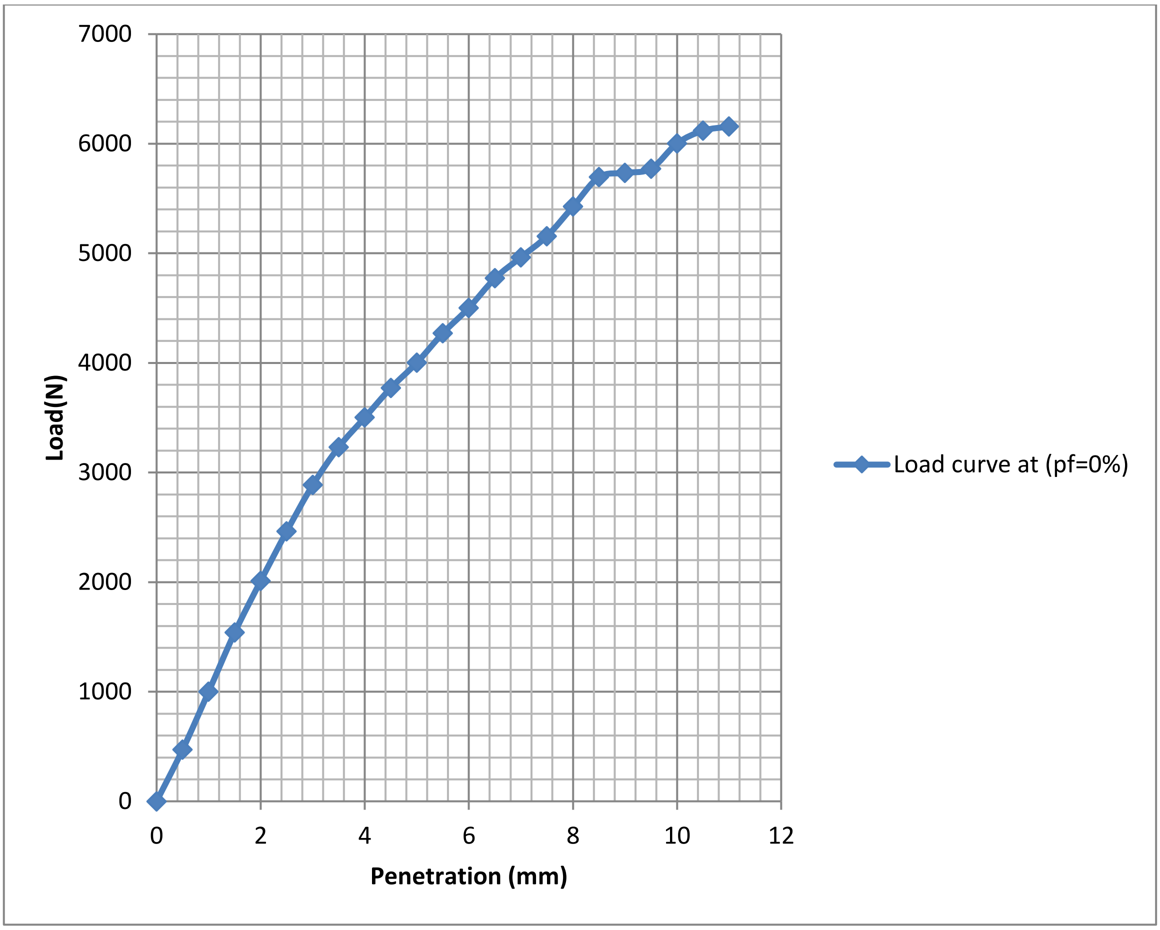

Fig.16: Load-Penetration Response in CBR Test of unreinforced Pond ash(P_f =0.0%)

Table 7: Load-Penetration Response of Reinforced Pondash (Pf =0.25%)

Penetration of plunger (mm)	**Load dial reading . (N/mm^2)**	**Load(N)**
0	0	0
0.5	0.1372	269.383625
1	0.392	769.6675
1.5	0.8428	1654.785125
2	1.078	2116.585625
2.5	1.2152	2385.96925
3	1.372	2693.83625
3.5	1.4896	2924.7365
4	1.617	3174.878438
4.5	1.764	3463.50375
5	1.862	3655.920625
5.5	1.96	3848.3375
6	2.058	4040.754375
6.5	2.1168	4156.2045
7	2.156	4233.17125
7.5	2.2344	4387.10475
8	2.254	4425.588125
8.5	2.3128	4541.03825
9	2.3716	4656.488375
9.5	2.4304	5513.924976
10	2.4892	5763.22298
10.5	2.548	6012.520984
11	2.5872	6261.818987
11.5	2.7048	6511.116991
12	2.744	6760.414995

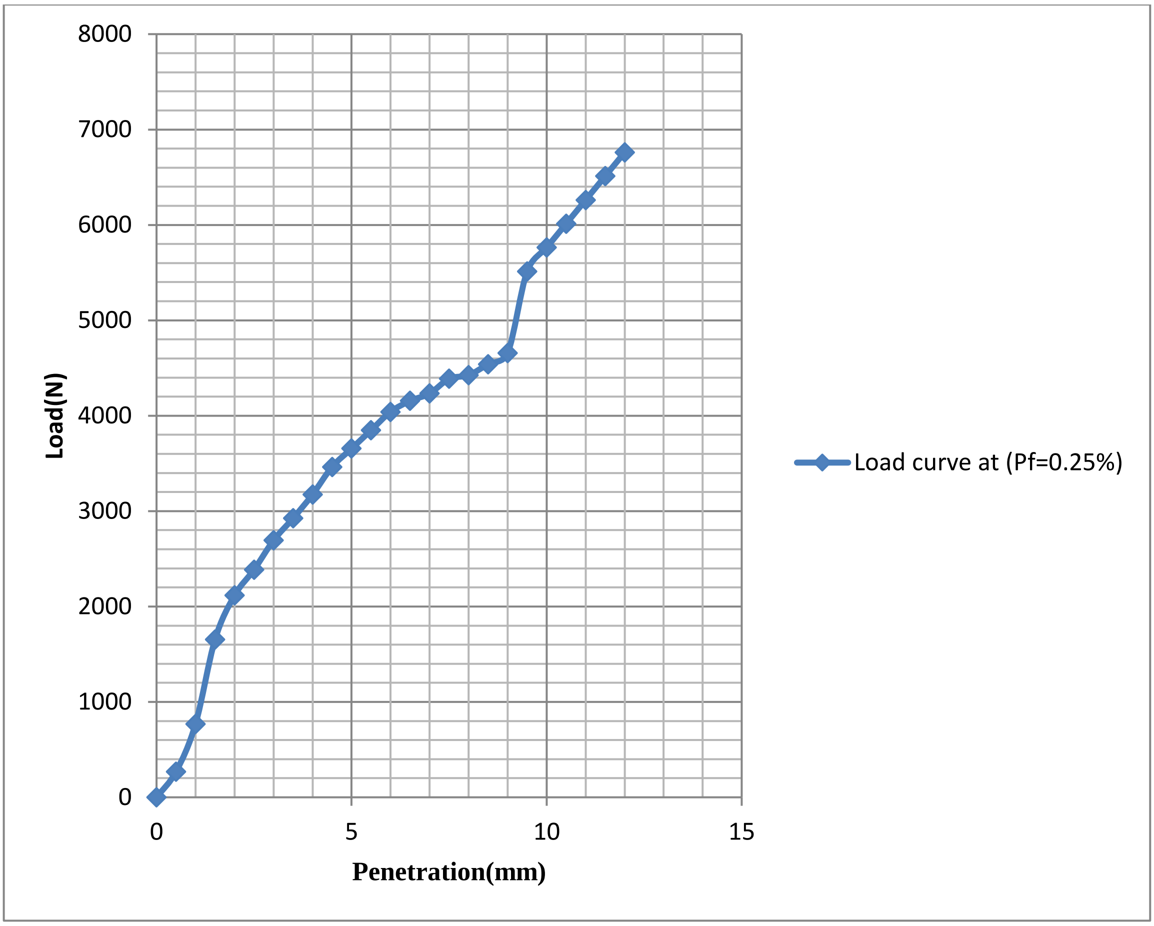

Fig-17: Load-Penetration Response in CBR Test of Reinforced Pond ash(P_f =0.25%)

Table 8: Load-Penetration Response of Reinforced Pondash (P_f =0.50%)

Penetration of plunger (mm)	**Load dial reading (N/mm^2)**	**Load(N)**
0	0	0
0.5	0.392	769.6675
1	0.7448	1462.368
1.5	1.0584	2078.102
2	1.3132	2578.386
2.5	1.5288	3001.703
3	1.7052	3348.054
3.5	1.862	3655.921
4	1.96	3848.338
4.5	2.0776	4079.238

5	2.156	4233.171
5.5	2.1952	4310.138
6	2.2344	4387.105
6.5	2.3128	4541.038
7	2.352	4618.005
7.5	2.3716	4656.488
8	2.3912	4694.972
8.5	2.4304	4771.939
9	2.4892	4887.389
9.5	2.5284	4964.355
10	2.6264	5156.772
10.5	2.6852	5272.222
11	2.744	5387.673
11.5	2.7832	5464.639
12	2.8028	5503.123

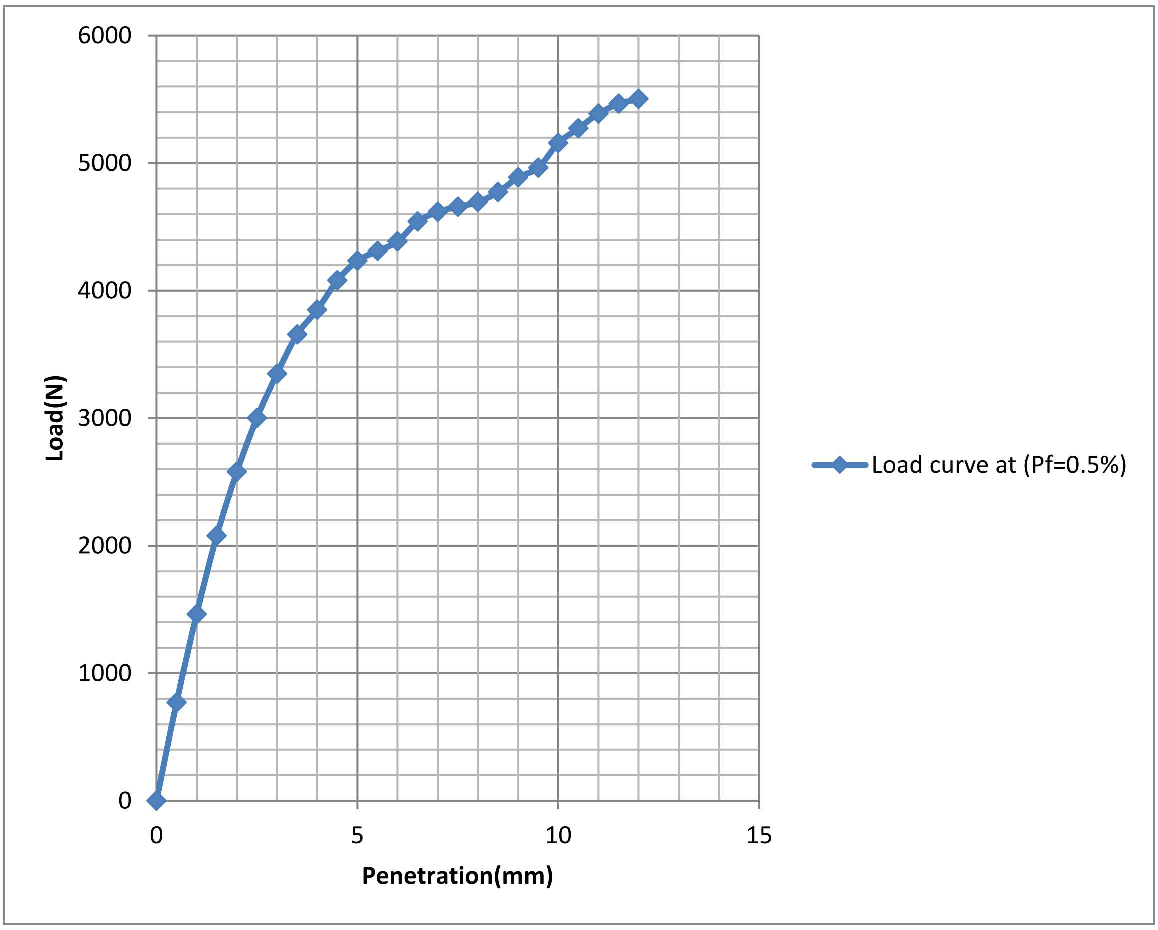

Fig.18: Load-Penetration Response in CBR Test of Reinforced Pond ash(P_f =0.50%)

Table 9: Load-Penetration Response of Reinforced Pondash (P_f =1.0%)

Penetration of plunger (mm)	**Load dial reading . (N/mm^2)**	**Load(N)**
0	0	0
0.5	0.4116	808.1509
1	0.7252	1423.885
1.5	1.0976	2155.069
2	1.4504	2847.77
2.5	1.7444	3425.02
3	1.9992	3925.304
3.5	2.2344	4387.105
4	2.4108	4733.455
4.5	2.5872	5079.806
5	2.7636	5426.156
5.5	2.9008	5695.54
6	3.0184	5926.44
6.5	3.0968	6080.373
7	3.1556	6195.823
7.5	3.234	6349.757
8	3.2928	6465.207
8.5	3.332	6542.174
9	3.3712	6619.141
9.5	3.4104	6696.107
10	3.4888	6850.041
10.5	3.5868	7042.458
11	3.626	7119.424
11.5	3.822	7504.258

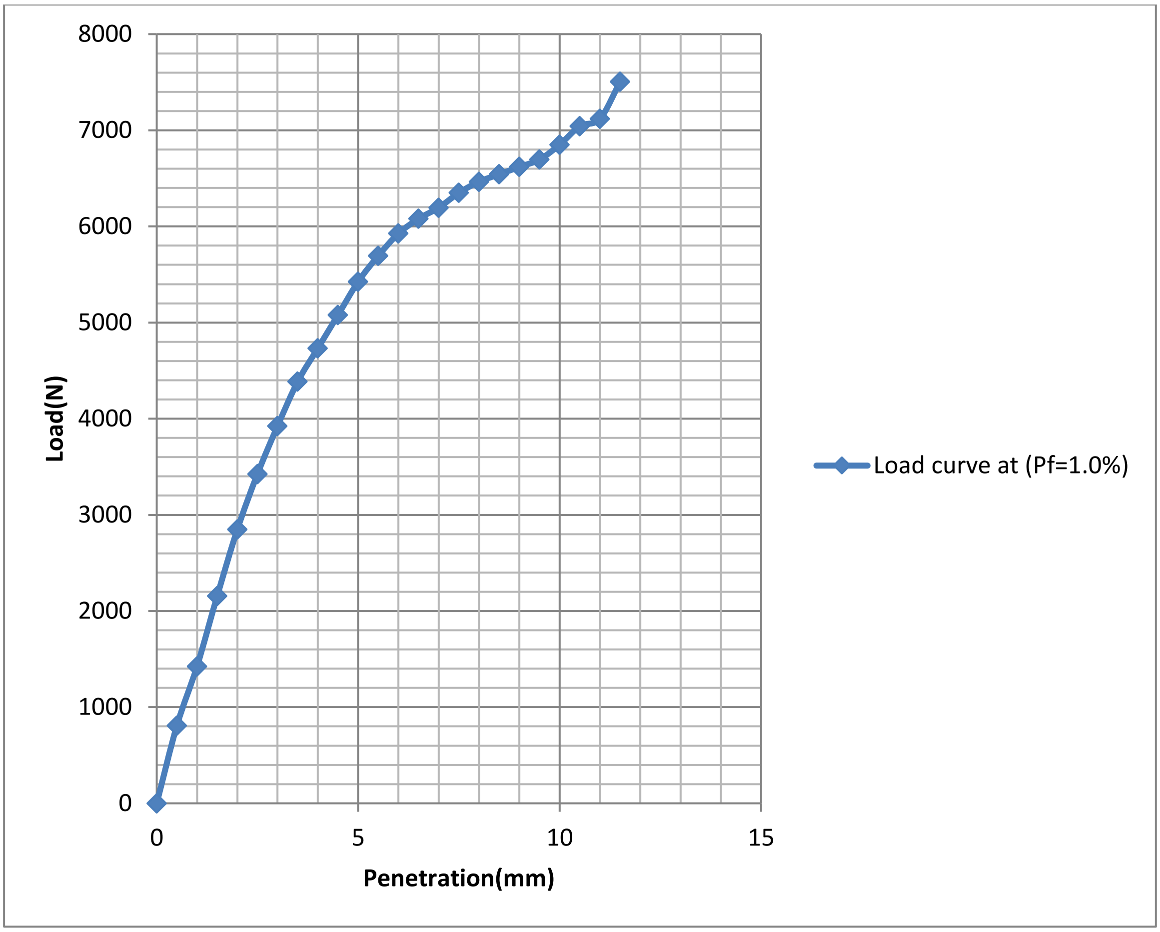

Fig.19: Load-Penetration Response in CBR Test of Reinforced Pond ash(P_f =1.0%)

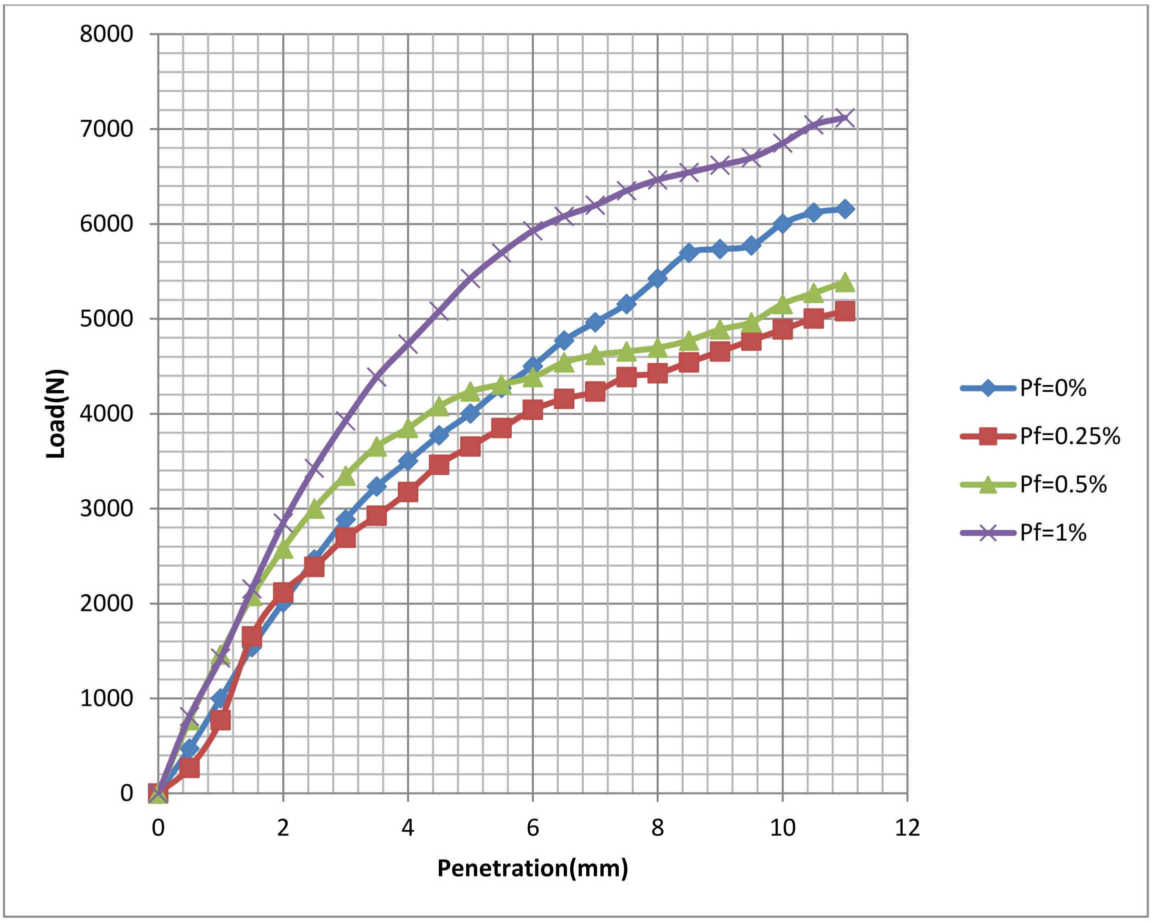

Fig.20:Comparison of Load-Penetration Response in CBR Test each Reinforcement of Pond ash.

CHAPTER-5

RESULTS AND ANALYSIS

Graphs Showing Variation in Direct Shear Test Results

Table 10: Normal v/s Shear Stress for Unreinforced Pond ash

Normal Stress (kN/mm^2)	**Load (kN)**	**Shear Stress (kN/m^2)**
100	0.23840	70
200	0.48061	130
300	0.62397	170

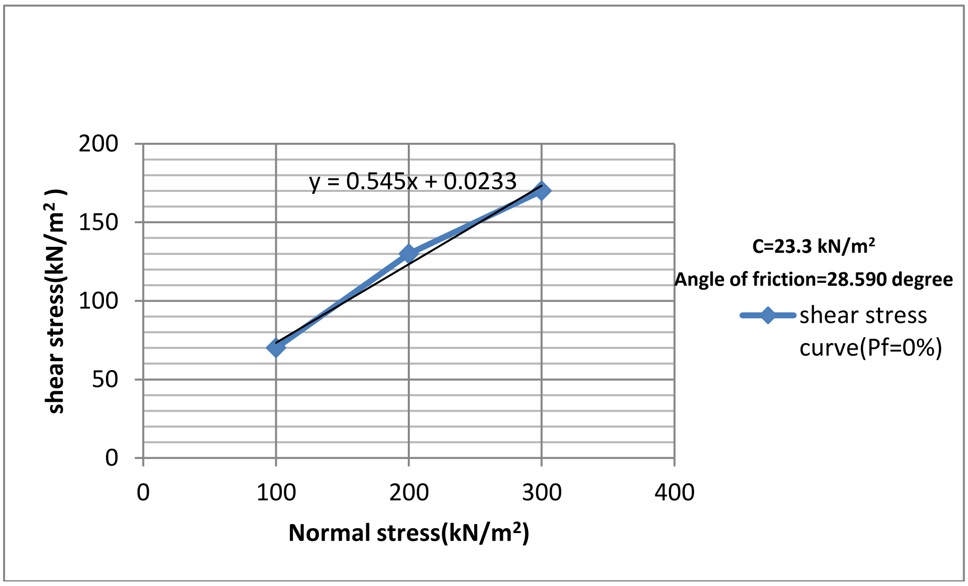

Fig 21: Failure envelope of unreinforced pond ash(P_f=0%)

The angle of friction and cohesion of unreinforced Pond-Ash are 28.590˚ & 23.3 kN/mm^2 respectively

Table 11: Normal v/s Shear Stress for Reinforced Pond ash(P_f =0.25%)

Normal Stress (kN/m^2)	**Load (kN)**	**Shear Stress (kN/m^2)**
100	0.31752	120
200	0.55698	160
300	0.63490	220

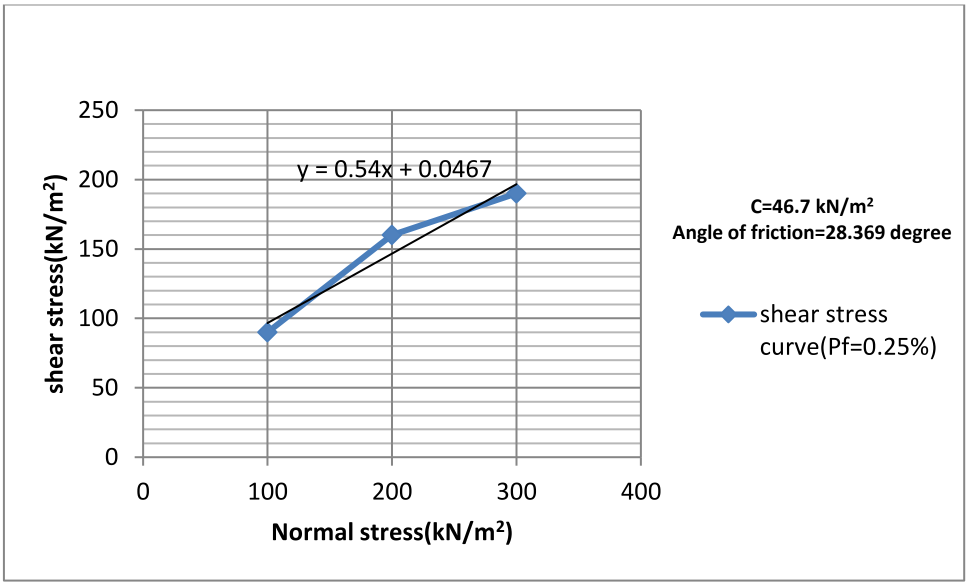

Fig 22: Failure envelope of Reinforced pond ash(P_f=0.25%)

The angle of friction and cohesion of 0.25% reinforced pond-ash are 28.369˚ & 46.7 kN/mm^2 respectively

Table 12: Normal v/s Shear Stress for Reinforced Pond ash (P_f =0.5%)

Normal Stress (kN/m^2)	**Load (kN)**	**Shear Stress (kN/m^2)**
100	0.41852	120
200	0.56898	160
300	0.77990	220

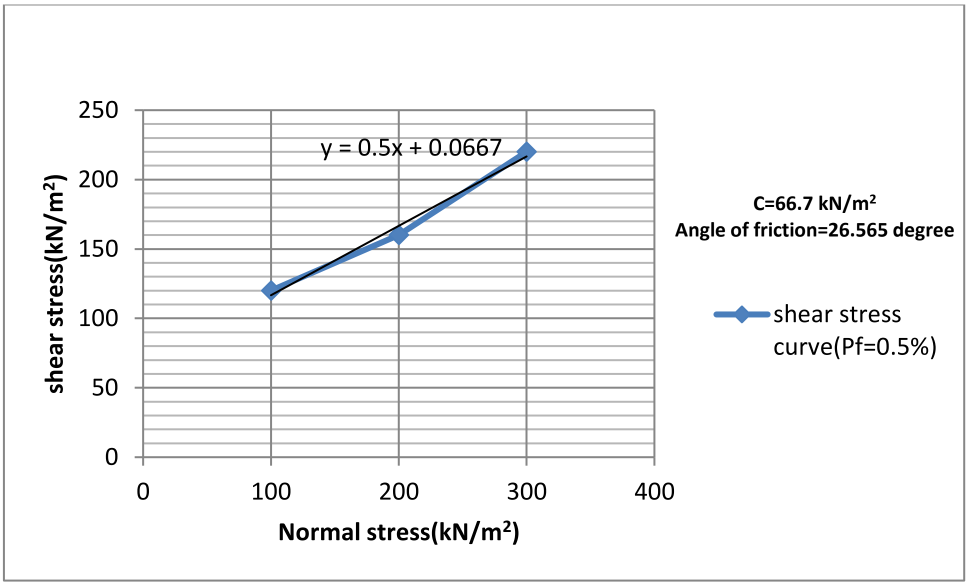

Fig 23: Failure envelope of Reinforced pond ash(P_f=0.5%)

The angle of friction and cohesion of 0.5% reinforced pond-ash are 26.565˚ & 66.7 kN/mm^2 respectively

Table 13: Variation in Normal v/s Shear Stress for Unreinforced Pond ash

Normal Stress (kN/m^2)	**Shear Stress (kN/m^2)**		
	Unreinforced	**Reinforced 0.25%**	**Reinforced 0.50%**
100	70	90	120
200	130	160	160
300	170	190	220

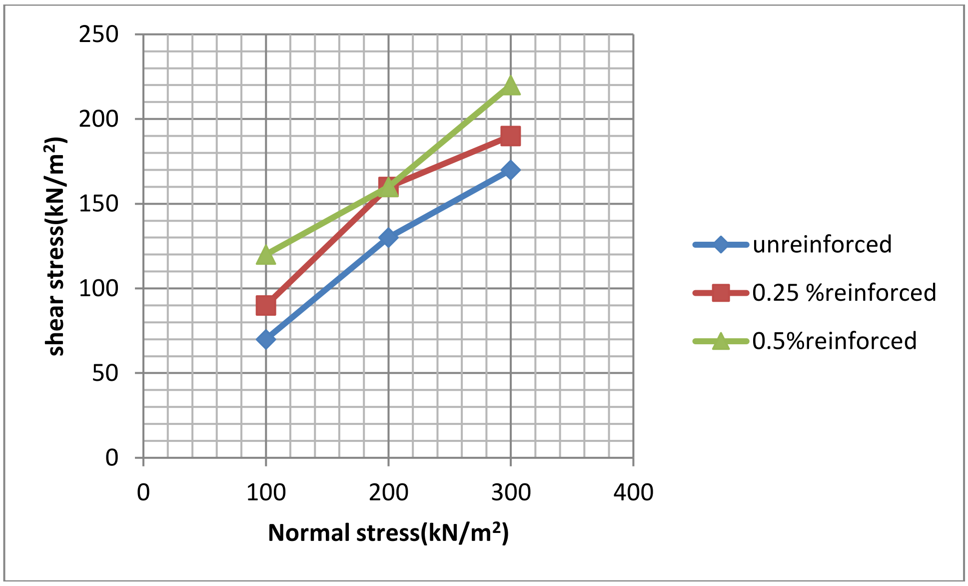

Fig 24: Comparison of failure envelope of differently reinforced pond ash.

Table 14: Change in Cohesion and angle of friction with variation in fibre content

P_f (%)	**Cohesion (kN/m^2)**	**ϕ(Degree)**
0	23.3	28.59
0.25	46.7	28.36
0.5	66.7	26.56

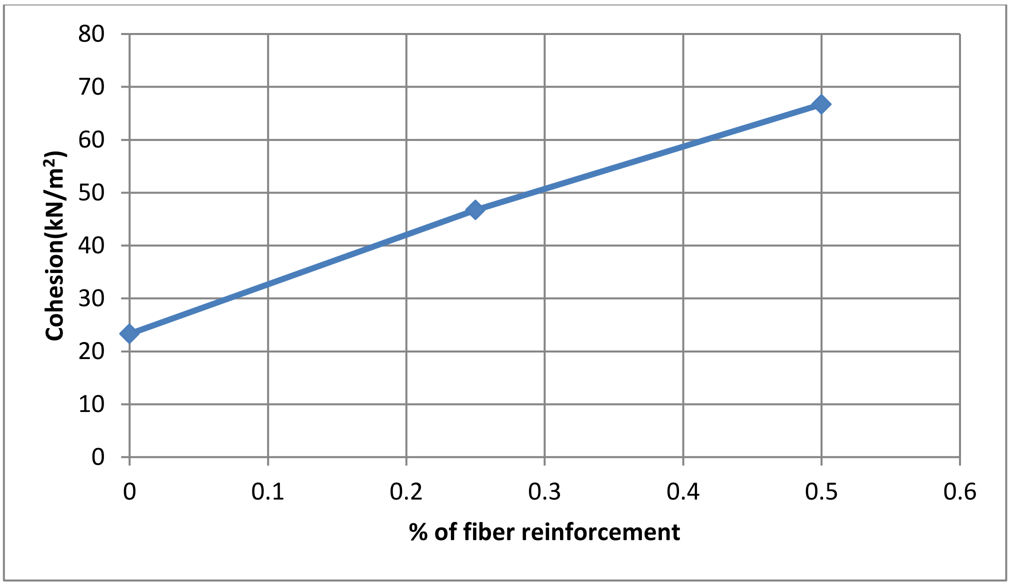

Fig 25: Variation of cohesion with fibre content

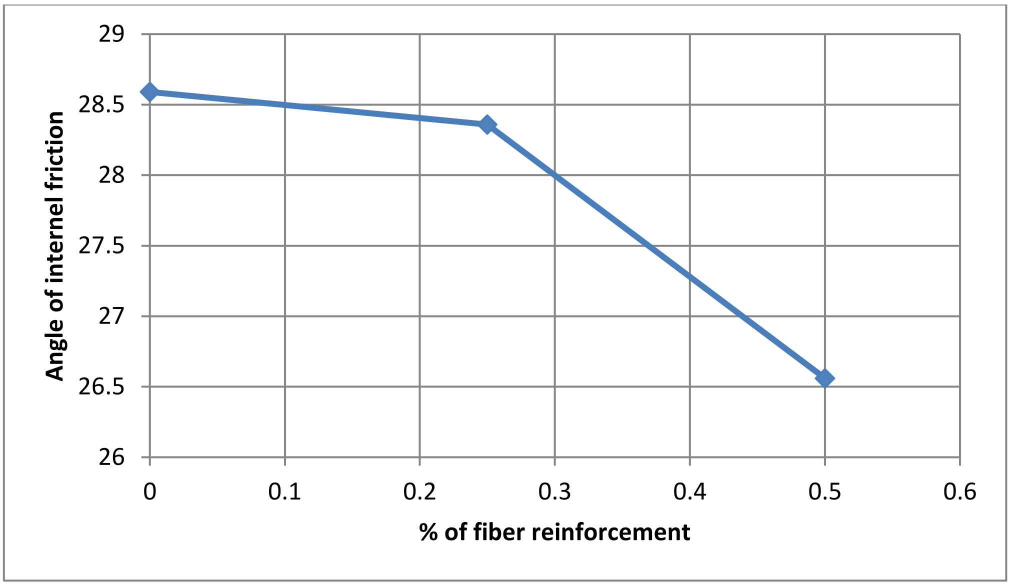

Fig-26: Change in angle of friction with varying fibre content

5.0 Graphs Showing Variation in CBR Test Results.

Table 15: CBR v/s fiber content%

CBR%	**P_f=0%**	**P_f=0.25%**	**P_f=0.5%**	**P_f=1%**
2.5 mm	18.34	17.77%	22.36%	25.51%
5 mm	19.87%	18.15%	21.02%	26.94%

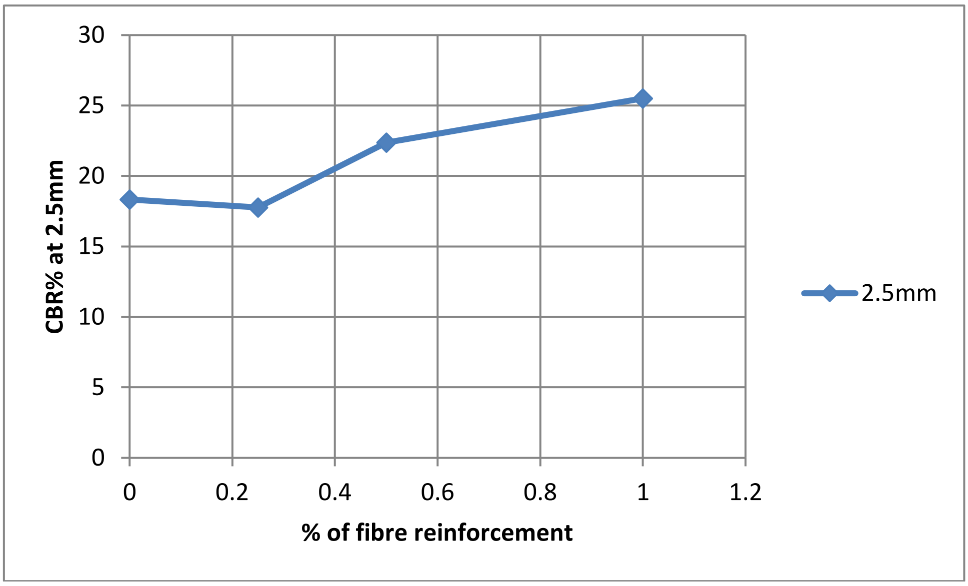

Fig 27: variation of CBR valueof 2.5mm versus fibre content.

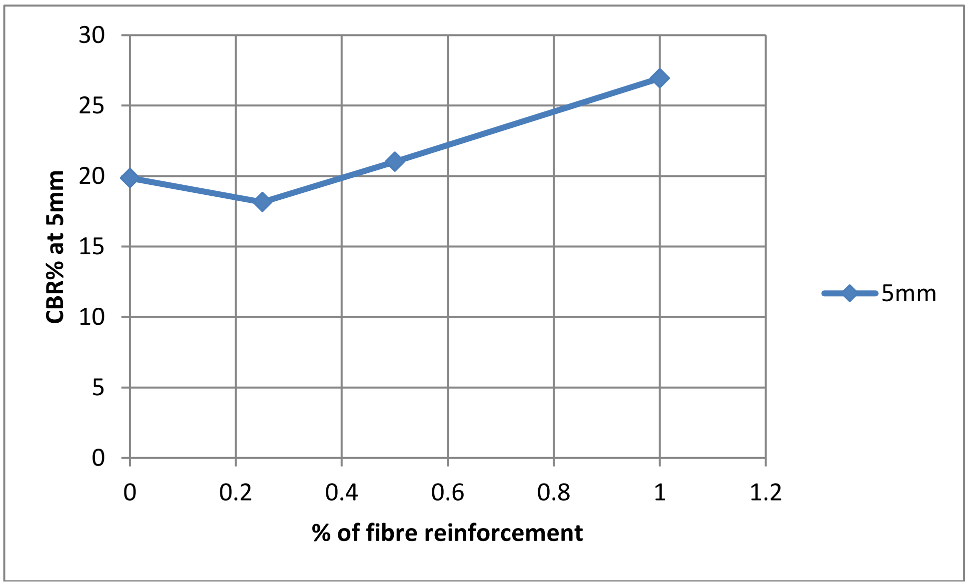

Fig 28: variation of CBR valueof 5mm versus fibre content.

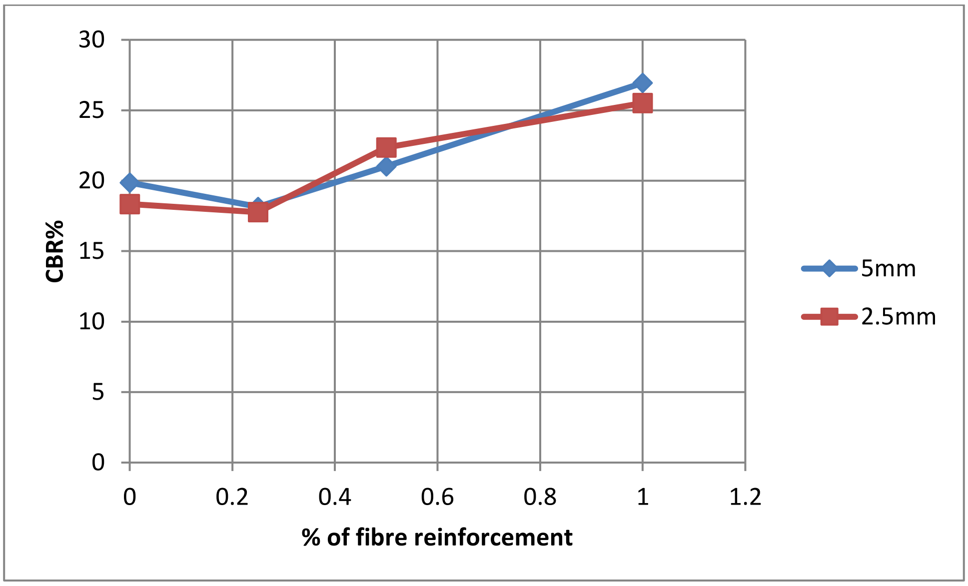

Fig 29 : Comparison of CBRvalue of 2.5mm and 5mm v/s fibre content.

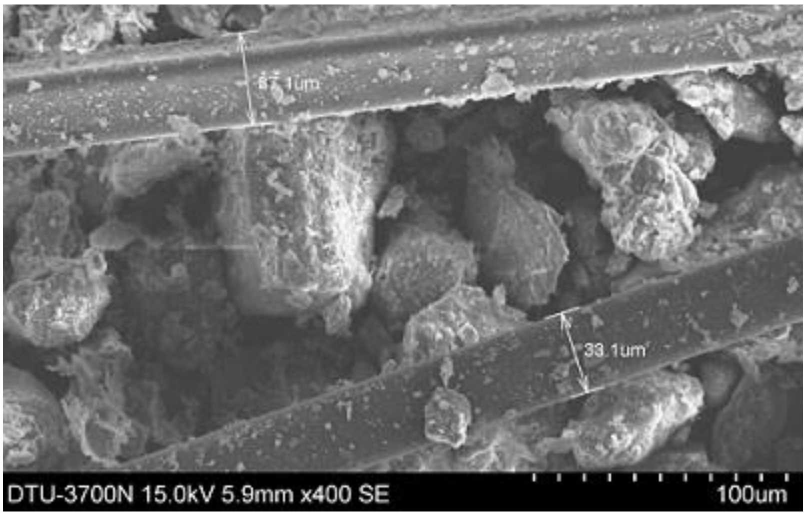

Fig 30 Scanning Electron Micrographs of Fibre Reinforced Pond ash

CHAPTER-6
CONCLUSION

CONCLUSIONS

1. For Unreinforced pond ash, the value of cohesion and angle of internal friction are 23.3 kN/m^2 & 28.59° respectively by Direct shear test.

2. For Reinforced pond ash (P_f=0.25%, P_f is percentage of fibre of total weight of pond Ash), value of cohesion and angle of friction are 46.7 kN/m^2 & 28.36° respectively by Direct shear test.

3. For Reinforced pond ash (P_f=0.50%), the value of cohesion and angle of friction are 66.7 kN/m^2 & 26.56° respectively by Direct shear test.

4. According to the Direct shear test, there was a 100.42% increase in the cohesion intercept due to the addition of 0.25% fibre into pond ash and 186.26% increase due to the addition of 0.50% fibre. Fig.25. suggests a linear rise in the cohesion due to the addition of fibre(Kumar, R, Kanaujia, V.K and Chandra,D, (1999).

5. But there was a 0.804% decrease in the angle of friction due to inclusion of 0.25% fibre into the pond ash and 7.1% decrease due to the addition of 0.50% fibre. Fig.26. suggests that the graph initially decreases at an decreasing rate and then at a increasing rate.

6. According to the CBR test, value of CBR(2.5mm) decreases from 18.34% to 17.77% i.e, decrement of 3.1 % on addition of 0.25 % fibre ,but increase to 22.36% i.e,21.9 % increment on 0.5 % fibre addition, similarly 25.51% i.e, 39.09% increment on 1% fibre addition in pond ash.

7. Value of CBR(5mm) decreases from 19.87% to 18.15% i.e, decrement of 8.6 % on addition of 0.25 % fibre ,but increase to 21.02% i.e,21.9 % increment on 5.7 % fibre addition, similarly 26.94% i.e, 35.05% increment on 1% fibre addition in pons ash.

8. There is also a rise in shear strength and CBR strength values of the fibre reinforced Pond ash[Singh S.P, Sharan A., (2015]

9. The above point may be explained with the fact that on the addition of fibre the total contact area increases between the Pond ash particles and the fibres which in turn increases the compressive strength.

10. The increase in shear strength may be explained by the fact that the friction between fibre and the pond ash increases due to abrasion of fibre by pond ash particles[2]. SEM images showing interlocking between pond ash particles and fibre can be seen in Fig.30. This pond ash particles-fibre interaction leads to increased resistance to applied loads, hence greater shear strength. Also better interlocking is achieved due to the triangular shape of the Recron-3S fibre.

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