EXPERIMENTAL STUDY ON POND ASH REINFORCED WITH GEOSYNTHETIC

A Thesis Report

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CERTIFICATE

Certified that **Mr.Vaibhav Sharma** (2K15/GTE/19) has carried out the project work presented in this thesis report entitled "**EXPERIMENTAL STUDY ON POND ASH REINFORCED WITH GEOSYNTHETIC**" for the award of degree of Master of Technology in Geotechnical Engineering at Department of Civil Engineering, DTU, Delhi under my supervision.

The report embodies results of original work, and studies are carried out by the student and the content of the report do not from the basis for the award of any other degree from any other University/Institution.

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Vaibhav Sharma

ABSTRACT

Pond ash known as a cohesionless material having very less plasticity and has possiblity to be utilize as a fill material in Geotechnical structures like retaining walls, embankment , below pavement, structural land filling etc. However according to the literature review compacted pond ash, which provides similar strain that of the earth material similarly graded in dry and moderately wet conditions, after the saturation it loses its shear strength significantly . So in most of the design it is recommended that provisions should made to keep the water away from the compacted pond ash fills by given that a layer of compacted soil to cover it. However the strength of the compacted pond ash fills can be recollected partially by reinforcing it in a proper manner. Soil reinforcement technique is one of all the more standard techniques used for increasing the load carrying capacity of poor soils. Metal strips, synthetic geotextiles, geogrid sheets, natural geotextiles at randomly distributed, synthetic and natural fibers are used effectively as reinforcing materials to soil. Further, the reinforcement of soil causes important improvement in physical property, shear strength, different properties, bearing capacity and economy. This can be a relatively easy technique for ground improvement and has tremendous potential as a cost effective solution to several Geotechnical problems.

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CHAPTER -1

INTRODUCTION

1. INTRODUCTION

There is necessity to increasing the usage of coal ashes. Pond Ash because of a non plastic cohesion less material has potential to be used as a fill material in Geotechnical structures like retaining wall, embankment, below pavement etc.,. Soil reinforcement technique is one of all the standard techniques used for improvement of poor soils. Metal strips, synthetic Geotextiles, geogrid sheets, natural Geotextiles at random distributed, synthetic and natural fibers are very effectively used as reinforcing materials for the poor soil. Further, reinforcement of soil with another material develops important improvement in physical property, shear strength, load carrying capacity, bearing capacity and low-cost of the project. This can be a reasonably easy technique for ground improvement and has tremendous potential as a cost effective explanation to several Geotechnical issues. Keeping this understanding associate experimental study is going to be done using geotextile layer at different positions in pond ash beds. The Geotextile layer area unit organized at different intervals in the soil sample with varied soil layer thickness and density of pond ash. In the laboratory a model test is performed to determine the bearing capacity of soil using different combination of reinforcement with different geotextile depth ratio and varying thickness of pond ash beds. Further, these test results will be compared with the result of soil which is unreinforced.

The current electricity generation in India by all the sources is 12,058 MW, 65- 70 % of that is thermal power (mostly coal based). According to an estimate 100,000 Capacity or additional would be needed within the next fifteen years as a result of repeatedly increasing demand for electricity. In India ash generation is around 175 million tons / year and is about to continue at a high rate into the probable future. Fly ash is that the residue of the coal combustion method in power plants. Nearly 73 of India's total installed power generation capacity is thermal, of that primarily coal based generation is almost 90 % (diesel, wind, gas & amp; steam adding to concerning 10 %). The 85 utility thermal power stations, additionally too many confined power plants, use bituminous or sub-bituminous coal and produce large volumes of fly ash. High ash content (30-40%) of Indian coals is contributing to those large volumes of fly ash. At present, nearly a hundred and seventy million tons of fly ash are being produced annually in India and nearly 65,000 acres of land are presently engaged by ash ponds. India's dependence on coal as a source of energy shall continue within the next era and so fly ash management would remain a very important area of national concern. Its undifferentiating disposal needs large volumes of land, water and energy. Pond ash deposit possess high compressibility, low bearing capacity, due to which acres of land gets wasted. Fly ash can be stabilized using a geotextile reinforced beds to increase the bearing capacity and structures may be planned on ash pond during a price effective manner.

CHAPTER 2

LITERATURE REVIEW

2. LITERATURE REVIEW

2.1 POND ASH:

An ash pond is a planned structure for the disposal of bottom ash and fly ash. The disposal of ash mixing with water into ash ponds is the most common ash disposal methodology which helps in different ways comprises dry disposal in landfills. Dry-handled ash is commonly recycled and converted into some good building materials. Wet disposal has been more prevalent because of economic reasons, but increasing environmental relating problems to concerning the location of ponds from thermal power plant has methodology to recognition of wet disposal. The wet methodology comprises of constructing a large pond and filling it with ash slurry (fly ash mixed with water), permitting the water to drain into the ground and evaporate from the ash over time. The ash pond area unit typically shaped using a ring embankment to border the disposal site. The embankments square construct using similar design parameters as embankment dams, together with zoned construction with clay cores. The planning technique is primarily based on handling seepage and making definite slope stability. Reinforced earth is a material that could be a arrangement of soil and reinforcement, properly placed to tolerate the developed tensile stresses and furthermore it improves the resistance of the soil within the direction of the greatest stress. The critical options of earth reinforced with a extra material are the friction between the earth and reinforcement, by means of friction the soil transfer forces to the reinforcement. The reinforcement has consequently developed tension when the earth mass is subjected to shear stresses along the reinforcement.

2.1.1 SOURCE OF MATERIALS :

Pond Ash: The pond ash was collected in gunny bags from Thermal power plant NTPC Badarpur. It was dried in the oven at 105˚C-110˚C and kept in an airtight container for further use.

Reinforcing Materials: PVC net having 1mm aperture and a GI strip of 1mm opening were used as circular parallel strips for reinforcing action.

2.1.2 USES OF POND ASH:

- In Land fill and dyke raising.
- In Structural fill for regaining 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.

2.1.3 LISTOF INDUSTRIES GENERATING POND ASH/FLY ASH:

Table 2.1 List of Industries Generating Pond Ash/Fly Ash

Name Of The Industry	Name Of The State Situated	Name Of The Place
Kothagudem	Andhra Pradesh	Nellore
Ramagundam	Andhra Pradesh	Vijaywada
Bongaigaon	Assam	Lakwa
Narup	Jharkhand	Chandrapura
Barauni	Jharkhand	Bokaro
Chandradurg	Bihar	Muzzafarpur
Patratu	Jharkhand	Ramgarh
Indraprasta	Delhi	Rajghat
Badarpur	Delhi	Mathura Road
Utraw	Gujarat	Gandhinagar
Sabarmati		Utkai
Wanakoi		

Mettur		Neyveli
Trombay	Maharastra	Nasik
Chola		Bhusawal
Singrauli	Uttar Pradesh	Mirjapur
Rihand		Panki
Paricha		Anapara
Obra		Rpc
Hardoganj		Tanda
Ferojgandhi		
Korba	Madhya Pradesh	Satpura
Amarkantak	Madhya_Pradesh	Vindhyachal
Gurunanak Dev	Bathinda	Ropar
Kota		
Raichur	Karnataka	
Ennore	Tamilnadu	Tuticorin

Chandanpur		Koradi
Talcher	Orissa	
Durgapur	West Bengal	Bundel
Santadir		Lolaghat
Farakka		DPL
C.E.S.C		Titalagarh
New Cossipore		Mulajore

(B) Steel Industry

Name Of The Industry	Name Of The State Situated
Bhillai Steel	Madhya Pradesh
Durgapur Steel	West Bengal
Rourkela Steel	Odisha

Bokaro Steel	Jharkhand
HSCO	Burnapur,(W.B)
Salem Steel	Tamil Nadu
Visakhapatnam Steel	Andhra Pradesh

(C) Aluminium Industry

Name Of The Industry	Name Of The State Situated
BALCO	Korba, (M.P)
NALCO	Odisha

(D) Copper Industry

Name Of The Industry	Name Of The State Situated
Chandmari Copper Project	Rajasthan
Khetri Copper Project	Rajasthan
Dariba Copper Project	Rajasthan
Indian Copper Complex	Bihar
Rakha Copper Project	Bihar
Malanjkhand Copper Project	Madhya Pradesh

2.1.4 FACTORS AFFECTING PROPERTIES OF POND ASH:

Effective utilization of pond ash in Geo-technical constructions as a replacement to standard earth materials needs special attention. The characteristic strength of the compacted pond ash mass reduces so much because of saturation. During this framework to enhance and retain the strength of compacted pond ash, cementing agents like cement or lime could also be extensively useful.

The stress-strain behavior of compacted pond ash mass is improved by inclusion of fiber reinforcements. Fiber reinforcements additionally improve the strength characteristics of the soil mass. Although, the utilization of reinforced earth materials has been widely recognized in several areas like railroads, retentive walls, embankments, foundations medium ,however the use of pond ash in situ of earth material has not drawn much attention of investigators.

2.2 USE OF REINFORCEMENT FOR IMPROVEMENT IN BEARING CAPACITY:

2.2.1 GENERAL MODES OF SHEAR FAILURE:

Experimental investigations have designated that the foundations on dense sand with relative density greater than 70 % fail suddenly with noticeable peak resistance once the settlement reaches about 7 % of the foundation breadth. The failure is among the looks of failure surfaces and by considerable bulging of a sheared mass of sand. This kind of failure is labelled as a general shear failure by Terzaghi (1943). Foundations on sand of relative density lying between 35% to 70 % don't show a sudden failure because the settlement exceeds concerning 8 % of the foundation breadth, bulging of sand starts at the surface. At settlements of concerning 15 % of foundation breadth is a clear boundary of sheared zones on the surface appears. However, the peak of base resistance may never be touched. This type of failure is named as local shear failure.

Vesic (1963) Mainly three types of failure takes place more than other failure during tests on model footings. It is generaly noted here that because the relative depth/width ratio will increase, the preventive relative densities at which failure types variation increase. The approximate limits of the types of failure to be affected as relative depth D_j, and relative density of sand D_r vary which is shown in Fig. 2.1, a comparable figure shows that there is an critical relative depth below that only punching shear failure occurs. For circular foundations, this essential relative depth, D_j, is around 4 times of width and for long rectangular foundations around 8 times of width.

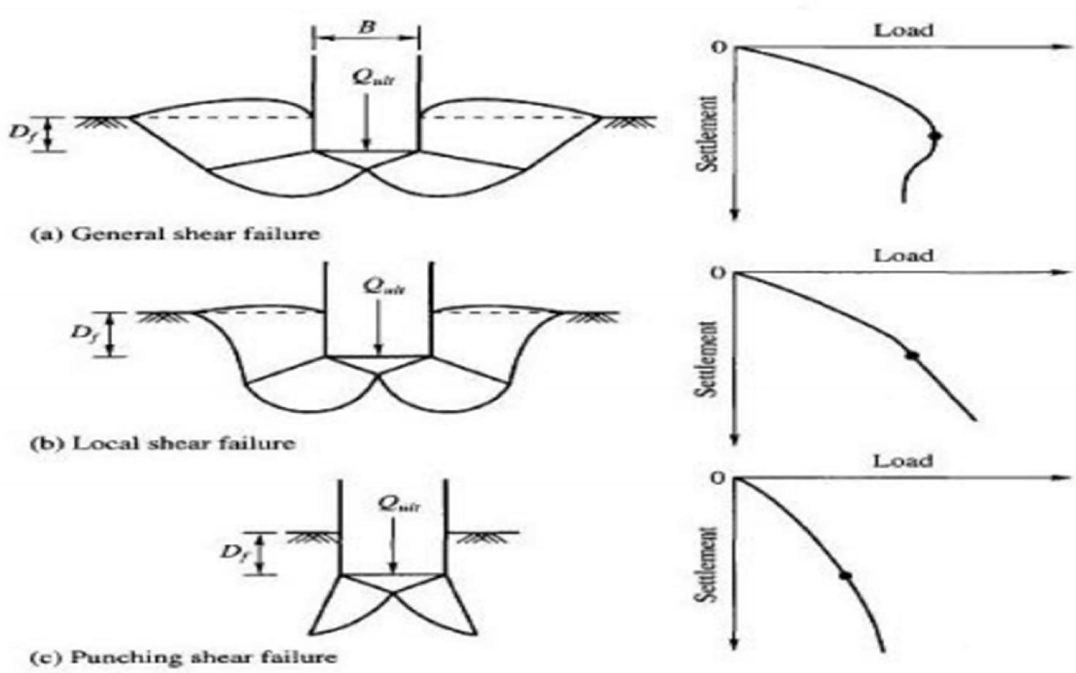


Fig 2.1 -Modes of bearing capacity failure (vesic, 1963)

2.2.2 IMPROVEMENT IN BEARING CAPACITY OF SOIL USING REINFORCEMENTS :

Singh H.P et al., [2012] Experimental study was directed with regionally accessible (Itanagar, Arunachal Pradesh, India) soil reinforcement with jute geotextile layers. The Jute Geotextile layers are systematized inside the soil sample in several arrangements like 1 layer, 2 layers, 3 layers, 4 layers etc. and in laboratory CBR values were determined in each soaked and unsoaked condition equivalent to each combination of reinforcing layer. Further, these test results were matched therewith of unreinforced soil. It had been determined that inclusion of Jute Geotextile layer will increase the CBR value of soil and this growth is more similar to 4 layers of Jute Geotextile layers. Thus, there is a substantial increase in CBR value of soil as a result of inclusion of Jute Geotextile layers as a reinforcement.

R.Binquet, et al. [1975] were the first to represent a organized study on bearing capacity of reinforced soil beds. Their study included model plate load tests with parametric distinction and proposed a method of analysis and design. After that they conducted model tests on 76.2mm wide strip footing on sand, reinforced with aluminum strips. The tests were conducted for the following three conditions.

1. Deep consistent sand layer
2. Sand layer over an extensive layer of very soft material pretending soft clay or peat
3. Sand layer above a fixed sized pocket of a very soft material such as a pocket of organic soiloracaver in lime stone.

In all three sequence of tests, they have examined the effect of number of layers and the depth of the topmost layer of the reinforcement on the bearing capacity. A new term bearing capacity ratio has been demarcated to compare the test data as:

$$BCR= q/q_o$$

Where,
q_o = For a given settlement the average contact pressure of the footing on the unreinforced soil.
q = At the same settlement the average contact pressure of the footing on reinforced soil bed.

USING SHEET REINFORCEMENT :

Y. Wasti , Butun M.D., [1996]. A sequence of laboratory model tests on a strip footing supported by sand, reinforced by at randomly distributed polypropylene fiber and mesh components was directed in order to match the results with those obtained from a unreinforced sand and with each other. For conducting the model tests, unvarying sand was compacted fill in the test box at its optimum moisture content and maximum dry density. Three varieties of reinforcement and two sizes of mesh elements having an corresponding opening size and one size of fiber element cut from themselves, were employed in varied amounts in the tests. It is shown by the results obtained that reinforcement of sand by randomly distributed inclusions of reinforcement caused an increment in the ultimate bearing capacity values and also the settlement at the ultimate load increase in general. The efficiency of separate reinforcing elements was determined to depend on the amount as well as the shape of the inclusions. The larger mesh size was obtained to be superior to different reinforcement considering the ultimate bearing capacity values. For the mesh elements there can be an optimum inclusion ratio, while fibers exhibited a linearly increasing trend on the basis of an increase in ultimate bearing capacity of the range of reinforcement amounts employed.

T.Yetimoglu Salbas O; [2003] An experiment was commenced to research the shear strength of sands reinforced with randomly distributed discrete fibers by carrying out direct shear tests. The result of the fiber reinforcement content on the shear strength was examined. The results of the tests indicated that peak shear strength and initial stiffness of the sand were not affected meaningfully by the fiber reinforcement. The horizontal displacements at failure were also found analogous for reinforced and unreinforced sands below a similar vertical normal stress. Fiber reinforcements, however, may reduce soil brittleness as long as smaller loss of post-peak strength. Thus, there seemed to be an increase in residual shear strength angle of the sand by iclusion of fiber reinforcements.

Chandra et al.; [2008] have reinforced the 3 types of soil clay, silty and sand with polypropylene fiber of 0.3 mm aperture. The fibers were cut into pieces of 15, 25, and 30mm in length and aspect ratio of 60, 80 and 100 respectively and with percentage of 0.75%, 1.5%, 2.25% and 3% by dry weight of soil. The static triaxial test of unreinforced and reinforced with fibre soil was conducted. Their result shows that the uniaxial compressive strength is 3.834, 4.846 and 9.732 MPa respectively.

USING FIBER REINFORCEMENT :

Maher and gray [1990] They have reinforced the coarse sand of 9 varieties at C_u=1 to 4, D_{50}=0.09 to 0.6mm, 100% wet content with rubber (dia=1.1mm, a_r=20, f_l=22mm), glass (dia=0.3mm, a_r=60, f_l=45mm), reed fiber (dia=0.3, a_r=20, f_l=18, 24,38mm). They have conducted drain triaxial tests which shows that low modulus fibers (rubber) subsidize very little to strength in spite of higher interface friction. Failures surface is plain and attuned at (45+Φ/2). An increase in particle sphericalness increase in crucial confining pressure and lower fiber contribution. Higher aspect ratio caused lower confining pressure and increasing shear strength.

Michalowski and Zaho [1996] They have provide inclusion of the dry sand (with C_u=1.53 and D_{50}=0. 79) with polyamide monofilament and steel fibers (dia 0.35,0.45 mm , aspect ratio 85 and 180, fiber length and content 26 and 0.52% respectively). The triaxial result shows that the inclusion of steel fibers increases the peak stress by 21% and presence of fibers occupied the sample dilation and made sample hard, before reaching the failure.

Bauer and Fatani; [1991] They have researched on silt sand (with C_u=5, D_{50}=0.9,c=10kN/m^2, Φ=47^0 at optimum moisture content), reinforced with steel fiber (rigid, dia=4 mm,fl=45 mm,,random) and copper(flexible , dia= 0.85 mm ,fl=75 mm,5,6 and 32 fibers aligned) They examined the direct shear test and pull out test at modified proctor density test of 2.19 t/m^3 and moisture content of 7.9%, Φ=36^0 and δ=24°. The result demonstrations that the residual strength of composite is 200^{th} to 300^{th} above than the unreinforced soil and well graded soil provide highest anchorage capacity.

Fatani et al. [1991] They had studied on the silt sand with Cu=4, D50=0.8, c=12 kN/m2, Φ=47^0 and reinforced with monofilament fiber of 75 mm long, orientated (to the shear plane at 45^0 to 90^0) at randomly, number of fibre varies from 6 to 34. The Drained direct test was done at modified proctor dry density (MDD) γ = 21.3 kN/m^3 and optimum moisture content (OMC) 7.9%, orientation of fiber is vertical to shear plane. The test result shows that fiber placed parallel to the test plane of direct shear box caused reduction in shear strength. In at random place, only 15-25 % fibers cross the shear plane and really impart the strength.

Charan et al. [1996] They had studied on silt sand to coarse sand (D50= 0.05-0.4 mm) reinforced with polypropylene (dia=0.32 mm, a_r=55 to 120, f_l=16 to 36, fc= 0.39 to 4.9%) and natural fibers coir and bhabar (ar = 45 to 95, fl= 16 to 36 mm, fc=0.5 to 3.5%). In this triaxial test and CBR test were conducted to check the failure of composite material. Triaxial result indicates that confining pressure less than critical confining i.e 1.2, strength of composite is unpretentious by improving the density of composite. The CBR value is improved by 2.5 times at fiber content at 1.45 %.

Wasti and Butun [1996] They had provide reinforcement of the sand soil (with Cu=3.985, Cc=1.172, D60 = 0.869 mm c= 6.38 ,Φ=46.8°) with polypropylene (35×55 mm small, 60×120mm big size and opening 10×10 mm 50mm long fiber by cutting mesh. They were conducted Laboratory model test on a strip footing 50mm (width) x 300 mm (length) supported by sand and casually distributed polypropylene fiber and mesh element. Results indicate that reinforcement of sand produced an increase in the ultimate bearing capacity values and settlement at ultimate load. The big mesh size is better than the other to increases in ultimate bearing capacity.

Lind.H and Eriksson [1990] Had reinforced the sand (Cu= 3.6 and D50=0.6mm) with monofilament polypropene fiber at fiber content of 0.28 % and 0.8 %. They were directed a field experiment by inserting a reinforced in the sand layer on the present road surface for field experiment. Their result concluded that no rutting is taken place.

2.2.3 BEARING CAPACITY IMPROVEMENT OF POND ASH/FLY ASH USING REINFORCEMENT :

Pond ash is an companion industrial waste having low bearing capacity and high settlement. Formerly a number of scientists researched regarding the project. They tried to improve the characteristics of pond ash by lime stabilization method and by reinforcing it by various Geotextiles.

M.V.S.Sreedhar et al., [2011] He considers the application of geosynthetic reinforced pond Ash as an overlay on soft soils to act as sub-grade of a pavement. It is used as an intervals reinforced type, the reinforcement is provided in fabric type however as in fiber type. The fiber is produced from a similar geotextile that is used in fabric type specified, the character of fabric property of the reinforcement is disregarded and the focus is only on its form. The results indicated that, the CBR characteristics of reinforced pond ash are advanced than un-reinforced pond ash. Among the reinforced pond ash, the reinforcement in fabric type is more active than that in fiber form. The effect of soaking with water on reinforced pond ash is additionally studied.

Kumar Pothal Goutham et.al; [2007], They had conducted triaxial test and load tests on reinforced pond ash and check accordingly improvement in bearing capacity. They reported that, ideal depth of location was 0.35B, wherever B is the breath of the model footing that resulted during a most enhancement of 32^{th} within the bearing capacity of reinforced pond ash. The modification in strength takes place due to effective compaction, controlling parameters like thickness of layer, compaction energy, tank dimension, moisture content, mould area, and relative density of the dry unit weight of pond ash are obtained.

Kumar et.al; [1999] They gave the results of laboratory examinations conducted on loose sand and pond ash specimens reinforced with indiscriminately distributed polyester fibers. The test results disclose that the inclusion of fibers in soils will increase the compressive strength, CBR value, peak friction angle, and plasticity of the specimens. It is concluded that the optimum fiber content for both loose sand and pond ash is roughly 0.25 to 0.45 % of the volume unit weight.

Sharan A., Singh S.P.; [2011] They had accompanied a series of CBR tests on reinforced pond ash. They reported an increase in bearing resistance with the fiber content. However, the rate of increase of strength with fiber content is not undeviating. At short strain levels the bearing resistance is found to remain almost constant with fiber content. However, at higher strain level the bearing resistance is seems to increase considerably to increase in fiber content. This indicates that to mobilize the strength of the fiber, higher strain is required further more; it is observed that for a given compacted density an increase in fiber content results in decrease of initial stiffness whereas the failure strain increases. This designates that inclusion of fiber gives ductility to the specimens. It can further be noticed that reduction in the post peak strain of a reinforced sample is relatively lower than the unreinforced sample.

2.2.4 SCOPE OF THE PRESENT WORK :

The literature review shows that an inadequate work has been done to explore the effectiveness of reinforcements in improving the load carrying capacity of the compacted pond ash. Keeping this in mind a series of laboratory tests were conducted to examine:

1. The effect of reinforcement size and placement position on the CBR value of the compacted pond ash.
2. The effect of water content and different type of geosynthetic on the CBR value of compacted pond ash.

CHAPTER -3

EXPERIMENTAL WORK AND METHODOLOGY

3. INTRODUCTION :

Experiments were conducted to determine various properties like specific gravity, grain size analysis and other geotechnical characteristics like cohesion value, internal angle of friction, maximum dry density, optimum moisture content of pond ash. For sand maximum and minimum dry density, bearing ratio for altered relative density also examined. Then the CBR value of pond ash was determined by performing tests for both saturated and unsaturated conditions. The following experiments were performed successively to observe the change in behavior of pond ash in different conditions.

3.1 MATERIAL USED:

POND ASH:

The sample passing through tha sieve of 2 mm diameter was collected and used in experiments. Pond ash was dried in the oven at 105˚C-110˚C and kept in an airtight container for further use.

3.2. SPECIFIC GRAVITY TEST:

The experiment is performed according to the IS code procedure. The specific gravity of pond ash was determined by density bottle and demonstrated. Specific gravity of pond ash was found as per IS: 2720 (Part III) 1980 and obtained as **2.18**.

3.3. DETERMINATION OF OMC & MDD OF POND ASH:

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 needed quantity of water and the wet sample was compacted in proctor mould either in 3 or 5 equal layers using standard proctor rammer of 2.6 kg and modified proctor rammer of 4.5 kg severally. The moisture content of the compacted mixture 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 varied compactive energy and therefore the corresponding OMC and MDD were determined. This was done to review the result of compactive energy on OMC and MDD.
The test results are presented in Table 3.1, 3.2 and graphs were plotted which are shown in Fig. 3.1, 3.2 .

Light compaction maximum dry density =11.51 KN /m^3, OMC=25.5
Heavy compaction maximum dry density = 12.517 KN /m^3 , OMC=22.

Table 3.1-Standard proctor test results for Pond ash:

Water content %	Dry density KN /m^3
16.8	10.59
20.1	10.98
23.2	11.28
25.5	11.507
28.1	11.37
31	11.08

Table 3.2- Modified Standard proctor test results for Pond ash

Water content %	Dry density KN/m^3
15.1	11.615
17.3	11.889
20.2	12.203
22	12.517
26.5	12.007
26.9	11.851

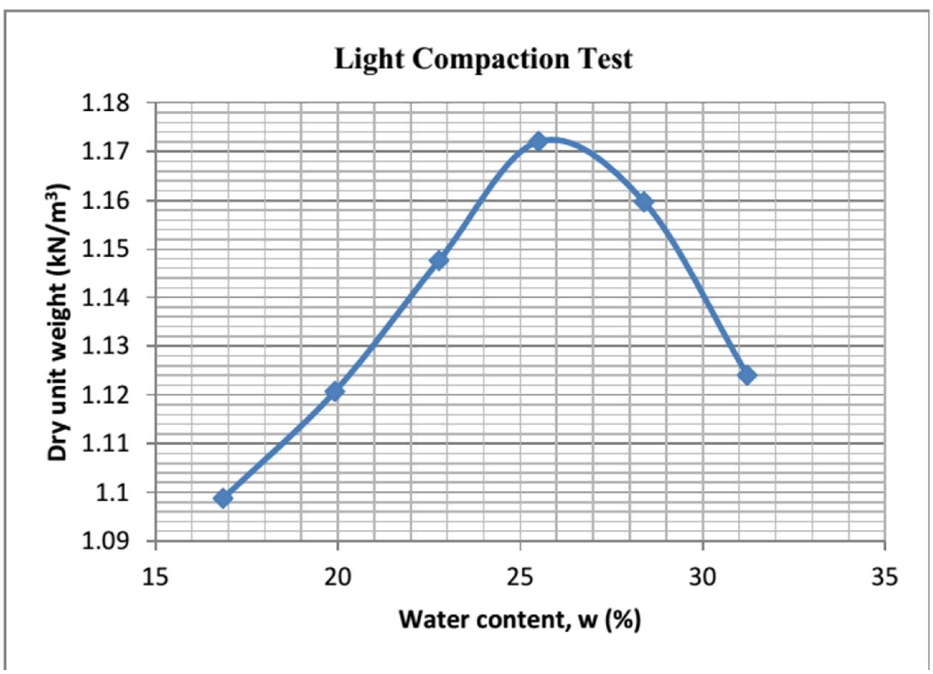


Fig-3.1- Water content- Dry unit weight of pond ash for Light compaction test

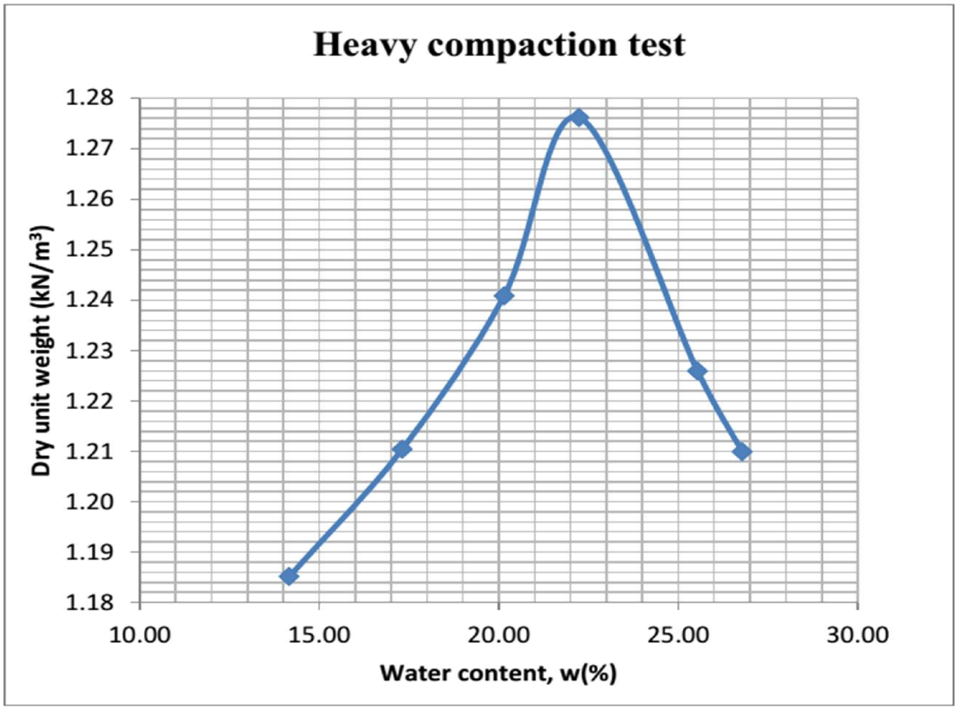


Fig-3.2- Water content- Dry unit weight of pond ash for Heavy compaction test

3.4 GRAIN SIZE ANALYSIS :

Grain size distributions for all samples pond ash was conducted as per IS: 2720 part (IV) for coarse fractions and hydrometer analysis were conducted for finer particles. The grain size distribution curves of pond ash is presented in Fig. 3.3. Coefficient of uniformity (Cu), coefficient of curvature (Cc) and mean diameter (D50) of the samples for pond ash is presented in Table 3.3.

Table 3.3- Grain size analysis

Parameters	**Pond ash**
Cu	3.85
Cc	1.12
D_{10} (mm)	0.13
D_{30} (mm)	0.27
D_{60} (mm)	0.5
D_{50} (Mean diameter)mm	0.31

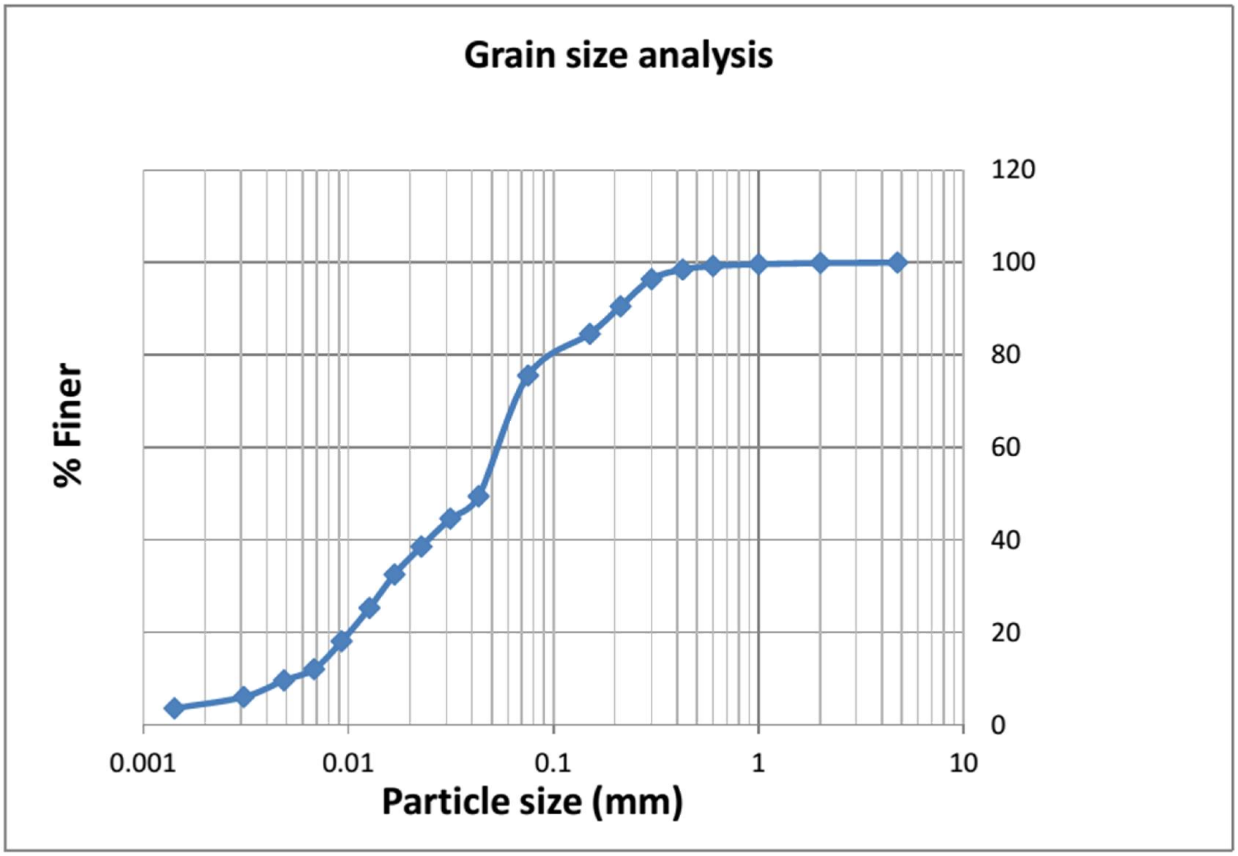


Fig 3.3- Grain size analysis of pond ash

3.5 DETERMINATION OF SHEAR PARAMATERS:

The shear parameters of sand and pond ash were determine at their corresponding dry density with compactive effort of 595 kJ/m3 as per IS: 2720 (Part 13) 1986. Test specimens were prepared corresponding to their maximum dry densities. These specimens were of size 60mm×60mm×25mm deep and sheared at a rate of 1.25 mm/minute. The shear strength parameters of the compacted specimens were determined from normal stress versus shear stress plots and it is given in Table 3.4, 3.5.

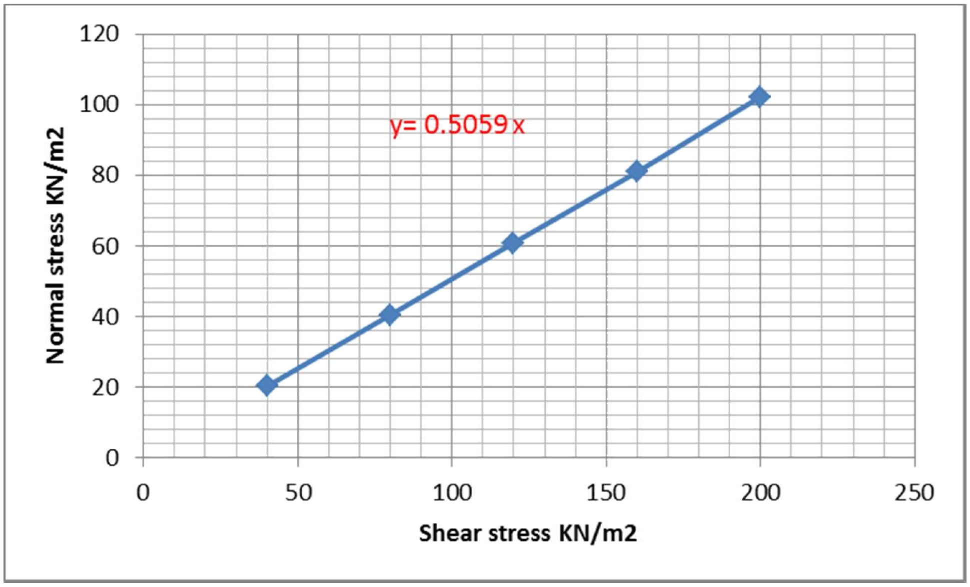


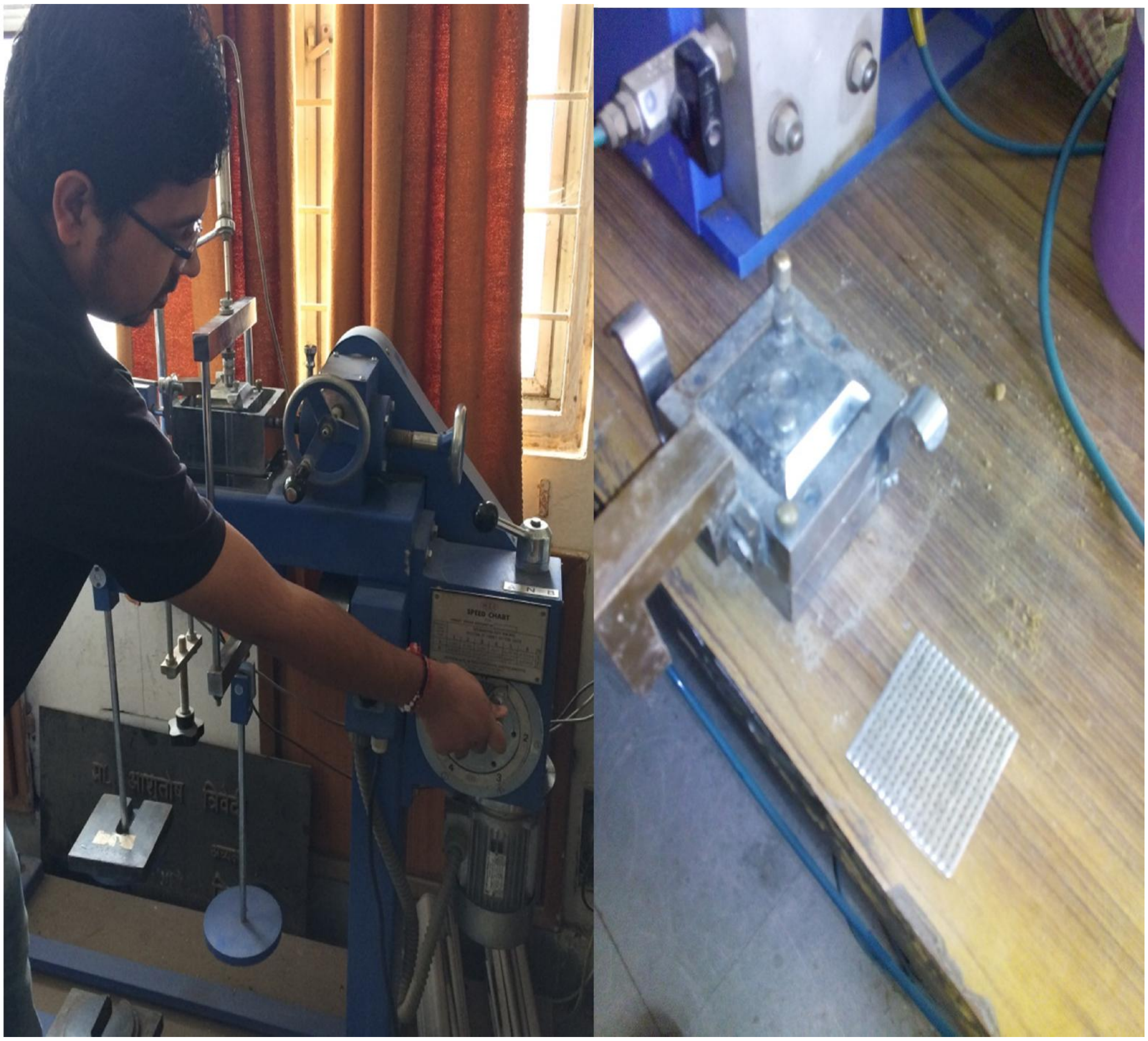
Fig 3.4- Normal stress v/s shear stress plot for Pond ash

Table 3.4- Results of direct shear test for Pond ash

Normal stress(KPa)	**Shear stress (KPa)**
40	20.2
80	40.5
120	60.71
160	81
200	102.2

Table 3.5- Variation of shear strength parameters (Cohesion and angle of internal friction)

S.No.	**Material**	**Cohesion (KN/m^2)**	**Angle of internal friction, Ø(in degree)**
2	Pond ash	0	27.1^0



DIRECT SHEAR TEST MACHINE AND DIFFERENT PARTS OF SHEAR BOX

3.6 - DETERMINATION OF CALIFORNIA BEARING RATIO:

3.6.1- CBR value of compacted pond ash:

The design of pavement includes the necessity of study of the properties of sub base and base of the soil. This includes the determination of strength and bearing capacity of the soil, this can be accomplished in the field by finding the CBR index of the soil. Whereas, the study necessitates the lab tests to be followed by field application, the following procedure determines the lab tests:
A cylindrical mould of dimensions 150 mm diameter, 175 mm height is used. At MDD and OMC the sample is prepared, over the sample spacer disc is placed and compacted

with the hydraulic jack till the level of the spacer disc reaches the top of the mould. The whole set up is placed on the CBR testing machine. Now a surcharge simulating the field conditions is placed at the middle of the mould, and the load is applied with a movable base set up at a constant strain rate of 1.2 mm/min. The piston applying load was 50 mm diameter and the applied load was recorded till the 13 mm penetration depth achieved. To assess the stability of pond ash the above test was conducted on the unsoaked condition, according to IS 2720 (Part XVI) -1987. The graph plotted was shown in Fig 4.1

3.6.2- CBR value of pond ash reinforced with Geosynthetics:

The CBR test as per IS 2720 (Part XVI) -1987 was conducted with different size of reinforcement from 5 to 15 cm uniformly varying at 2.5 cm along the diameter and CBR values of pond ash at different depths is studied (2.5cm, 5cm,7.5cm, 10cm). The two different kinds of reinforcement considered in the present study are Galvanized iron (GI) and Poly Vinyl chloride (PVC), and the graphs are shown in Fig 4.2 to 4.19.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 INTRODUCTION:

A series of CBR tests were conducted on compacted pond ash and compacted pond ash reinforce ether with grid reinforcements of G I & PVC are a layer of overlain sand. The position of reinforcements and the size were varied. Further the thickness of over lain sand layer and the relative densities of sand were varied and CBR test conducted. The test results are presented in the following sub sections.

4.1.1 Load deformation of compacted pond ash:

The load deformation behavior of pond ash compacted to either standard proctor densities are modified proctor densities as shown in fig 4.1 as the compaction energy increases the stiffens as well as the failure load increases the CBR value corresponding to 2.5 mm penetration and 5 mm penetration are found for samples compacted at standard proctor density and these values are for samples compacted at modified proctor density.

Table 4.1 CBR value of unsoaked compacted pond ash:

Compaction energy	CBR value corresponding to 2.5mm penetration (%)	CBR value corresponding to 5mm penetration (%)
Light compaction	10.34	9.4
Heavy compaction	19.42	17.6

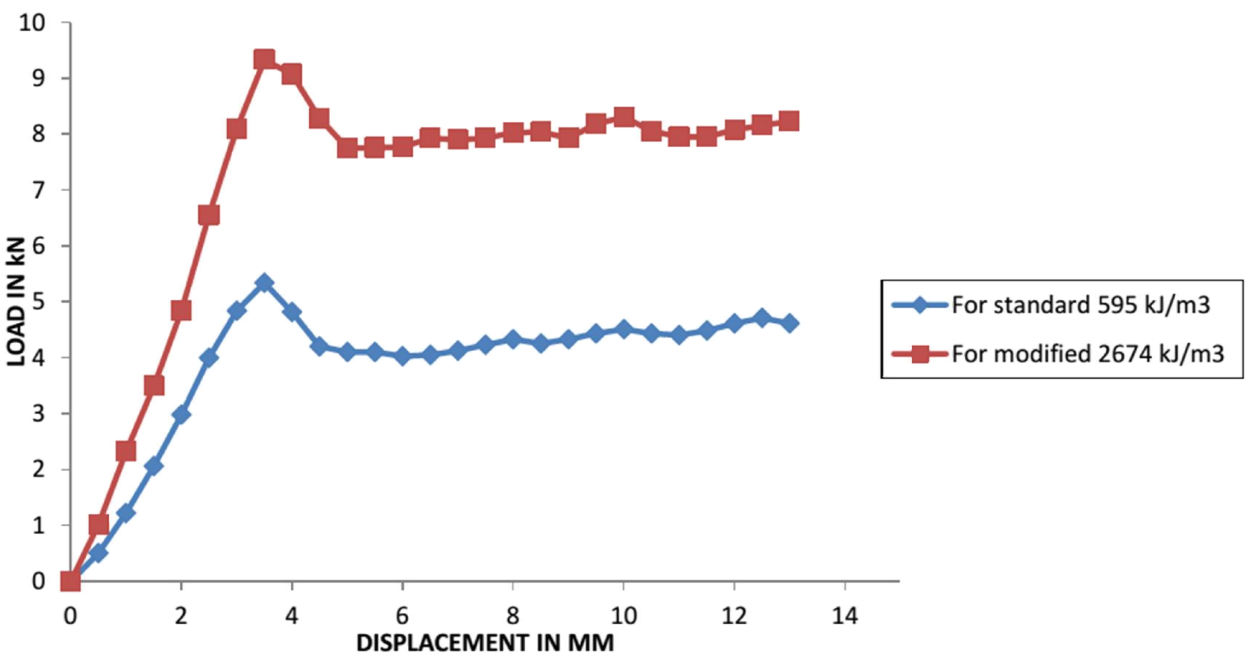


Fig. 4.1 load deformation behavior of compacted pond ash

4.1.2 LOAD DEFORMATION BEHAVIOR OF COMPACTED POND ASH REINFORCED WITH G.I &P.V.C NETS:

A series of CBR tests were conducted in compacted pond ash specimens reinforced with GI& PVC nets. The diameter of the reinforcements were varied as 5 cm ,7.5cm, 10cm, 12.5 cm& 15 cm and these reinforcement were placed either at 2.5 cm , 5 cm,7.5 cm&10 cm depth below the top surface. The pond ash sample were compacted either standard Proctor density or modified Proctor density. The reinforcements were net type made up of GI or PVC material the load deformation curves obtained for these test variables are given in Fig 4.2 to 4.16. Figures 4.3 to 4.9 shows the load deformation curves when different sizes of the reinforcements were placed at the depth of either 2.5 cm ,5cm,7.5cm &10cm respectively. It's seen at a given depth as the size of the reinforcement increase the stiffens of the load settlement was increased so as the failure load. Furthermore as the samples are compacted with higher load its failure load increase. However the strain at failure load is found to be almost same for the all sizes of reinforcement.it is seen that once the pond ash is reinforced G.I nets it carried higher load than PVC reinforced pond ash at comparable test conditions. This may be due to the higher stiffens of G.I net than PVC nets. Further the higher apertures sizes in G.I net makes possible an interaction between the pond ash particle below and above the net, which is absent in the PVC reinforcement. The aperture in PVC net is quite small prohibiting and interaction between pond ash below and above it thus acting as a separator.

For standard (compaction energy 595 kJ/m^3) -

Reinforcement position: 2.5 cm from top

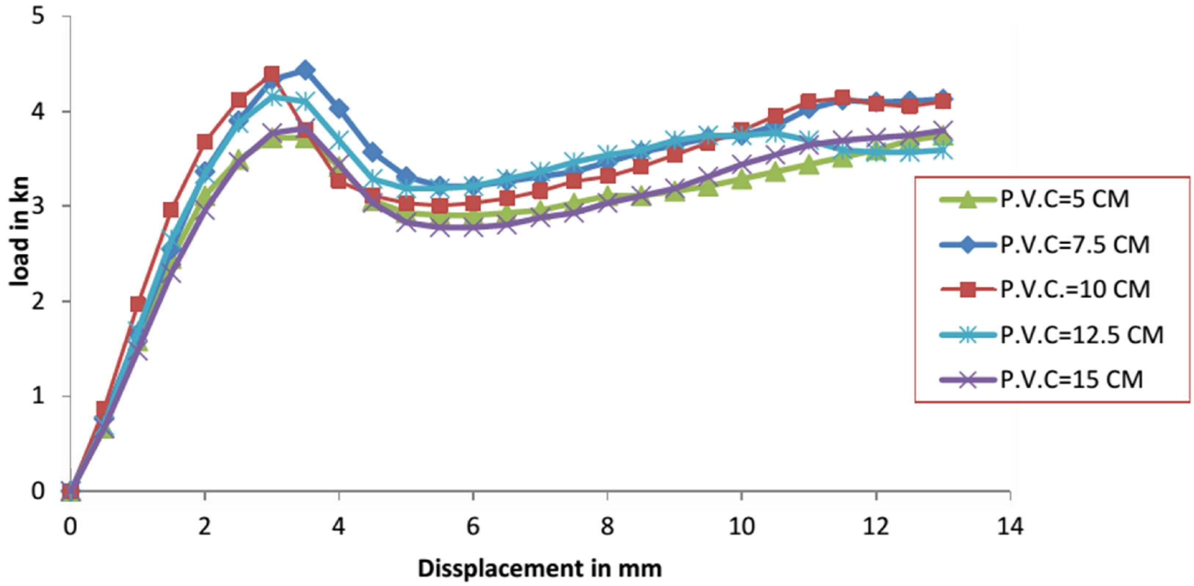


Fig 4.2 load deformation behavior of compacted pond ash (standard density) reinforced with PVC nets

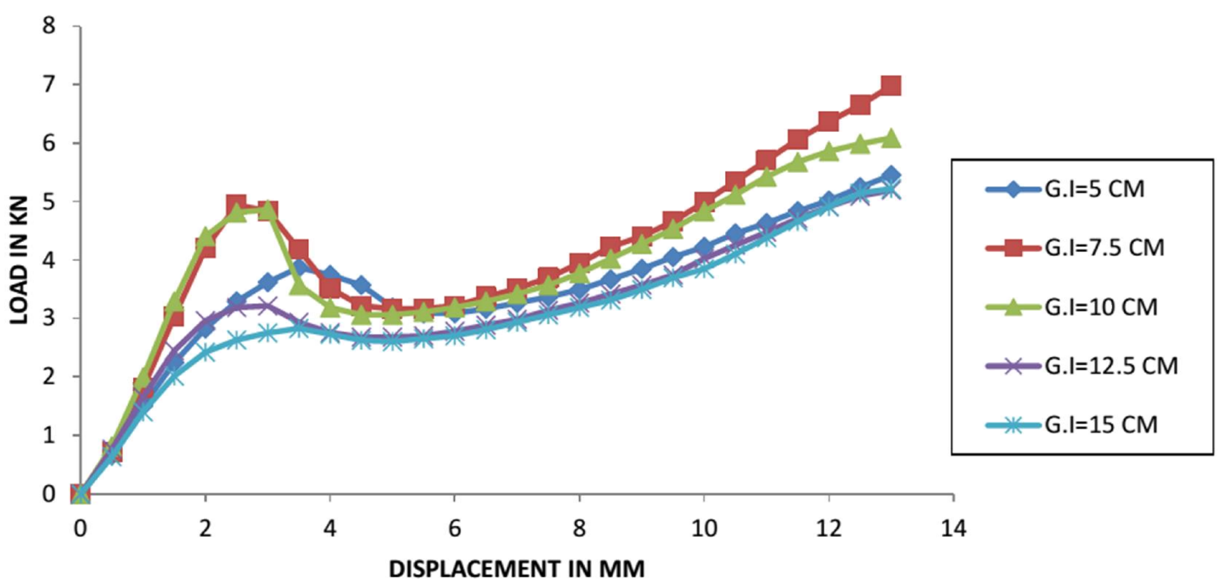


Fig 4.3 Load deformation behavior of compacted pond ash (standard density) reinforced with GI Nets

Reinforcement position: 5 cm from top

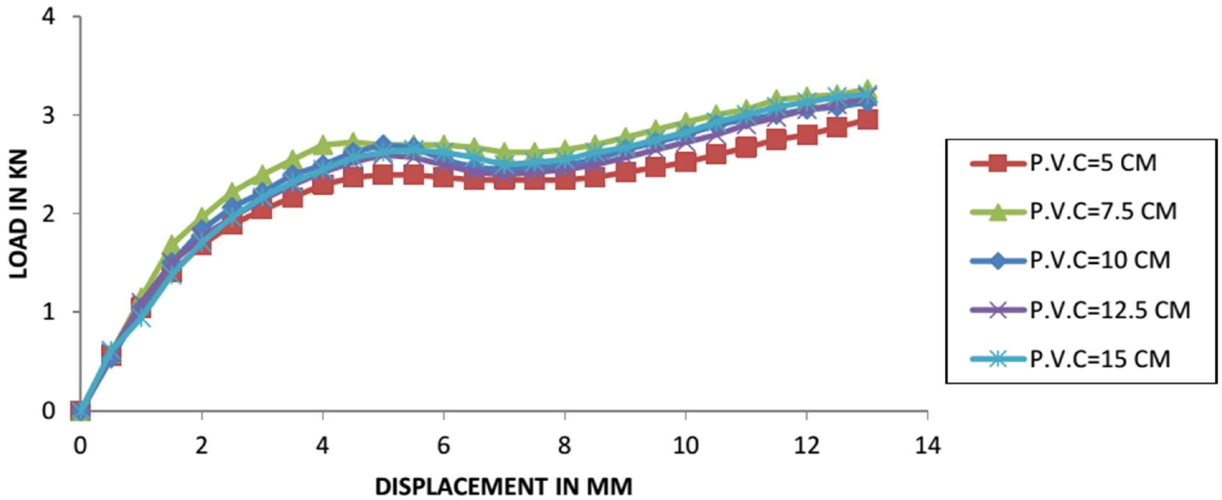


Fig 4.4 load deformation behavior of compacted pond ash (standard density) reinforced with PVC nets

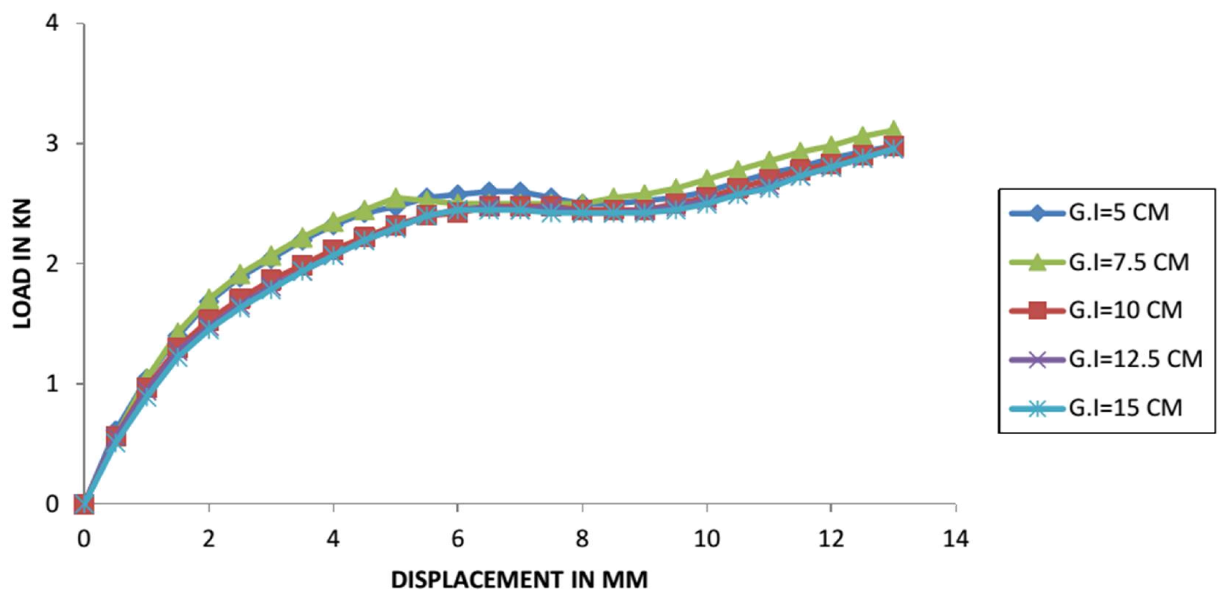


Fig 4.5 Load deformation behavior of compacted pond ash (standard density) reinforced with GI Nets

Reinforcement position: 7.5 cm from top

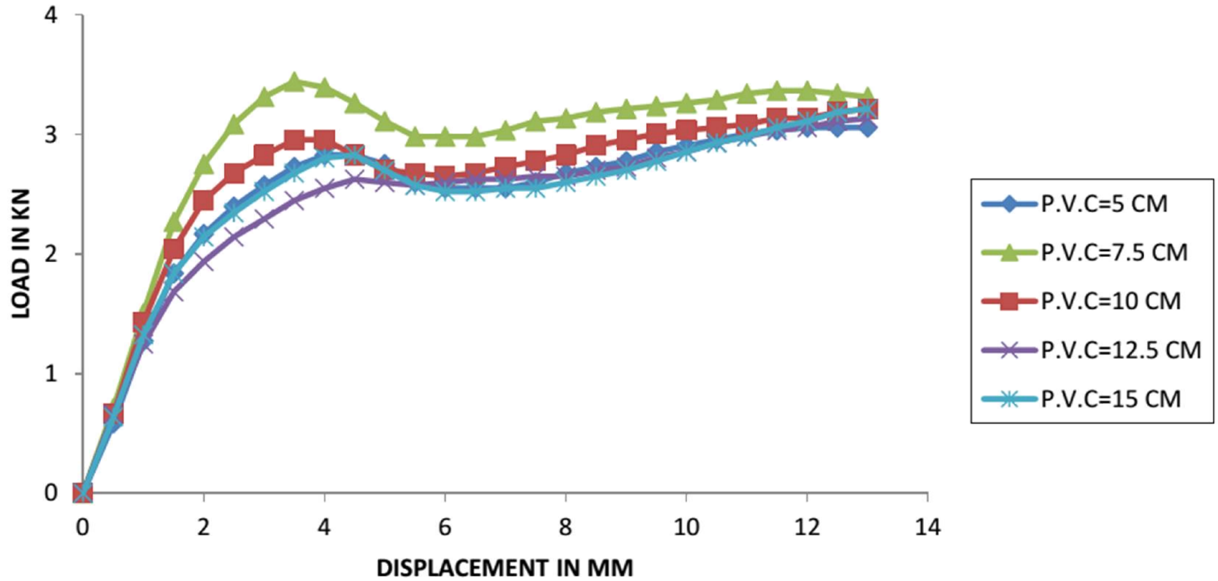


Fig 4.6 load deformation behavior of compacted pond ash (standard density) reinforced with PVC nets

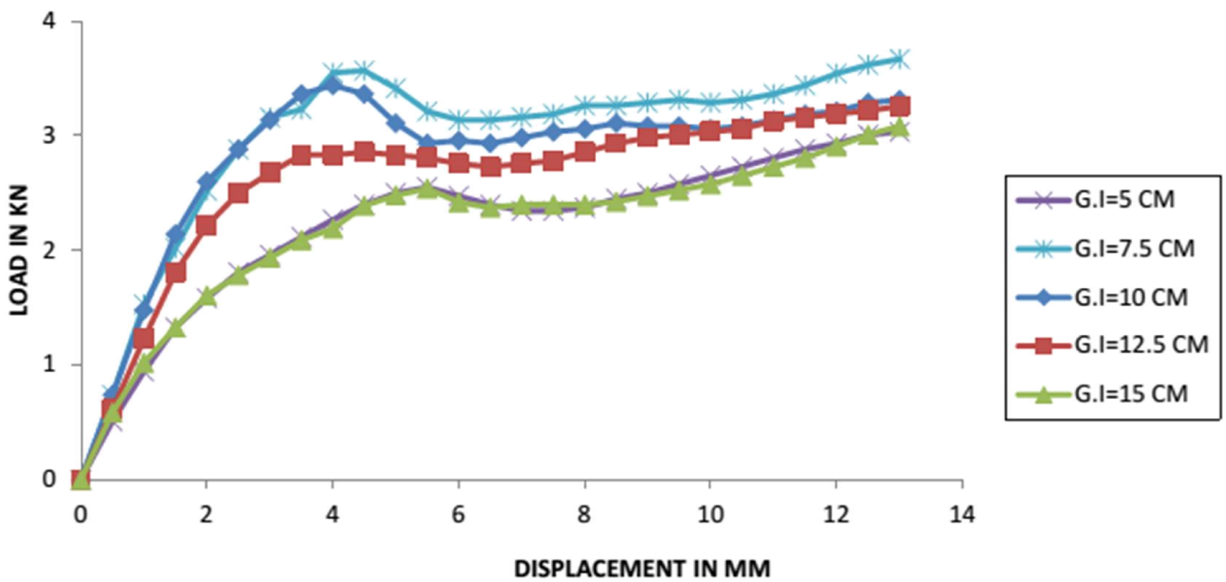


Fig 4.7 Load deformation behavior of compacted pond ash (standard density) reinforced with GI Nets

Reinforcement position: 10 cm from top

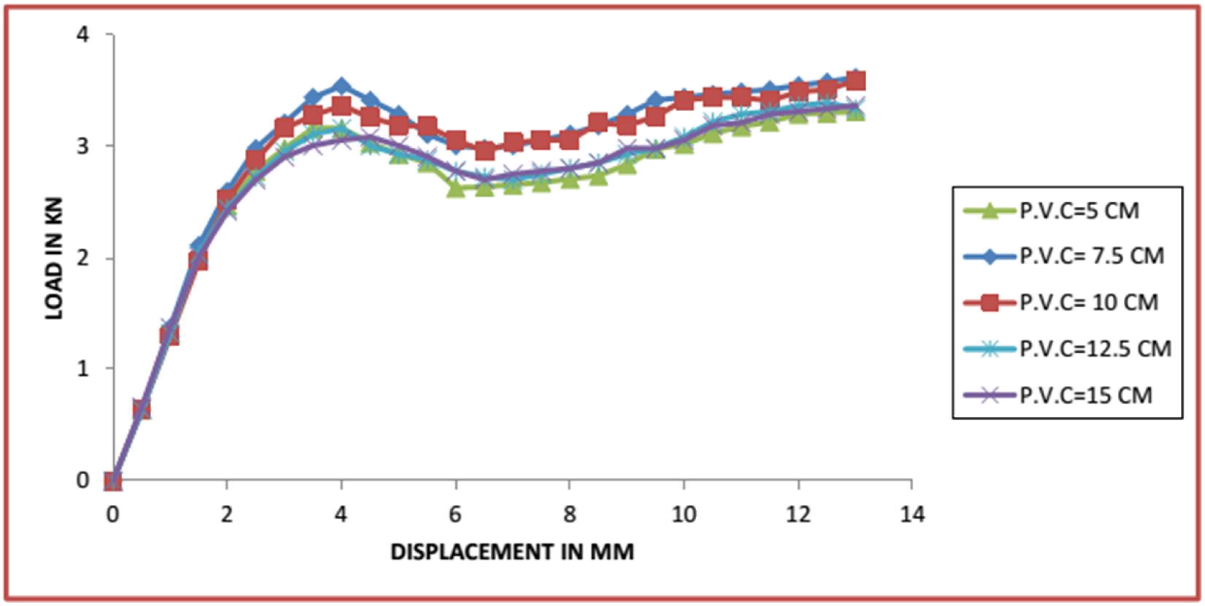


Fig 4.8 load deformation behavior of compacted pond ash (standard density) reinforced with PVC nets

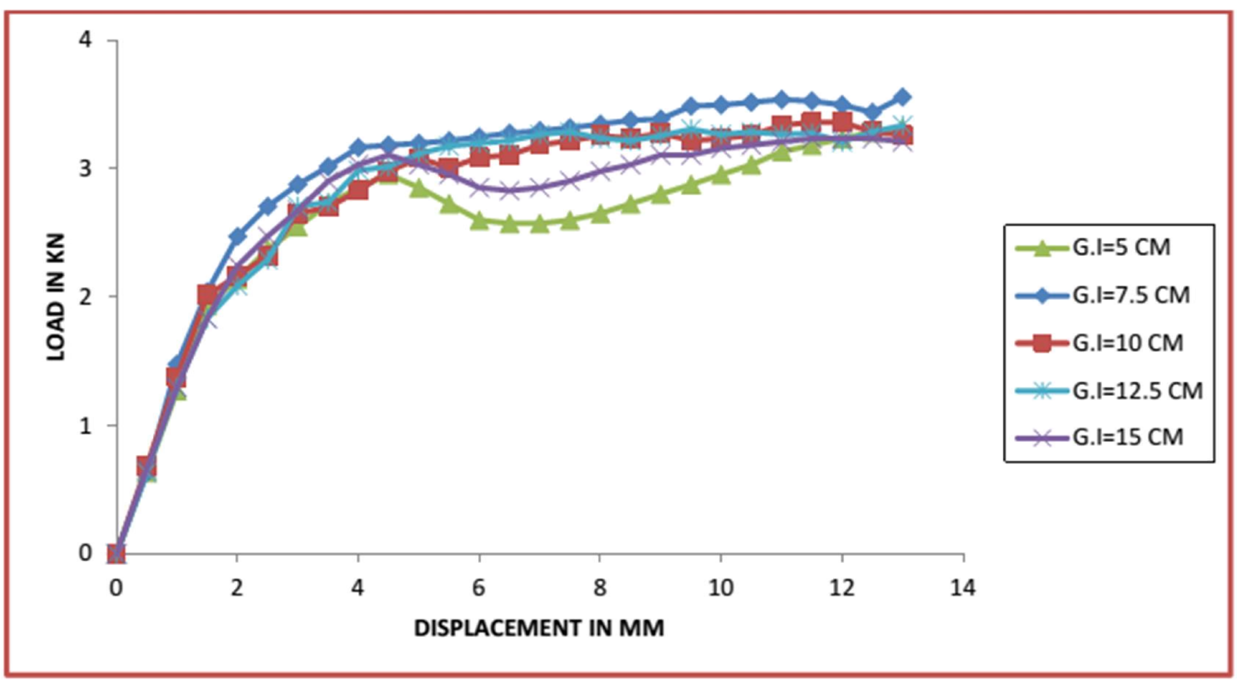


Fig 4.9 Load deformation behavior of compacted pond ash (standard density) reinforced with GI Nets

FOR MODIFIED (COMPACTION ENERGY 2674 KJ/M^3)

Reinforcement position: 2.5 cm from top

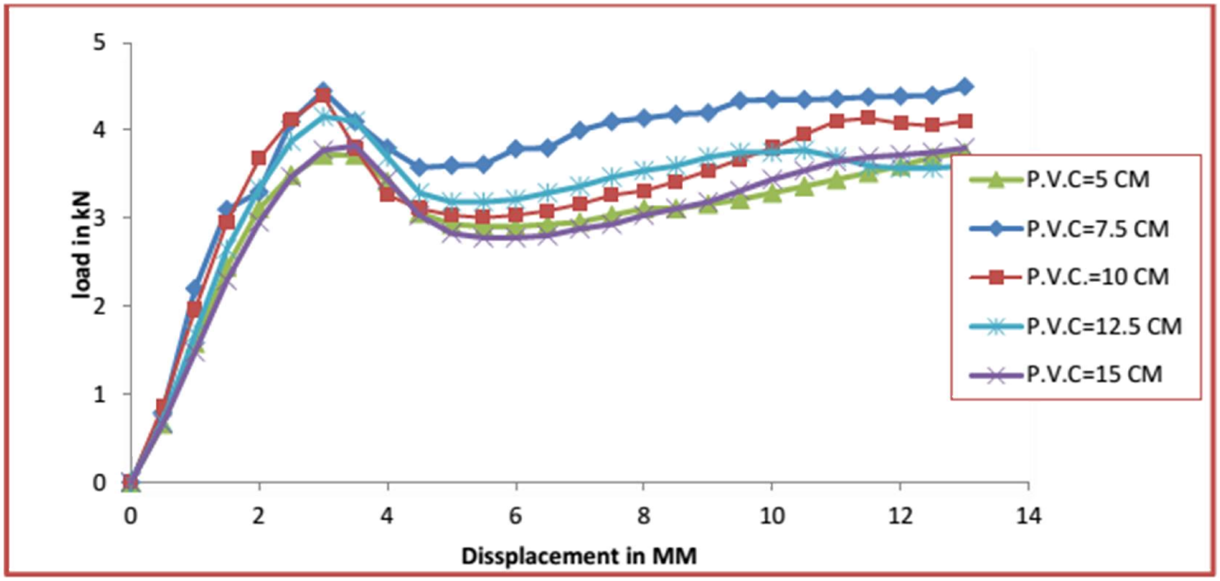


Fig 4.10 load deformation behavior of compacted pond ash (standard density) reinforced with PVC nets

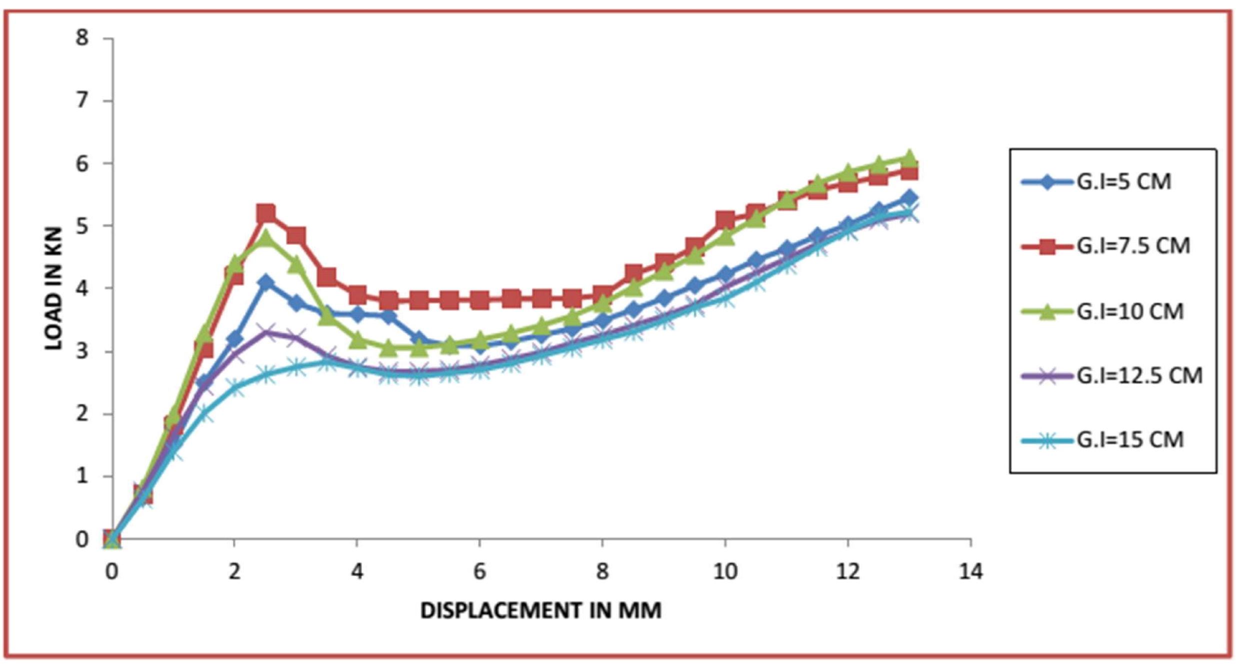


Fig 4.11 Load deformation behavior of compacted pond ash (standard density) reinforced with GI Nets

Reinforcement position: 5 cm from top

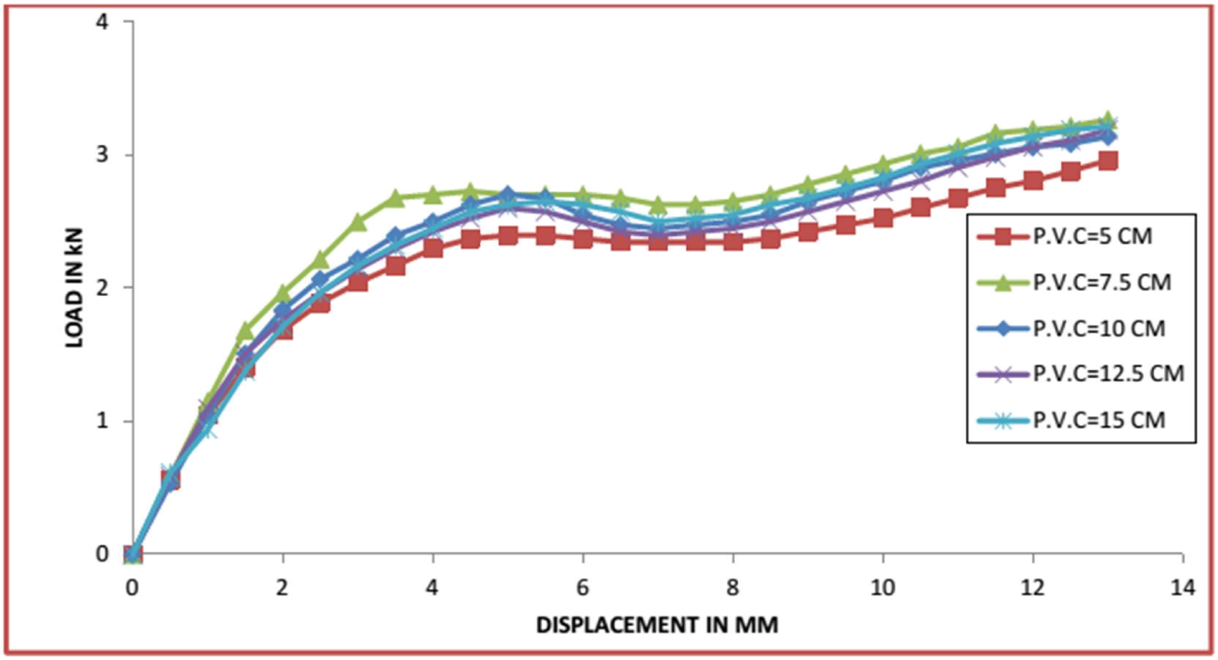


Fig 4.12 load deformation behavior of compacted pond ash (standard density) reinforced with PVC nets

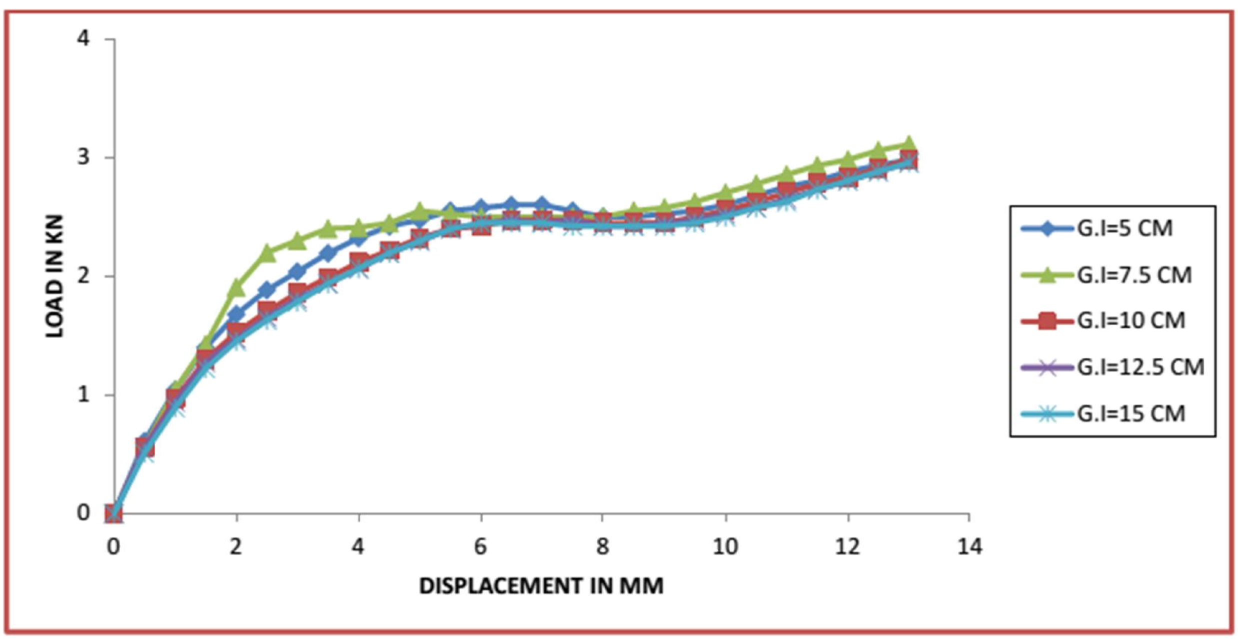


Fig 4.13 Load deformation behavior of compacted pond ash (standard density) reinforced with GI Nets

Reinforcement position: 7.5 cm from top

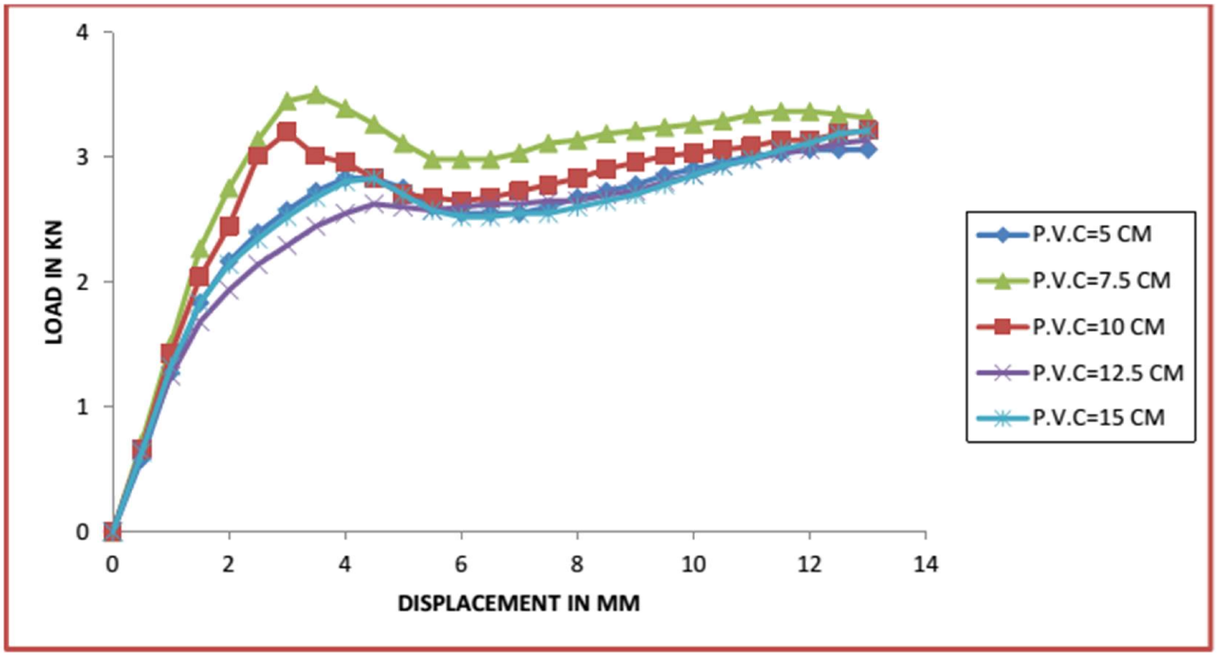


Fig 4.14 load deformation behavior of compacted pond ash (standard density) reinforced with PVC nets

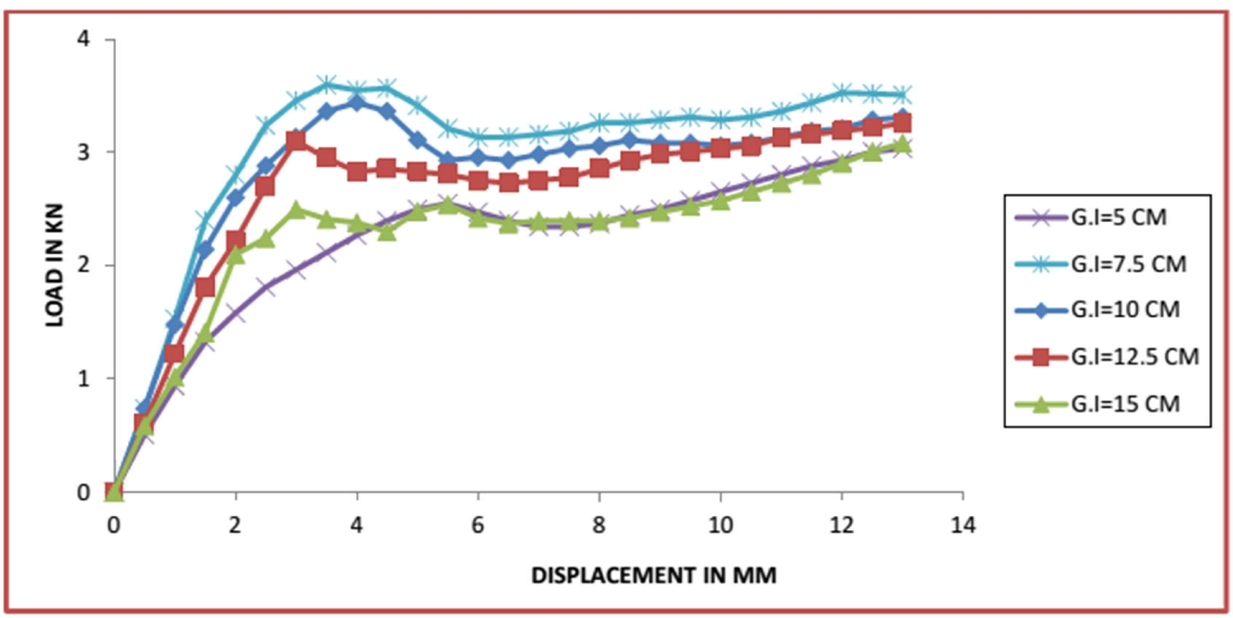


Fig 4.15 Load deformation behavior of compacted pond ash (standard density) reinforced with GI Nets

Reinforcement position: 10 cm from top

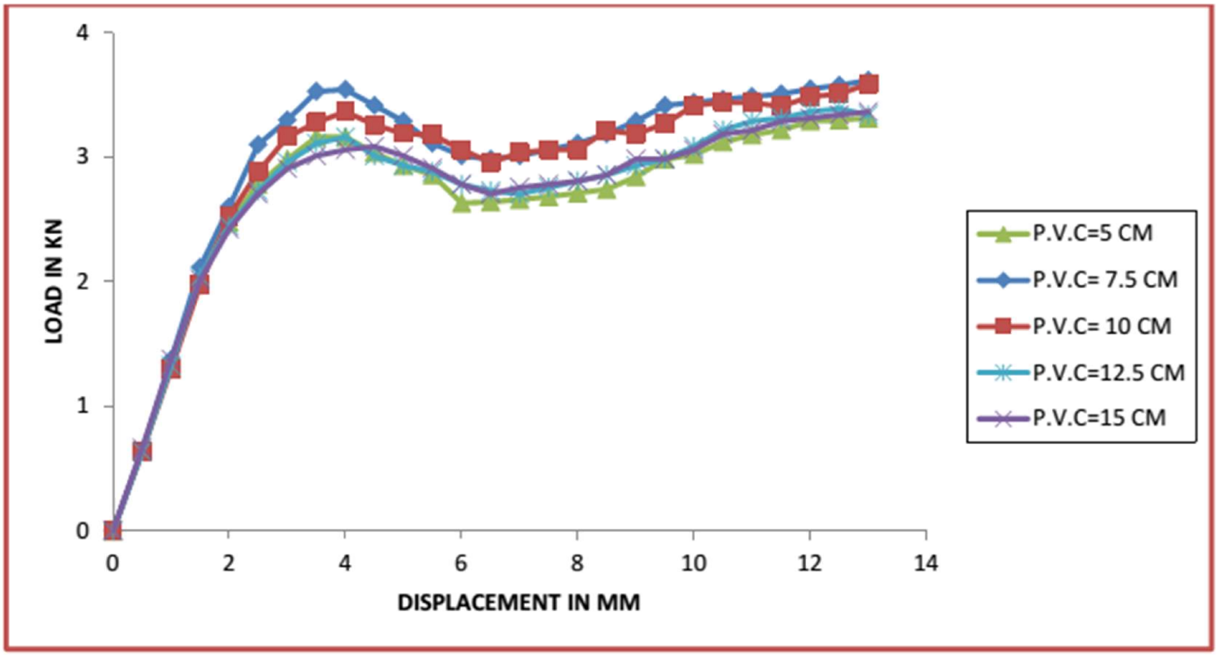


Fig 4.16 load deformation behavior of compacted pond ash (standard density) reinforced with PVC nets

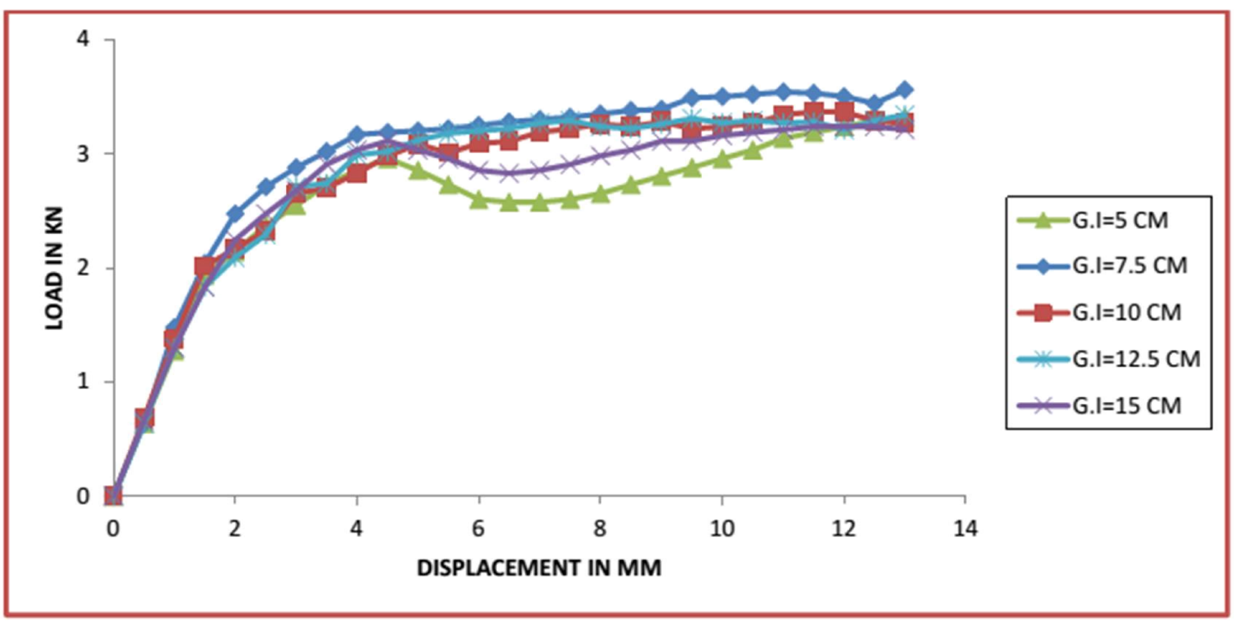


Fig 4.17 Load deformation behavior of compacted pond ash (standard density) reinforced with GI Nets

4.1.3 EFFECT OF REINFORCEMENT SIZE ON CBR VALUE:

Variation of CBR value with depth of reinforcement for samples compacted at standard proctor density and reinforced with G.I reinforcements as shown in Figure. CBR values of pond ash increases with the inclusion of reinforcement. However when the depth of reinforcement greater than two times of diameter of footing shows no significant changes in CBR. It was observed that the CBR values of reinforced pond ash increases with increase in stiffness of reinforcement. The present work used two types of reinforcement namely PVC and GI. At the same reinforcement depth, inclusion of GI material found to give more CBR value than PVC irrespective of the test condition. Fig 4.18 to Fig 4.25 shows the variation of CBR value with position of reinforcement (compacted samples of both at standard density and modified density). Inclusion of reinforcement in compacted pond ash generally found to increases the CBR value and therefore strength subsentially.

For compacted at standard density:

At 2.5 mm penetration:

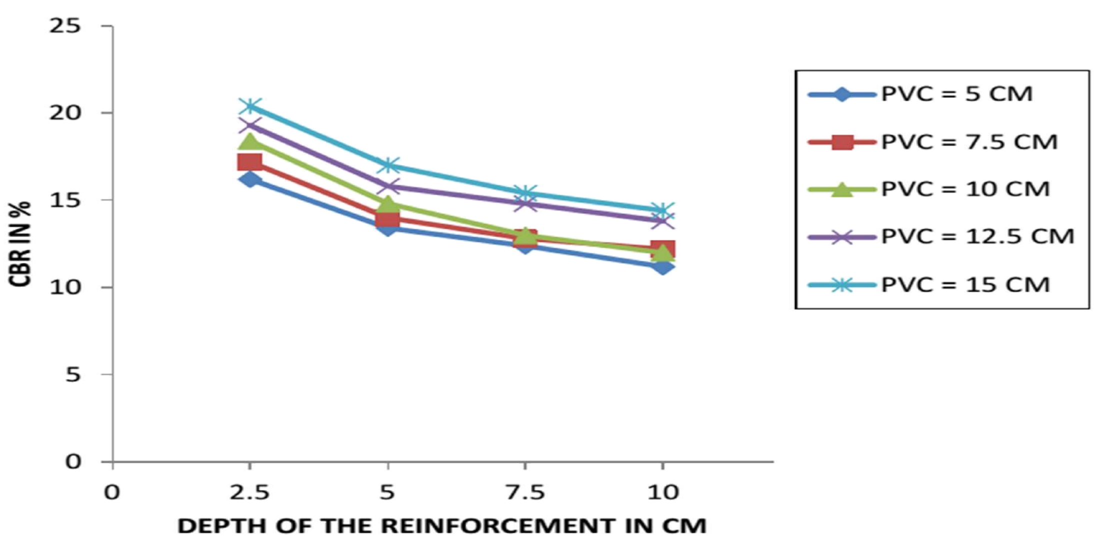


Fig 4.18 variation of CBR value with position of reinforcement (samples compacted at standard density)

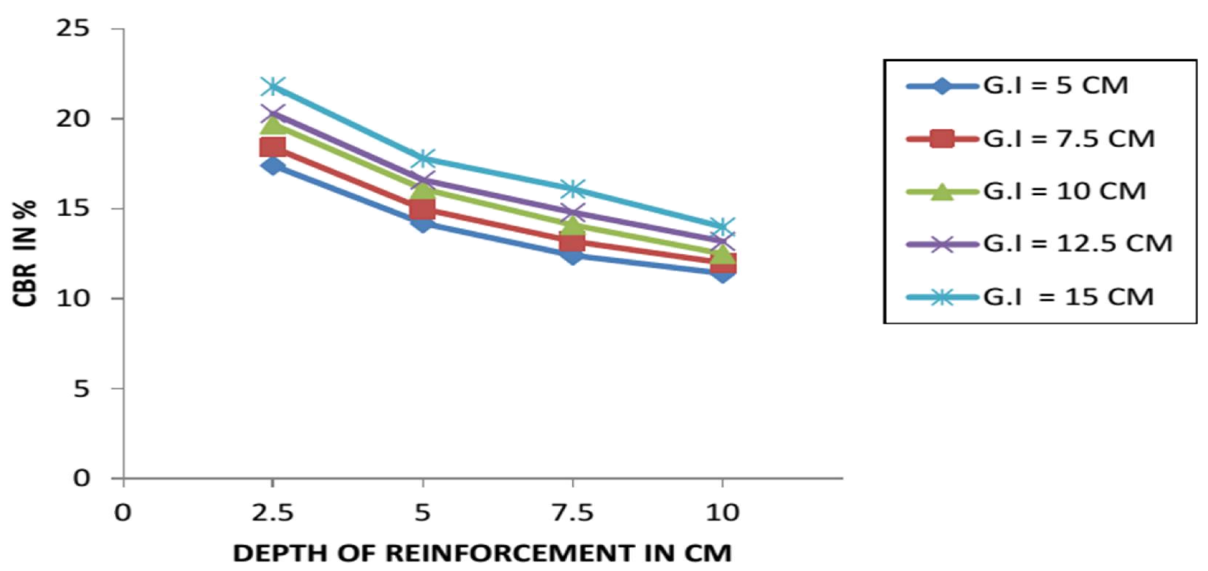


Fig 4.19 variation of CBR value with position of reinforcement (samples compacted at standard density)

At 5 mm penetration:

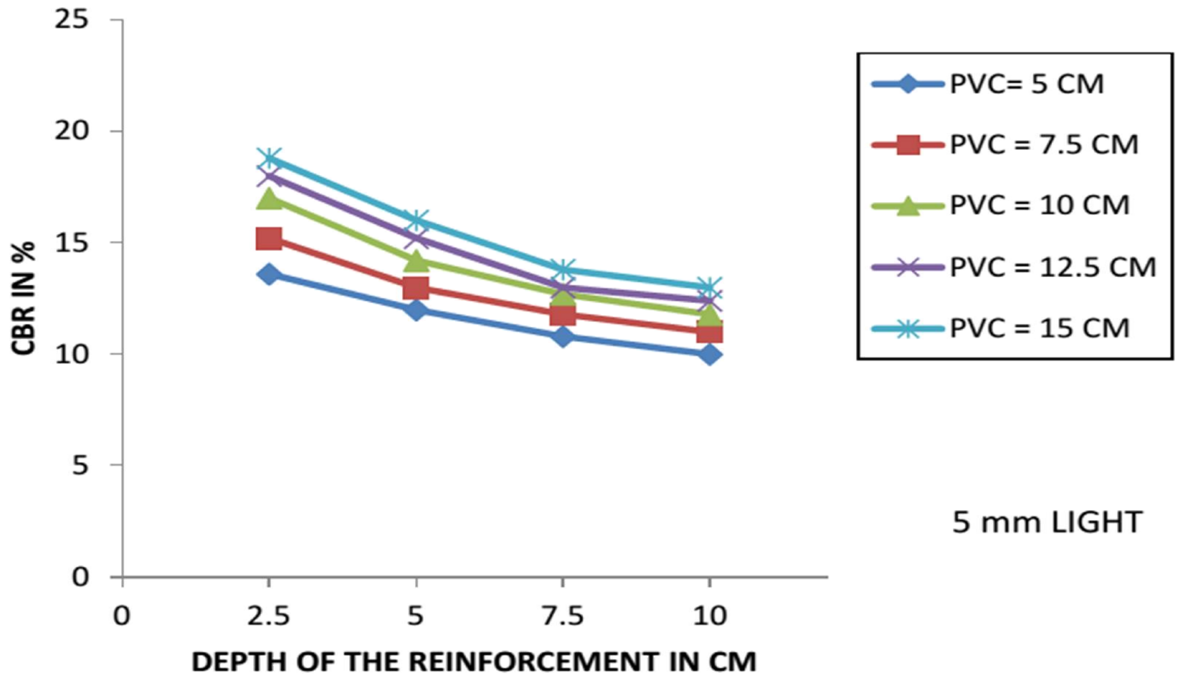


Fig 4. variation of CBR value with position of reinforcement (samples compacted at standard density)

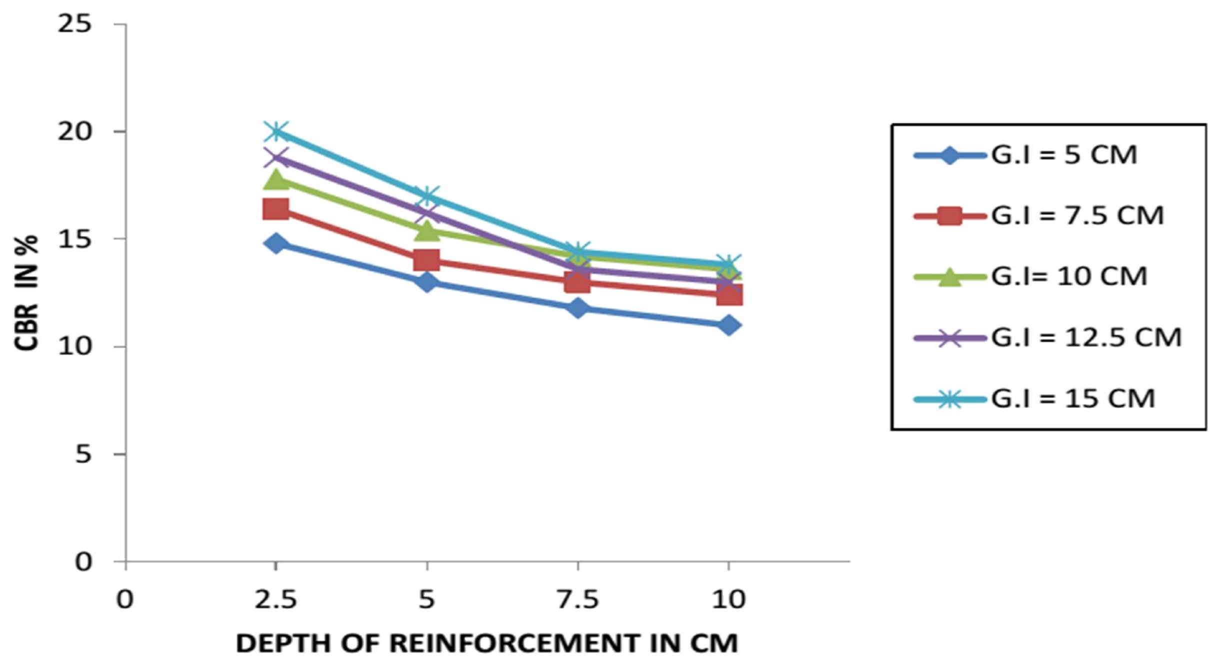


Fig 4.21 variation of CBR value with position of reinforcement (samples compacted at standard density)

For compacted at modified density:

2.5 mm penetration:

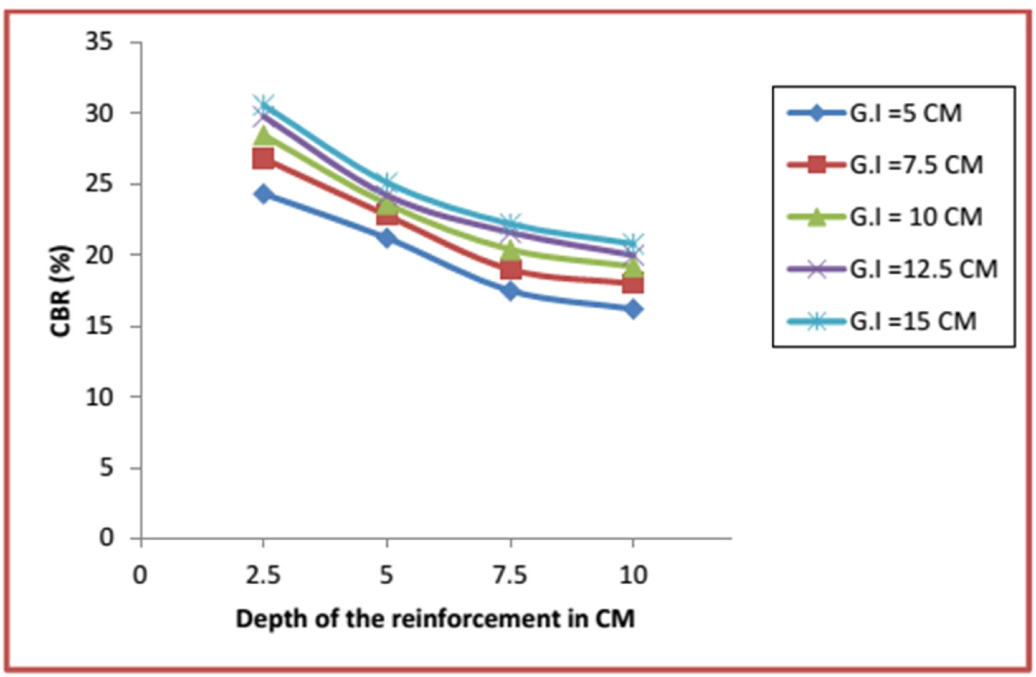


Fig 4.22 variation of CBR value with position of reinforcement (samples compacted at nodified density)

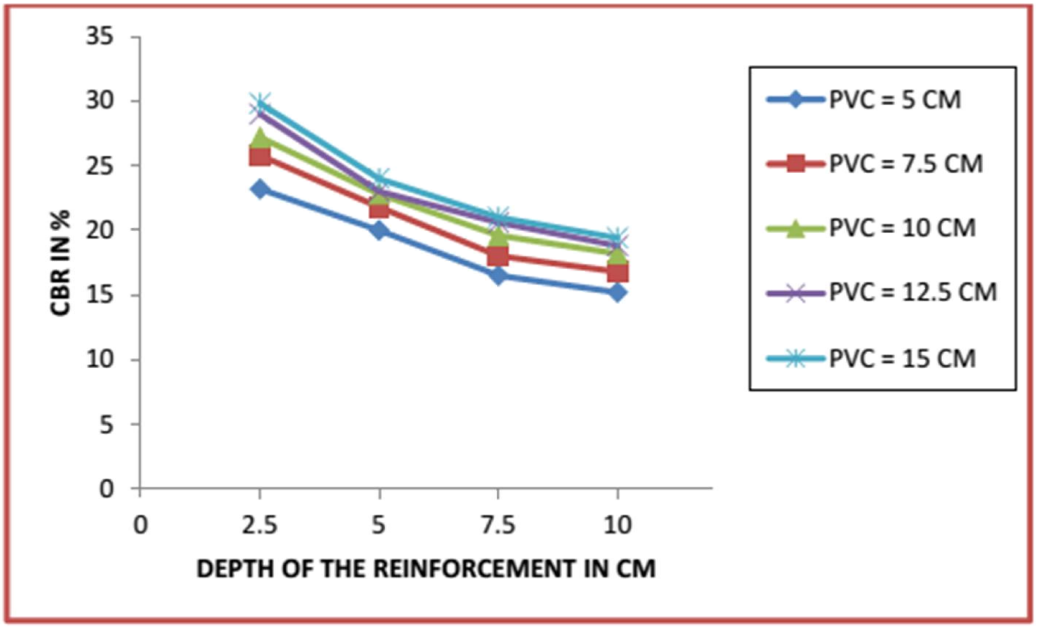


Fig 4.23 variation of CBR value with position of reinforcement (samples compacted at modified density)

At 5 mm penetration :

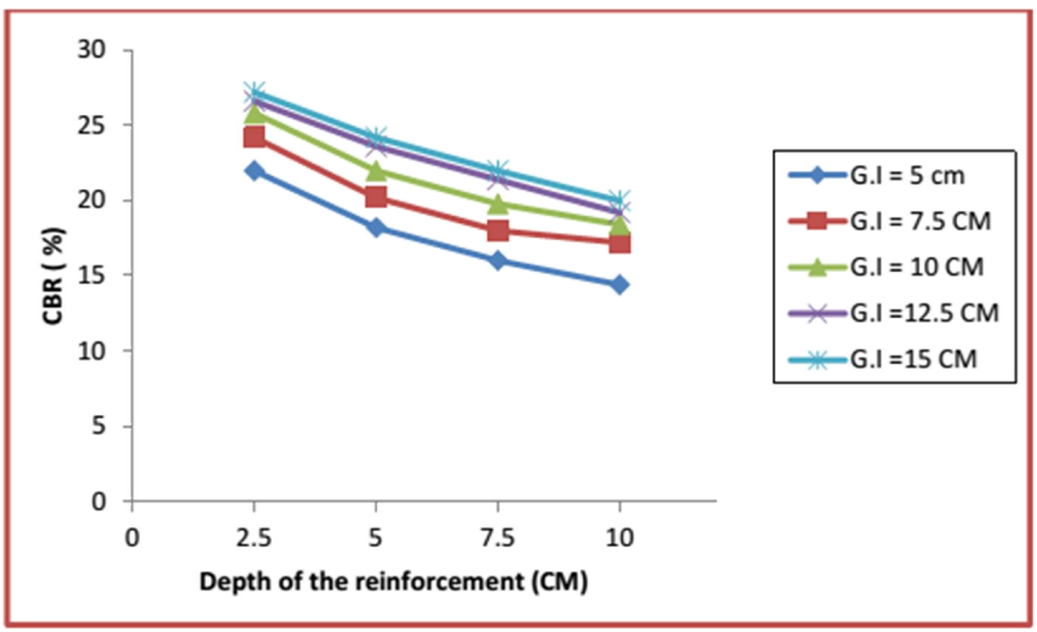


Fig 4.24 variation of CBR value with position of reinforcement (samples compacted at modified density)

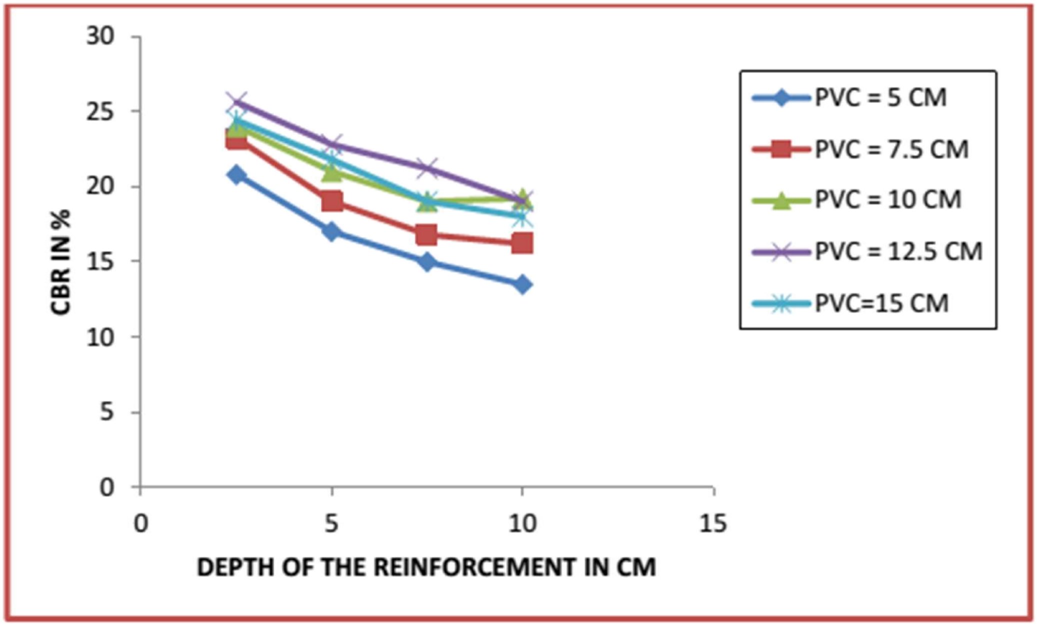


Fig 4.25 variation of CBR value with position of reinforcement (samples compacted at modified density)

TABLE 4.2: CBR values of reinforced pond ash:

For compacted at standard Density:

Position of rein forcement (depth)in cm	P.V.C.5 CM		P.V.C 7.5 CM		P.V.C 10 CM		P.V.C 12.5 CM		P.V.C. 15 CM	
	2.5 MM	5 MM	2.5 MM	5 MM	2.5 MM	5 MM	2.5 MM	5 MM	2.5 MM	5 MM
2.5	16.2	13.6	17.2	15.2	18.4	17	19.3	18	20.4	18.8
5	13.4	12	14	13	14.8	14.2	15.8	15.2	17	16
7.5	12.4	10.8	12.8	11.8	13	12.7	14.8	13	15.4	13.8
10	11.2	10	12.2	11	12	11.8	13.8	12.4	14.4	13

Position of rein forcement (depth)in cm	G.I. 5 CM		G.I. 7.5 CM		G.I. 10 CM		G.I 12.5 CM		G.I 15 CM	
	2.5 MM	5 MM	2.5 MM	5 MM	2.5 MM	5 MM	2.5 MM	5 MM	2.5 MM	5 MM
2.5	17.4	14.8	18.4	16.4	19.7	17.8	20.3	18.8	21.8	20
5	14.2	13	15	14	16.1	15.4	16.6	16.2	17.8	17
7.5	12.4	11.8	13.2	13	14.1	14.2	14.8	13.6	16.1	14.4
10	11.4	11	12	12.4	12.5	13.6	13.2	13	14	13.8

For compacted at modified Density:

Position of rein forcement (depth)in cm	P.V.C.5 CM		P.V.C 7.5 CM		P.V.C 10 CM		P.V.C 12.5 CM		P.V.C. 15 CM	
	2.5 MM	5 MM	2.5 MM	5 MM	2.5 MM	5 MM	2.5 MM	5 MM	2.5 MM	5 MM
2.5	23.2	20.8	25.8	23.2	27.2	24.8	29	25.6	29.8	24.4
5	20	17	21.8	19	22.8	21.2	23	22.8	24	21.8
7.5	16.5	15	18	16.8	19.6	20.6	20.6	21.2	21	21
10	15.2	13.5	16.8	16.2	18.2	19.2	18.8	18.4	19.4	17.8

Position of rein forcement (depth)in cm	G.I. 5 CM		G.I. 7.5 CM		G.I. 10 CM		G.I 12.5 CM		G.I 15 CM	
	2.5 MM	5 MM	2.5 MM	5 MM	2.5 MM	5 MM	2.5 MM	5 MM	2.5 MM	5 MM
2.5	24.32	22	26.8	24.2	28.46	25.8	29.8	26.6	30.6	27.2
5	21.2	18.2	22.8	20.2	23.6	22	24.2	23.6	25.1	24.2
7.5	17.51	16	19	18	20.4	19.8	21.6	21.4	22.2	22
10	16.22	14.4	18	17.2	19.2	18.4	20	19.2	20.8	20

4.1.4 EFFECT OF REINFORCEMENT POSITION ON CBR VALUES (PVC & G.I):

Variation of CBR value with varying diameter of reinforcement for samples compacted at standard proctor density and modified proctor density reinforced with G.I and PVC reinforcements as shown in Figure. From the figure it is observed that the CBR values of pond ash increases with the increase in diameter of reinforcement located within two times the diameter of footing below top surface. It was found that the CBR value increases with increase in stiffness of reinforcement. In the present study, the diameter of footing varied from 5 cm to 15 cm with a constant increment of 2.5 cm and depth of reinforcement varied from 2.5 cm to 10 cm. Fig 4.26 to Fig 4.33 shows the variation of CBR value with size of reinforcement (compacted samples of both at standard density and modified density). It was observed that the CBR values of reinforced pond ash increases with increase in stiffness of reinforcement. At the same reinforcement depth, inclusion of GI material found to give more CBR value than PVC irrespective of the test condition.

For compacted at standard density:

At 2.5 mm penetration:

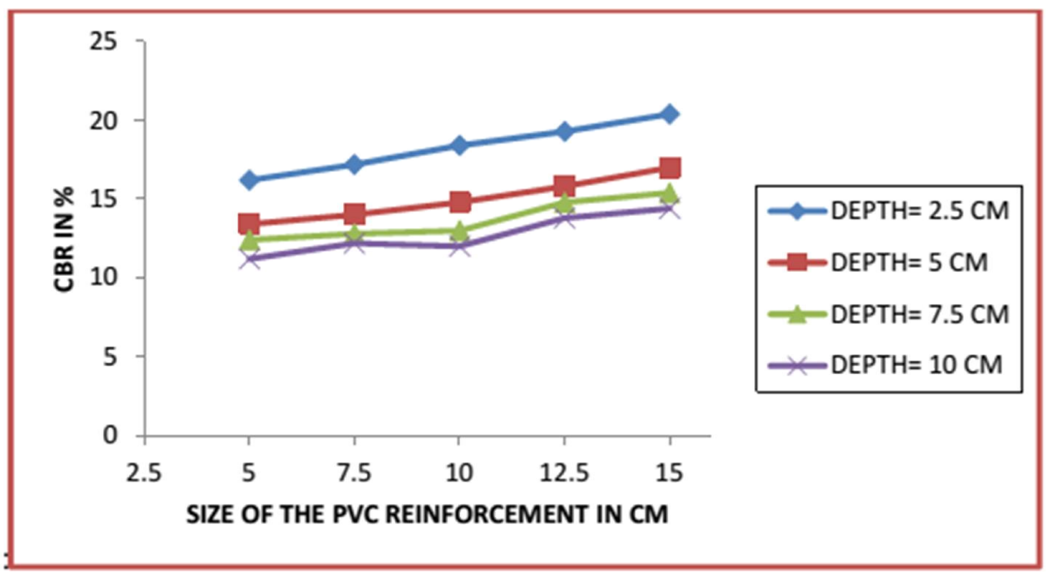


Fig 4.26 variation of CBR value with position of reinforcement (samples compacted at standard density)

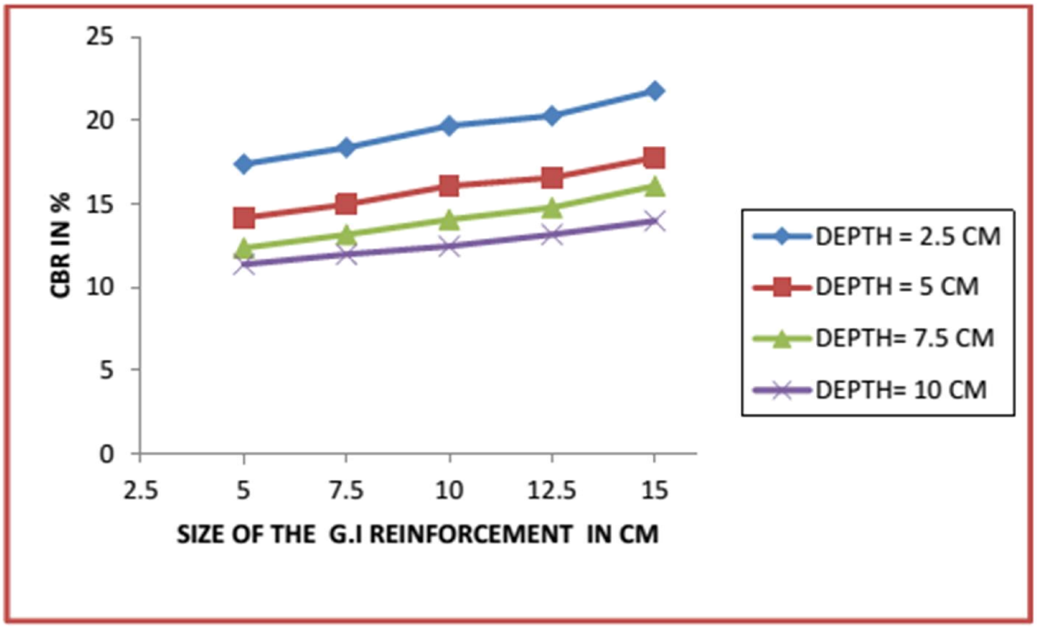


Fig 4.27 variation of CBR value with position of reinforcement (samples compacted at standard density)

At 5 mm penetration:

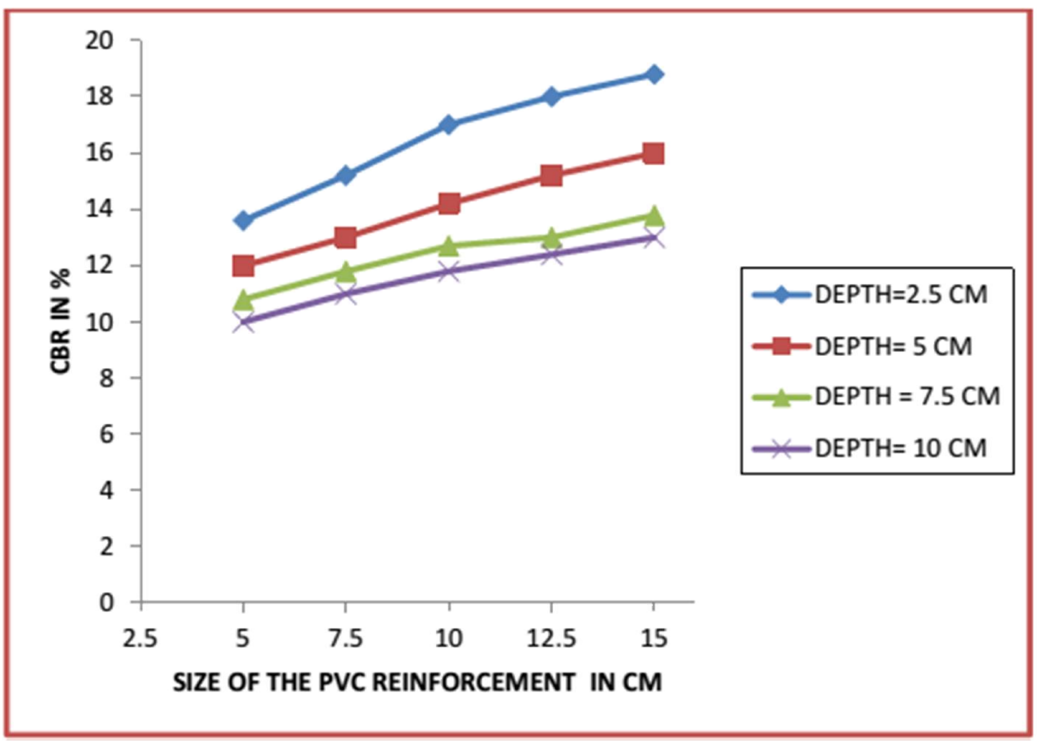


Fig 4.28 variation of CBR value with position of reinforcement (samples compacted at standard density)

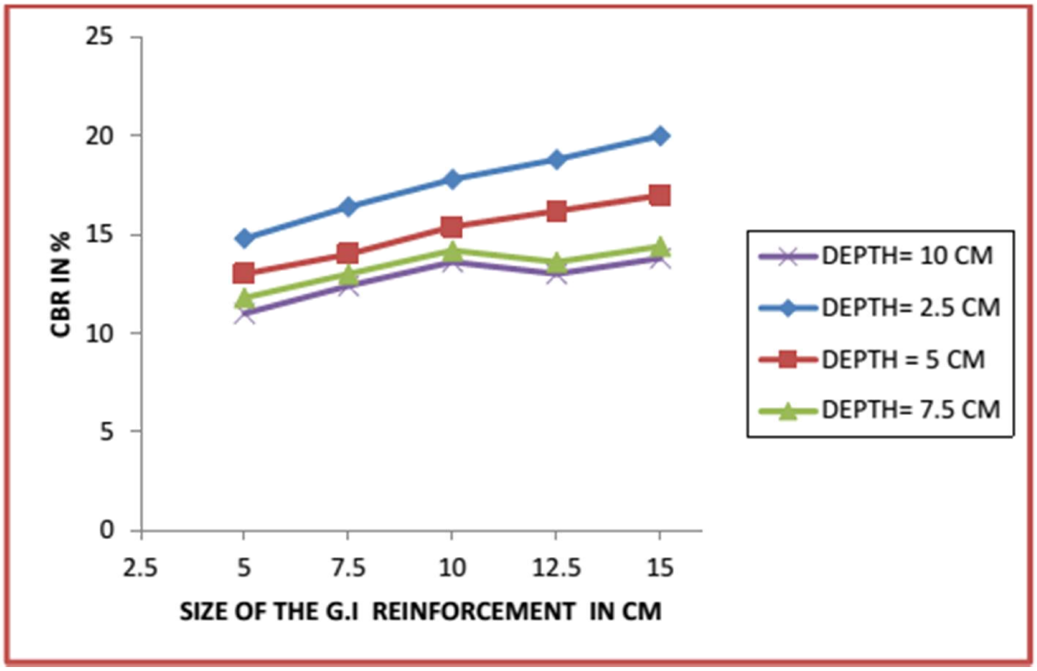


Fig 4.29 variation of CBR value with position of reinforcement (samples compacted at standard density)

At 2.5 mm penetration at modified density:

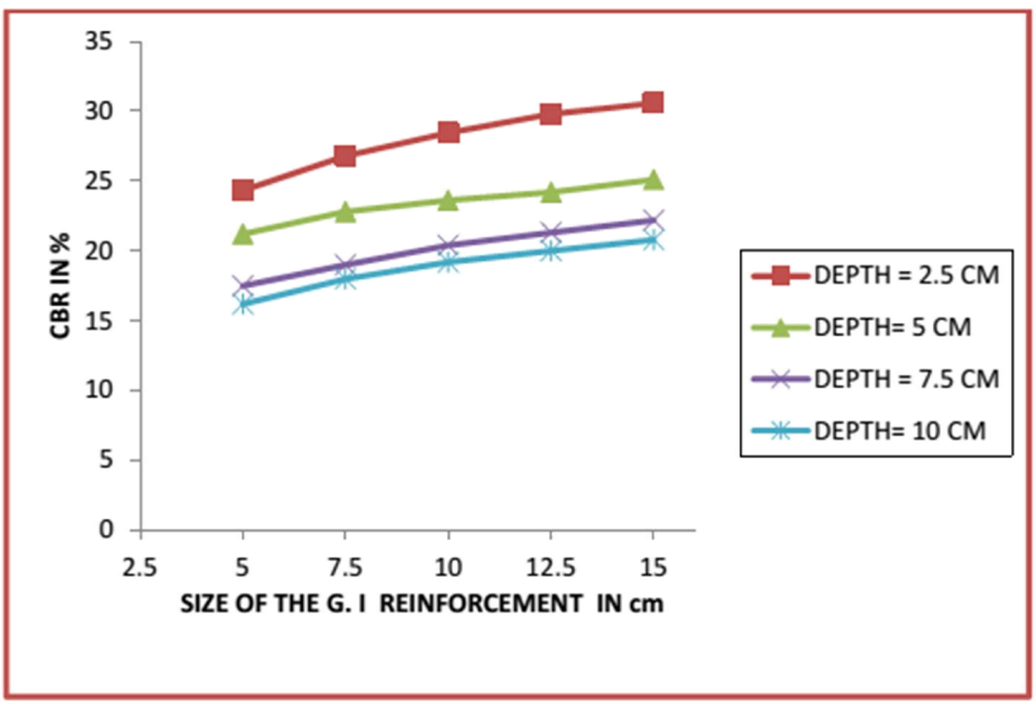


Fig 4.30 variation of CBR value with position of reinforcement (samples compacted at modified density)

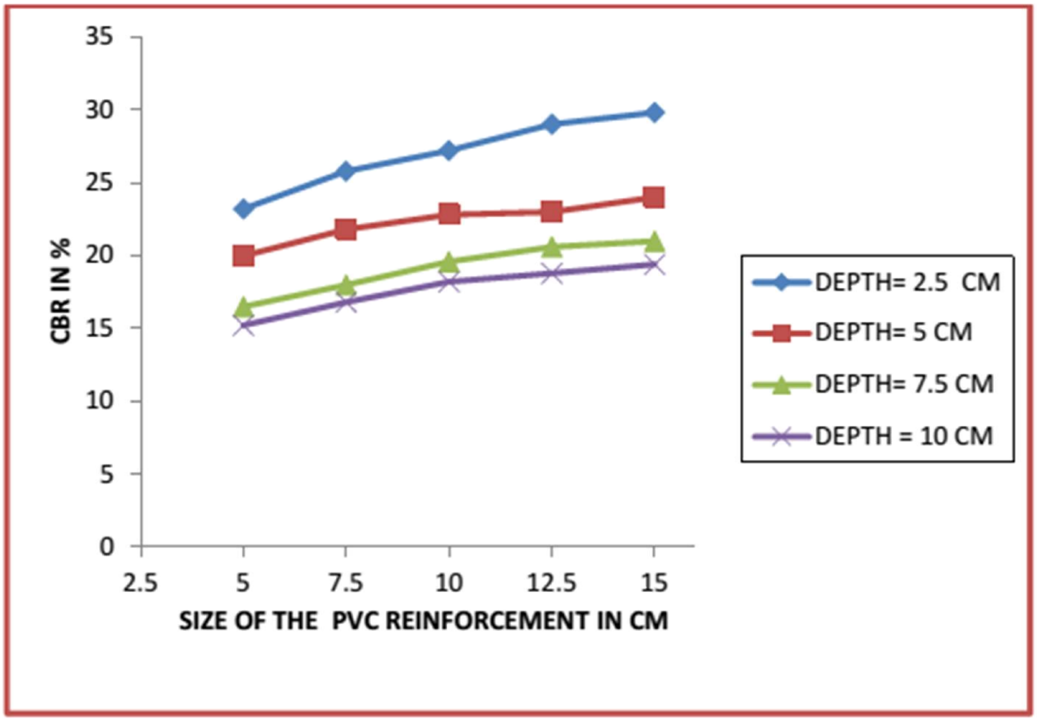


Fig 4.31 variation of CBR value with position of reinforcement (samples compacted at modified density)

At 5 mm penetration level:

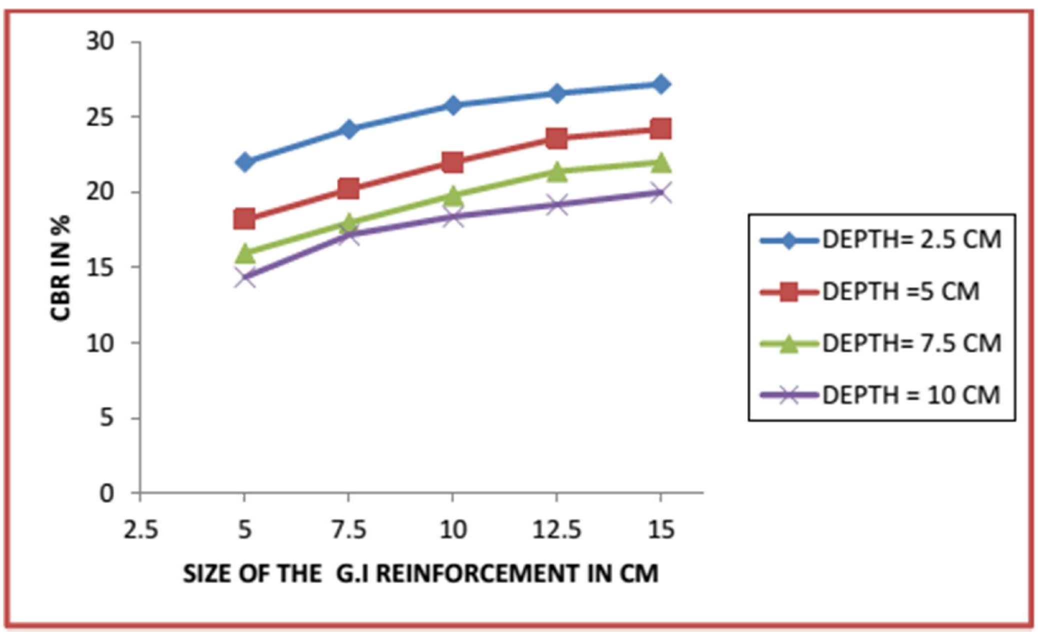


Fig 4.32 variation of CBR value with position of reinforcement (samples compacted at modified density)

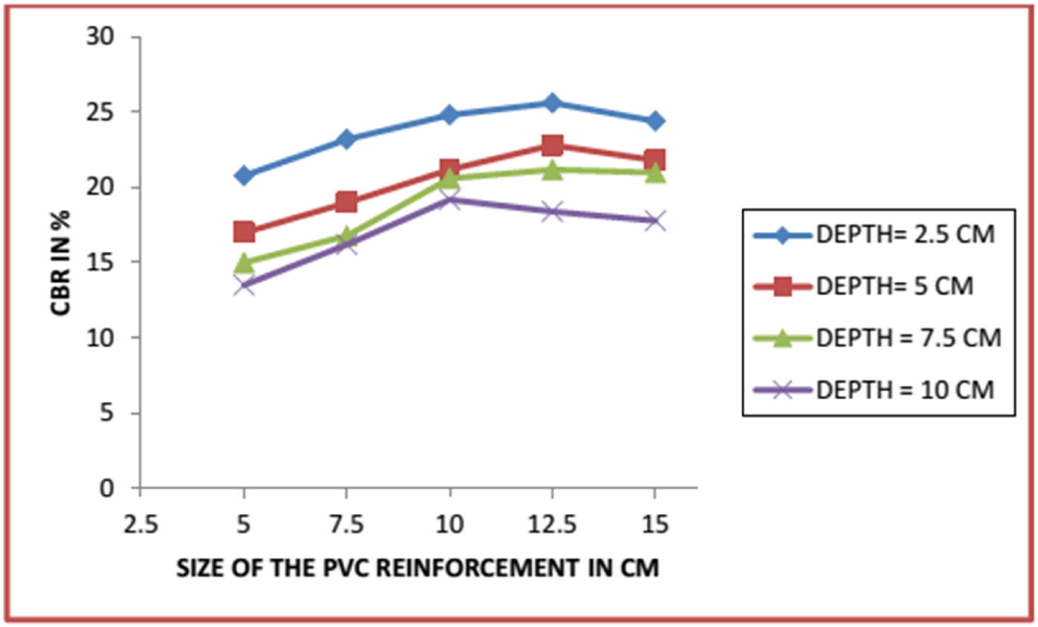


Fig 4.33 variation of CBR value with position of reinforcement (samples compacted at modified density)

CHAPTER 5:

CONCLUSION

Based on experimental results following conclusion are derived :

1. Pond ash compacted at modified proctor density gives approximately two times higher CBR value than sample compacted at standard proctor density.

2. For a given location of reinforcement as the size of reinforcement (diameter of reinforcement sheet) increases the CBR value increases.

3. CBR value decreases as the depth of reinforcement increases. When the depth of reinforcement is higher than the two times the diameter of the plunger (5 cm), practically there is no improvement in the bearing capacity of reinforced pond ash over unreinforced one.

4. At the same depth of reinforcement, inclusion of GI material found to give more CBR value than PVC irrespective of the test condition.

5. Load carrying capacity of pond ash beds can be increased approximately upto three times in comparison to unreinforced pond ash.

6. By using PVC and GI sheet geosynthetics as a reinforcing elements we can use pond ash an effective structural material at retaining wall, embankement, below pavement and as a fill material below structural foundation.

CHAPTER 6 :

SCOPE OF THE PRESENT STUDY:

Other reinforcement materials like fiber, geogrid can be used to study the effectiveness of improvement.

Other cementing materials like cement, lime be used alone or in combination to study the improvement in bearing capacity.

Interfacial shear resistance of reinforcement to be studied.

Correlation can be formulated by considering reinforcement property, geometry property of footing and property of soil domain.

CHAPTER 7

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