A COMPARATIVE STUDY ON STRENGTH IMPROVEMENTAND CBR PROPERTIES OF NIT HOSTEL AREA SOIL BY USING CALCIUM CARBIDE RESIDUE AND FLY ASH

Vikash Anand

Sanjay Bhobhariya

Department of Civil Engineering
NATIONAL INSTITUTE OF TECHNOLOGY
ROURKELA-769008

A COMPARATIVE STUDY ON STRENGTH IMPROVEMENTAND CBR PROPERTIES OF NIT HOSTEL AREA SOIL BY USING CALCIUM CARBIDE RESIDUE AND FLY ASH

A Thesis Submitted to the
National Institute of Technology, Rourkela
In Partial Fulfillment for the Requirements
Of
BACHELOR OF TECHNOLOGY
In

CIVIL ENGINEERING
By

SANJAY BHOBHARIYA Roll No. - 109CE0545

VIKASH ANAND Roll No. - 109CE0626

Under the guidance of

Dr. Nagendra Roy

Department of Civil Engineering
NATIONAL INSTITUTE OF TECHNOLOGY
ROURKELA-769008

CERTIFICATE

This is to certify that the report entitled "A COMPARATIVE STUDY ON STRENGTH IMPROVEMENT AND CBR PROPERTIES OF NIT HOSTEL ARE SOIL BY USING CALCIUM CARBIDE RESIDUE AND FLY ASH" submitted by SANJAY BHOBHARIYA (ROLL NO:109CE0545) and VIKASH ANAND (ROLL NO:109CE0626) in partial fulfillment of the requirements for the award of BACHELOR OF TECHNOLOGY Degree in Civil Engineering at the National Institute of Technology, Rourkela is an authentic work carried out by them under my supervision and guidance.

To the best of my knowledge, the matter embodied in this report has not been submitted to any other University/ Institute for the award of any degree or diploma.

Date: 11-05-2012
Place: Rourkela

Prof. N. Roy
Professor and Head
Department of Civil Engineering
National Institute of Technology Rourkela

ACKNOWLEDGEMENT

We feel extremely happy to express our gratitude to our guide Prof. Nagendra Roy , Professor and HOD, Civil Engineering Department, National Institute of Technology, Rourkela, for his valued guidance, constant encouragement , help at every stages for the execution of laboratory work and giving us his valuable time inspite of his hectic schedule.

We would like to thank all the faculty members of Civil Engineering Department for their guidance through out our B.Tech career and helping us in learning valuable information .

We are grateful to the staff and members of the Geotechnical Engineering Laboratory for their service and cooperation with us.

Last but not the least, We would like to thanks NIT Rourkela for providing us this platform and friends for encouraging and helping through out.

Vikash Anand

Sanjay Bhobhariya

Contents **Page no.**

Abstract :

The main objective of this experimental study is to improve the properties of the soil by adding the waste material which can cause environmental pollution. Calcium Carbide Residue and Fly Ash mixture which are waste product of acetylene gas factories and steel plant respectively has been selected to add in the soil sample in different ratios. The soil properties with and without adding of waste materials (Calcium Carbide residue and Fly Ash) have been studied. An attempt has been made to use these waste material for improving the strength and CBR values of soil which will also prove environment friendly. Thus , from this experimental study will help in reduction of pollution and improvement of soil strength.

CHAPTER – 1

INTRODUCTION

From the starting of construction work, the imprtotance of enhancing soil properties has come to the light. Ancient civilizations of the Chinese, Indian, Romans and Incas utilized various methods to improve soil strength etc., and these methods were so effective that they are still used in constructing buildings and roads .

Here, in this project ,Our whole work revolve around the properties of soil and its stability . Basically for any structure , the foundation has the priority importance not strong foundation means not safe structure and the foundation depends a lot on the soil nearby . Soil with higher stability has more strong foundation and thus having very strong and durable structure . So in short we can say that the whole structure on any construction related things indirectly or directly depends on the soil stability . Thus for any construction work we need to have proper knowledge about soil and its properties and the factor affecting the soil .

After the commencement of Modern era in India after 1970's the shortage of land comes infront. We had to do construction over the weak soil , thus it became necessity to improve the strength of the soil at the construction site and then various method comes to improve the soil stability . Lots of further work is done after that in this field and addition of Calcium Carbide Residue and Fly Ash is the new way for this and it seems quite beneficial as these are the waste products of factories and can cause environmental pollution.

Calcium Carbide Residue (CCR):

It is by-product of **Acetylene gas Production Process** which is a slurry that mainly contains Calcium Hydroxide ($Ca(OH)_2$) along with SiO_2 , $CaCO_3$ and other metal oxides. In India, there are many Acetylene Gas factories and PVC Chemical Plants which produces CCR in large amount which is mainly dumped in the landfills causing environmental pollutions due to its alkalinity. CCR production is described in the following equation:

$$CaC_2 + 2H_2O \longrightarrow C_2H_2 + Ca(OH)_2$$

CHEMICAL COMPOSITION OF CCR :

CHEMICAL COMP.(%)	CaO	SiO2	Al2O3	Fe2O3	MgO	SO3	K2O	LOI
CCR	70.78	6.49	2.55	3.25	0.69	0.66	7.93	1.35

FLY ASH :

It is one of the residues formed in combustion, and consists of the fine particles that rise with the flue gases. Fly ash is captured from the chimneys of **coal-fired power plants** . It mainly consists of SiO_2 and Al_2O_3 due to which it is pozzolanic in nature. It has a large uniformity coefficient and it consists of clay sized particles .The fly ash manufacture in India is around 100 million ton per year which pollutes river water that endanger aquatic and human life.It has pH somewhere between 10 and 12, a medium to strong base. This can also cause lung damage if present in sufficient quantities.

CHEMICAL COMPOSITION OF FLYASH :

CHEMICAL COMP.(%)	CaO	SiO2	Al2O3	Fe2O3	MgO	SO3	K2O	LOI
CCR	12.15	45.69	24.69	11.26	2.87	1.57	2.66	1.30

CHAPTER 2

LITERATURE REVIEW

2.1 Previous Work done before our Project :

The mixture of CCR and FA produces a cementitious material because CCR contains a lot of $Ca(OH)_2$, while FA is a pozzolanic material which helps in increasing binder content in soil results in strengthening of soil .

Consoliet (2001) have reported the possibility of using CCR and fly ash to stabilize a nonplasticy, silty sand. The study of soil stabilization with a mixture of CCR and pozzolanic materials is an engineering, economic, and environmental challenge for geotechnical engineers and researchers.

Chai Jaturapitakkul and Boonmark Roongreung (2003) investigated that the ratio of calcium carbide residue to rice husk ash of 50:50 by weight obtains the highest compressive strength of mortar. The compressive strength of mortar could be as high as 15.6 MPa at curing age of 28 days and increased to 19.1 MPa at 180 days.

Y. J. Du , Y. Y. Zhang , and S. Y. Liu (2009) investigated Strength and California Bearing Ratio Properties of Natural Soils Treated by Calcium Carbide Residue which is used as embankment filling material in China Highway Engineering practice . From the tests, it is found that calcium carbide residue treated soils have better performance than that of lime treated soils .

Horpibulsuk (2009) studied that Fly ash disperses the soil-cement clusters into smaller clusters, thereby increasing the reactive surface for hydration and pozzolanic reactions.

Makaratat N., Jaturapitakkul C., and Laosamathikul T. (2010) studied the effects of Calcium Carbide Residue–Fly Ash Binder on Mechanical Properties of Concrete. The effects of fly ash finenesses and water to binder (*W*/*B*) ratios of CR-FA concretes on setting times, compressive strength, modulus of elasticity, and splitting tensile strength were investigated.

Suksun Horpibulsuk, Ph.D. (2012) Studied Soil Stabilization by Calcium Carbide Residue and Fly Ash and he revealed that the input of CCR reduces specific gravity and soil plasticity; thus, the maximum dry unit weight and water sensitivity.

2.2 SOIL PROPERTIES :

2.2.1 SPECIFIC GRAVITY :

Specific Gravity is defined as the ratio between the mass of any substance of a definite volume divided by mass of equal volume of water. For soils, it is the number of times the soil solids are heavier in the assessment to the equal volume of water present . It basically denotes the number of times that soil is heavier than water.

Specific gravities for different soil are not same generally , the general range in which the specific gravity of soil can be categorized are :

Sand	2.63-2.67
Silt	2.65-2.7
Clay and Silty clay	2.67-2.9
Organic soil	<2.0

Table- 1

2.2.2 Particle Size Distribution

The composition of soil is of particles of a variety of sizes and shapes, the range of particle size present in the same soil sample is from a few microns to a few centimeters. Many physical properties of the soil such as its strength, permeability, density etc are determined by the different size particles present in the soil sample.

Sieve analysis which is done for coarse drained soils only and the other method is sedimentation analysis used for fine grained soil sample are the two methods of finding Particle size distribution. Both are followed by plotting the results on a semi-log graph where ordinate is the percentage finer N and the abscissa is the particle diameter i.e. sieve size on a logarithmic scale.

We had done the sieve analysis only as we are dealing with coarse drained soil here.

Well graded or poorly graded (uniformly graded) are mainly the types of soil found. Well graded soils have particles from all the size ranges in a good amount. On the other hand, if soil has particles of some sizes in excess and deficiency of particles of other sizes it is said to be poorly or uniformly graded.

2.2.3. SHEAR STRENGTH :

Shearing stresses are prompted in a loaded soil and when these stresses reach their limiting value, deformation starts in the soil which leads to failure of the soil mass. The shear strength of a soil is its resistance to the deformation caused by the shear stresses acting on the loaded soil. The shear strength of a soil is one of the most important features. There are several experiments which are used to determine shear strength such as Direct Shear Test or Unconfined Compression Test etc.

The shear resistance offered is made up of three parts:

i) The structural resistance to the soil displacement is caused due to the soil particles getting interlocked,

ii) The frictional resistance at the contact point of various particles, and

iii) Cohesion or adhesion between the surface of the particles.

In case of cohesionless soils, the shear strength is entirely dependent upon the frictional resistance, while in others it comes from the internal friction as well as the cohesion.

Methods for measuring shear strength:

a) Direct Shear Test (DST)

This is the most common test used to determine the shear strength of the soil. In this experiment the soil is put inside a shear box closed from all sides and force is applied from one side until the soil fails. The shear stress is calculated by dividing this force with the area of the soil mass. The three conditions in which this test is performed are – undrained, drained and consolidated undrained depending upon the setup of the experiment.

b) Unconfined Compression Test (UCS test)

UCS is basically a specific case of tri axial test where the horizontal forces acting are zero. There is no confining pressure in this test and the soil sample tested is subjected to vertical loading only. The specimen used is cylindrical and is loaded there until it fails due to shear.

2.2.4 California Bearing Ratio(unsoaked) Test

CBR is the **ratio of force per unit area** required to penetrate a soil mass with standard load at the rate of 1.25 mm/min. to that required for the **subsequent penetration** of a standard material. The following table gives the standard loads used for different penetrations for the standard material with a C.B.R. value of 100% :

Penetration of plunger (mm)	Standard load (kg)
2.5	1370
5	2055
7.5	2630
10	3180
12.5	3600

Table- 2

CBR value is calculated by this formula :

$$C.B.R. = (\text{Test load}/\text{Standard load})100$$

CHAPTER-3

EXPERIMENTAL INVESTIGATIONS

3.1 Scope of work

The experiments which are conducted in laboratory :

1 . Specific gravity of soil samples

2. Grain size distribution of soil samples

3. Standard Procter Test to find out maximum dry density(MDD) and optimum moisture content (OMC) of soil samples .

4.Strength test to determine the Compressive strength of Calcium carbide residue (CCR) and Fly Ash mixed in different proportion

5. Direct shear test of soil samples and soil sample mixed with different percentage of mixture of soil sample of CCR and Fly Ash.

6. Unconfined Compressive Strength Test of soil samples and soil sample mixed with different percentage of mixture of soil sample of CCR and Fly Ash.

7. California Bearing Ratio (Unsoaked) test of soil samples and soil sample mixed with different percentage of mixture of soil sample of CCR and Fly Ash.

3.2 Materials :

- Soil Sample – 1

  Location : Behind the hall 5 , the new construction area , NIT Rourkela

- Soil Sample – 2

  Location : From the road side near Satish Dhawan Hall of Residence , NIT Rourkela

- Soil Sample – 3

  Location : Near the bridge situated behind hall 8 , NIT Rourkela

- Fly Ash

  Location : Rourkela Steel Plant , (SAIL)

- Calcium Carbide Residue

  Location : Gas Welding shop from different places in Rourkela.

3.3 Preparation of samples

At first we had find that in which proportion CCR and Fly Ash should be mixed. For this we had peformed cube test for different ratios of CCR and Fly Ash to check the compressive strength and taken the reading after 28 days. The ratio in which the compression comes out maximum will be taken and it is further mixed with the soil sample to increase its strength.The reading comes out as –

- When CCR and Fly Ash (by weight) are taken in the ratio of **60:40** then the compressive strength of the sample after 28 days of curing comes out as **23.56 MPa**

- When CCR and Fly Ash (by weight) are taken in the ratio of **70:30** then the compressive strength of the sample after 28 days of curing comes out as **27.8 MPa**

- When CCR and Fly Ash (by weight) are taken in the ratio of **80:20** then the compressive strength of the sample after 28 days of curing comes out as **26.87 Mpa**

- Hence we had selected **70:30** ratio of CCR and Fly Ash for mixing with the soil sample to improve the strength as its compressive strength come out maximum .

Following steps were carried out while mixing soil samples with different proportions of mixture of Calcium Carbide Residue and Fly Ash.

All soil sample were dried in oven for 24 hours .

Dry Calcium Carbide Residue was Sieved through 1mm sieve , then Calcium Carbide Residue and Fly Ash was hand mixed in proportion of 70:30 by weight .

The different percentage adopted in the present study for the percentage of mixture of CCR and Flyash are 0% , 10 %, 15% , 25%.

After that each soil sample was divided in four parts and each part was mixed with these different proportion and test were performed.

3.4 Brief steps involved in the experiments

3.4.1 SPECIFIC GRAVITY :

the ratio between the weight of the soil solids and weight of equal volume of water is termed as Specific Gravity. The measurement is done in a volumetric flask in a experimental setup where the volume of the soil is found out and its weight is then further divided by the weight of equal volume of water.

Specific Gravity $G = W2-W1 / (W4-W1) - (W3-W2)$

W1- Weight of bottle

W2- Weight of bottle + Dry soil

W3- Weight of bottle + Soil + Water

W4- Weight of bottle + Water

3.4.2 PARTICLE SIZE DISTRIBUTION :

The results from sieve analysis of the soil when plotted on a semi-log graph with particle diameter or the sieve size as the X-axis with logarithmic axis and the percentage passing as the Y-axis gives a clear idea about the particle size distribution. From the help of this curve, D10 and D60 are resolute. This D10 is the diameter of the soil below which 10% of the soil particles lie. The ratio of, D10 and D60 gives the uniformity coefficient (Cu) which in turn is a measure of the particle size range in the soil sample .

3.4.3 STANDARD PROCTOR TEST :

Standard proctor Test covers the determination of the relationship between the moisture content and density of soils compacted in a mould of a given size with a 2.5 kg rammer dropped from a height of 30 cm. It is a laboratory method of experimentally determining the optimal moisture content at which a given soil type will become most dense and achieve its maximum dry density. The name Proctor is given in honor of R. R. Proctor who in 1933 showed that the dry density of a soil for a compactive effort depends on the amount of water the soil contains during soil compaction. His original test is most commonly referred to as the standard Proctor compaction test; which laterly was updated to create the modified Proctor compaction test.

These laboratory tests generally consist of compacting soil at identified moisture content into a cylindrical mold of standard dimensions using a compactive effort. The soil that is usually compacted into the mold to a certain amount of equal layers, each receiving a number blows from a standard weighted hammer at a standad height. This process is then repeated for different values of moisture contents and the dry densities are determined for each case. The graphical relationship of the dry density to moisture content is then plotted considering the values found to establish the compaction curve. The maximum dry density is finally obtained from the peak point of the compaction curve and its corresponding moisture content, which is known as the optimal moisture content.

$$\text{Wet density} = \frac{\text{weight of wet soil in mould gms}}{\text{volume of mould cc}}$$

$$\text{Moisture content \%} = \frac{\text{weight of water gms}}{\text{weight of dry soil gms}} * 100$$

$$\text{Dry density } \gamma_d \text{ (gm/cc)} = \frac{\text{wet density}}{1+\frac{\text{moisture content}}{100}}$$

3.4.4 DIRECT SHEAR TEST

It is mainly used to determine the shear strength of the soil. In many engineering such as design of foundation, retaining walls , slab bridges, etc the value of internal friction and cohesion of the soil involved are required for the design . These parameter are quickly and easily determined using this test. The test is performed on three or four specimens from a relatively undisturbed soil sample.A specimen is placed in a *shear box* which has two stacked rings to hold the sample; the contact between the two rings is at approximately the mid-height of the sample. A *confining stress* is applied vertically to the specimen, and the upper ring is pulled laterally until the sample fails, or through a specified strain . The load applied and the strain induced is recorded at frequent intervals to determine a stress-strain curve for each confining stress. Several specimens are tested at varying confining stresses to determine the shear strength parameters, the soil cohesion (c) and the angle of internal friction (commonly *friction angle*) (ϕ). The results of the tests on each specimen are plotted on a graph with the peak (or residual) stress on the x-axis and the confining stress on the y-axis. The y-intercept of the curve which fits the test results is the cohesion, and the slope of the line or curve is the friction angle.

Direct shear tests can be performed under several conditions. The sample is normally saturated before the test is run, but can be run at the in-situ moisture content. The rate of strain can be varied to create a test of *undrained* or *drained* conditions, depending whether the strain is applied slowly enough for water in the sample to prevent pore-water pressure build up.

The advantages of the direct shear test over other shear tests are the simplicity of setup and equipment used, and the ability to test under differing saturation, drainage, and consolidation conditions. The relation between C and φ are establish as

$$\tau = c + \sigma * \tan(\varphi)$$

3.4.5 UNCONFINED COMPRESSION TEST :

The objective of the unconfined compression test is to determine the UU (unconsolidated, undrained) strength of a cohesive soil in an inexpensive manner. The unconfined compressive strength (qu) is the compressive stress at which the unconfined cylindrical soil sample fails under simple compressive test. The experimental setup constitutes of the compression device and dial gauges for load and deformation. The load was taken for different readings of strain dial gauge starting from $\varepsilon = 0.005$ and increasing by 0.005 at each step. The corrected cross-sectional area was calculated by dividing the area by $(1- \varepsilon)$ and then the compressive stress for each step was calculated by dividing the load with the corrected area .

It is not always possible to conduct the bearing capacity test in the field. Sometimes it is cheaper to take the undisturbed soil sample and test its strength in the laboratory. Also to choose the best material for the embankment, one has to conduct strength tests on the samples selected. Under these conditions it is easy to perform the unconfined compression test on undisturbed and remoulded soil sample. Now we will investigate experimentally the strength of a given soil sample.

The shear strength is defined as half the compressive strength.

3.4.5 California Bearing ratio Test (Unsoaked)

The CBR test is carried out on a compacted soil (by 30 blows) in a CBR mould 150 mm in diameter and 175 mm in height, provided with detachable collar of 50 mm and a detachable perforated base plate. A displacer disc, 50 mm deep inside the mould during the specimen preparation by which specimen of 125 mm deep is obtained. The moulding dry density and water content should be remained same as would be maintained during field compaction. Generally, CBR values of both soaked as well as unsoaked samples are determined but we have determined only unsoaked values. Each surcharge slotted weight, 147 mm in diameter with a central whole 53 mm in diameter and weighing 2.5 kg is considered approximately equivalent to 6.5 cm of construction. A minimum of two surcharge weights (i.e. 5kg surcharge load) isused which are placed on the specimen. Load is applied so that the penetration is approximately 1.25mm/min. The load readings are recorded at diffrent penetrations, 0, 0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, 5.5, 6, 6.5, 7, 8, 9, 10, 11, 12, and 12.5mm. The maximum load and penetration is recorded if it occurs for a penetration of less than 12.5 mm.

CHAPTER- 4

RESULTS & DISCUSSIONS

4.1 SPECIFIC GRAVITY :

Sample 1

sample number	1	2	3
mass of empty bottle (M1) in gms.	116.53	121.53	122.73
mass of bottle+ dry soil (M2) in gms.	166.53	171.53	172.73
mass of bottle + dry soil + water (M3) in gms.	394.74	398.48	399.84
mass of bottle + water (M4) in gms.	363.51	366.37	367.38
specific gravity	2.66	2.79	2.85
Avg. specific gravity	2.77		

Table- 3

Sample 2

sample number	1	2	3
mass of empty bottle (M1) in gms.	114.63	112.53	116.53
mass of bottle+ dry soil (M2) in gms.	164.63	162.53	166.53
mass of bottle + dry soil + water (M3) in gms.	383.42	379.62	385.93
mass of bottle + water (M4) in gms.	352.51	348.19	354.72
specific gravity	2.62	2.69	2.66
Avg. specific gravity	2.66		

Table- 4

Sample 3

sample number	1	2	3
mass of empty bottle (M1) in gms.	117.64	113.95	123.59
mass of bottle+ dry soil (M2) in gms.	167.64	163.95	173.59
mass of bottle + dry soil + water (M3) in gms.	388.36	380.68	392.94
mass of bottle + water (M4) in gms.	356.73	348.85	361.48
specific gravity	2.72	2.75	2.70
Avg. specific gravity	2.72		

Table- 5

4.2 PARTICLE SIZE DISTRIBUTION :

SAMPLE 1

Sieve size	Retained (g)	Retained (%)	Cumulative retained (%)	Cumulative finer (%)
20	0	0	0	100
10	72.64	7.264	7.264	92.736
6.25	154.83	15.483	22.747	77.253
4.75	114.93	11.493	34.24	65.76
2	473.94	47.394	81.634	18.366
1	52.63	5.263	86.897	13.103
0.425	41.56	4.156	91.053	8.947
0.15	12.29	1.229	92.282	7.718
0.075	9.8	0.98	93.262	6.738
<0.075	67.38	6.738	100	0

Table- 6

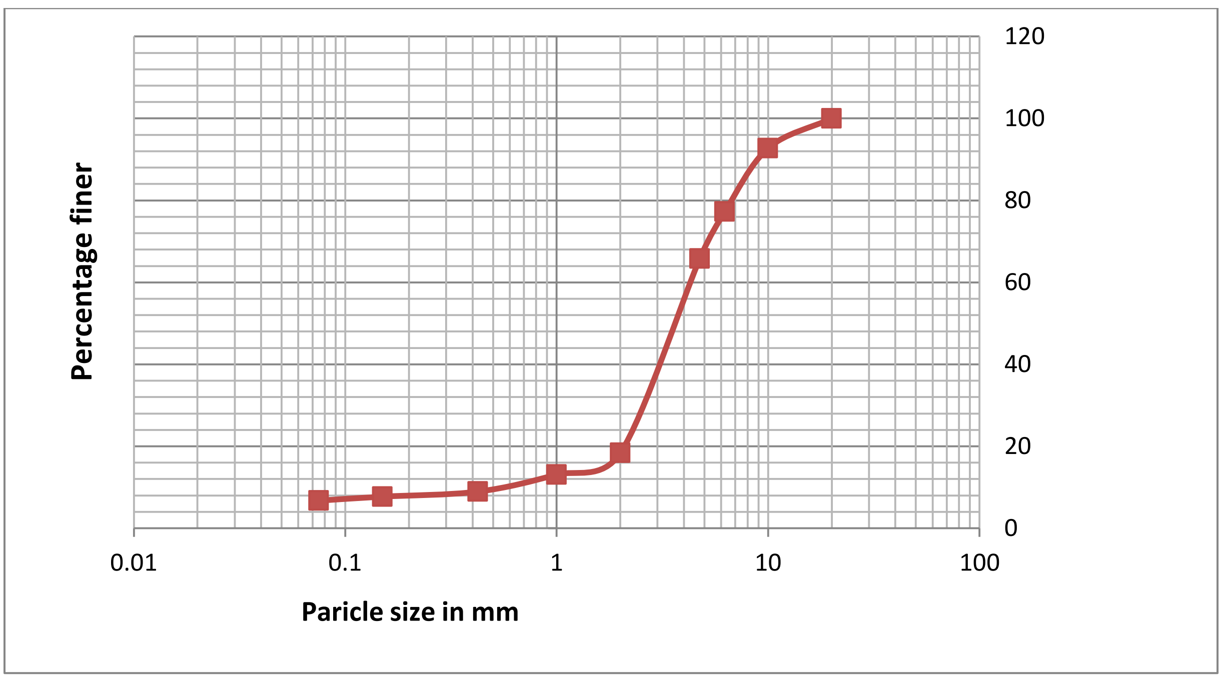


Fig-1

Sample 2

Sieve size	Retained (g)	Retained (%)	Cumulative retained (%)	Cumulative finer (%)
20	0	0	0	100
10	110.69	11.069	11.069	88.931
6.25	137.84	13.784	24.853	75.147
4.75	154.69	15.469	40.322	59.678
2	421.97	42.197	82.519	17.481
1	49.31	4.931	87.45	12.55
0.425	41.56	4.156	91.606	8.394
0.15	15.58	1.558	93.164	6.836
0.075	6.84	0.684	93.848	6.152
<0.075	61.52	6.152	100	0

Table- 7

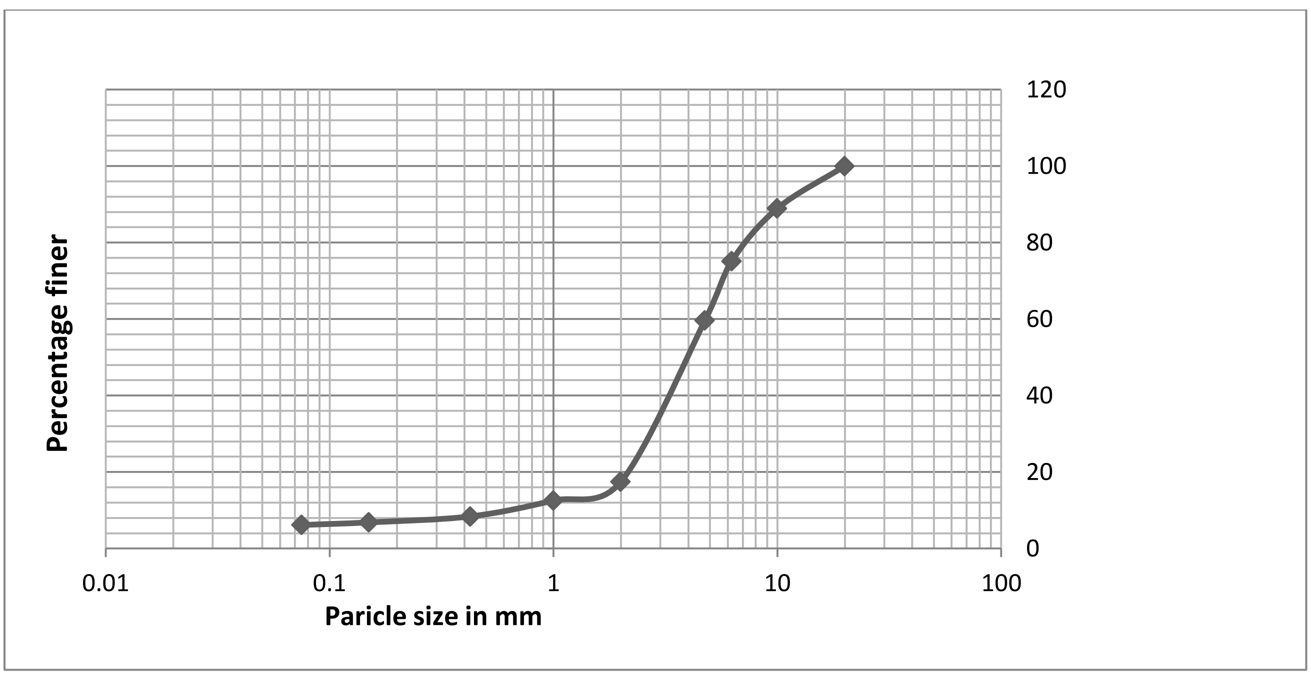


Fig-2

SAMPLE 3

Sieve size	Retained (g)	Retained (%)	Cumulative retained (%)	Cumulative finer (%)
20	23.53	2.353	2.353	97.647
10	96.52	9.652	12.005	87.995
6.25	167.83	16.783	28.788	71.212
4.75	138.97	13.897	42.685	57.315
2	385.83	38.583	81.268	18.732
1	39.74	3.974	85.242	14.758
0.425	45.83	4.583	89.825	10.175
0.15	23.62	2.362	92.187	7.813
0.075	11.46	1.146	93.333	6.667
<0.075	66.67	6.667	100	0

Table- 8

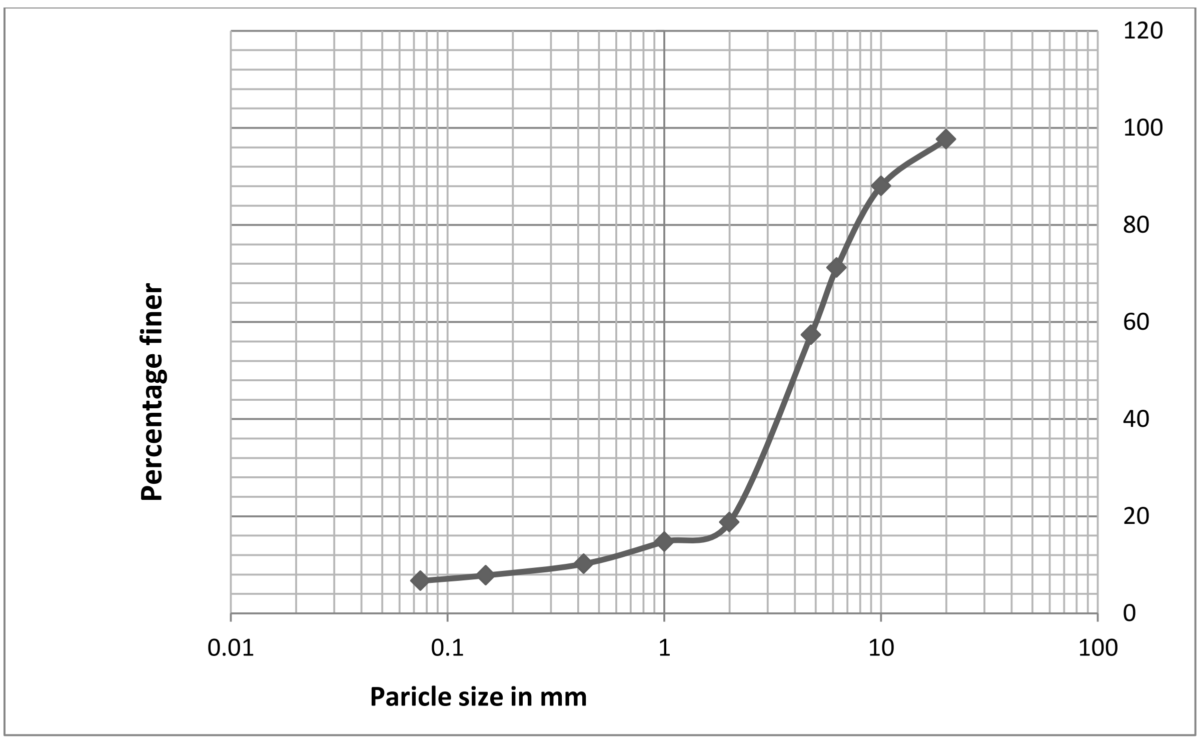


Fig-3

4.3 Standard Proctor Test :

SAMPLE 1

Test No.	1	2	3	4	5
Weight of empty mould(Wm) gms	1892	1892	1892	1892	1892
Internal diameter of mould (d) cm	10	10	10	10	10
Height of mould (h) cm	13	13	13	13	13
Volume of mould (V)=(π/4) d2h cc	1000	1000	1000	1000	1000
Weight of Base plate (Wb) gms	1900	1900	1900	1900	1900
Weight of empty mould + base plate (W') gms	3782	3782	3782	3782	3782
Weight of mould + compacted soil + Base plate (W1) gms	5818	5952	6126	6119	6110
Weight of Compacted Soil (W1-W') gms = Ww gms	2036	2170	2344	2337	2328
Container no.	20.02	20.25	20.4	20.32	23.2
Weight of Container (X1) gms	20.02	20.25	20.4	20.32	22.6
Weight of Container + Wet Soil (X2) gms	124.2	120.4	131.6	110.6	140.8
Weight of Container + dry soil (X3) gms	116.57	110.69	118.93	99.37	123.43
Weight of dry soil (X3-X1) gms	96.55	90.44	98.53	79.05	100.83
Weight of water (X2-X3) gms	7.63	9.71	12.67	11.23	17.37
Water content W%= X2-X3/X3-1	7.90	10.74	12.86	14.21	17.23
Wet density Vt = Ww/V gm/cc	2.04	2.17	2.34	2.34	2.33
Dry density ϒd= Vt/1 + (W/100) gm/cc	1.89	1.96	2.08	2.05	1.99

Table- 9

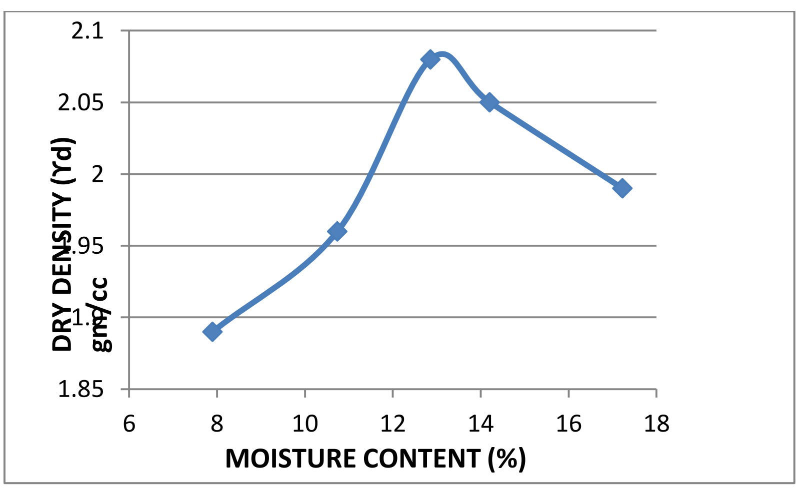


Fig-4

OMC = 13.2 % AND MDD = 2.08 gm/cc

SAMPLE 2

Test No.	1	2	3	4	5
Weight of empty mould(Wm) gms	1892	1892	1892	1892	1892
Internal diameter of mould (d) cm	10	10	10	10	10
Height of mould (h) cm	13	13	13	13	13
Volume of mould (V)=(π/4) d2h cc	1000	1000	1000	1000	1000
Weight of Base plate (Wb) gms	1900	1900	1900	1900	1900
Weight of empty mould + base plate (W') gms	3782	3782	3782	3782	3782
Weight of mould + compacted soil + Base plate (W1) gms	5478	5652	5850	5820	5796
Weight of Compacted Soil (W1-W') gms = Ww gms	1696	1870	2068	2038	2014
Container no.	18.54	20.4	20.32	22.6	21.8
Weight of Container (X1) gms	18.54	20.4	20.32	22.6	21.8
Weight of Container + Wet Soil (X2) gms	109.52	153.63	147.47	137.53	143.81
Weight of Container + dry soil (X3) gms	101.85	139.74	132.74	121.93	124.73
Weight of dry soil (X3-X1) gms	83.31	119.34	112.42	99.33	102.93
Weight of water (X2-X3) gms	7.67	13.89	14.73	15.6	19.08
Water content W%= X2-X3/X3-1	9.21	11.64	13.10	15.71	18.54
Wet density Vt = Ww/V gm/cc	1.70	1.87	2.07	2.04	2.01
Dry density ϒd= Vt/1 + (W/100) gm/cc	1.55	1.68	1.83	1.76	1.70

Table- 10

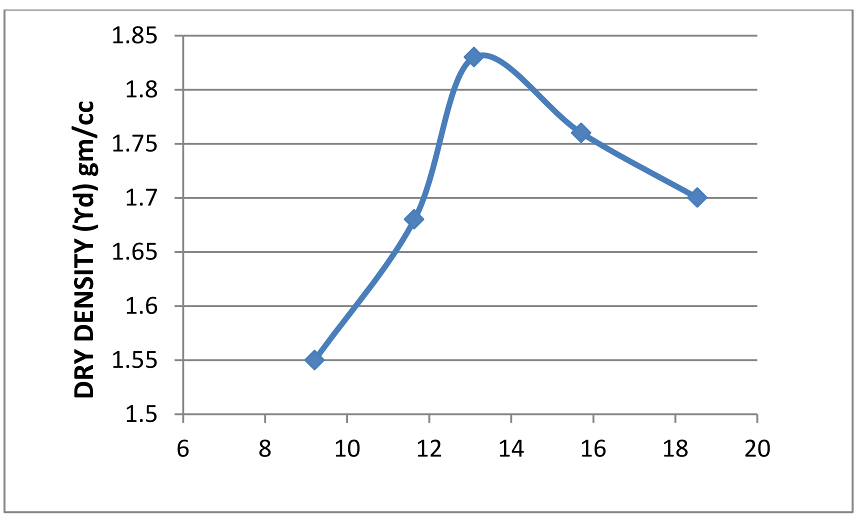


Fig-5

OMC = 13.4 % and MDD = 1.8425 gm/cc

SAMPLE 3

Test No.	1	2	3	4	5
Weight of empty mould(Wm) gms	1892	1892	1892	1892	1892
Internal diameter of mould (d) cm	10	10	10	10	10
Height of mould (h) cm	13	13	13	13	13
Volume of mould (V)=(π/4) d2h cc	1000	1000	1000	1000	1000
Weight of Base plate (Wb) gms	1900	1900	1900	1900	1900
Weight of empty mould + base plate (W') gms	3782	3782	3782	3782	3782
Weight of mould + compacted soil + Base plate (W1) gms	5749	5897	6016	6074	6025
Weight of Compacted Soil (W1-W') gms = Ww gms	1967	2115	2234	2292	2243
Container no.	22.4	18.6	24.2	19.4	21.8
Weight of Container (X1) gms	22.4	18.6	24.2	19.4	21.8
Weight of Container + Wet Soil (X2) gms	124.93	139.68	169.37	133.94	156.49
Weight of Container + dry soil (X3) gms	115.67	126.59	150.48	117.82	133.38
Weight of dry soil (X3-X1) gms	93.27	107.99	126.28	98.42	111.58
Weight of water (X2-X3) gms	9.26	13.09	18.89	16.12	23.11
Water content W%= X2-X3/X3-1	9.93	12.12	14.96	16.38	20.71
Wet density Vt = Ww/V gm/cc	1.97	2.12	2.23	2.29	2.24
Dry density ϒd= Vt/1 + (W/100) gm/cc	1.79	1.89	1.94	1.97	1.86

Table- 11

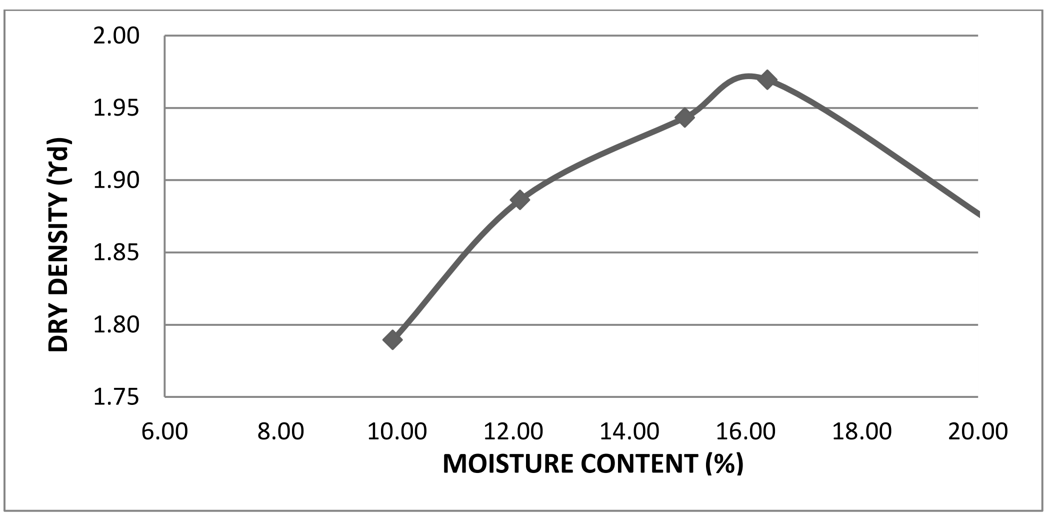


Fig-6

MDD = 1.97 AND OMC =16 %

4.4 DIRECT SHEAR TEST

Sample 1 :-

Volume of shear Box	6 x 6 x 2.5 cm3 = 90 cm3
shear area of box	6 x 6 cm2 = 36 cm2
Maximum dry density of soil in gm/cc	2.08
Optimum moisture content of soil	13.20%
Weight of the soil to be filled in the shear box in gms	187.2
Weight of water to be added in gms	24.71

Table- 12

Without adding CCR and FA :-

Sample No.	Normal Stress(kg/cm2)	Proving ring reading	Shear Load (N)	Shear Load (kg)	Shear Stress (kg/cm2)
1	0.5	57	218.03	22.22	0.62
2	1	94	359.55	36.65	1.02
3	1.5	113	432.23	44.06	1.22
4	2	153	585.23	59.66	1.66

Table- 13

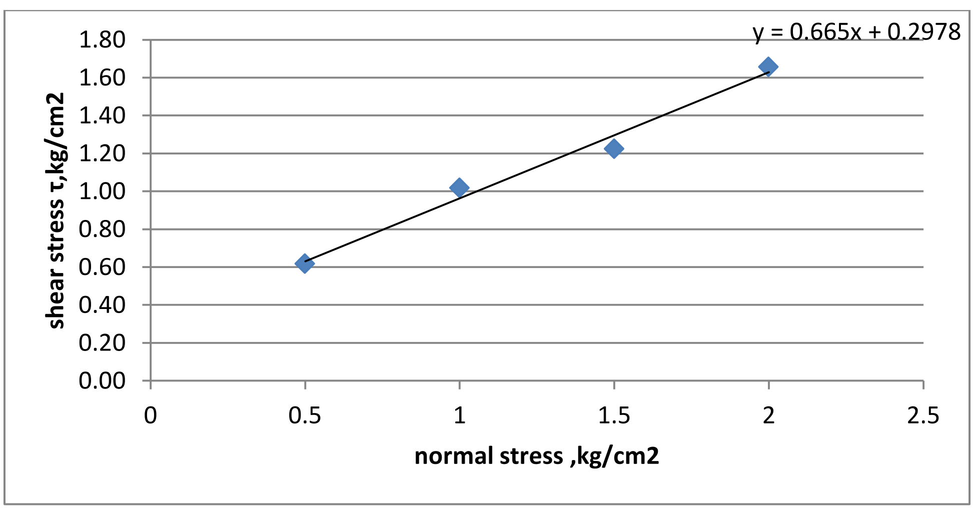


Fig-7

Cohesion = .2978 kg/cm2

Phi = 33.623 degree

After adding 10% CCR and FA mixture :

Sample No.	Normal Stress(kg/cm2)	Proving ring reading	Shear Load (N)	Shear Load (kg)	Shear Stress (kg/cm2)
1	0.5	67	256.28	26.12	0.73
2	1	103	393.98	40.16	1.12
3	1.5	123	470.48	47.96	1.33
4	2	164	627.30	63.94	1.78

Table- 14

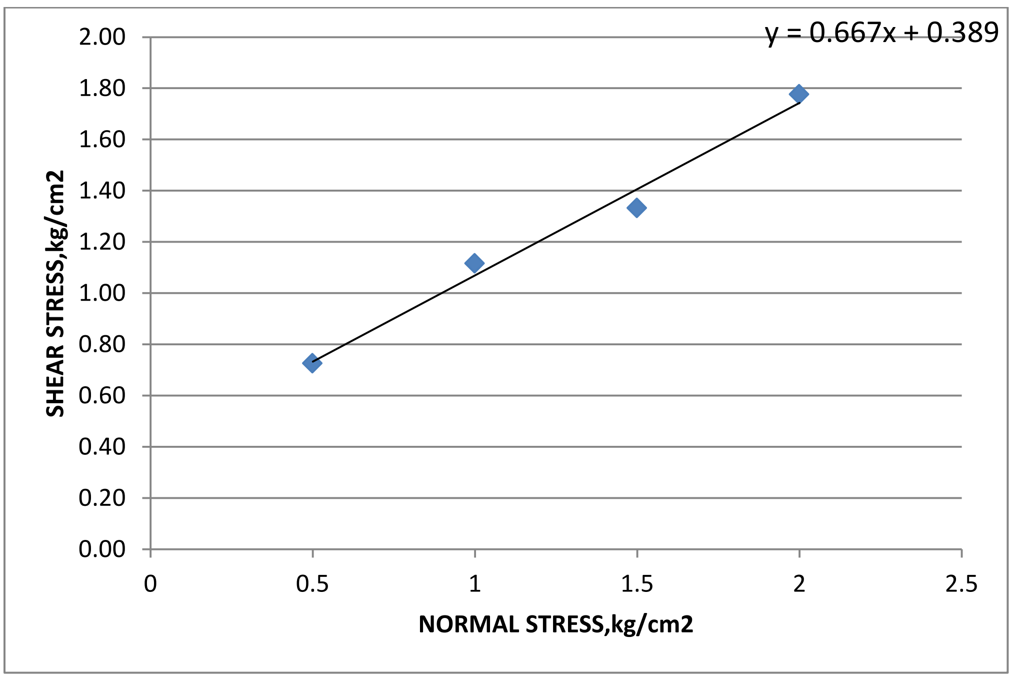


Fig-8

Cohesion = .389 kg/cm2

Phi = 33.73 degree

After adding 15% CCR and FA mixture

Sample No.	Normal Stress(kg/cm2)	Proving ring reading	Shear Load (N)	Shear Load (kg)	Shear Stress (kg/cm2)
1	0.5	74	283.05	28.85	0.80
2	1	113	432.23	44.06	1.22
3	1.5	128	489.60	49.91	1.39
4	2	176	673.20	68.62	1.91

Table- 15

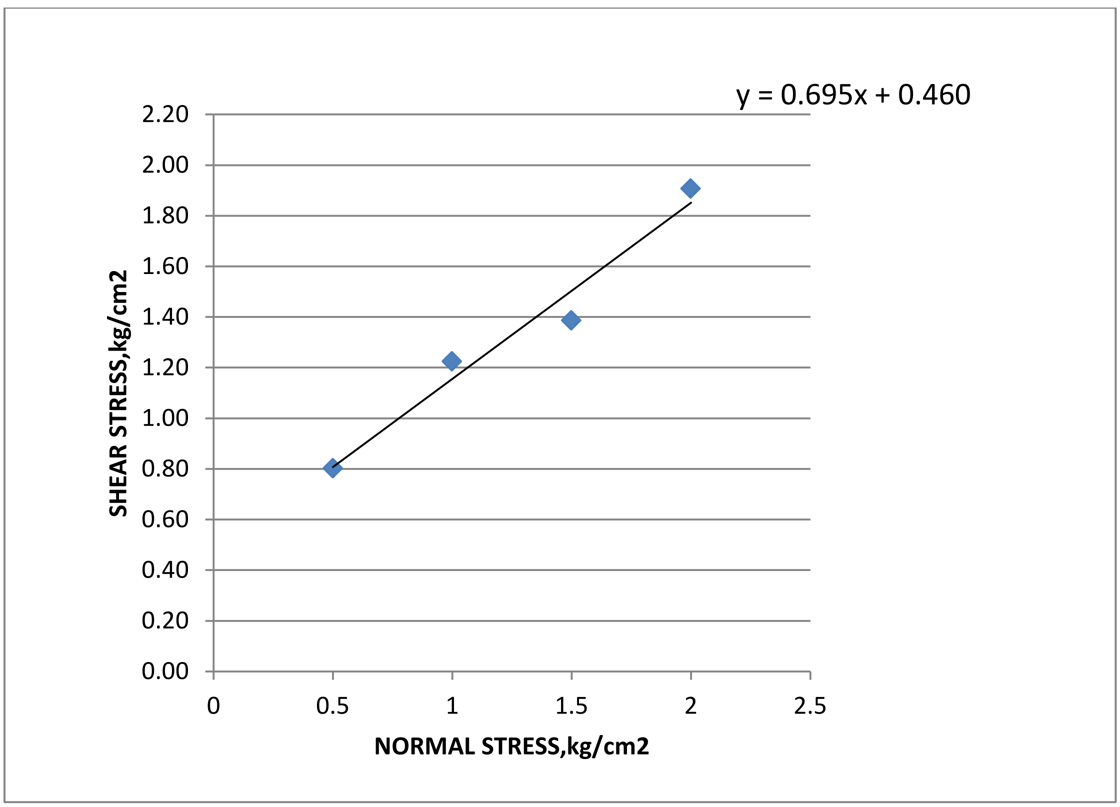


Fig-9

Cohesion = .460 kg/cm2

Phi = 34.799 degree

After adding 20% CCR and FA mixture

Sample No.	Normal Stress(kg/cm2)	Proving ring reading	Shear Load (N)	Shear Load (kg)	Shear Stress (kg/cm2)
1	0.5	82	313.65	31.97	0.89
2	1	119	455.18	46.40	1.29
3	1.5	134	512.55	52.25	1.45
4	2	186	711.45	72.52	2.01

Table- 16

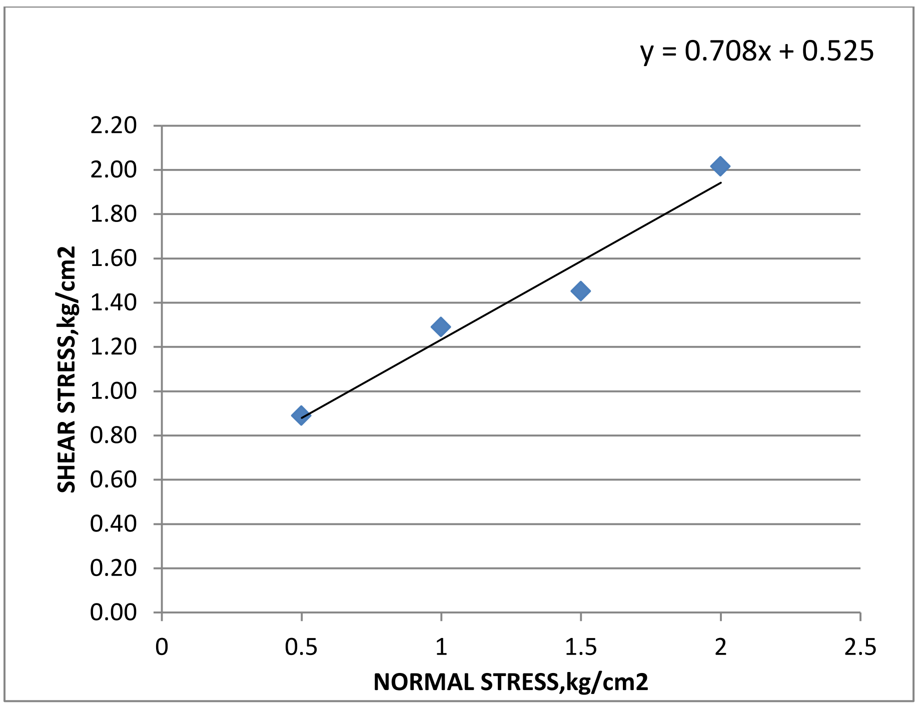


Fig-10

Cohesion = .525 kg/cm2

Phi = 35.29 degree

SAMPLE 2 :

Without Adding CCR and FA :

Volume of shear Box	6 x 6 x 2.5 cm3 = 90 cm3
shear area of box	6 x 6 cm2 = 36 cm2
Maximum dry density of soil in gm/cc	1.8425
Optimum moisture content of soil	13.40%
Weight of the soil to be filled in the shear box in gms	165.825
Weight of water to be added in gms	22.22

Table- 17

Sample No.	Normal Stress(kg/cm2)	Proving ring reading	Shear Load (N)	Shear Load (kg)	Shear Stress (kg/cm2)
1	0.5	53	202.73	20.67	0.57
2	1	84	321.30	32.75	0.91
3	1.5	109	416.93	42.50	1.18
4	2	146	558.45	56.93	1.58

Table- 18

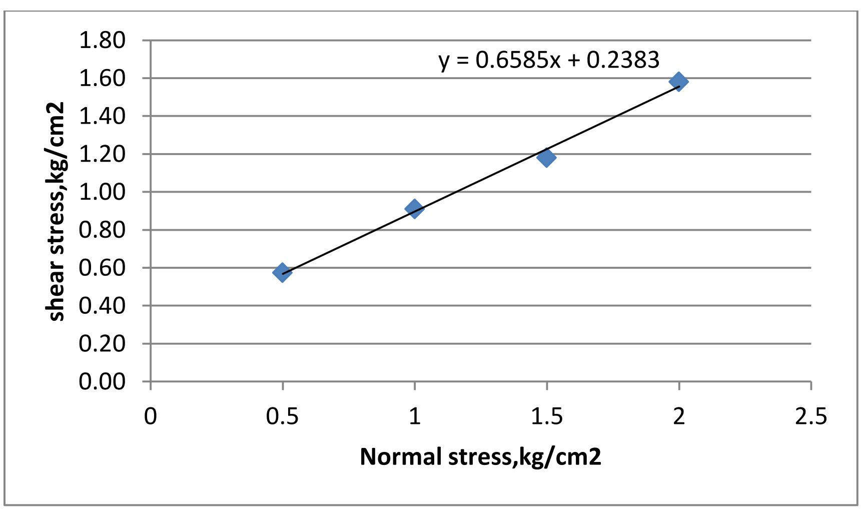


Fig-11

Cohesion = .2383 kg/cm2

Phi = 33.364 degree

After adding 10% CCR and FA mixture

Sample No.	Normal Stress(kg/cm2)	Proving ring reading	Shear Load (N)	Shear Load (kg)	Shear Stress (kg/cm2)
1	0.5	66	252.45	25.73	0.71
2	1	91	348.08	35.48	0.99
3	1.5	116	443.70	45.23	1.26
4	2	163	623.48	63.56	1.77

Table- 19

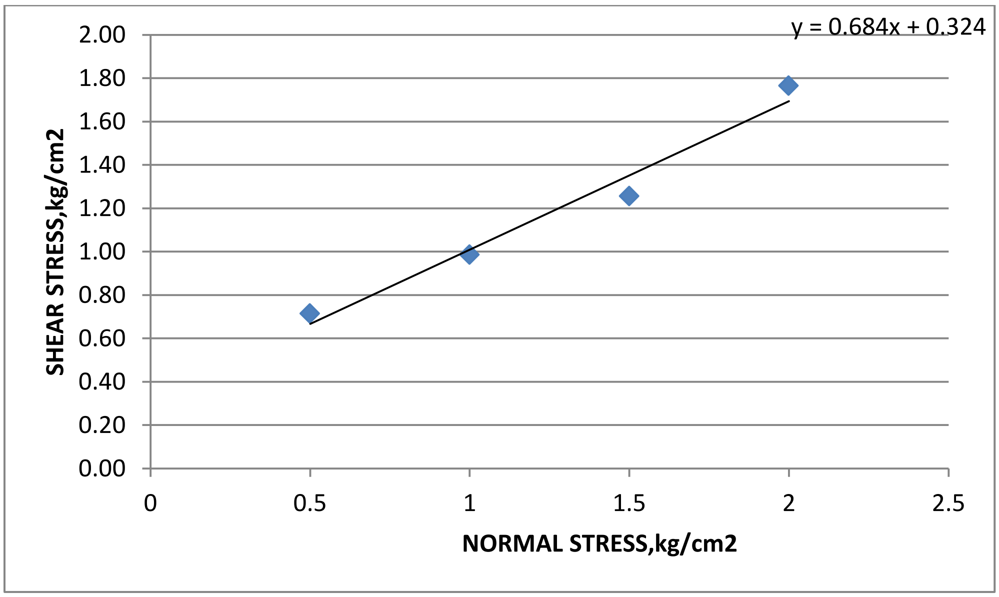


Fig-12

Cohesion = .324 kg/cm2

Phi = 34.37 degree

After adding 15% CCR and FA mixture

Sample No.	Normal Stress(kg/cm2)	Proving ring reading	Shear Load (N)	Shear Load (kg)	Shear Stress (kg/cm2)
1	0.5	73	279.23	28.46	0.79
2	1	98	374.85	38.21	1.06
3	1.5	127	485.78	49.52	1.38
4	2	172	657.90	67.06	1.86

Table- 20

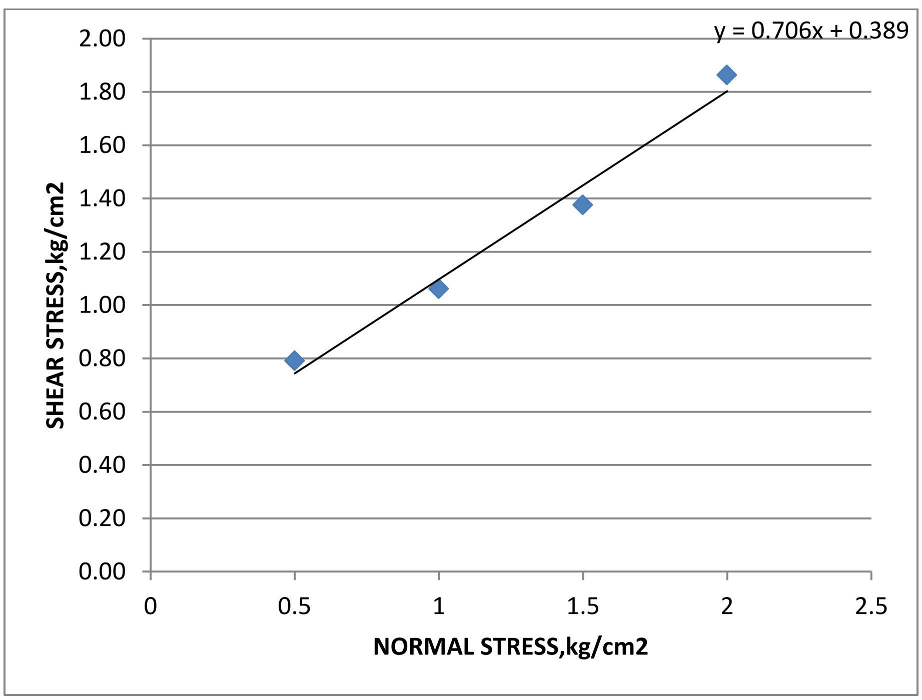


Fig-13

Cohesion = .389 kg/cm2

Phi = 35.22 degree

After adding 20% CCR and FA mixture

Sample No.	Normal Stress(kg/cm2)	Proving ring reading	Shear Load (N)	Shear Load (kg)	Shear Stress (kg/cm2)
1	0.5	82	313.65	31.97	0.89
2	1	112	428.40	43.67	1.21
3	1.5	135	516.38	52.64	1.46
4	2	178	680.85	69.40	1.93

Table- 21

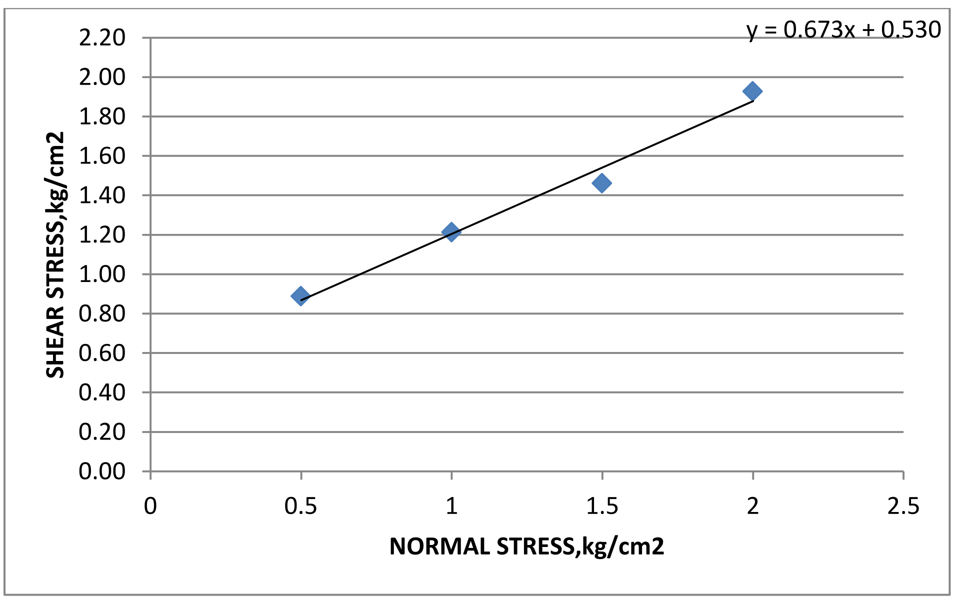


Fig-14

Cohesion = .530 kg/cm2

Phi = 35.94 degree

SAMPLE 3 :

Without Adding CCR and FA :-

Volume of shear Box	6 x 6 x 2.5 cm3 = 90 cm3
shear area of box	6 x 6 cm2 = 36 cm2
Maximum dry density of soil in gm/cc	1.8425
Optimum moisture content of soil	13.40%
Weight of the soil to be filled in the shear box in gms	165.825
Weight of water to be added in gms	22.22

Table- 22

Sample No.	Normal Stress(kg/cm2)	Proving ring reading	Shear Load (N)	Shear Load (kg)	Shear Stress (kg/cm2)
1	0.5	59	225.68	23.00	0.64
2	1	97	371.03	37.82	1.05
3	1.5	124	474.30	48.35	1.34
4	2	159	608.18	62.00	1.72

Table- 23

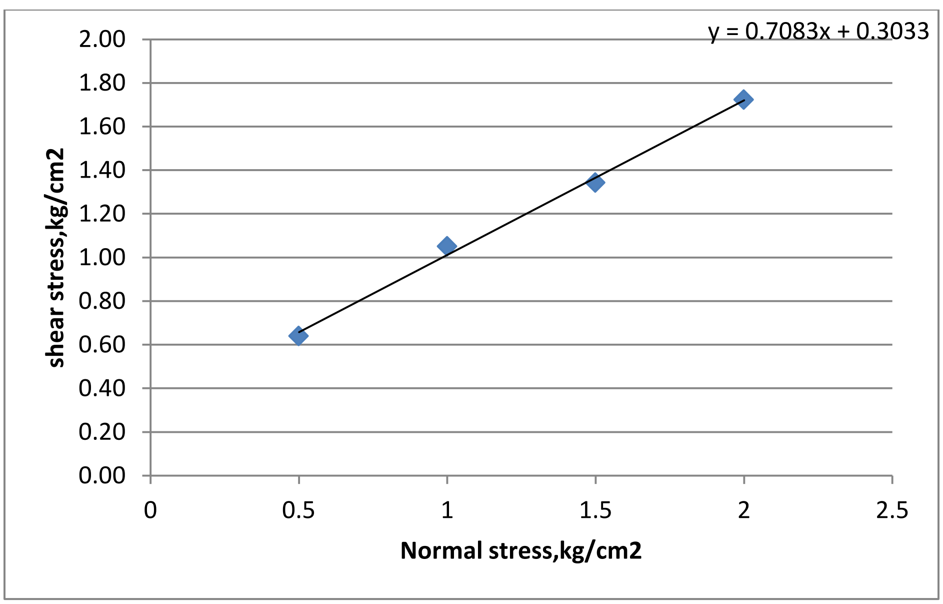


Fig-15

Cohesion = .3033 kg/cm2

Phi = 35.310 degree

After adding 10% CCR and FA mixture

Sample No.	Normal Stress(kg/cm2)	Proving ring reading	Shear Load (N)	Shear Load (kg)	Shear Stress (kg/cm2)
1	0.5	69	263.93	26.90	0.75
2	1	109	416.93	42.50	1.18
3	1.5	134	512.55	52.25	1.45
4	2	171	654.08	66.67	1.85

Table- 24

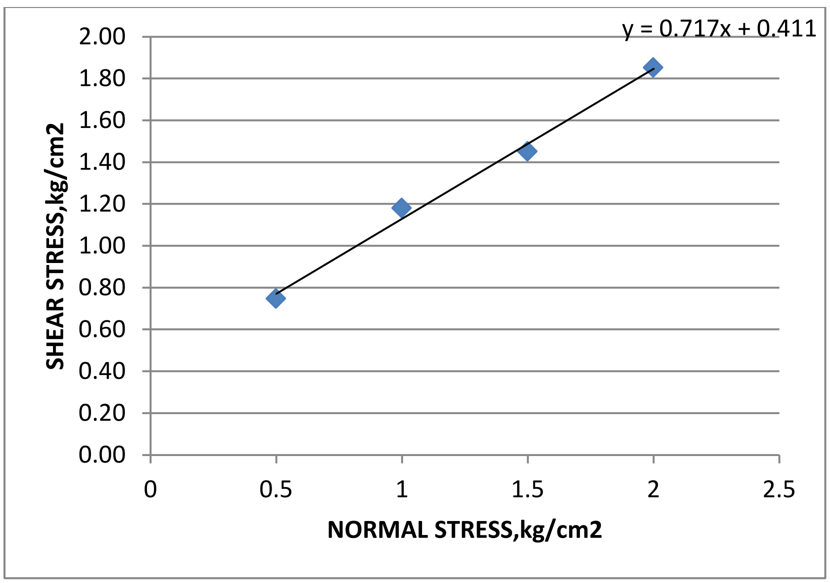


Fig-16

cohesion = 0.411 kg/cm2
phi = 35.64 degree

After adding 15% CCR and FA mixture

Sample No.	Normal Stress(kg/cm2)	Proving ring reading	Shear Load (N)	Shear Load (kg)	Shear Stress (kg/cm2)
1	0.5	78	298.35	30.41	0.84
2	1	118	451.35	46.01	1.28
3	1.5	147	562.28	57.32	1.59
4	2	184	703.80	71.74	1.99

Table- 25

Fig-17

cohesion = 0.487 kg/cm2
phi = 36.9 degree

After adding 20% CCR and FA mixture

Sample No.	Normal Stress(kg/cm2)	Proving ring reading	Shear Load (N)	Shear Load (kg)	Shear Stress (kg/cm2)
1	0.5	84	321.30	32.75	0.91
2	1	126	481.95	49.13	1.36
3	1.5	153	585.23	59.66	1.66
4	2	189	722.93	73.69	2.05

Table- 26

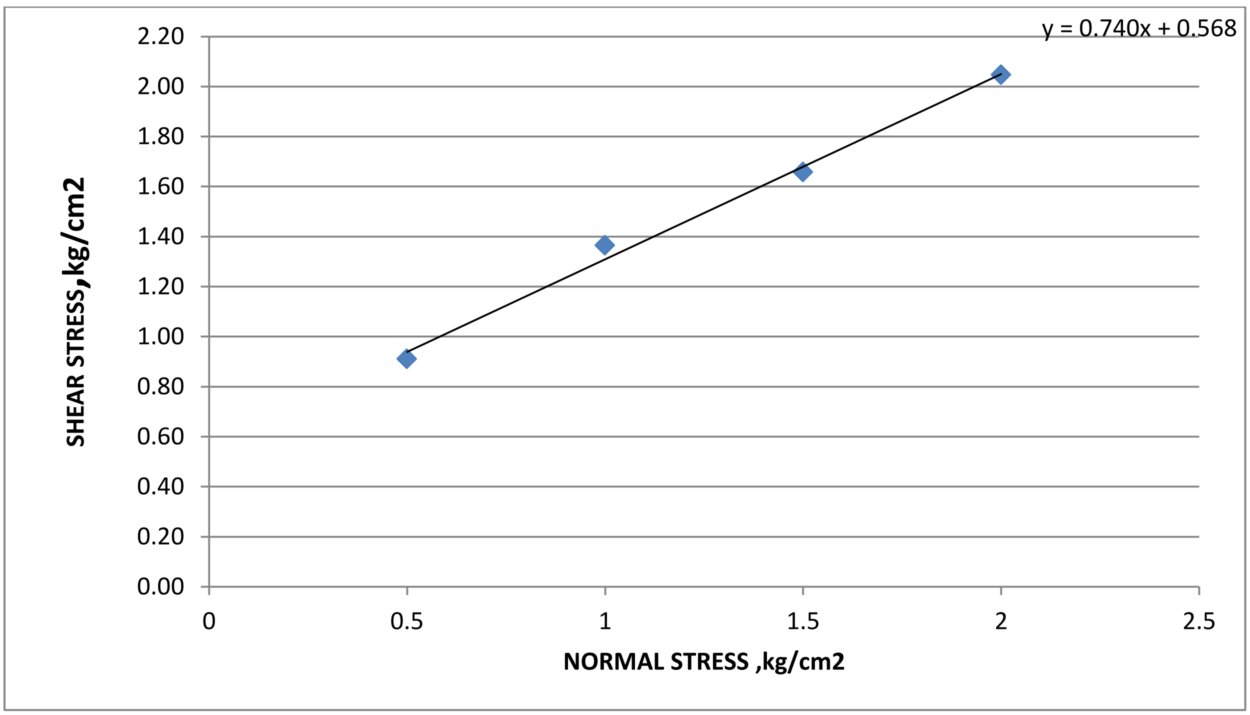


Fig-18

cohesion = 0.568 kg/cm2
phi = 36.9601 degree

4.5 UCS test

Sample 1

Without Adding CCR and FA :-

Dial gauge reading	Strain(ϵ)	Proving ring reading	corrected area	load (N)	Axial Stress (Mpa)
0	0	0	19.625	0	0
50	0.005	37	19.72	61.42	0.03114
100	0.01	71	19.82	117.86	0.05946
150	0.015	83	19.92	137.78	0.06915
200	0.02	94	20.03	156.04	0.07792
250	0.025	104	20.13	172.64	0.08577
300	0.03	97	20.23	161.02	0.07959
350	0.035	89	20.34	147.74	0.07265

Table- 27

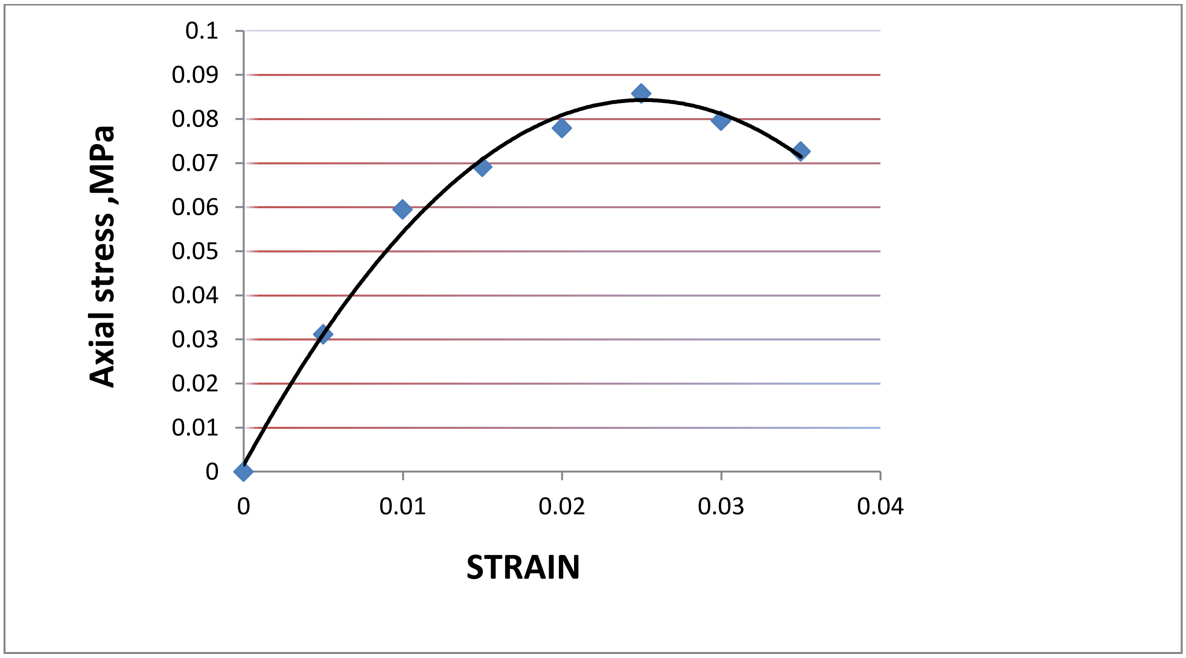


Fig-19

UCS = 0.08577 MPa

After adding 10% CCR and FA mixture

Dial gauge reading	Strain(ϵ)	Proving ring reading	corrected area	load (N)	Axial Stress (Mpa)
0	0	0	19.625	0	0
50	0.005	45	19.72	74.7	0.03787
100	0.01	81	19.82	134.46	0.06783
150	0.015	92	19.92	152.72	0.07665
200	0.02	104	20.03	172.64	0.08621
250	0.025	112	20.13	185.92	0.09237
300	0.03	103	20.23	170.98	0.08451
350	0.035	93	20.34	154.38	0.07591

Table- 28

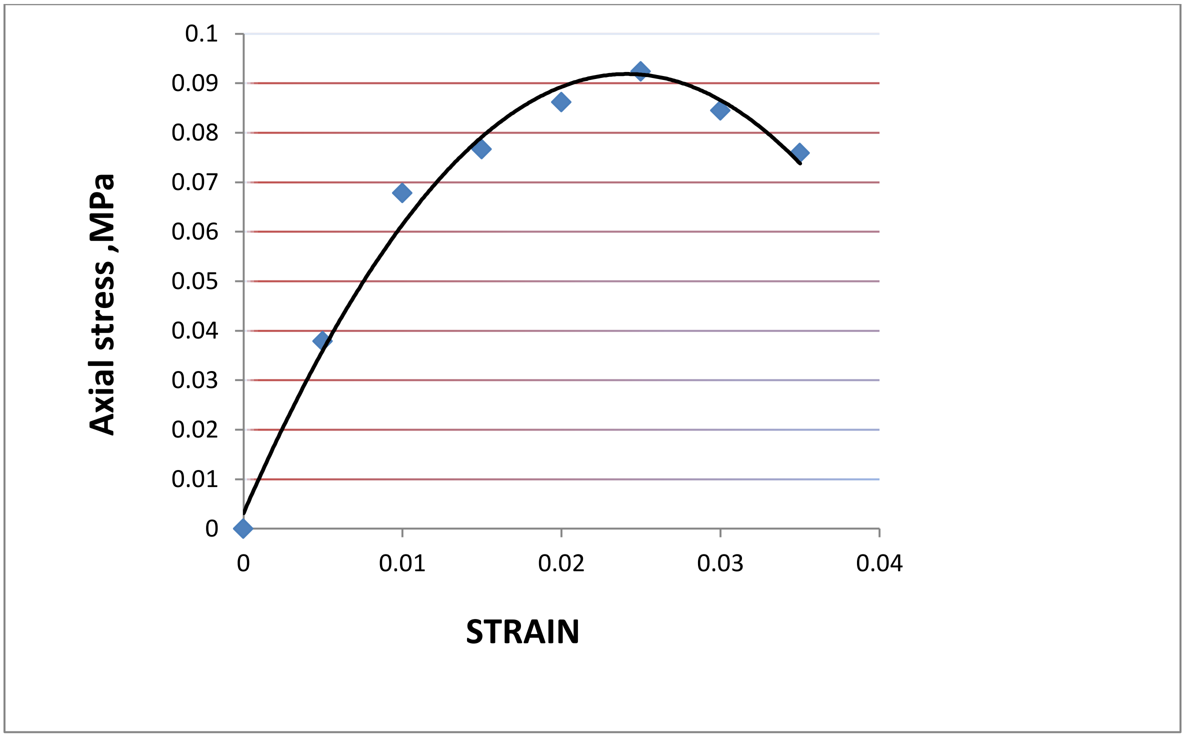


Fig-20

UCS = 0.09237 MPa

After adding 15% CCR and FA mixture

Dial gauge reading	Strain(ϵ)	Proving ring reading	corrected area	load (N)	Axial Stress (Mpa)
0	0	0	19.625	0	0
50	0.005	48	19.72	79.68	0.04040
100	0.01	84	19.82	139.44	0.07034
150	0.015	96	19.92	159.36	0.07998
200	0.02	109	20.03	180.94	0.09035
250	0.025	115	20.13	190.9	0.09484
300	0.03	107	20.23	177.62	0.08779
350	0.035	96	20.34	159.36	0.07836

Table- 29

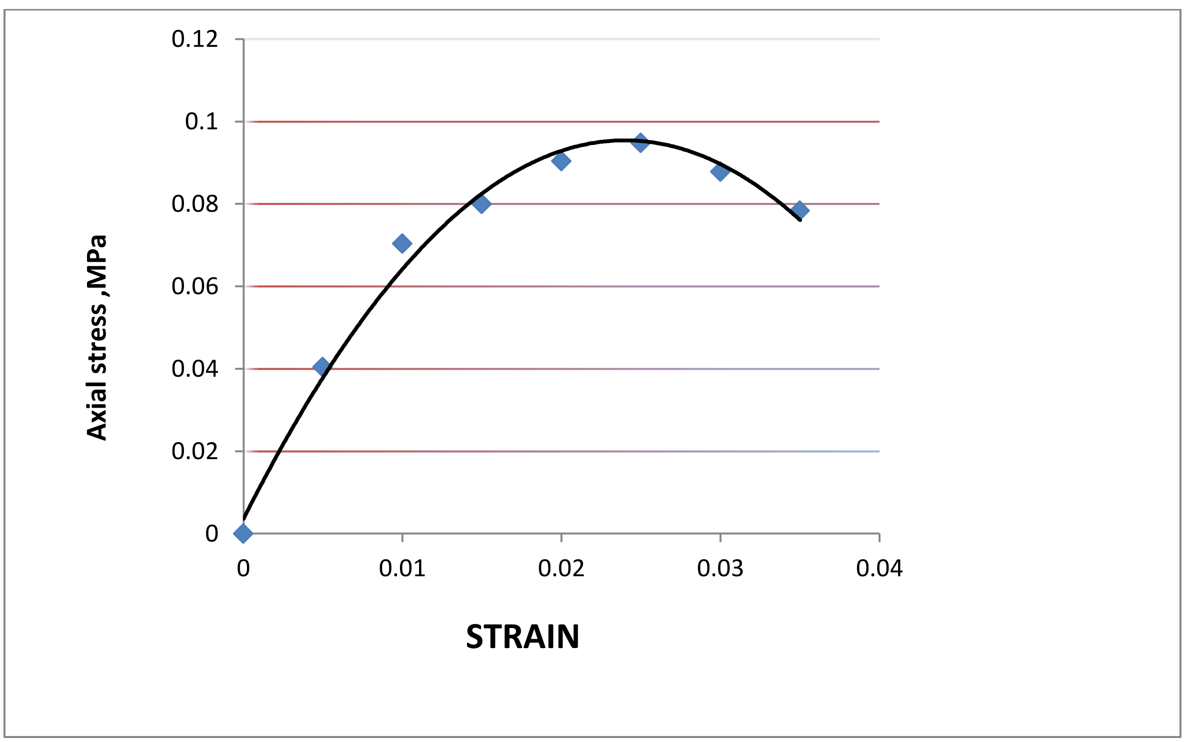


Fig-21

UCS = 0.09484 MPa

After adding 20% CCR and FA mixture

Dial gauge reading	Strain(ϵ)	Proving ring reading	corrected area	load (N)	Axial Stress (Mpa)
0	0	0	19.625	0	0
50	0.005	53	19.72	87.98	0.04461
100	0.01	89	19.82	147.74	0.07453
150	0.015	101	19.92	167.66	0.08415
200	0.02	109	20.03	180.94	0.09035
250	0.025	116	20.13	192.56	0.09567
300	0.03	107	20.23	177.62	0.08779
350	0.035	101	20.34	167.66	0.08244

Table- 30

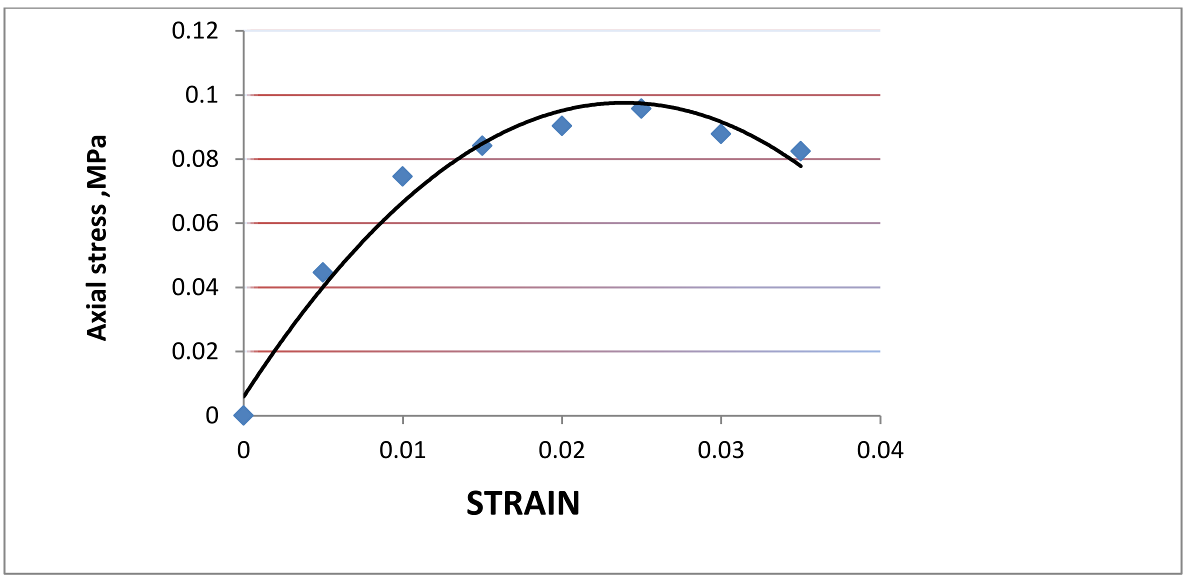


Fig-22

UCS = 0.09567 MPa

Sample 2

Without Adding CCR and FA :-

Dial gauge reading	Strain(ϵ)	Proving ring reading	corrected area	load (N)	Axial Stress (Mpa)
0	0	0	19.625	0	0
50	0.005	34	19.72	56.44	0.02862
100	0.01	66	19.82	109.56	0.05527
150	0.015	83	19.92	137.78	0.06915
200	0.02	91	20.03	151.06	0.07543
250	0.025	99	20.13	164.34	0.08165
300	0.03	94	20.23	156.04	0.07713
350	0.035	83	20.34	137.78	0.06775

Table- 31

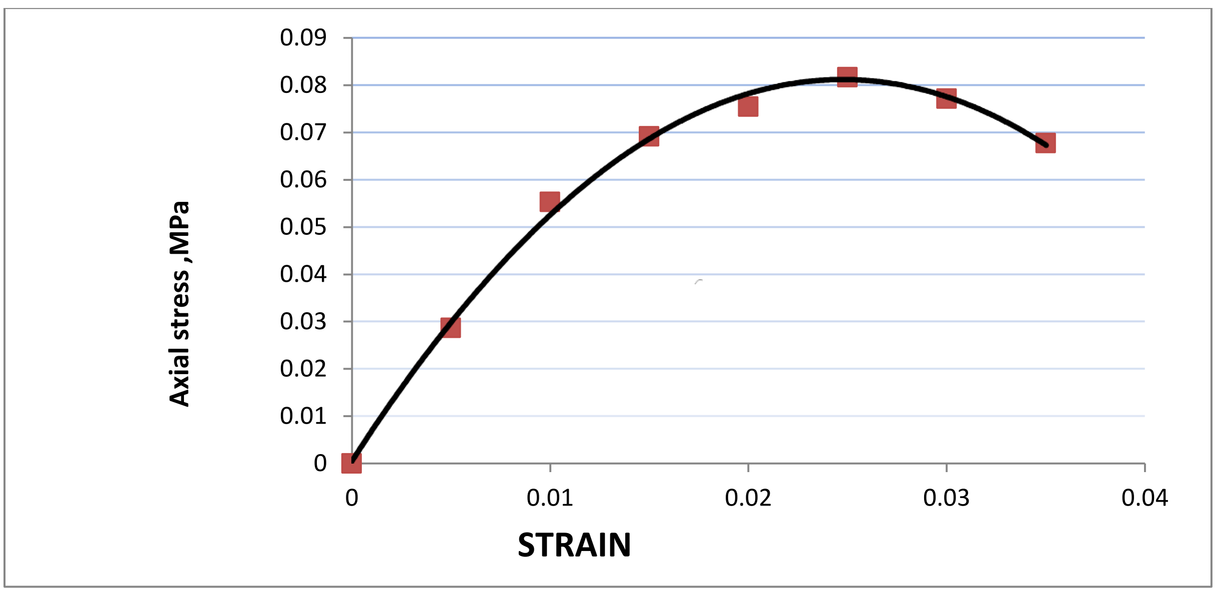


Fig-23

UCS = 0.08165 MPa

After adding 10% CCR and FA mixture

Dial gauge reading	Strain(ϵ)	Proving ring reading	corrected area	load (N)	Axial Stress (Mpa)
0	0	0	19.625	0	0
50	0.005	41	19.72	68.06	0.0345
100	0.01	75	19.82	124.5	0.0628
150	0.015	89	19.92	147.74	0.0742
200	0.02	97	20.03	161.02	0.0804
250	0.025	106	20.13	175.96	0.0874
300	0.03	99	20.23	164.34	0.0812
350	0.035	91	20.34	151.06	0.0743

Table- 32

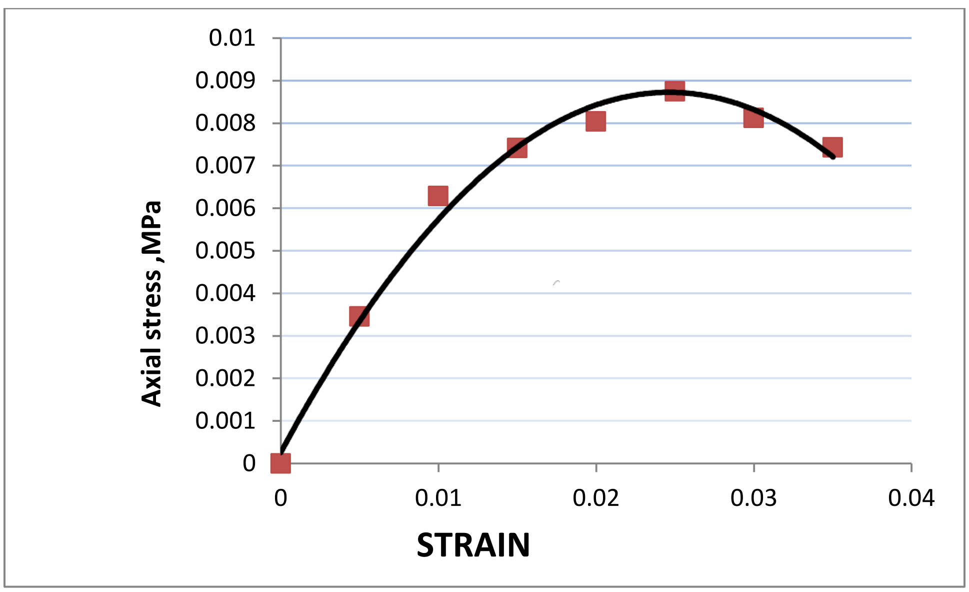


Fig-24

UCS = 0.0874 MPa

After adding 15% CCR and FA mixture

Dial gauge reading	Strain(ϵ)	Proving ring reading	corrected area	load (N)	Axial Stress (Mpa)
0	0	0	19.625	0	0
50	0.005	45	19.72	74.7	0.03787
100	0.01	79	19.82	131.14	0.06615
150	0.015	95	19.92	157.7	0.07915
200	0.02	104	20.03	172.64	0.08621
250	0.025	108	20.13	179.28	0.08907
300	0.03	99	20.23	164.34	0.08123
350	0.035	89	20.34	147.74	0.07265

Table- 33

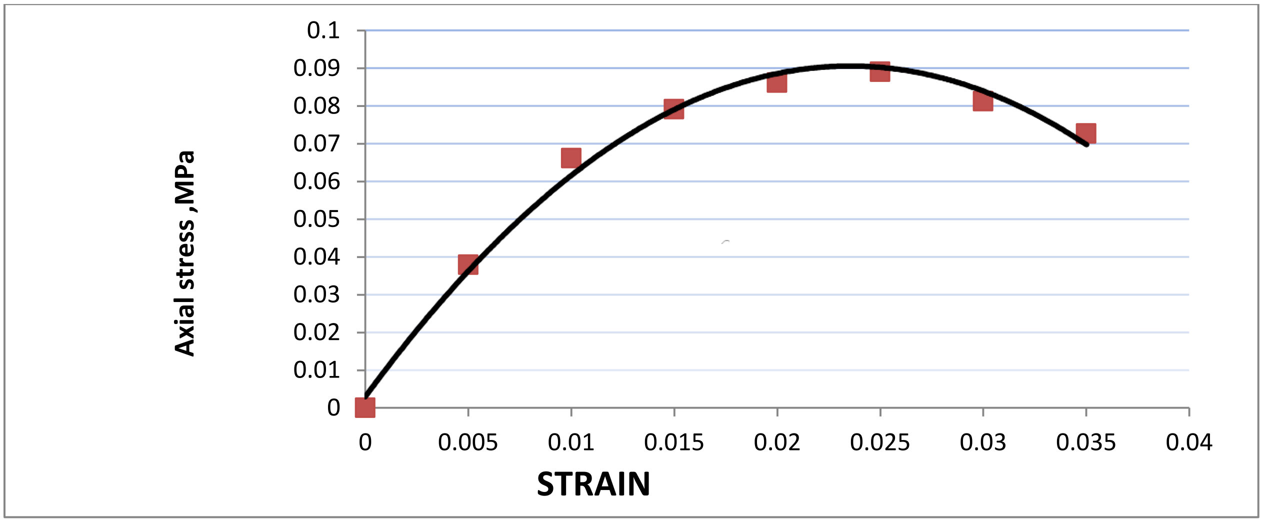


Fig-25

UCS = 0.08907 MPa

After adding 20% CCR and FA mixture

Dial gauge reading	Strain(ϵ)	Proving ring reading	corrected area	load (N)	Axial Stress (Mpa)
0	0	0	19.625	0	0
50	0.005	34	19.72	56.44	0.0286
100	0.01	78	19.82	129.48	0.0653
150	0.015	95	19.92	157.7	0.0792
200	0.02	101	20.03	167.66	0.0837
250	0.025	110	20.13	182.6	0.0907
300	0.03	105	20.23	174.3	0.0862
350	0.035	94	20.34	156.04	0.0767

Table- 34

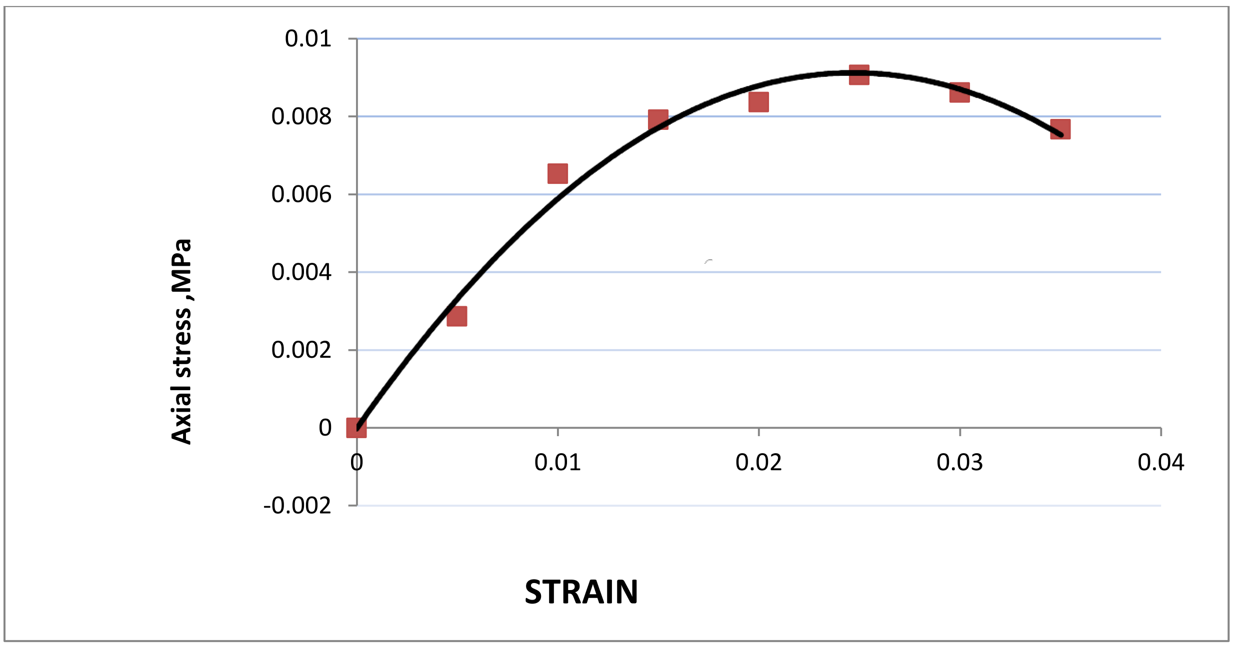


Fig-26

UCS = 0.0907 MPa

Sample3

Without Adding CCR and FA :-

Dial gauge reading	Strain(ϵ)	Proving ring reading	corrected area	load (N)	Axial Stress (Mpa)
0	0	0	19.625	0	0
50	0.005	32	19.72	53.12	0.0269
100	0.01	57	19.82	94.62	0.0477
150	0.015	68	19.92	112.88	0.0567
200	0.02	79	20.03	131.14	0.0655
250	0.025	87	20.13	144.42	0.0718
300	0.03	76	20.23	126.16	0.0624
350	0.035	69	20.34	114.54	0.0563

Table- 35

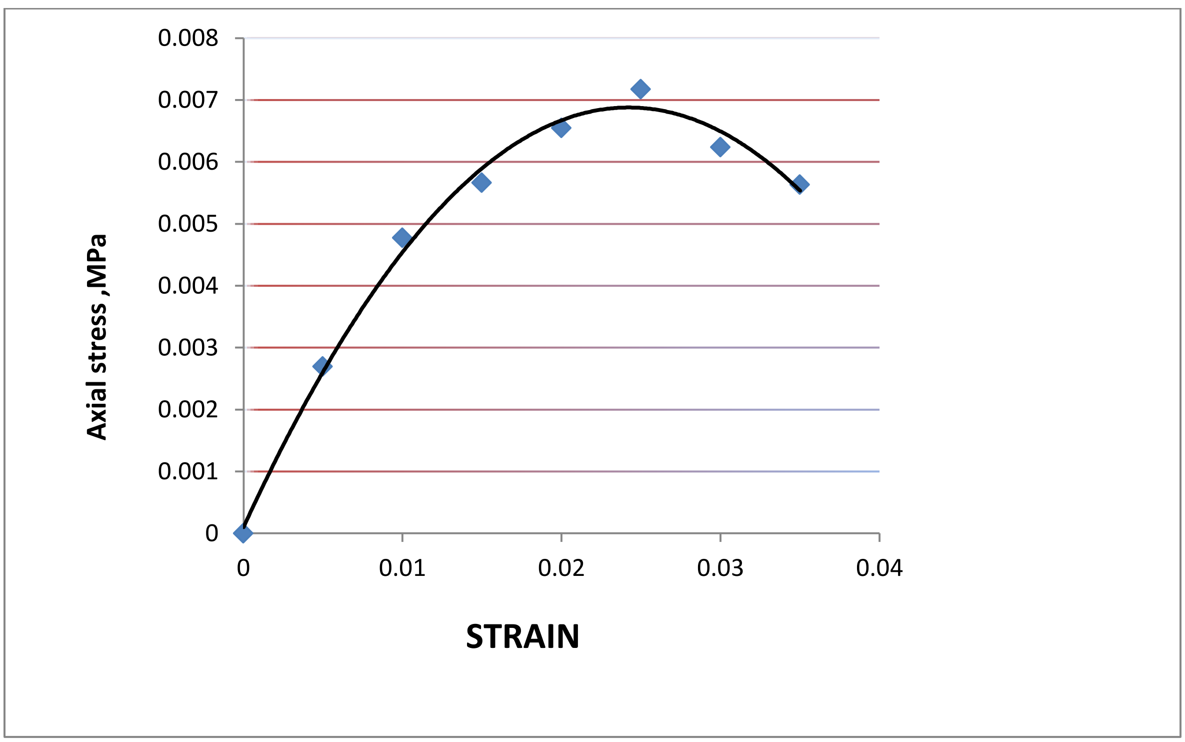


Fig-27

UCS = 0.0698 MPa

After adding 10% CCR and FA mixture

Dial gauge reading	Strain(ϵ)	Proving ring reading	corrected area	load (N)	Axial Stress (Mpa)
0	0	0	19.625	0	0
50	0.005	38	19.72	63.08	0.03198
100	0.01	66	19.82	109.56	0.05527
150	0.015	75	19.92	124.5	0.06249
200	0.02	88	20.03	146.08	0.07295
250	0.025	95	20.13	157.7	0.07835
300	0.03	91	20.23	151.06	0.07466
350	0.035	84	20.34	139.44	0.06857

Table- 36

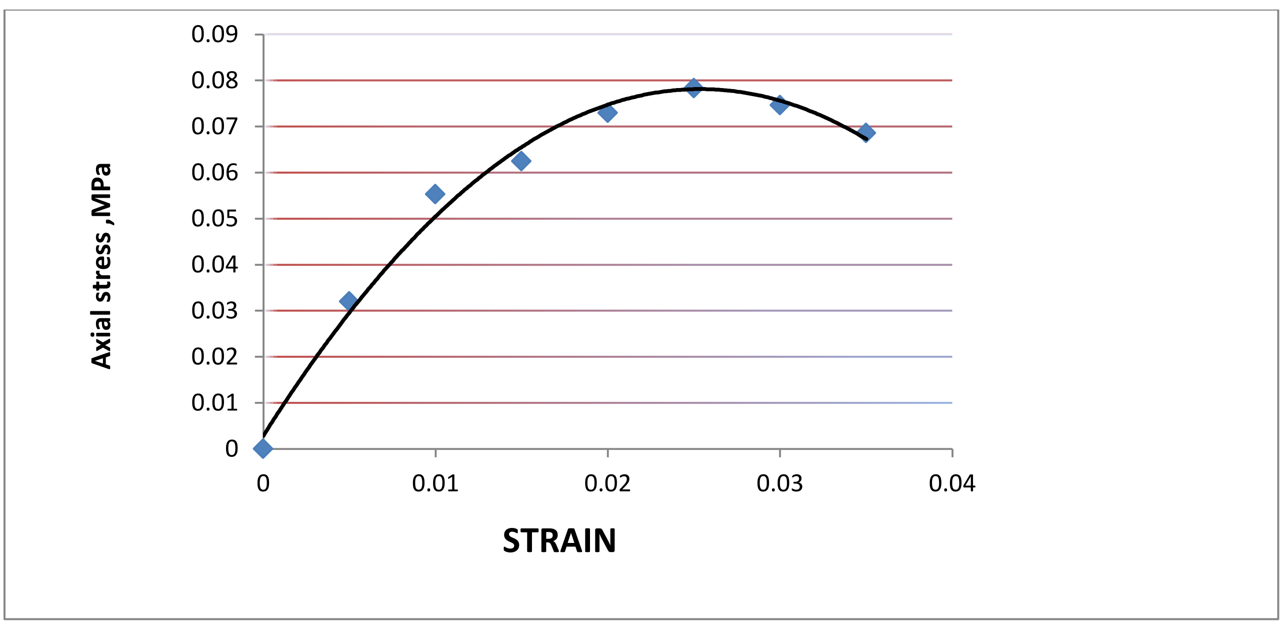


Fig-28

UCS = 0.07835 MPa

After adding 15% CCR and FA mixture

Dial gauge reading	Strain(ϵ)	Proving ring reading	corrected area	load (N)	Axial Stress (Mpa)
0	0	0	19.625	0	0
50	0.005	41	19.72	68.06	0.03451
100	0.01	69	19.82	114.54	0.05778
150	0.015	82	19.92	136.12	0.06832
200	0.02	91	20.03	151.06	0.07543
250	0.025	97	20.13	161.02	0.08000
300	0.03	92	20.23	152.72	0.07548
350	0.035	86	20.34	142.76	0.07020

Table- 37

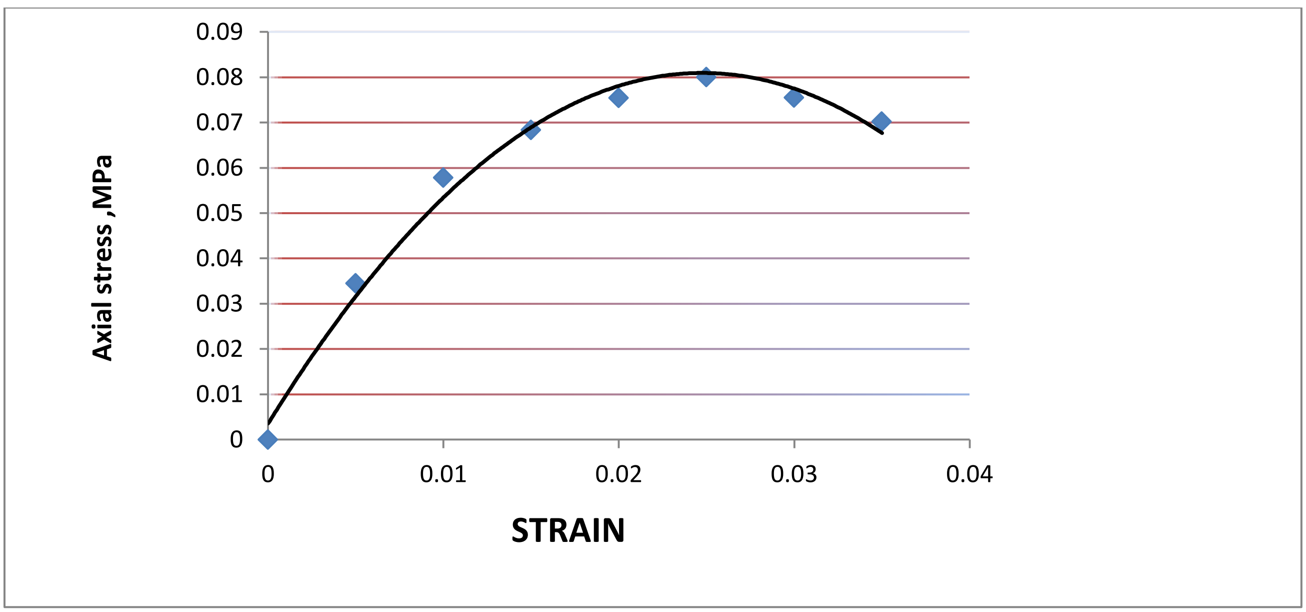


Fig-29

UCS = 0.08000 MPa

After adding 20% CCR and FA mixture

Dial gauge reading	Strain(ϵ)	Proving ring reading	corrected area	load (N)	Axial Stress (Mpa)
0	0	0	19.625	0	0
50	0.005	44	19.72	73.04	0.0370
100	0.01	68	19.82	112.88	0.0569
150	0.015	83	19.92	137.78	0.0692
200	0.02	91	20.03	151.06	0.0754
250	0.025	99	20.13	164.34	0.0816
300	0.03	93	20.23	154.38	0.0763
350	0.035	84	20.34	139.44	0.0686

Table- 38

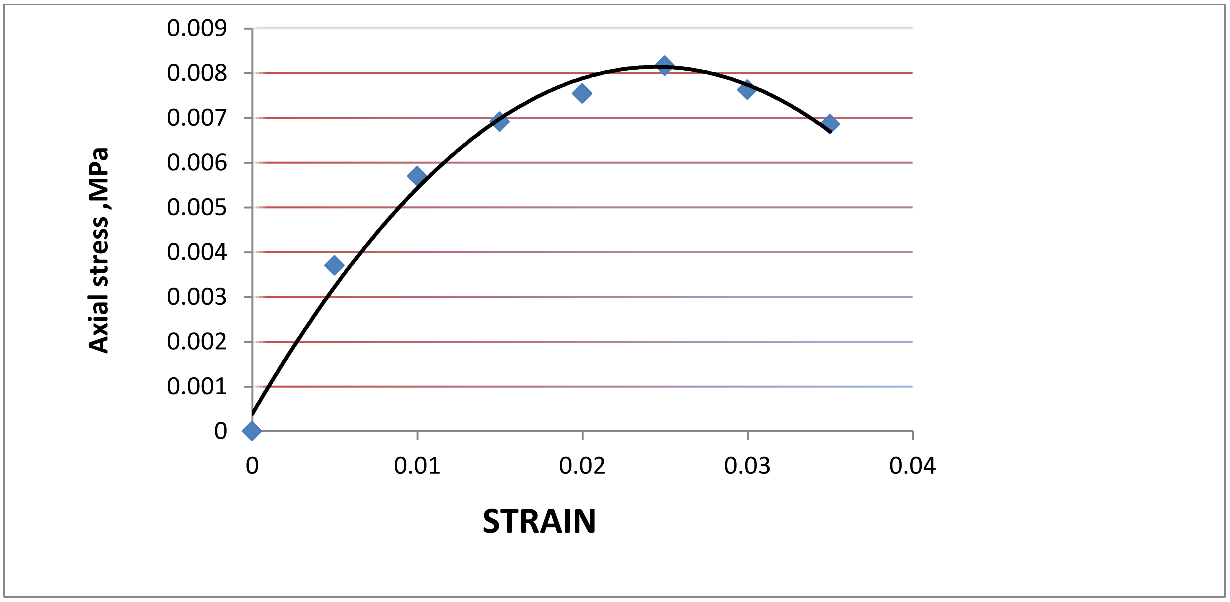


Fig-30

UCS = 0.08516 MPa

4.6 CBR (Unsoaked) test

SAMPLE 1 :

Without Mixing CCR and Fly Ash :

penetration dial		load dial	
readings	penetration (mm)	proving ring reading	load (kg)
0	0	0	0
50	0.5	15	99.75
100	1	27	179.55
150	1.5	39	259.35
200	2	51	339.15
250	2.5	60	399
300	3	66	438.9
350	3.5	71	472.15
400	4	76	505.4
450	4.5	81	538.65
500	5	85	565.25
550	5.5	89	591.85
600	6	92	611.8
650	6.5	95	631.75
700	7	97	645.05
750	7.5	99	658.35
800	8	101	671.65
850	8.5	103	684.95
900	9	104	691.6
950	9.5	105	698.25
1000	10	105	698.25
1050	10.5	106	704.9
1100	11	107	711.55
1150	11.5	108	718.2
1200	12	108	718.2
1250	12.5	109	724.85

Table-39

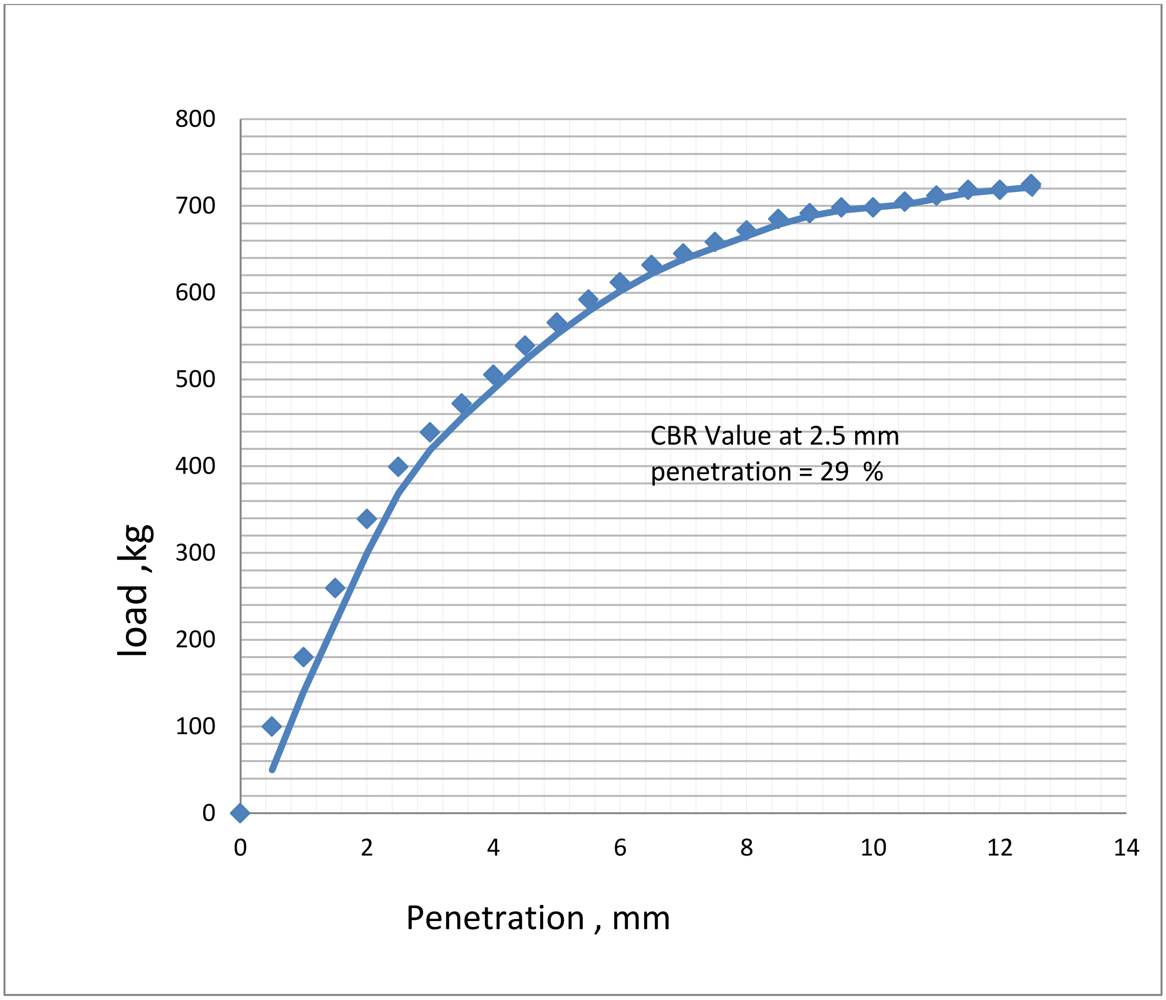
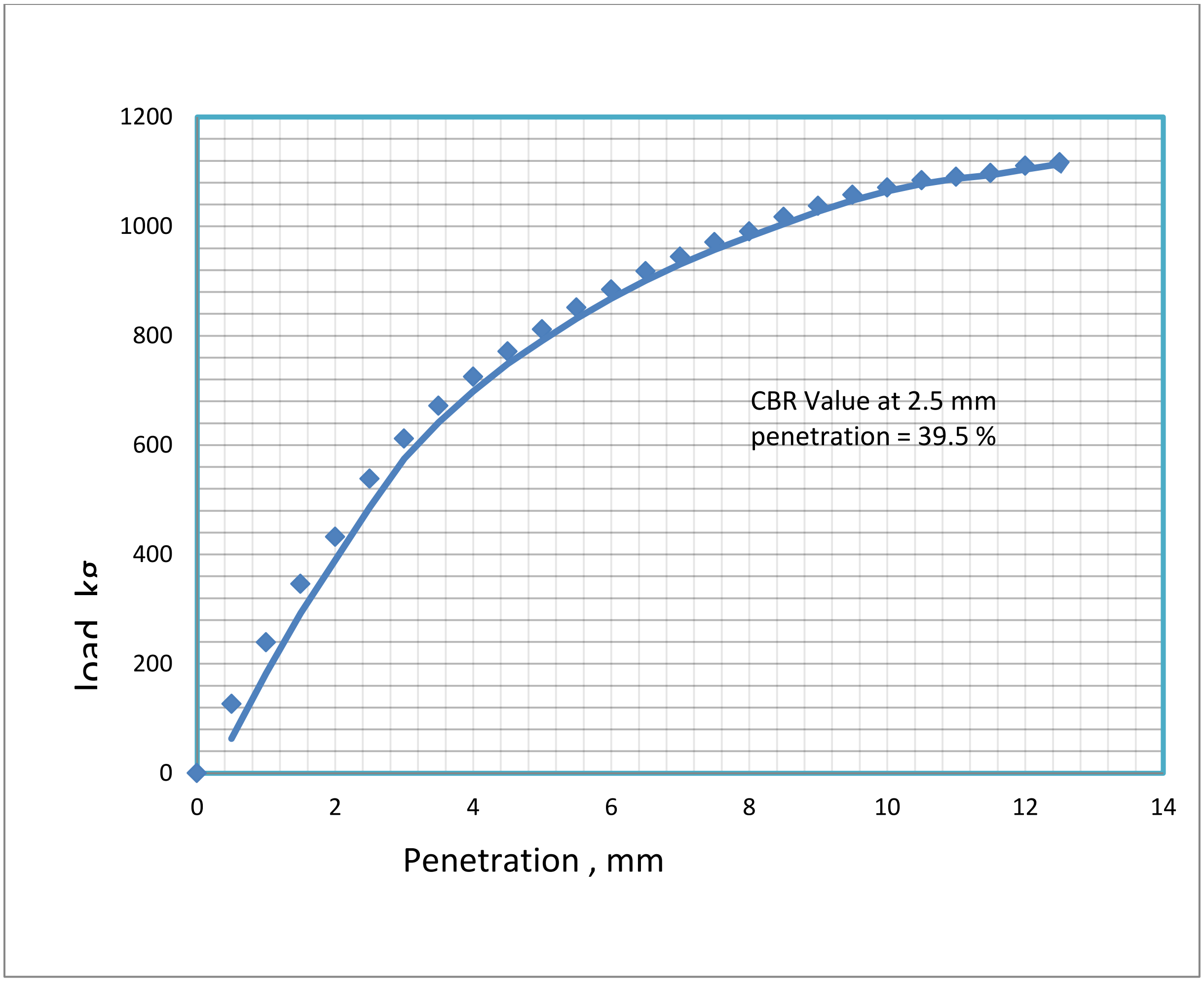

800
700
600
500
400
300
200
100
0
load ,kg
0
2
4
6
8
10
12
14
Penetration , mm
CBR Value at 2.5 mm
penetration = 29 %

Fig.-31

After adding 10 % of CCR and Fly Ash :

penetration dial		load dial	
readings	penetration (mm)	proving ring reading	load (kg)
0	0	0	0
50	0.5	19	126.35
100	1	36	239.4
150	1.5	52	345.8
200	2	65	432.25
250	2.5	81	538.65
300	3	92	611.8
350	3.5	101	671.65
400	4	109	724.85
450	4.5	116	771.4
500	5	122	811.3
550	5.5	128	851.2
600	6	133	884.45
650	6.5	138	917.7
700	7	142	944.3
750	7.5	146	970.9
800	8	149	990.85
850	8.5	153	1017.45
900	9	156	1037.4
950	9.5	159	1057.35
1000	10	161	1070.65
1050	10.5	163	1083.95
1100	11	164	1090.6
1150	11.5	165	1097.25
1200	12	167	1110.55
1250	12.5	168	1117.2

Table-40



1200
1000
800
600
400
200
0
load, kg
0
2
4
6
8
10
12
14
Penetration , mm
CBR Value at 2.5 mm
penetration = 39.5 %

Fig.-32

After mixing 15 % of CCR and Fly Ash :

penetration dial		load dial	
readings	penetration (mm)	proving ring reading	load (kg)
0	0	0	0
50	0.5	22	146.3
100	1	41	272.65
150	1.5	60	399
200	2	79	525.35
250	2.5	95	631.75
300	3	110	731.5
350	3.5	123	817.95
400	4	131	871.15
450	4.5	142	944.3
500	5	151	1004.15
550	5.5	159	1057.35
600	6	166	1103.9
650	6.5	173	1150.45
700	7	179	1190.35
750	7.5	185	1230.25
800	8	190	1263.5
850	8.5	194	1290.1
900	9	199	1323.35
950	9.5	203	1349.95
1000	10	207	1376.55
1050	10.5	210	1396.5
1100	11	213	1416.45
1150	11.5	215	1429.75
1200	12	216	1436.4
1250	12.5	218	1449.7

Table-41

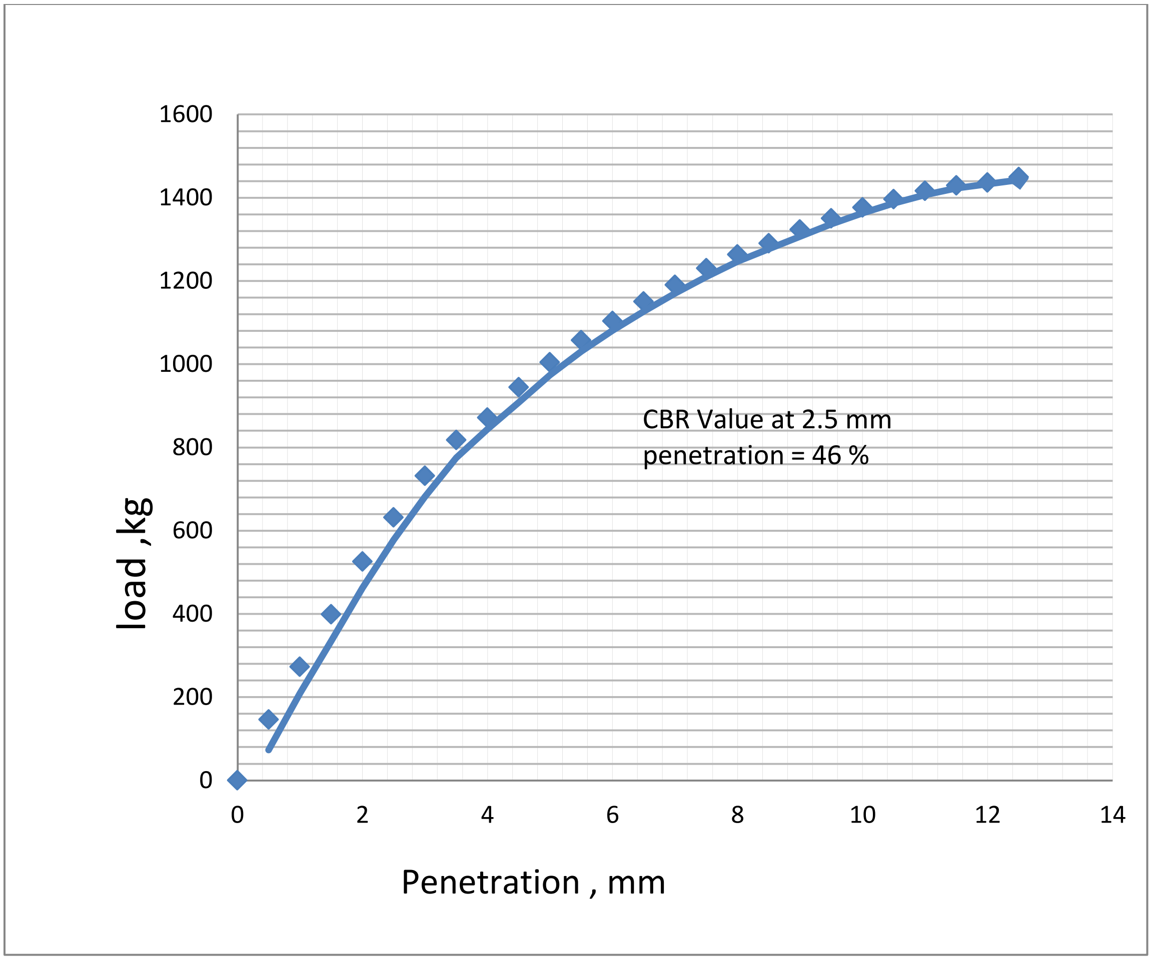

1600
1400
1200
1000
800
600
400
200
0
load ,kg
0
2
4
6
8
10
12
14
Penetration , mm
CBR Value at 2.5 mm
penetration = 46 %

Fig.-33

After mixing 20 % of CCR and Fly Ash :

penetration dial		load dial	
readings	penetration (mm)	proving ring reading	load (kg)
0	0	0	0
50	0.5	24	159.6
100	1	46	305.9
150	1.5	67	445.55
200	2	85	565.25
250	2.5	103	684.95
300	3	119	791.35
350	3.5	134	891.1
400	4	149	990.85
450	4.5	162	1077.3
500	5	173	1150.45
550	5.5	182	1210.3
600	6	190	1263.5
650	6.5	198	1316.7
700	7	206	1369.9
750	7.5	211	1403.15
800	8	215	1429.75
850	8.5	219	1456.35
900	9	223	1482.95
950	9.5	226	1502.9
1000	10	229	1522.85
1050	10.5	231	1536.15
1100	11	233	1549.45
1150	11.5	233	1549.45
1200	12	234	1556.1
1250	12.5	235	1562.75

Table-42

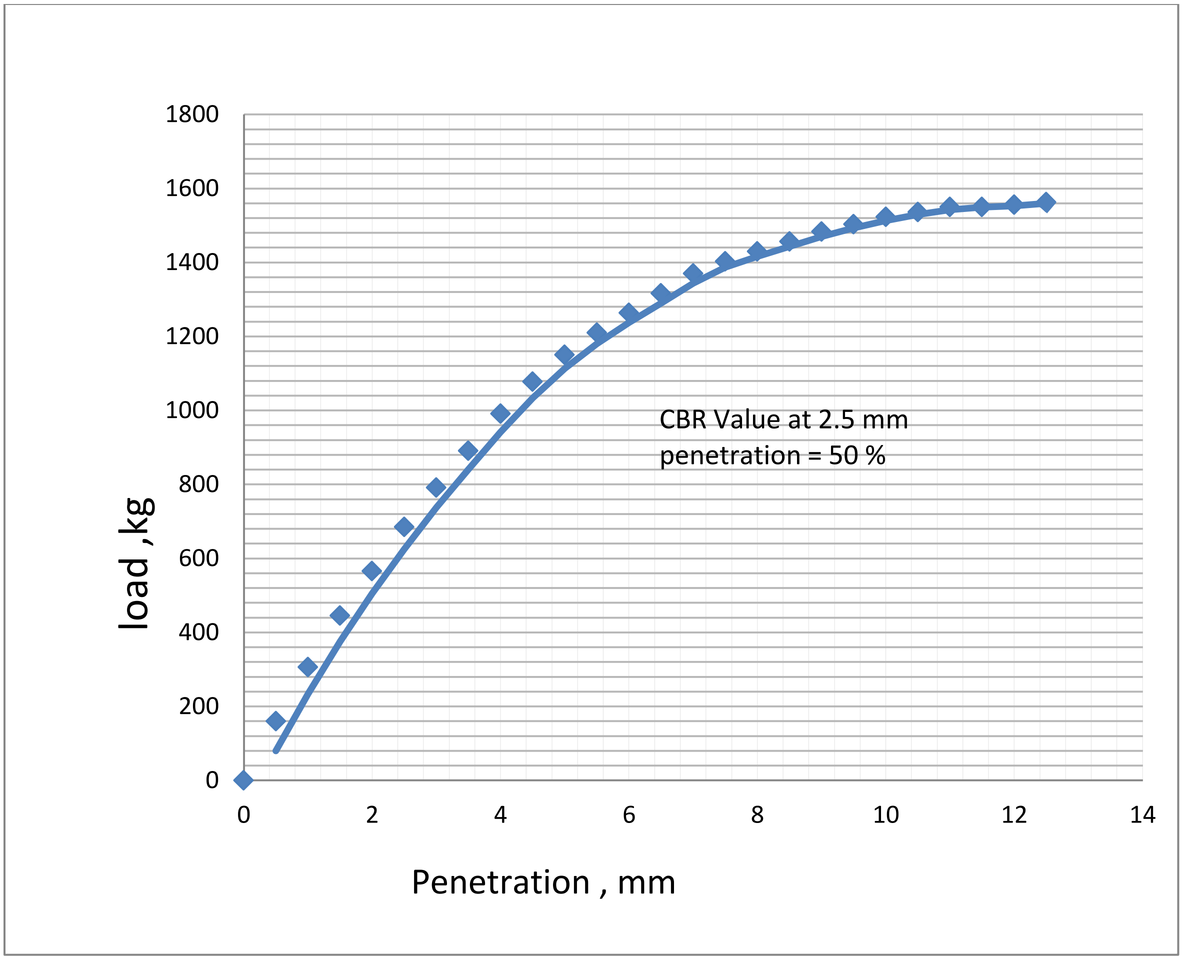

1800
1600
1400
1200
1000
800
600
400
200
0
0
2
4
6
8
10
12
14
load ,kg
Penetration , mm
CBR Value at 2.5 mm
penetration = 50 %

Fig.-34

SAMPLE 2 :

Without mixing CCR and Fly Ash :

penetration dial		load dial	
readings	penetration (mm)	proving ring reading	load (kg)
0	0	0	0
50	0.5	18	119.7
100	1	36	239.4
150	1.5	50	332.5
200	2	62	412.3
250	2.5	73	485.45
300	3	81	538.65
350	3.5	88	585.2
400	4	95	631.75
450	4.5	101	671.65
500	5	106	704.9
550	5.5	112	744.8
600	6	117	778.05
650	6.5	121	804.65
700	7	126	837.9
750	7.5	130	864.5
800	8	133	884.45
850	8.5	136	904.4
900	9	138	917.7
950	9.5	141	937.65
1000	10	143	950.95
1050	10.5	145	964.25
1100	11	147	977.55
1150	11.5	149	990.85
1200	12	151	1004.15
1250	12.5	152	1010.8

Table-43

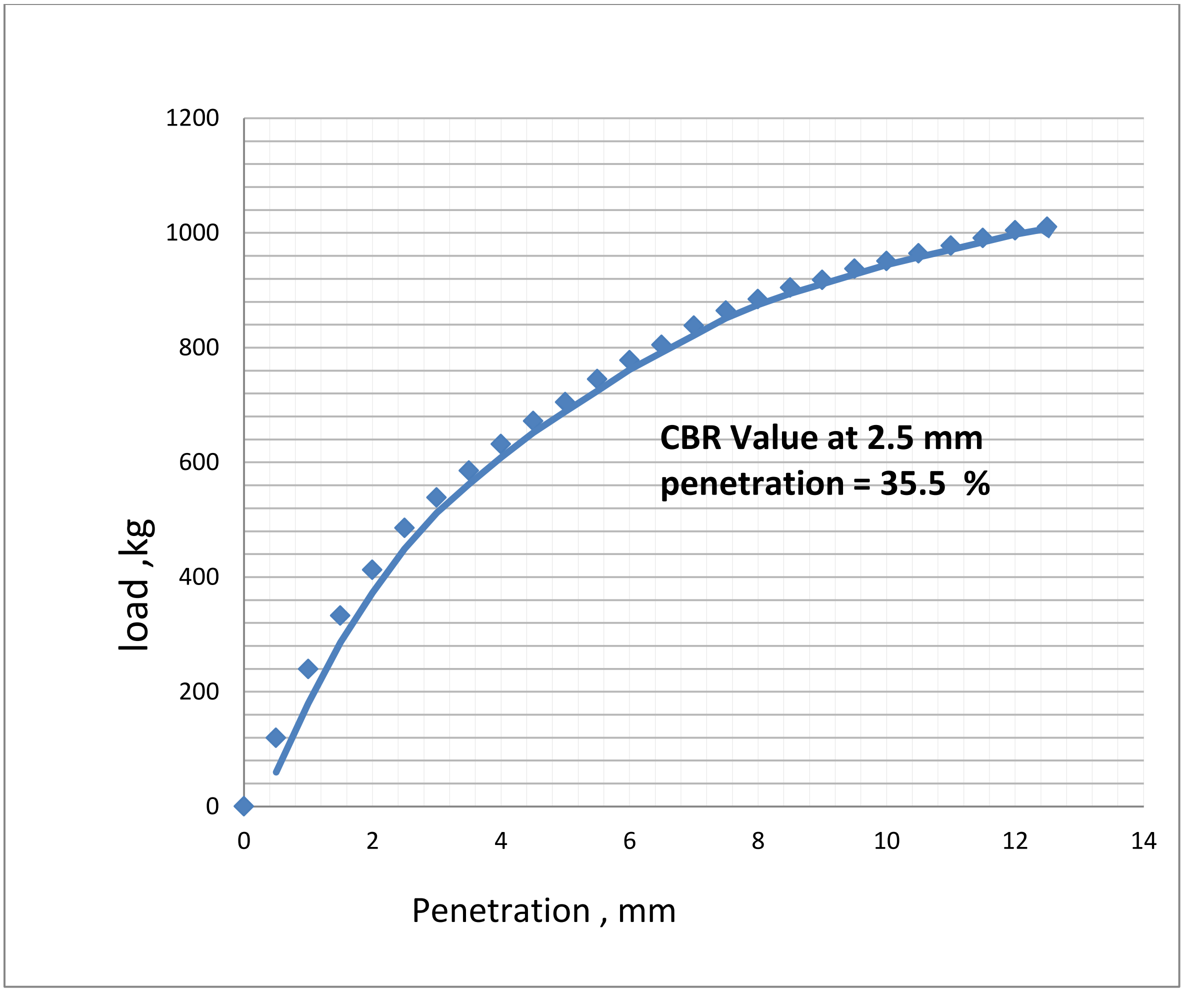

1200
1000
800
600
400
200
0
load ,kg
0
2
4
6
8
10
12
14
Penetration , mm
CBR Value at 2.5 mm
penetration = 35.5 %

Fig.-35

After mixing 10 % of CCR and Fly Ash :

penetration dial		load dial	
readings	penetration (mm)	proving ring reading	load (kg)
0	0	0	0
50	0.5	22	146.3
100	1	42	279.3
150	1.5	62	412.3
200	2	81	538.65
250	2.5	97	645.05
300	3	112	744.8
350	3.5	125	831.25
400	4	133	884.45
450	4.5	144	957.6
500	5	152	1010.8
550	5.5	161	1070.65
600	6	168	1117.2
650	6.5	175	1163.75
700	7	181	1203.65
750	7.5	187	1243.55
800	8	192	1276.8
850	8.5	196	1303.4
900	9	201	1336.65
950	9.5	204	1356.6
1000	10	209	1389.85
1050	10.5	212	1409.8
1100	11	215	1429.75
1150	11.5	217	1443.05
1200	12	218	1449.7
1250	12.5	220	1463

Table-44

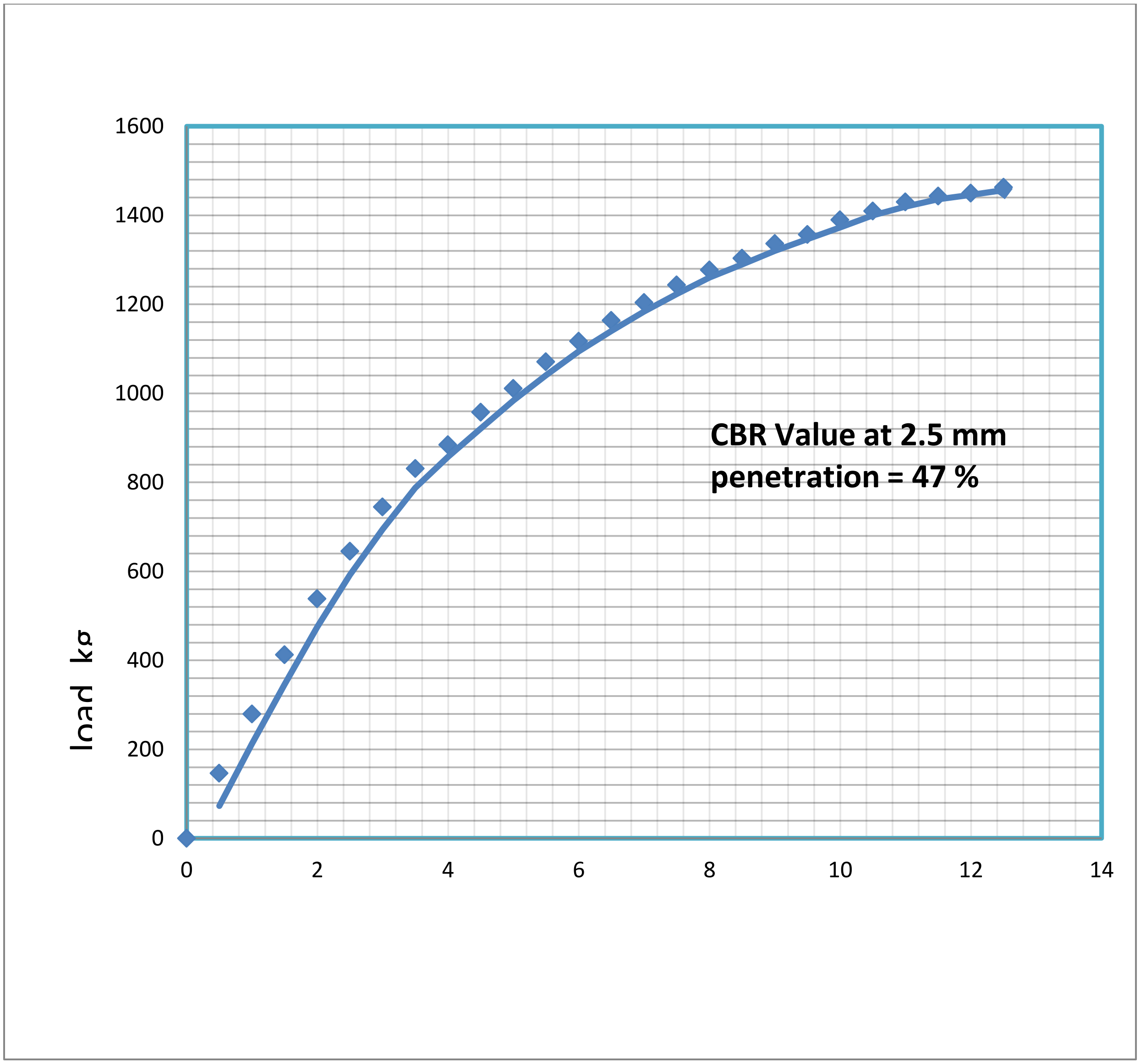

1600
1400
1200
1000
800
600
400
200
0
load kg
0
2
4
6
8
10
12
14
CBR Value at 2.5 mm
penetration = 47 %

Fig.-36

After mixing 15 % of CCR and Fly Ash :

penetration dial		load dial	
readings	penetration (mm)	proving ring reading	load (kg)
0	0	0	0
50	0.5	24	159.6
100	1	47	312.55
150	1.5	71	472.15
200	2	93	618.45
250	2.5	113	751.45
300	3	131	871.15
350	3.5	148	984.2
400	4	164	1090.6
450	4.5	177	1177.05
500	5	189	1256.85
550	5.5	198	1316.7
600	6	207	1376.55
650	6.5	216	1436.4
700	7	222	1476.3
750	7.5	228	1516.2
800	8	232	1542.8
850	8.5	235	1562.75
900	9	238	1582.7
950	9.5	241	1602.65
1000	10	244	1622.6
1050	10.5	246	1635.9
1100	11	248	1649.2
1150	11.5	249	1655.85
1200	12	250	1662.5
1250	12.5	251	1669.15

Table-45

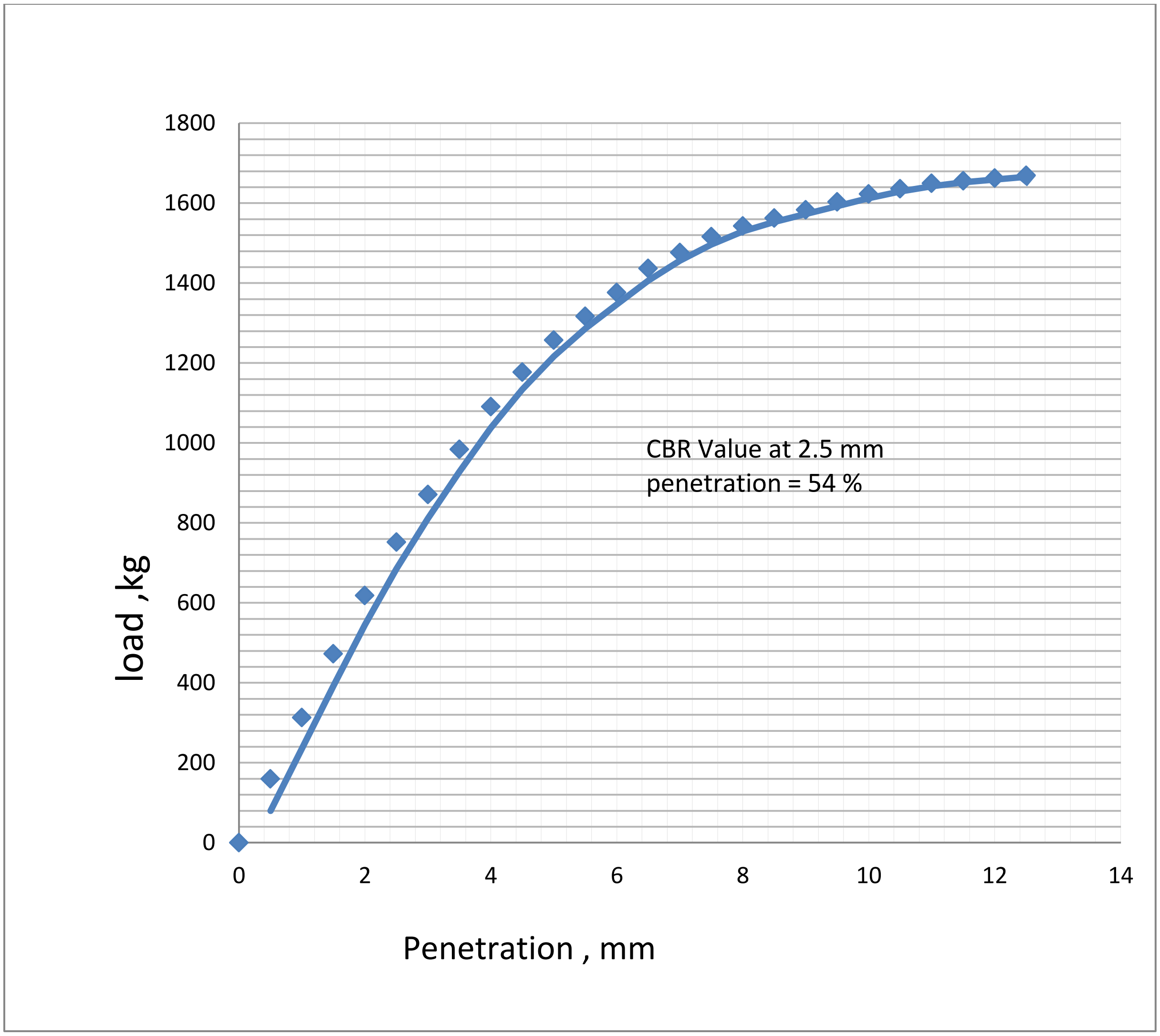

1800
1600
1400
1200
1000
800
600
400
200
0
0
2
4
6
8
10
12
14
load ,kg
Penetration , mm
CBR Value at 2.5 mm
penetration = 54 %

Fig.-37

After mixing 20 % of CCr and Fly ash

penetration dial		load dial	
readings	penetration (mm)	proving ring reading	load (kg)
0	0	0	0
50	0.5	26	172.9
100	1	51	339.15
150	1.5	74	492.1
200	2	98	651.7
250	2.5	121	804.65
300	3	138	917.7
350	3.5	156	1037.4
400	4	173	1150.45
450	4.5	188	1250.2
500	5	201	1336.65
550	5.5	213	1416.45
600	6	221	1469.65
650	6.5	230	1529.5
700	7	238	1582.7
750	7.5	246	1635.9
800	8	253	1682.45
850	8.5	257	1709.05
900	9	259	1722.35
950	9.5	262	1742.3
1000	10	264	1755.6
1050	10.5	266	1768.9
1100	11	267	1775.55
1150	11.5	268	1782.2
1200	12	269	1788.85
1250	12.5	270	1795.5

Table-46

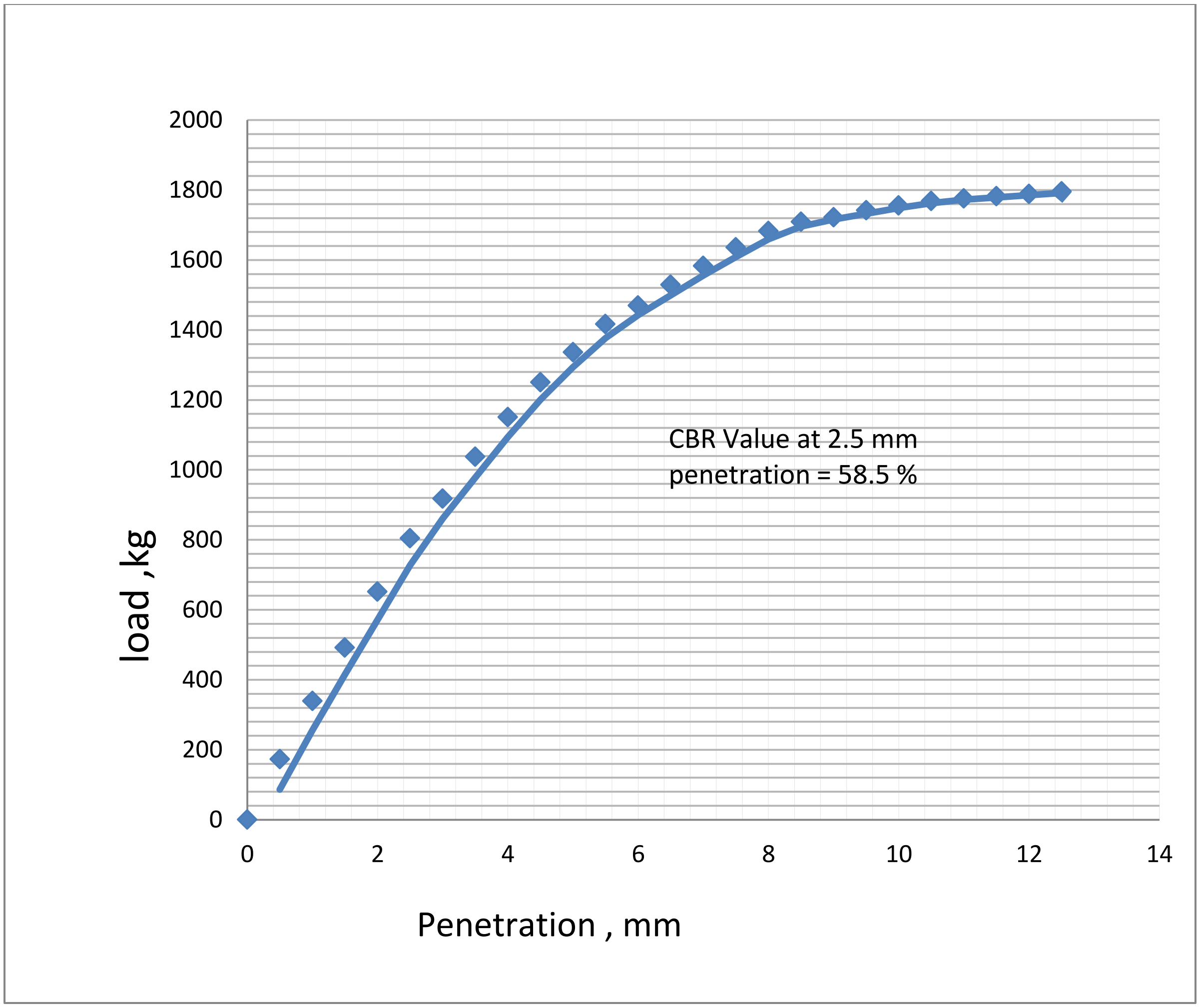

2000
1800
1600
1400
1200
1000
800
600
400
200
0
0
2
4
6
8
10
12
14
load ,kg
Penetration , mm
CBR Value at 2.5 mm
penetration = 58.5 %

Fig.-38

SAMPLE 3

Without mixing CCR and Fly Ash :

penetration dial		load dial	
readings	penetration (mm)	proving ring reading	load (kg)
0	0	0	0
50	0.5	13	86.45
100	1	25	166.25
150	1.5	36	239.4
200	2	44	292.6
250	2.5	53	352.45
300	3	62	412.3
350	3.5	69	458.85
400	4	73	485.45
450	4.5	79	525.35
500	5	82	545.3
550	5.5	85	565.25
600	6	89	591.85
650	6.5	92	611.8
700	7	94	625.1
750	7.5	96	638.4
800	8	98	651.7
850	8.5	99	658.35
900	9	101	671.65
950	9.5	102	678.3
1000	10	104	691.6
1050	10.5	105	698.25
1100	11	106	704.9
1150	11.5	106	704.9
1200	12	107	711.55
1250	12.5	108	718.2

Table-47

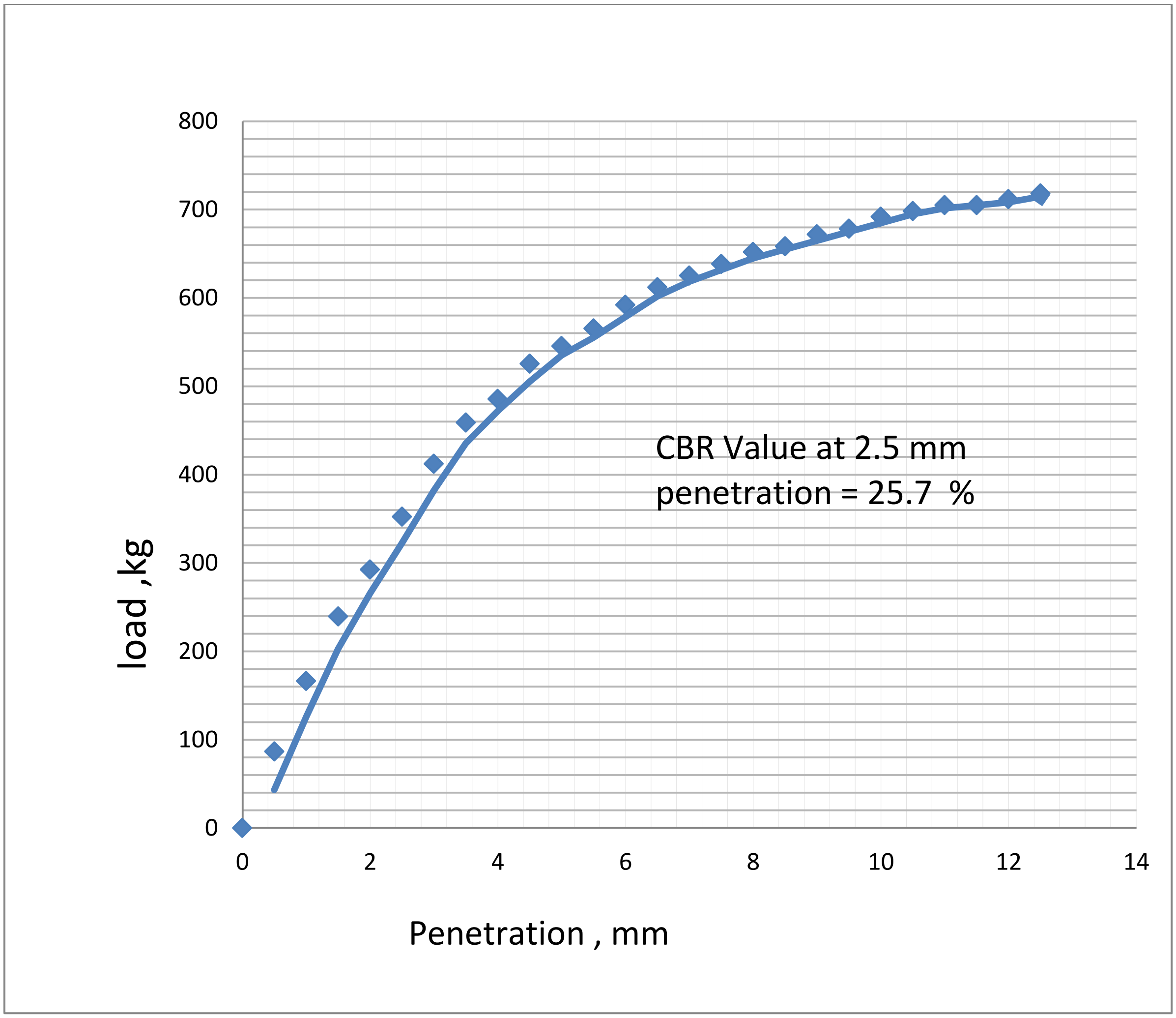
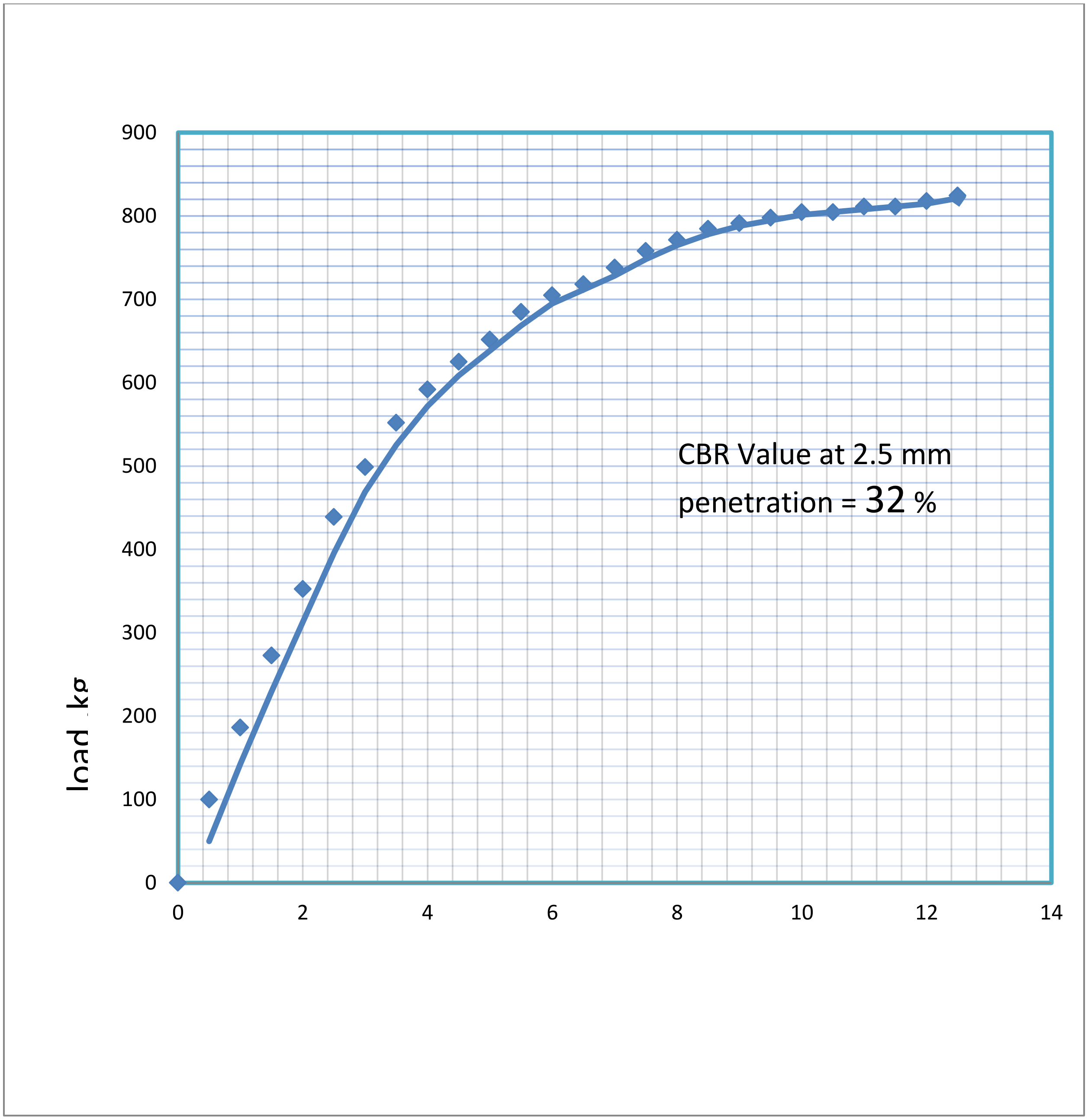

800
700
600
500
400
300
200
100
0
0
2
4
6
8
10
12
14
load ,kg
Penetration , mm
CBR Value at 2.5 mm
penetration = 25.7 %

Fig.-39

After mixing 10 % CCR and Fly Ash :

penetration dial		load dial	
readings	penetration (mm)	proving ring reading	load (kg)
0	0	0	0
50	0.5	15	99.75
100	1	28	186.2
150	1.5	41	272.65
200	2	53	352.45
250	2.5	66	438.9
300	3	75	498.75
350	3.5	83	551.95
400	4	89	591.85
450	4.5	94	625.1
500	5	98	651.7
550	5.5	103	684.95
600	6	106	704.9
650	6.5	108	718.2
700	7	111	738.15
750	7.5	114	758.1
800	8	116	771.4
850	8.5	118	784.7
900	9	119	791.35
950	9.5	120	798
1000	10	121	804.65
1050	10.5	121	804.65
1100	11	122	811.3
1150	11.5	122	811.3
1200	12	123	817.95
1250	12.5	124	824.6

Table-48



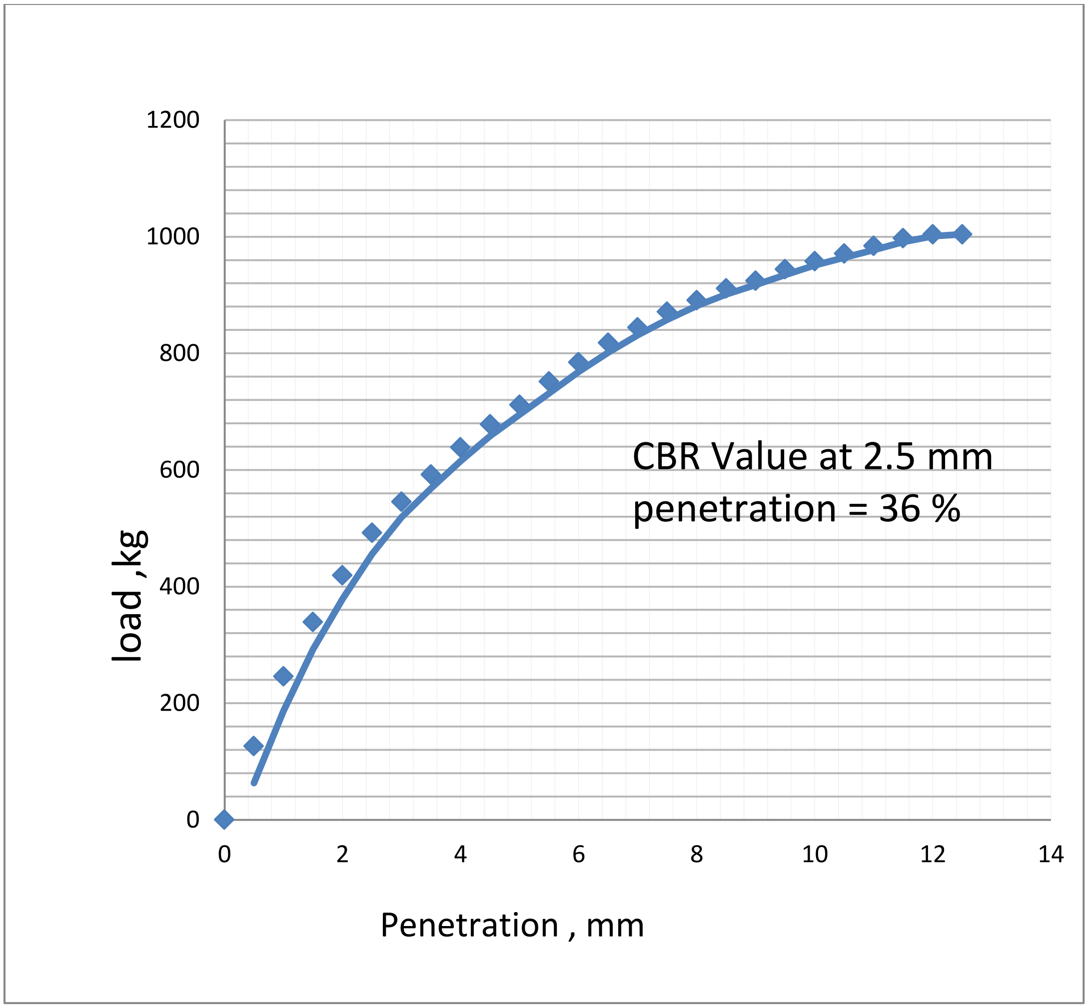
900
800
700
600
500
400
300
200
100
0
load, kg
0
2
4
6
8
10
12
14
CBR Value at 2.5 mm
penetration = 32 %

Fig.-40

After mixing 15 % of CCR and Fly Ash :

penetration dial		load dial	
readings	penetration (mm)	proving ring reading	load (kg)
0	0	0	0
50	0.5	19	126.35
100	1	37	246.05
150	1.5	51	339.15
200	2	63	418.95
250	2.5	74	492.1
300	3	82	545.3
350	3.5	89	591.85
400	4	96	638.4
450	4.5	102	678.3
500	5	107	711.55
550	5.5	113	751.45
600	6	118	784.7
650	6.5	123	817.95
700	7	127	844.55
750	7.5	131	871.15
800	8	134	891.1
850	8.5	137	911.05
900	9	139	924.35
950	9.5	142	944.3
1000	10	144	957.6
1050	10.5	146	970.9
1100	11	148	984.2
1150	11.5	150	997.5
1200	12	151	1004.15
1250	12.5	151	1004.15

Table-49



1200
1000
800
600
400
200
0
0
2
4
6
8
10
12
14
load ,kg
Penetration , mm
CBR Value at 2.5 mm penetration = 36 %

Fig.-41

After mixing 20 % of CCR and Fly Ash :

penetration dial		load dial	
readings	penetration (mm)	proving ring reading	load (kg)
0	0	0	0
50	0.5	18	119.7
100	1	37	246.05
150	1.5	53	352.45
200	2	67	445.55
250	2.5	79	525.35
300	3	81	538.65
350	3.5	92	611.8
400	4	101	671.65
450	4.5	110	731.5
500	5	118	784.7
550	5.5	125	831.25
600	6	131	871.15
650	6.5	137	911.05
700	7	142	944.3
750	7.5	147	977.55
800	8	151	1004.15
850	8.5	155	1030.75
900	9	158	1050.7
950	9.5	161	1070.65
1000	10	163	1083.95
1050	10.5	165	1097.25
1100	11	166	1103.9
1150	11.5	167	1110.55
1200	12	168	1117.2
1250	12.5	168	1117.2

Table-50

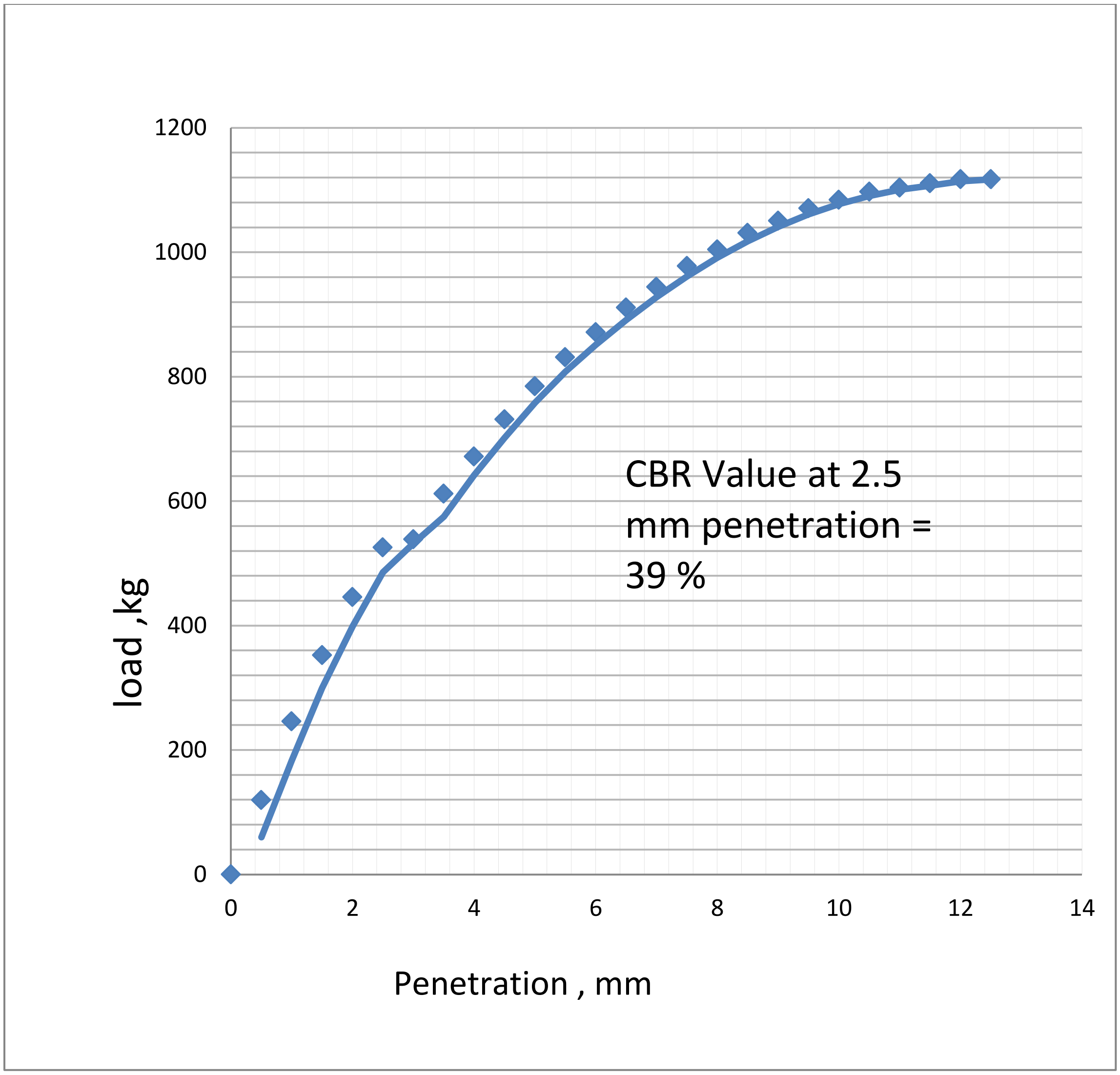

1200
1000
800
600
400
200
0
0
2
4
6
8
10
12
14
load ,kg
Penetration , mm
CBR Value at 2.5 mm penetration = 39 %

Fig.-42

4.7 Discussions :

The relationship between shear strength parameter(COHESION) and Percentage of CCR-FA mixture –

(a) cohesion and CCR-FA mixture

Sample 1 :-

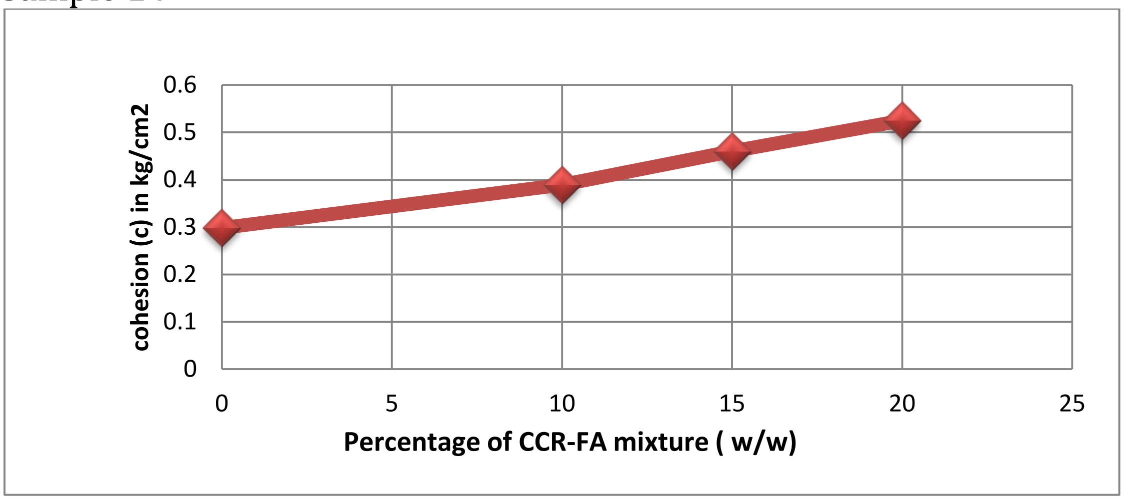


Fig.-43

Sample 2 –

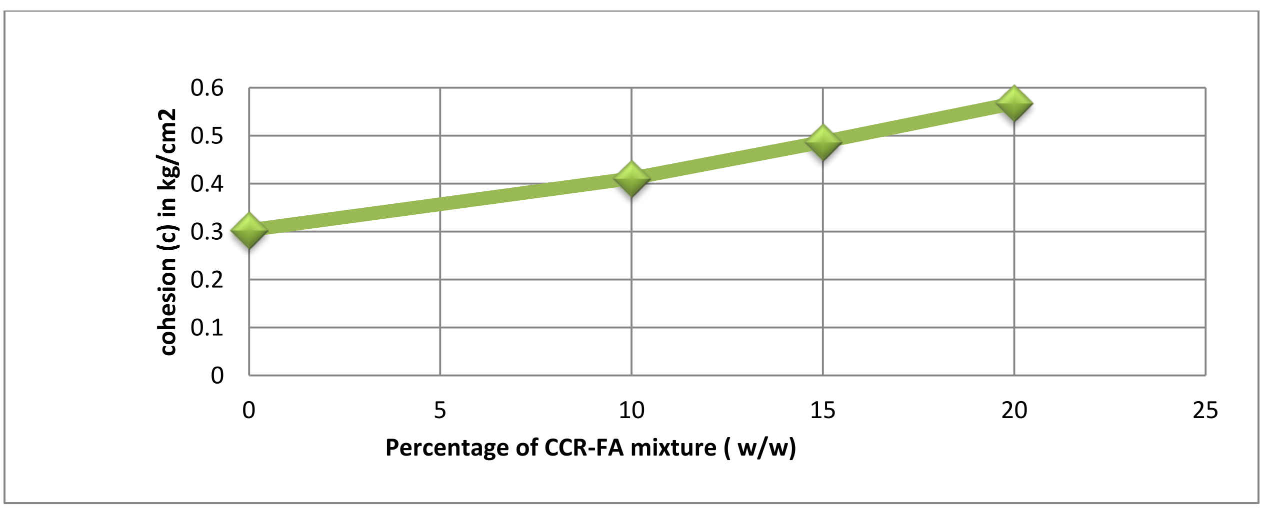


Fig.-44

Sample 3 :-

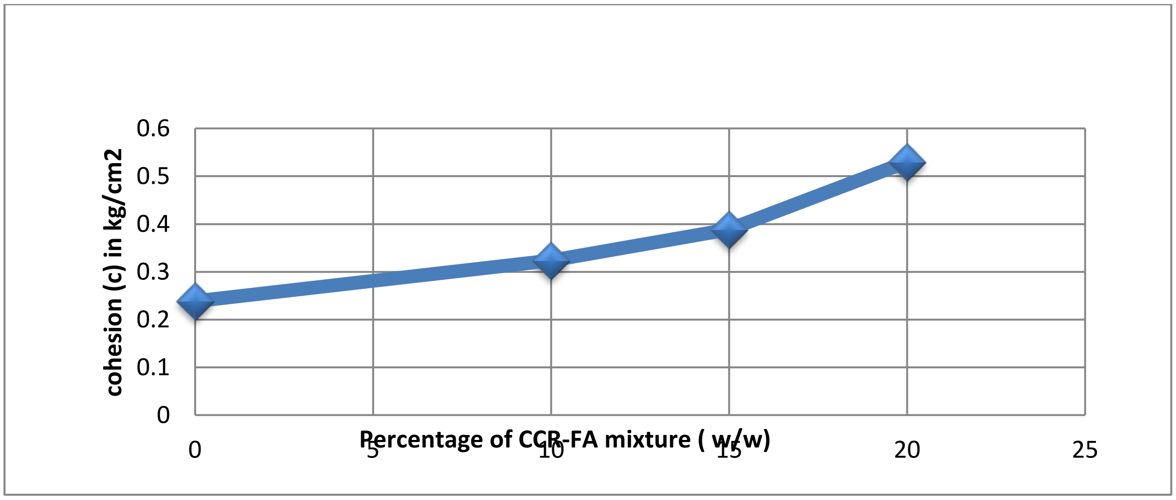


Fig.-45

- From the above observation we find out that the change in shear strength of the soil is very large .
- The cohesion value for sample 1 increased from 0.31 kg/cm2 to 0.53 kg/cm2 , a net of about 67%.
- The cohesion value for sample 2 increased from 0.27 kg/cm2 to 0.50 kg/cm2 , a net of about 83%.
- The cohesion value for sample 3 increased from 0.31 kg/cm2 to 0.57 kg/cm2 , a net of about 80%.

The relationship between Axial Stress and percentage of CCR-Fly Ash mixture :

SAMPLE 1

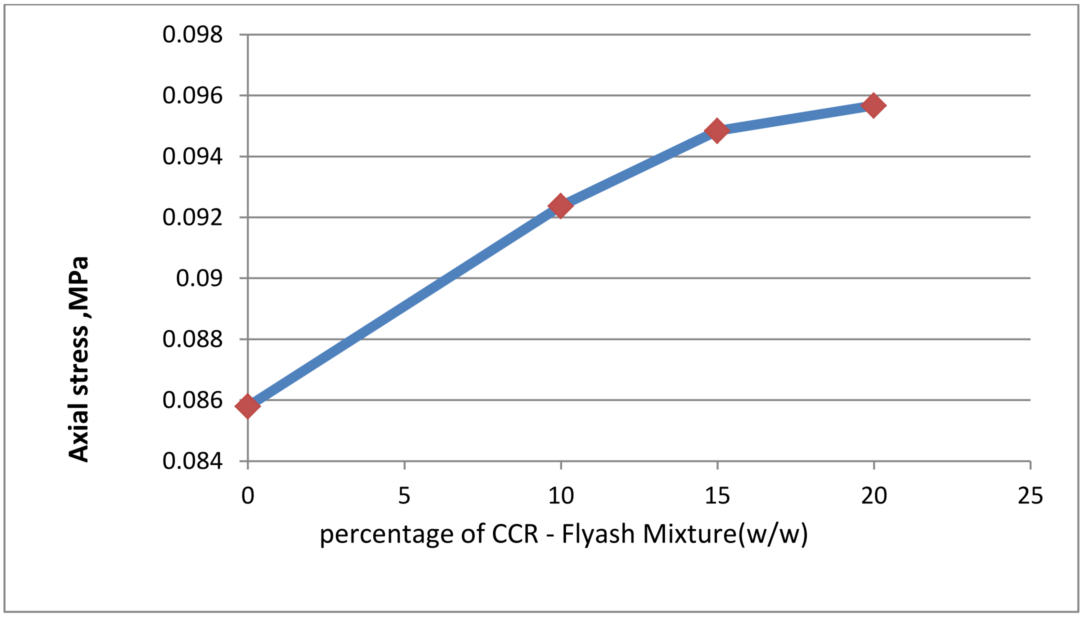


Fig.-46

\SAMPLE 2

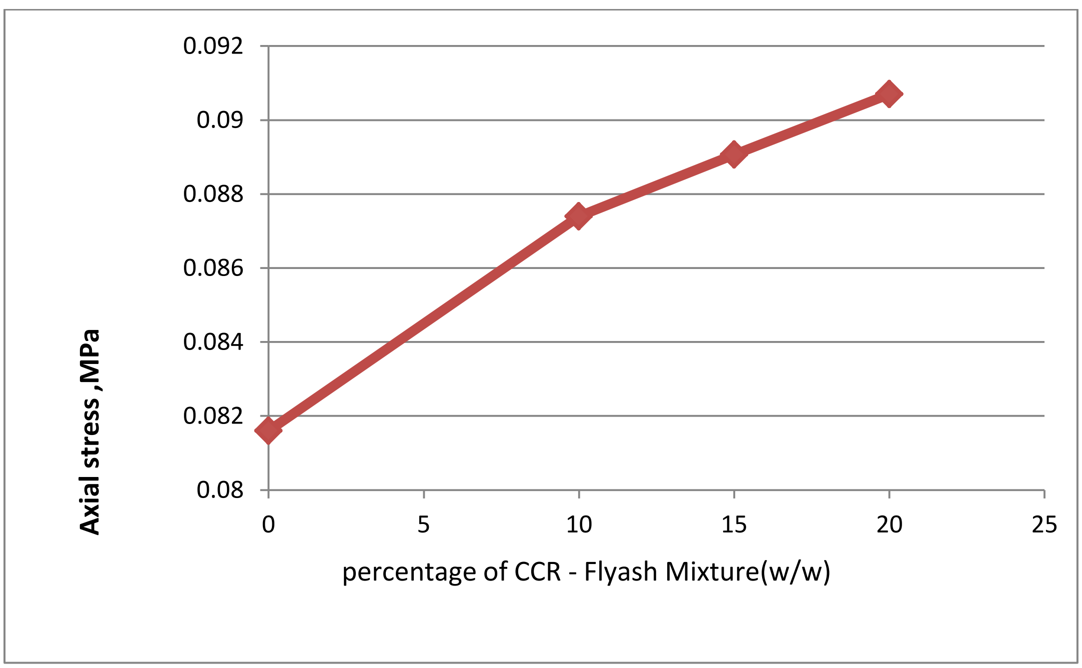


Fig.-47

SAMPLE 3

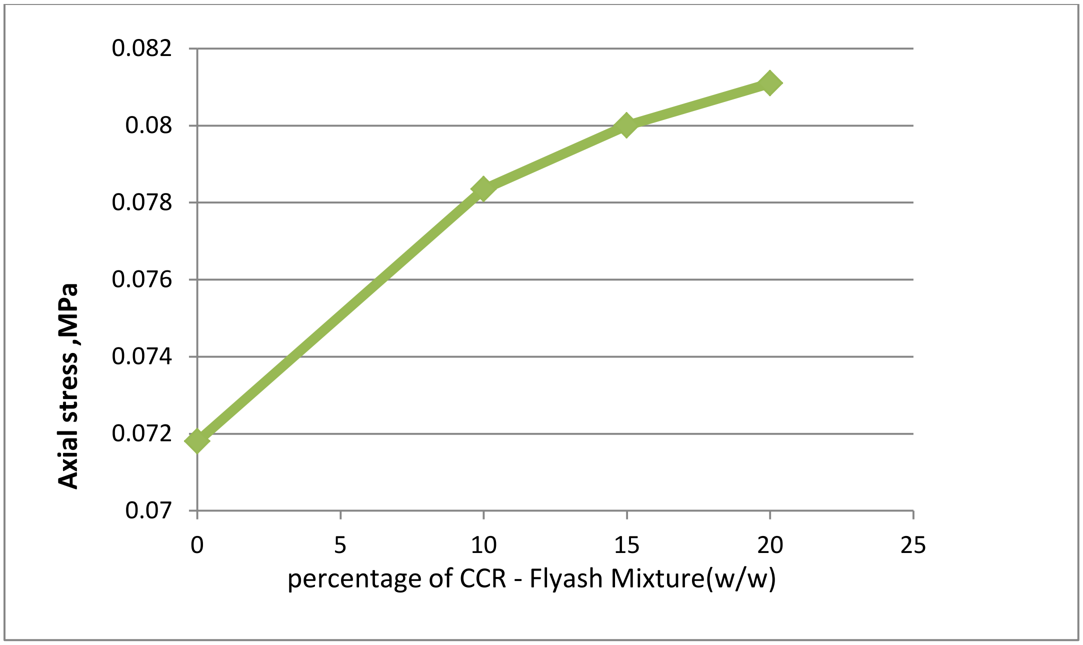


Fig.-48

- The unconfined compressive strength for sample 1 increased from 0.086 MPa to 0.095 MPa , a net of about 10.45%.
- The unconfined compressive strength for sample 2 increased from 0.0818 MPa to 0.0905 MPa , a net of about 11.024%.
- The unconfined compressive strength for sample 3 increased from 0.072 MPa to 0.081 MPa , a net of about 12.5 %.

The relationship between CBR (unsoaked) percentage and percentage of CCR-Fly Ash mixture :

SAMPLE 1

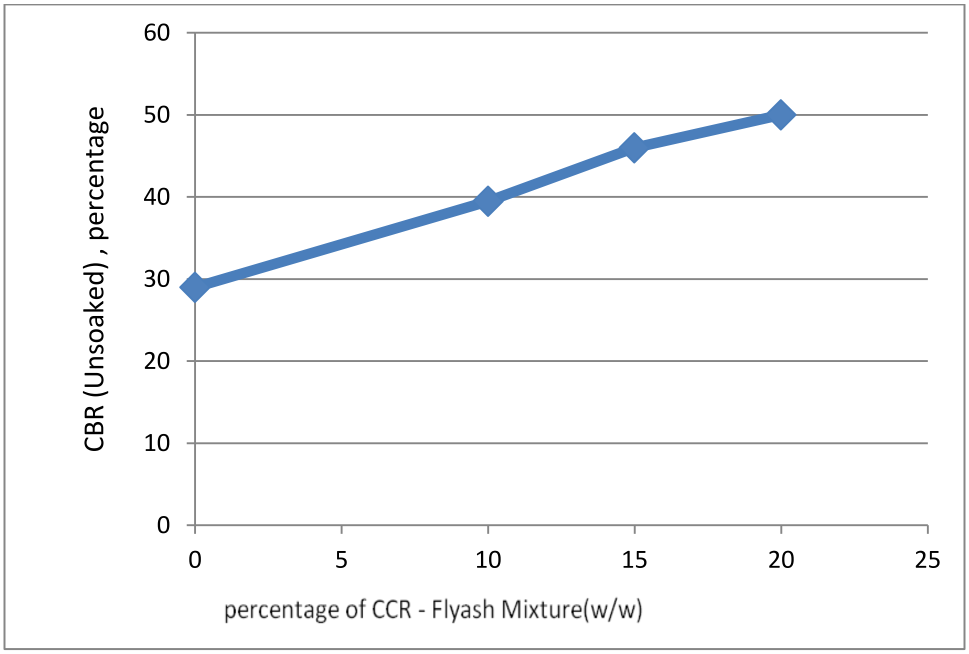


Fig.-49

SAMPLE 2

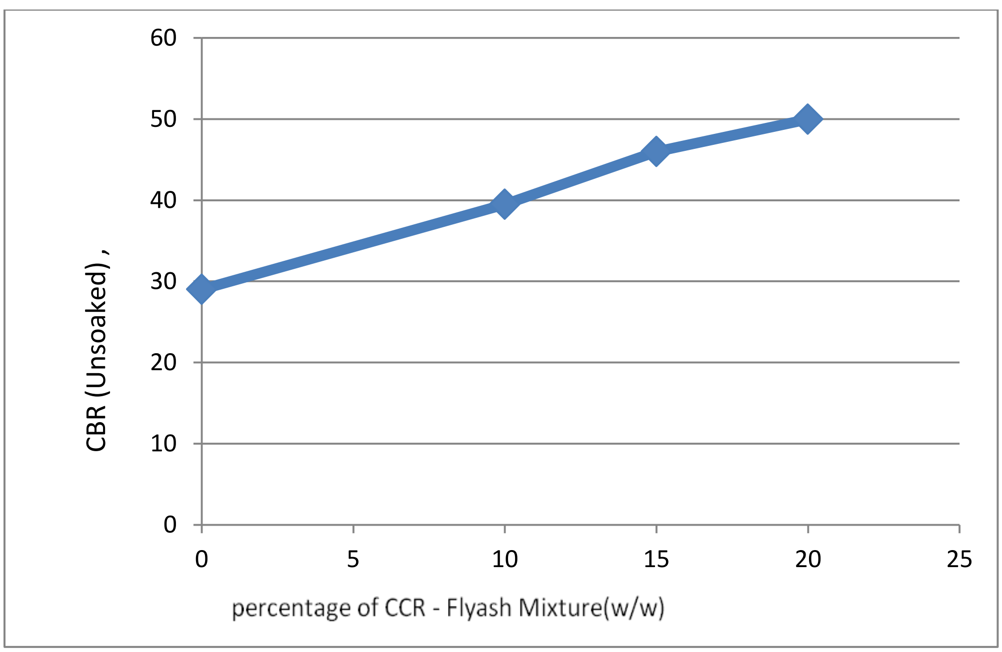


Fig.-50

SAMPLE 3

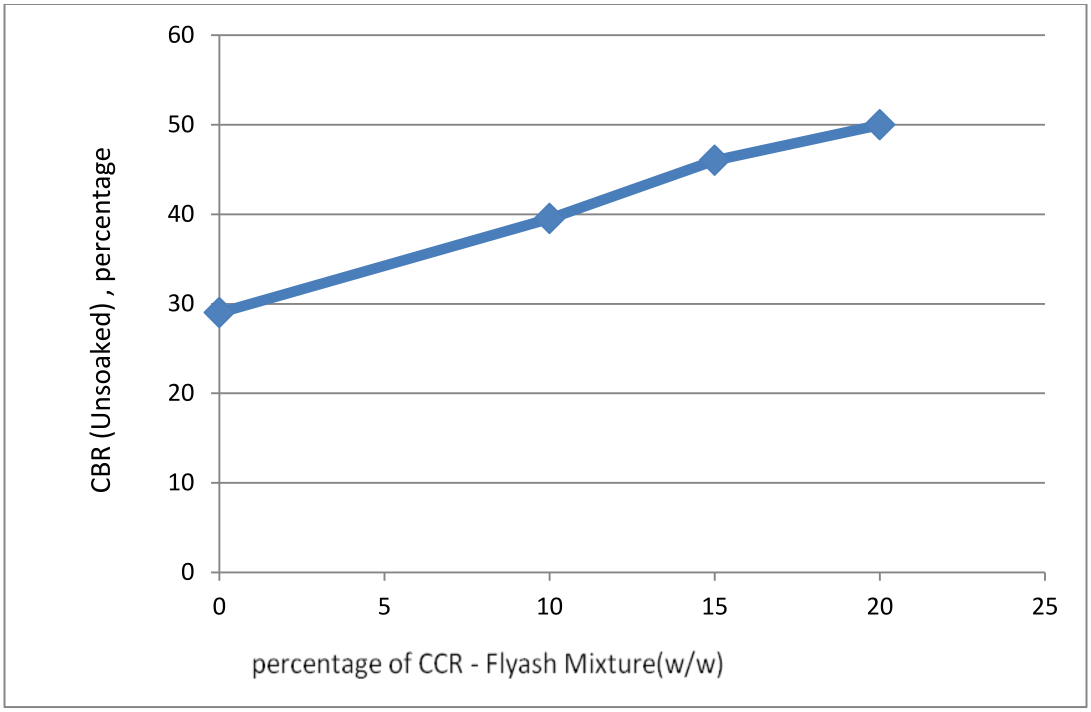


Fig.-51

- The CBR value for sample 1 increased from 29 to 50 kg , a net increase of about 72%.
- The CBR value for sample 2 increased from 25.7 to 39 , a net increase of about 52%.
- The CBR value for sample 3 increased from 35.5 to 58.5 , a net increase of about 65%.

4.8 CONCLUSIONS

- The soil taken from different site present in the same locality have different properties in general.
- The waste product i.e. Calcium Carbide Residue and Fly Ash can be used to increase the stability of soil.
- The ratio of CCR and FA in the mixture that will increase stability of soil at maximum extent is 70 :30.
- We had found a considerable increase in compressive strength and cohesion of soil after adding CCR and Fly Ash in the mentioned ratio.
- The amount of mixture of CCR and Fly ash added to the soil cannot be generalised but standard increment is observed till mixing 15-20 % of soil weight as further adding increase the strength in very small quantity which is not profitable at all.
- From all the work we had done so far we can conclude that waste materials Calcium Carbide Residue and Fly Ash mixture can be used to increase the strength of the soil which also decrease the environmental pollution cause by these two.

REFERENCES

- *Consoli, N. C., Prietto, P. D. M., Carroro, J. A. H., and Heineck, K. S.(2001). "Behavior of compacted soil-fly ash-carbide lime mixture."J. Geotech. Geoenviron. Eng., 127(9), 774–782.*

- *Jaturapitakkul, C., and Roongreung, B. (2003). "Cementing material from calcium carbide residue-rice hush ash." J. Mater. Civ. Eng., 15(5),470–475.*

- *Y. J. Du; Y. Y. Zhang; and S. Y. Liu (2009) "Investigation of Strength and California Bearing Ratio Properties of Natural Soils Treated by Calcium Carbide Residue " Geo-Frontiers Advances in Geotechnical Engineering Page no.-1237*

- *Horpibulsuk, S., Rachan, R., and Raksachon, Y. (2009). "Role of fly ash on strength and microstructure development in blended cement stabilized silty clay." Soils Found., 49(1), 85–98.*

- *Makaratat, N., Jaturapitakkul, C., and Laosamathikul, T. (2010). "Effects of Calcium Carbide Residue–Fly Ash Binder on Mechanical Properties of Concrete." J. Mater. Civ. Eng., 22(11), 1164–1170.*

- *Horpibulsuk, S., Phetchuay, C., and Chinkulkijniwat, A. (2012). "Soil Stabilization by Calcium Carbide Residue and Fly Ash." J. Mater. Civ. Eng., 24(2), 184–193*

- *Das B.M, 1992, Fundamentals of Soil Dynamics, Elsevier.*

- *Punmia B.C. 2007, "Soil Mechanics & Foundations" Laxmi Publications .*

- *Sen Arpan , Kashyap Rishabh (2012) " Soil stabilization using waste fibre materials" B Tech thesis , NIT Rourkela .*

IS code Referred :

- *IS: 2720 (part16) - 1987-Laboratory Determination of CBR.*
- *IS: 2720 (part 4)- 1985- Grain size Analysis.*
- *IS: 2720(part 7)- 1980 – Compaction Test*
- *IS:2386 (part 3) – specific gravity*
- *IS: 2720 (part 13) Direct shear test.*
- *IS: 2720 (part 10)-1991- Un Confined Compressive Test*