"STUDY ON STRENGTH PROPERTIES OF SOIL USING WASTES AS STABILIZING MATERIAL"

A PROJECT

Submitted in partial fulfillment of the requirements for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

Under the supervision of

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To

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HIMACHAL PRADESH
May,2017

Dedicated to Our Families

CERTIFICATE

This is to certify that the work which is being presented in the project report titled **"Study On Strength Properties Of Soil Using Waste as Stabilizing Material"** in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology in Civil Engineering and submitted to the Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat is an authentic record of work carried out by **Shubham Kumar(131629) , Ajay Sharma(131689)** and **Prince(131609)** during a period from July 2016 to December 2016 under the supervision of **Dr. Ashish Kumar**, Associate Professor, Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat.

The above statement made is correct to the best of our knowledge.

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DECLARATION

We hereby declare that the project entitled **“Study on strength properties of soil using waste as stabilizing material.”** Submitted by us to Jaypee university of information technology, waknaghat in partial fulfillment of the Degree of Bachelor of Technology in Civil Engineering is a record of bonafide project work carried out by us under the guidance of **Dr. Ashish Kumar**. The information submitted herein is true and original.

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The prospect of working in a group with a high level of accountability fostered a spirit of team work and created a feeling of oneness which thus expanded our range of vision, motivated us to perform to the best of our ability and create a report of highest quality. To do best quality work, with utmost sincerity and precision has been our constant Endeavour. We extent our deep appreciation and thanks to the authors of various research papers which are referred in order to do this project.

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Abstract

Soil is the basic foundation for any civil engineering structure. It is required to bear the loads without failure. In some places, soil may be weak which cannot resist the oncoming loads. In such cases, soil stabilization is needed. Numerous methods are available in the literature for soil stabilization. But sometimes, some of the methods like stabilization by using plastic waste, brick powder, glass powder etc. adversely affect the composition of the soil the material.

In this study, plastic waste, brick powder and glass powder were mixed with soil to investigate the relative strength gain in terms of shear strength. The effect of these materials on the geotechnical characteristics was investigated by conducting Standard Proctor compaction tests and direct shear test. The tests were performed as per Indian Standard specifications.

The following materials were used for preparing the samples:

i. Soil
ii. Plastic
iii. Brick powder
iv. Glass Powder

The soil used for these experiments was brought from a site, Dehlan near Una. The physical properties of the soil were determined as per IS specifications.

In this test program, without additives soil was tested to find the optimum moisture content, DST value, UCS, CBR. Materials were added in varying percentages and that fraction for which maximum strength is obtained was found out.

CHAPTER 1

INTRODUCTION

1.1 General:

The soil stabilization means to increase the stability of soil as well as bearing strength of the soil by the use of proper compaction, proportioning and or the addition of suitable stabilizer. The basic principles in soil stabilization are as follows:

1. Evaluating the properties of the given soil.
2. Selecting the method for the lacking property of soil by the effective and economical method of stabilization.
3. Designing the stabilized soil mix for stability and durability values.
4. Considering the construction procedure by compacting the stabilized layers.

1.2 History:

Many ancient cultures including the Chinese, Romans and other utilized various techniques to improve soil suitability, many of them were so useful that many of the buildings and other structure they constructed still exist today.

Soil stabilization is the permanent physical and chemical changes of soil to increase their physical and chemical properties. Soil Stabilization can increase the shear strength of a soil, thus improving the carrying capacity of a soil to support structure and foundations. Stabilization can be used to improve the sub-grade materials by expansive clays to granular materials. Stabilization can be achieved with a variety of materials. There are the different techniques to improve soil stabilization. This report presents the details of studies conducted on the possible use of waste materials for soil stabilization.

Waste such as plastic, brick and glass powder increases sub-grade stiffness and, it works as a strong foundation (capable to support and distribute loads under moist conditions). This report consists of summary of the usefulness of these materials used with soil.

1.3 SCOPE:

The soil used in the study has been taken from Dehlan (Una) Pavement subgrade over there is composed soil whose bearing capacity is extremely low. Due to this reason, the roads require maintenance to take up repeated wheel loads. This proves to be uneconomical and at the same time, condition of roads during rainy seasons is extremely poor. Soil stabilization can be done using various materials, but appropriate use of these materials which is a waste material from different location, at the same point of time difficult-to-dispose material will be much significant.

- To increase the shear strength of given soil.
- Reduction in settlement.
- Reduction in cracks formation in soil.
- To avoid disposal problems of plastic waste.

1.4 OBJECTIVES:

The major objectives of the project are:

1. To explore the use of plastic waste, used bricks and glass powder in the construction work.
2. To study the effect of these materials on the shear strength, and compressive strength of soil.
3. To find the optimum percentage by weight of soil of stabilizing materials.
4. Comparison between the materials on the basis of shear and compressive strength as well as individual comparison on the basis of their varying percentages.

1.5 APPLICATIONS:

1. Stabilization of landslides: To restore a failed slope, the soil is often substituted with a various type of soil with better geotechnical properties (HDPE), significantly increasing material costs and the environmental impact.

Fig 1.1: Stabilization of landslides

2. Retaining walls: Reinforced soil, due to the usage of HDPE geogrid is a technical and structural method to steel reinforced concrete. From an economical viewpoint a reduction in the overall construction costs of at least 35% can be achieved.

Fig 1.2: Retaining walls

3. Construction of road and railway embankments:

A road or railway embankment is normally a big structure, the construction of which always involves moving large amounts of soil normally of good quality.

It also causes inconvenience for the community, both in terms of land and the environmental impact such a structure has. Global warming is the main issue of decay of plastic which has to be deal with the future of next generation. Pollution play a vital role specially solid waste i.e. Plastic waste which is the major source of solid waste pollution. Each year more than 550 billion plastic bags are used which is a reason of environment concern. It produce very harmful chemicals & directly affect the humans and animals, so focus to solve the problem and use the solid waste as a reinforcing material.

To limit costs, it's necessary to construct road embankments having steeper slopes, or else to construct them having the same shape but using economical or easily available on-site fill soil with poor mechanical properties. The geogrids are used for construction of steep slopes, still guaranteeing performances within the safety factor.

Fig 1.3: Construction of a road embankment

Fig 1.4: Construction of a railways embankment

CHAPTER 2

LITERATURE REVIEW

2.1 Literature review:

Soil Stabilization is the process of mixing materials with a soil to improve basic properties of the soil. The process may include the mixing of soil to achieve a desired strength.

Additives that may change the gradation, texture and plasticity, or act as a binder for confinement of the soil. Process of decreasing plasticity and to improve the texture of a soil is called soil modification. Soil stabilization includes the effects from improvement with a remarkable additional strength.

Use of stabilizing material in soil has been advocated by several researchers for improving some specific properties of soil.

Soil stabilization using powdered glass by researchers **(J. Olufowobi, A. Ogundoju, B. Michael in 2007**) with different %age of glass powder 1%, 2%, 5%, 10% and 15% by weight of soil has been done. Various tests like moisture content, specific gravity, particle size distribution tests were performed to classify the soil. CBR and direct shear tests were performed on the soil with and without the addition of the powdered glass. Results showed increase in the maximum dry density values on addition of the powdered glass and with corresponding gradual increase up to 5% glass powder content after which it started to decrease at 10% and 15% powdered glass content. The highest CBR value of 14.90% were obtained at 5% glass powder content.

Sand stabilized with glass fibers (**Shivanand Mali, Baleshwar Singh, IIT Guwahati 2005**). The soil was brought from the nearby bank of Brahmaputra River. Synthetic glass fibers of 25 mm length were added in the soil sample. Five fiber contents (1%,2%, 3%, 4% and 5%) by dry weight of soil were used with three different relative densities (50%,65% and 82%) of the soil**.** As the fibers content increases, the contribution of the relative friction becomes larger.

Soil reinforced using plastic waste (**International Journal of Research in Engineering and Technology**). The plastic collected from used plastic chairs are collected and are made into various strips. CBR test was conducted to obtain the CBR Value on the samples with plastic strips on different percentages of 2, 4, 6, 8 and 10 and the results obtained are represented as load vs penetration graphs. From the results obtained, it is evident that waste plastic increases the CBR value of soil. There is a major increase in CBR value when the soil is mixed with plastic strips and compared to that of soil with no plastic.

Behavior of Soils Stabilized by Plastic Waste Materials **Building and Construction Engineering Department, University of Technology, Baghdad**. The material used in the study as plastic waste is taken from the General Company for Plastic Industries in Baghdad. The plastic is cut into circular pieces (1-3) mm diameter and 5mm thick. Direct shear test is done on Stabilized soil. Results shows that the %age of increase in friction angle for sandy soil lies between (14.5%) to (47.6%) is more than that of clayey soil which ranges from (14.5%) to (52.5%).

Soil reinforced by early Indian methods i.e. used bricks (**R.P .Kulkarni, Maharashtra Engineering Research Institute, Nasik, Maharashtra**). Bricks of twelve angular (25cm) and also the utensil ukha was used to stabilize the soil. These moulds were placed along with wooden pieces, bricks and ukha are burnt for 24 hours.

The floor of burnt brick is called Surkhi, Bricks prepared from soil stabilised by addition as were known to be strong than those prepared from soil which is not stabilise in this manner. There is a increase in CBR value when the soil is mixed with brick powder and compared to that of soil without brick powder.

Soil structure

The sand particles in the soil are arranged in two ways sheet like structures composed of tetrahedral silica and octahedral alumina. The sheets form various combinations, but there are three main types of formations. kaolinite, which consists of alternate silica and alumina sheets which are bonded together. That form of structure is stable and does not swell when wetted Montmorillonite, which is composed of two layers of silica and one alumina sheet having a weak bond between layers.

Weak bonding between these layers allows water and other cations to enter between the layers, results in swelling in the clay particle Illite which is very similar to montmorillonite, has potassium ions between layers which help in bonding the layers together. Inter layer bonding illite is therefore stronger than that of montmorillonite, but weaker than that of kaolinite. Clay particles are small in size but have a less density, results in a large surface area for interaction with water and cations, the clay particles have negatively charged surfaces which attract cations, polar molecules, water forming a bound water layer around the negative charged clay particles. The amount of water covering the clay particles is same as that of the amount of water that is available for the clay particle to take in and release. This moisture variation over the clay particles causes increase in volume and swelling pressures within clays that are confined.

2.2 Uses of stabilization

Pavement design depends on the fact that minimum structural quality will be gained by each layer of material in the pavement system. Each layer should resist shearing, resist excessive deflections which cause fatigue cracking within the layer or in overlying layers, and avoid excessive permanent deformation through densification. Because of increase in quality of a soil layer, the carrying capacity of layer to spread the load over a greater area is increased in order to have reduction in the thickness of the soil and surface layers may be allowed.

(i) Quality improvement

The improvement gained by stabilization includes proper soil gradation, decreasing the plasticity index or swelling potential, and enhance the durability and strength. In moist condition, stabilization may also be used to give a working platform for construction process. The soil quality improvement is termed as soil modification.

(ii)Thickness reduction

The two major factors strength and stiffness of a soil layer can be improved by the use of stabilizers to allow a reduction in thickness of the stabilized material compared with an un-stabilized or unbound material.

2.3 STABILIZATION TECHNIQUES:

1. Soil stabilization with Plastic material:

Today, due to the growing population and development activities, it results in discharge of large amount of wastes. Disposal of these different wastes produced by different industries and urban areas has become a problem. These materials are non-biodegradable causing environmental threat by polluting the surroundings. “Waste plastic is one type”, which is normally used for shopping carry bags, storage and marketing for different purposes due to its most useful character of small volume and weight. Most of these plastics are specifically made for one time use, having small life span and are being thrown immediately after use. Though, at various places waste plastics are collected for recycling or reuse purposes, but however; the secondary markets said that plastics have not developed as recycling program. Therefore, the quantity of plastics which is being currently reused and recycled is just a fraction of the total volume produced per year. The estimated municipal solid waste production in India up to the year 2002 was of the order of 40 million tons per year. From this plastic constitute around 5 % of the total waste.

With these few reasons stated above, it is very needful that we find ways to re-utilize these plastic wastes. So, the investigation and attempt has been made to show the potential of recycled plastic wastes as soil reinforcement for improving the strength of soils.

Plastic material can be used to modify and improve the properties of the soil into by increasing its strength and durability. The quantity of material added will depend upon the factor that the soil is to be modified or stabilized. The stabilization method is most commonly used for stabilizing soil. Stabilization of soil with plastic has been widely used in road construction.

Fig 2.1: Plastic strips

2. Soil stabilization with Brick Powder:

Soil Stabilization using brick powder as a stabilizing agent is an ancient Indian method. In this study, the results of brick powder on sandy soil is calculated. It determines the strength of soil in its both state that is natural state as well as when mixed with different proportion of brick dust (from 0 to 21%).

Addition of brick powder lowers its liquid limit, plasticity index and shrinkage index, increase its plastic limit and shrinkage limit. The brick powder is added in such a way that the effectiveness as well as bearing strength of the sandy soil increases.

Fig 2.2: Surkhi

3. Soil stabilization with Glass Powder:

Ecological and environmental importance of different materials includes:

(i) the movement of non-recycled waste generated from landfills for useful applications.

(ii) the reduction in ill effects of producing cement powder, namely use of non-renewable resources.

(iii) the reduction in the use of resources for cement production process.

The economic benefits of using various materials were found in situations where the cost of the optional material is less than cement powder while giving comparable performance. The cost must take into account the source of the alternative material.

Glass is a 100 % recyclable material; According to EPA statistics, the municipal solid waste (MSW) stream in the India contains around 5.32 % of waste glass or 12.57 million tons. In 2004, just 19.8 % of this sum is reused. So, except clear linear forwardness of glass recuperation, its recycling rate is the lowest, compared to normal MSW recuperation level 30.68%.

Fig 2.3: Glass Powder

CHAPTER 3

EXPERIMENTAL PROGRAM

3.1 General:

In this chapter, a wide variety of different experiments has been performed on soil and the same stabilized using plastic materials, brick powder and glass powder and are explained.

Experiments such as specific gravity, sieve analysis, standard proctor test have been done to find out the index properties of soil. To increase the load carrying capacity of soil, different percentages of stabilizing material such as plastic waste, brick powder and glass powder have been added into the soil and various tests have been performed.

3.2 MATERIALS USED

1. Soil:

Soil which is used to perform the project work has been taken from Dehlan (Una). After performing sieve analysis as per (3.4.1), result shows that the soil over there is well graded sand. Various tests like Direct shear test, Unconfined compression test, California bearing test have been done on soil with varying percentages of plastic waste, used bricks and glass powder as stabilizing materials.

Table 1: Properties of Soil

Sr. No.	**Materials**	**Property**	**Value**
1	**Soil**		
		Specific Gravity	2.678
		Coefficient of uniformity	6.1
		Coefficient of curvature	1.05
		%passing 75 micron	18%
		classification	SW
		dry density	1.7 g/cc
		Omc	22%

2. Additives:

The stabilizers/additives used for soil stabilization and improvement include plastic materials, brick powder and glass powder. The soil was mixed with the stabilizers for which there are expectation of increasing its soil properties. The amount of additive used was found based on factor of testing the soil strength for addition of different percentages and selecting the one with more strength.

Table 2: Physical properties and chemical composition of material used

1	**Plastic**		
		average length	12 mm
		fusion point	165℃
		burning point	590°C
		modulus of elasticity	3500Mpa
		Breaking tensile strength	350 Mpa
		unit weight	0.91 g/cc
		Thickness	0.03 mm
2	**Glass**		
		Density	2500 Kg/m^3
		compression resistant	800 Mpa
		E	70000 Mpa
		Bending strength	45 Mpa
		softening temperature	6000 °C
		specific gravity	2.71
3	**Surkhi**		
		% passing 75 micron	17%
		specific gravity	2.57

3.3 Test on soil and material:

3.4 Specific gravity test

The specific gravity of a soil is the ratio of the mass of a given volume of the material at a standard temperature to the mass of an equal volume of de-aired or gas-free distilled water at a standard temperature. The specific gravity of a soil is used for the phase relationship of air, water, and solids in a defined volume of the soil sample.

Test Procedure

- First weight ‘W1’ of the specific gravity bottle.
- Transfer the oven dried sample to the specific gravity bottle (about 50gm, about 10-20gm when 50cc stoppered bottle is used or 100gm when 500ml bottle is used.
- Weigh the bottle ‘W2’ with the soil sample.
- Add distilled water in the bottle to fill nearly three fourth of the bottle.
- Remove the entrapped air by subjecting the sample in vacuum or by boiling in a sand-bath till all the air bubbles removed while occasionally rolling the bottle to assist in removal of air.
- Then cool it to the room temperature and fill the bottle with distilled water up to the mark and clean and dry the outside surface with a clean, dry cloth and note down the temperature.
- Determine the weight of the bottle with water and soil, ‘W3’
- Then remove the soil and water from the bottle and thoroughly clean it
- Again weigh ‘W4’ after filling with distilled water up to the mark and drying outside
- From the data obtained from above, determine specific gravity of the soil.

3.4 Details of testing:

The various tests conducted on the sample are as follows:

3.5.1 Sieve Analysis

3.5.2 Standard proctor’s test

3.5.3 Direct shear test

Firstly, the above tests were conducted on soil sample to determine its properties DST test is conducted to determine its strength. Thereafter, some percentages of materials used are added to the soil sample to stabilize it. And the % of the additives gives the optimum strength to the soil are taken by performing DST test on them.

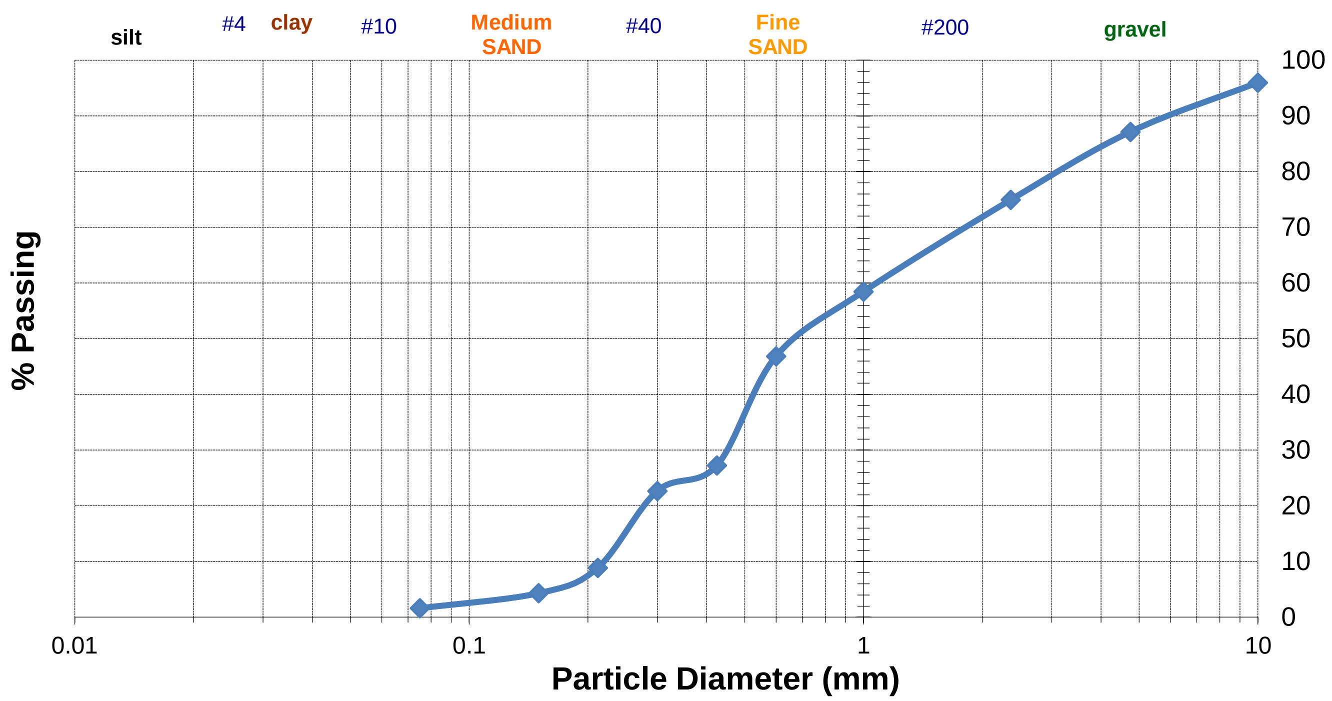
Soil preparation:

The soil was taken from site in large amount. It is taken to the laboratory and dried in oven for 24 hours in pans. This soil due to loss of water formed big lumps which is broken to smaller pieces or even fine powder and is sieved according to the needs of various experiments.

3.4.1 Sieve Analysis:

It is a procedure used to find the particle size distribution (called *gradation*) of a granular material.

It can be done on any non-organic or organic granular materials including sands, crushed rock, clays, granite, coal, soil a wide range of manufactured powders, grain and seeds, down to a minimum size depending on the perfect method. Due to this simple technique of particle sizing, it is probably the most common method.



Sieve Analysis Data

Cu=D60/D10=6.1
Cc=D30^2/(D60*D10)=1.05

Test Procedure

Soil passing 4.75mm I.S. Sieve and retained on 75micron Sieve contains no of fines.

Those soils can be directly dry sieved rather than wet sieving.

Dry Sieving:

1. Take 500gm of the soil sample from the representative sample.
2. Perform sieve analysis using a set of standard sieves as given in the data sheet.
3. The sieving may be done in two ways i.e. hand or mechanical sieve shaker for 10min.
4. Weigh the material which is retained on each sieve.
5. The % of soil retained on each sieve is find by total weight of the soil sample taken.
6. From these results the percentage of soil passing through each sieve is calculated.
7. Draw the grain size curve for the soil in the semi-logarithmic graph paper provided.

Wet Sieving:

If the soil contains a considerable quantity (say more than 5%) of fine particles, a wet sieve analysis is required.

All lumps are broken into individual particles.

1. Take 500gm of oven dried sample and soaked the whole sample in water.
2. For heavy clays if deflocculation is used, 2% calgon solution is used instead of water.
3. The sample is agitated and soaked for period of 10 minutes.
4. The material is sieved by 75micron sieve.
5. It is washed so that the water filtered becomes clear.
6. The soil which is retained on 75 micron sieve is taken and dried in oven.
7. Sample is sieved through the shaker for 10 min and retained material is weighted.
8. The material that would have retained on pan is equal to the total mass of soil taken for dry sieve analysis minus the sum of the masses of material retained on all sieves.
9. Draw the grain size distribution curve for the soil in a semi-logarithmic graph paper.

Result: Cu=D60/D10=6.1

Cc=(D30^2/(D60*D10)=01.05

3.4.2 Standard proctor test:

This is used to measure the optimal moisture content at which a soil will become mostly dense and achieve maximum dry density.

Test Procedure

1. Take oven-dried sample, approximately 5 kg in the pan. Thoroughly mix it with sufficient water to dampen it with water content of 4-6 %.
2. Weigh the mould without base plate and collar. Fix the collar and the base plate. Place the soil in the Proctor mould and compact it in 3 different layers giving 25 blows per layer with the 2.5 kg rammer falling through each layer. The blows should be distributed uniformly over the surface of each soil layer.
3. Remove the collar from mould; trim the soil even with the top of mould using a straight edge and weigh it.
4. Divide the weight of the compacted soil specimen by 944 cc and note the result as the bulk density.
5. Remove the soil sample from mould and slice vertically and obtain a small sample for water content.
6. Thoroughly break the remainder of the material till it pass a no.4 sieve as judged by the eye. Add water in sufficient amount to increase the moisture content of the soil sample by one or two percentage and repeat the above procedure for each increment of water added to sample. Continue the series of determination till there is either a decrease or no change in the wet unit weight of the compacted soil sample.

Fig 3.1: Standard Proctor test

3.4.3 Direct shear test:

The concept of direct shear is easy and mostly recommended for granular soils, sometimes on soils containing some cohesive soil content also. The cohesive soils have issues in controlling the strain rate to drained or undrained loading. In granular soils, loading can always taken to be drained. A diagram of shear box shows that soil sample is placed in a square box which is divided into upper and lower halves. Lower section is fixed and upper section is pushed or pulled horizontally w.r.t to other sections; forcing the soil sample to shear/fail along horizontal plane separating into two halves. Under a defined Normal force, the Shear force is increased from zero till the sample is fully sheared.

Test Procedure

1. Check the inner dimensions of the sampler, and put all parts of the direct shear together.
2. Calculate volume of the sampler. Weigh the sampler also.
3. Place the soil into the sampler in three smooth layers (nearly 10 mm thick each before tamping). If dense sample is required, tamp the soil with equal number of blows in each layer for the desired density.
4. After compacting three layers, level the top layer and weigh the soil sampler with the soil. Find the weight of wet soil sample and calculate density of soil sample to confirm the obtainment of required density.
5. Place the soil sample inside the direct shear apparatus and put upper porous stone above, pressure pad and loading block on top of soil sample.
6. Adjust the dial gauge and proving ring to the zero position after setting up the specimen set up. Apply the required normal stress say 0.5 kg/$\boldsymbol{cm^2}$, add water at the top of direct shear box set up and wait for at least 25 minutes to ensure saturation and then remove the shear pin.
7. Note the final vertical dial gauge reading which measures the deformation in vertical direction due to saturation of soil.
8. Note the initial reading of the dial gauge and proving ring before starting the shearing procedure.
9. Check all adjustments to find that there is no connection between two parts except sand.
10. Fix the strain controlled frame to the desired strain rate. Start the motor. Note the reading of the shear force in proving ring w.r.t the change in horizontal dial gauge reading and vertical deformation in vertical dial gauge till failure occurs.
11. The steps from 1to 10 has to be repeated for other two normal stresses (1.0 kg/$\boldsymbol{cm^2}$ and 1.5 kg/$\boldsymbol{cm^2}$).

3.4.4 CBR test:

The California bearing ratio test is penetration test meant to find subgrade strength of roads and pavements. The results obtained by the tests are used with the empirical curves in determining thickness of pavement and component layers. This is the most commonly used for the design of flexible pavements.

TOOLS:

1. Cylindrical mould with inside diameter 150 mm and height 175 mm having a removable extension collar 50 mm height and detachable perforated bottom plate 10 mm thick.
2. Spacing disc 148 mm in dia and 47.7 mm of height along with handle.
3. Rammers of wt. of 2.6 kg and a drop of 310 mm, weight 4.89 kg with a drop 450 mm.
4. Weight annular metal weight and several slotted weights weighing 2.5 kg, 147 mm in dia, with a hole 53 mm in diameter.
5. Load machine. Having a capacity of at least 5000 kg and having a movable head or base which moves at a uniform rate of 1.25 mm/min. Complete using load indicating device.
6. Metal penetrating piston 50 mm dia and 100 mm in length.
7. Two dial gauges having reading to 0.01 mm.
8. Sieves 4.75 mm and 20 mm.
9. Mixing bowl, straight edge, scales soaking tank or pan, drying oven, filter paper and containers.

Dynamic Compaction

1. Take nearly 4.5 to 5.5 kg soil and mix it thoroughly with the desired water.
2. Fix extension collar and base plate on the mould. Insert the spacer disc on base. Put the filter paper on surface of the spacer disc.
3. Compact the mixed soil in the mould using light compaction or heavy compaction. For light compaction, compact it in 3 equal layers, each layer is given 55 blows using the 2.6 kg rammer. In heavy compaction compact it in 5 layers, 56 blows to each layer using the 4.89 kg rammer.
4. Remove collar and trim the soil.
5. Move the mould upside down and remove base plate and displacer disc.
6. Weigh it with compacted soil and then find out the bulk density and dry density.
7. Place filter paper on the top surface of the soil and then clamp the perforated bottom plate on to it.

8. Procedure for Penetration Test:

9. Put the mould assembly with weights on the penetration test machine.

10. Place the piston at the center of specimen with the least load, but it should not exceed 4 kg so that proper contact of the piston on the sample is made.

11. Move the stress and strain dial gauge to zero. Apply load on the piston to have penetration rate is about 1.25 mm/min.

12. Note load readings at penetrations of 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 4.0, 5.0, 7.5, 10 and 12.5 mm. Record maximum load and penetration occurs for a penetration less than 12.5 mm.

13. Remove mould from the loading equipment. Take 20 to 50 g of soil from the top 3 cm layer and find the moisture content.

Fig3.2: CBR test

3.4.5 UNCONFINED COMPRESSION TEST

The UCS test is the most popular method soil shear testing because it is the fastest and economical methods to find shear strength. The method is used mainly for saturated, cohesive soils from thin-walled sampling tubes. The unconfined compression test is not appropriate for dry sands and crumbly clays because the materials will fall apart without land of lateral confinement.

PROCEDURE

1. The procedure is to examine loading frame. Rotate the crank and read the load and deformation dial gages. Find the calibration constant for the proving ring and the units of the deformation dial gauge.
2. Shear the samples at a strain rate of 1% per minute. From the length of soil sample, find the deformation at 1% strain.
3. Find the initial height and diameter of the sample with calipers. Find the weight of the sample and determine the total unit weight.
4. Put the soil sample on the loading frame, place the proving ring and zero dials.
5. Readings should be taken at strains of 0,0.1,0.2, 0.5, 1,2,3,4,5,6,8, 10, 12 14, 16, 18 and 20 percent.
6. Note readings of force (F) taken from the proving ring dial gauge and stress on the ends of the sample is computed. Shear the soil sample at a strain rate of 1% per minute.
7. Remove the loading frame and find the water content of the soil sample.

Fig3.3: UCS test

Table 3.1: Details of Experimental Specimen

S.No.	Name of Test	IS Code	% of material added			No. of Experiments
			Plastic	Surkhi	Glass	
1	Direct Shear Test	2720-13-1986	0.105	10	5	3
			0.110	12.5	8	3
			0.115	15	10	3
			0.120	17.5		2
				20		1
						Total=12
2	Unconfined Compression Test	2720-10-1991	0.105	10	5	3
			0.110	12.5	8	3
			0.115	15	10	3
			0.120	17.5		2
				20		1
						Total=12
3	CBR Test	2720-31-1990	0.105	10	5	3
			0.110	12.5	8	3
			0.115	15	10	3
			0.120	17.5		2
				20		1
						Total=12

CHAPTER 4

ANALYSIS OF DATA AND RESULTS

4.1 General

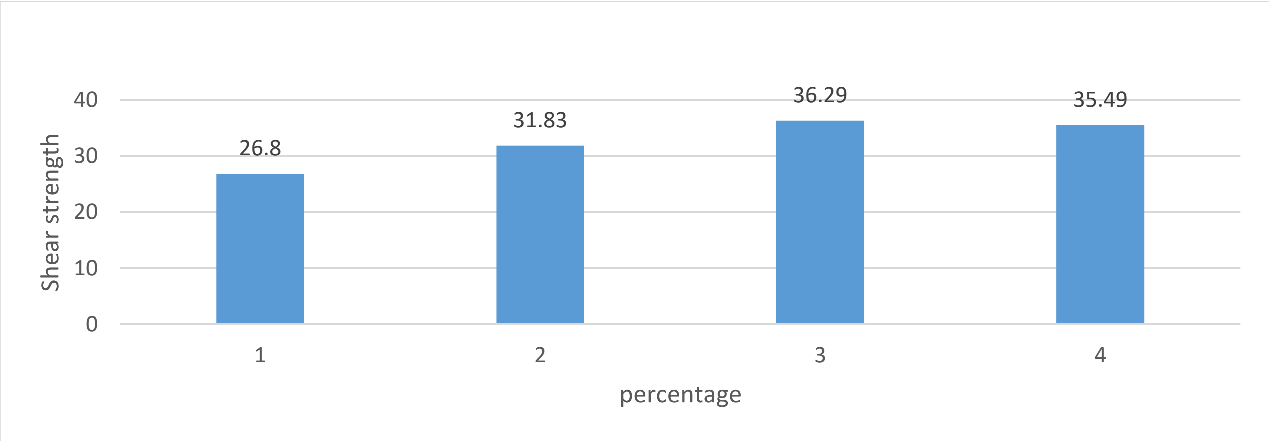
The main objective of the present study is to study the Strength Properties of Soil using waste materials for which a series of experiments were conducted. Particularly three main tests were conducted i.e. Standard Proctor's Test, Direct Shear Test, CBR, UCS in geotechnology Laboratory of Civil Engineering Department of Jaypee University of Information Technology, Waknaghat. The results were analysed and discussed as under.

4.2 Analysis of the Results

The analysis of the results that are provided in the annexure is given below and on the basis of those results, there is individual comparison of materials at their varying percentages and also there is comparison between the materials on the basis of their shear and compressive strengths.

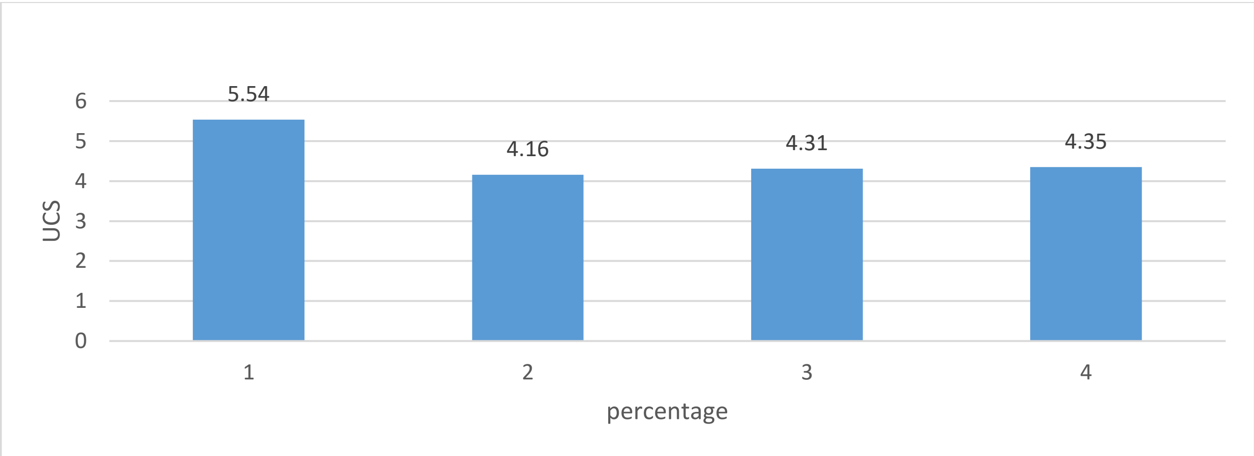
A.1 Strength comparison in plastic at different percentages.

A.1.1. Shear Strength Comparison.



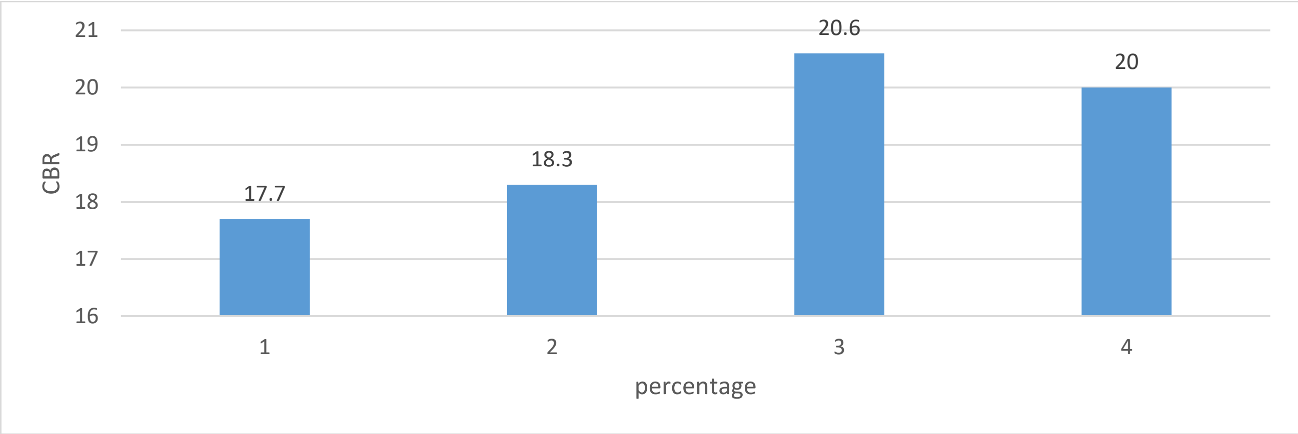
0.105%	**0.110%**	**0.115%**	**0.120%**

A.1.2. UCS Comparison.



0.105%	**0.110%**	**0.115%**	**0.120%**

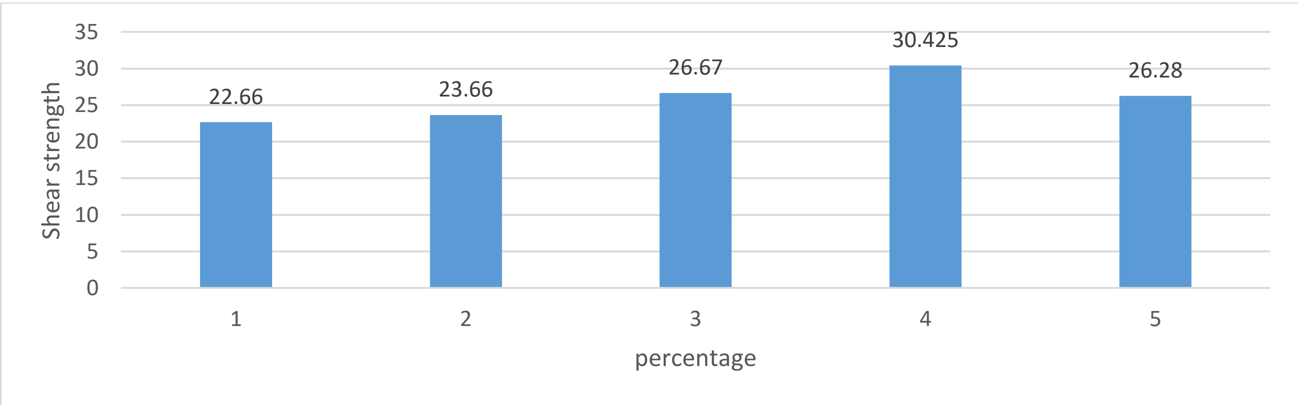
A.1.3. CBR Comparison.



0.105%	**0.110%**	**0.115%**	**0.120%**

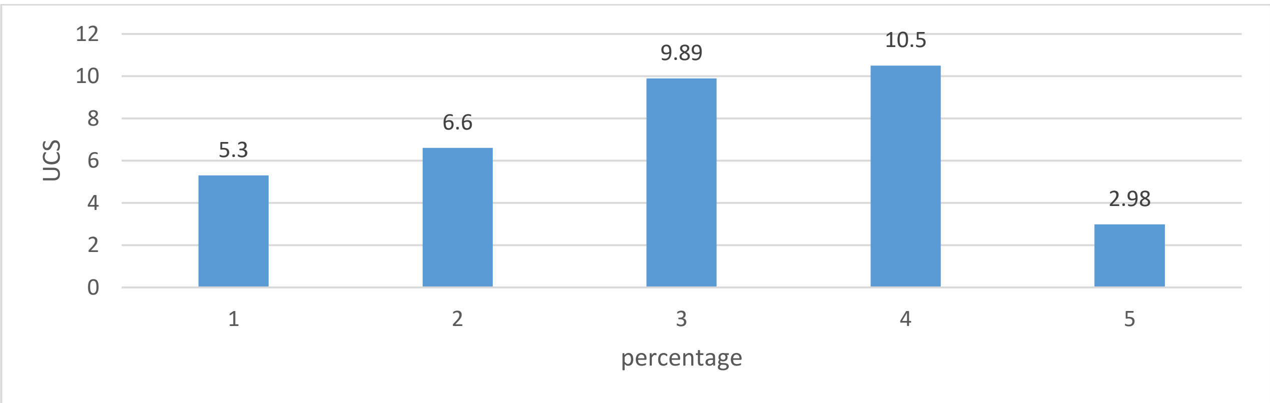
A.2 Strength comparison in Surkhi at different percentages.

A.2.1. Shear Strength Comparison.



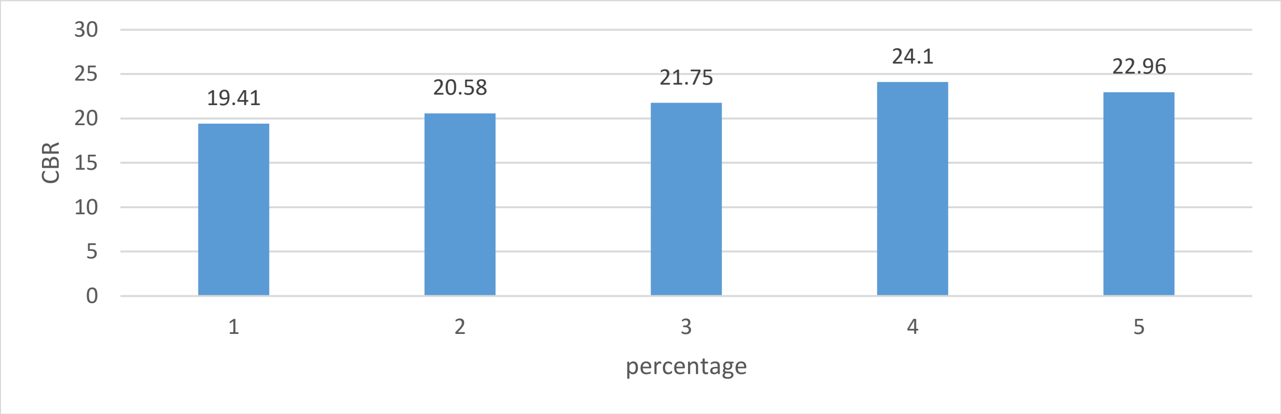
10%	**12.5%**	**15%**	**17.5%**	**20%**

A.2 .2. UCS Comparison.



10%	**12.5%**	**15%**	**17.5%**	**20%**

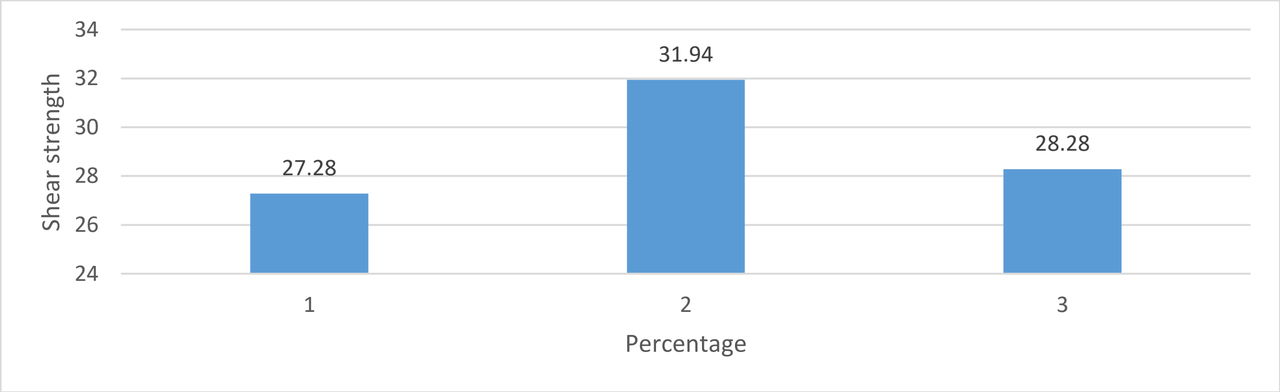
A.2.3. CBR Comparison.



10%	12.5%	15%	17.5%	20%

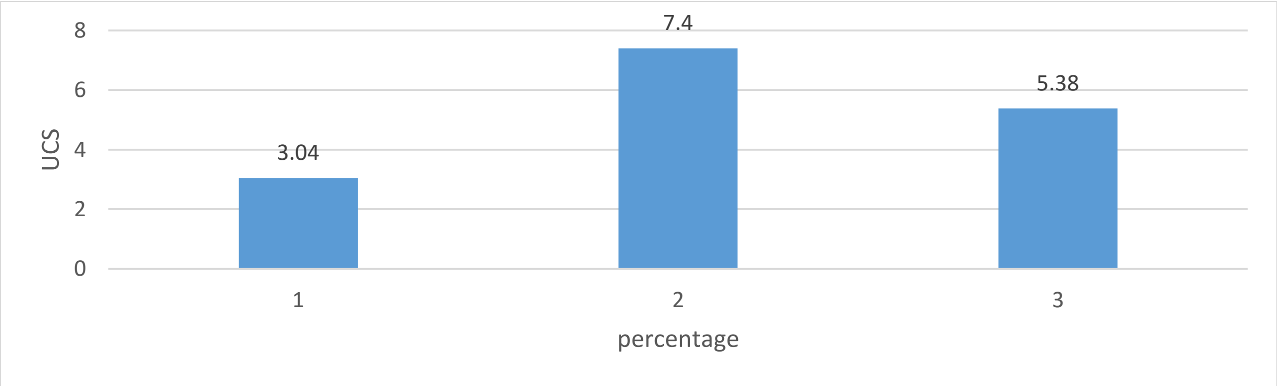
A.3 Strength comparison in Glass at different percentages.

A.3.1. Shear Strength Comparison.



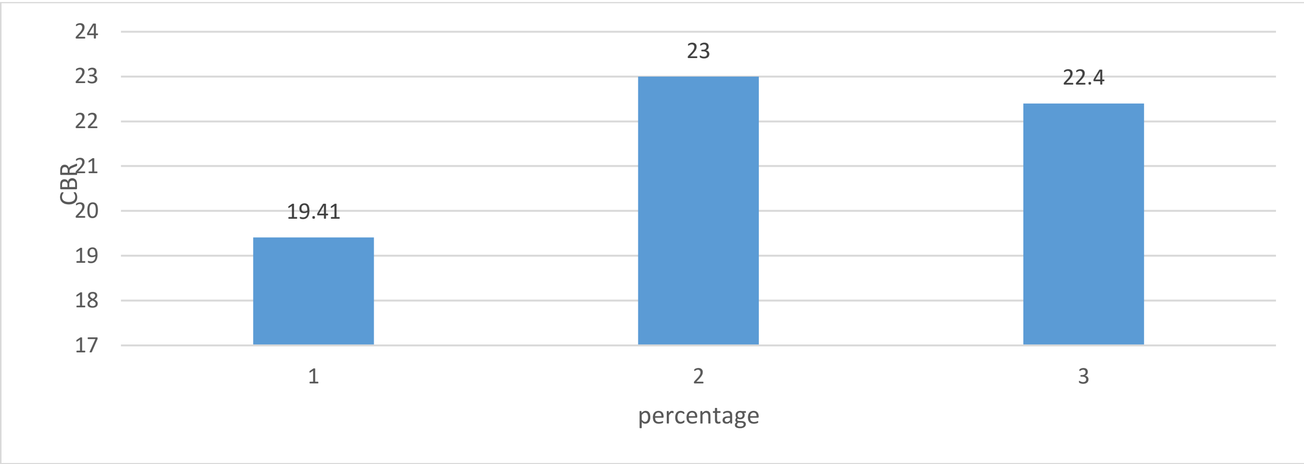
5%	8%	10%

A.3.2. UCS Comparison.



5%	8%	10%

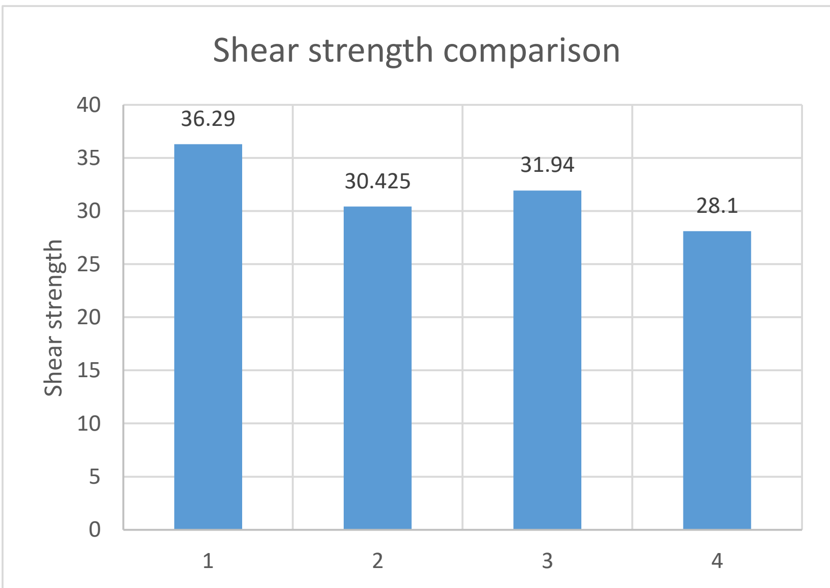
A.3.3. CBR Comparison.



5%	8%	10%

B.1 Comparison of Shear Strength of the normal soil and stabilized soil .

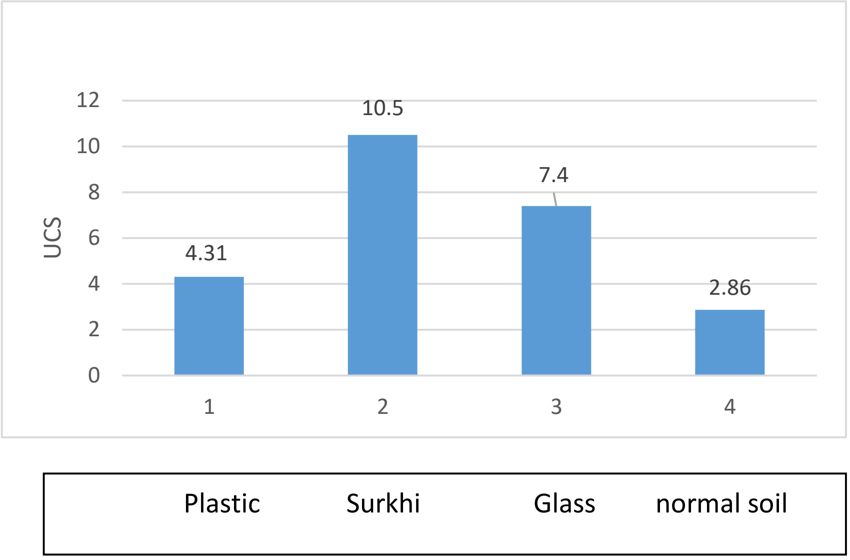
Stabilizing Material	Percentage (%)	Shear Strength (N/cm^2)
Plastic	0.105	26.8
Plastic	0.11	31.83
Plastic	0.115	36.29
Plastic	0.12	35.49
Surkhi	10	22.66
Surkhi	12.5	23.66
Surkhi	15	26.67
Surkhi	17.5	30.425
Surkhi	20	26.28
Glass	5	27.28
Glass	8	31.94
Glass	10	28.28
Simple Soil		28.1



Plastic Surkhi Glass normal soil

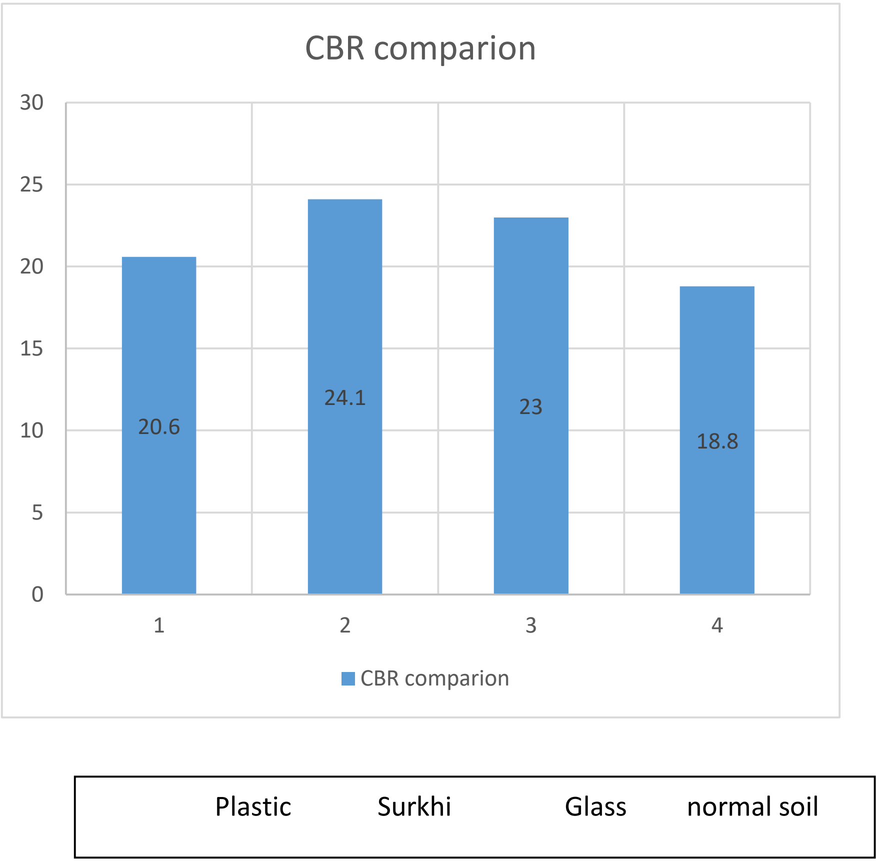
B.2 Comparison of the Unconfined compressive strength of normal soil and stabilized soil.

Stabilizing Material	Percentage (%)	Shear Strength (KN/m^2)
Plastic	0.105	5.54
Plastic	0.11	4.16
Plastic	0.115	4.31
Plastic	0.12	4.35
Surkhi	10	5.3
Surkhi	12.5	6.6
Surkhi	15	9.89
Surkhi	17.5	10.5
Surkhi	20	2.98
Glass	5	3.04
Glass	8	7.4
Glass	10	5.38
Simple Soil		2.86



B.3 Comparison of the CBR value of normal soil and stabilized soil.

Stabilizing Material	Percentage (%)	CBR(%)
Plastic	0.105	17.7
Plastic	0.11	18.3
Plastic	0.115	20.6
Plastic	0.12	20
Surkhi	10	19.41
Surkhi	12.5	20.58
Surkhi	15	21.75
Surkhi	17.5	24.1
Surkhi	20	22.96
Glass	5	19.41
Glass	8	23
Glass	10	22.4
Simple Soil		18.8



CHAPTER 5

CONCLUSION

Conclusion

Different types of materials are available and are used to increase strength of soil. Many past studies have been done on use of waste materials in soil. The materials which we have used mainly leads to increase in strength of soil.

In the present study we have used plastic strips, Surkhi and glass. After conducting the experiments to calculate the shear strength of soil following conclusions have been drawn:

1. The addition of plastic strips at optimum percentage (0.115%) in soil leads to increase in shear strength of soil by 1.292 times.
2. The addition of Surkhi at optimum percentage (17.5%) in soil leads to increase in shear strength of soil by 1.083 times.
3. The addition of glass at optimum percentage (8%) in soil leads to increase in shear strength of soil by 1.136 times.
4. The addition of plastic strips at optimum percentage (0.115%) in soil leads to increase in unconfined compressive strength of soil by 1.612 times.
5. The addition of Surkhi at optimum percentage (17.5%) in soil leads to increase in unconfined compressive strength of soil by 3.671 times.
6. The addition of glass at optimum percentage (8%) in soil leads to increase in unconfined compressive strength of soil by 2.59 times.
7. The addition of plastic strips at optimum percentage (0.115%) in soil leads to increase in CBR of soil by 1.1 times.
8. The addition of Surkhi at optimum percentage (17.5%) in soil leads to increase in CBR of soil by 1.282 times.
9. The addition of glass at optimum percentage (8%) in soil leads to increase in CBR of soil by 1.223 times.

Discussion of Results :-

From the above results, it can be interpreted that addition of plastic strips at its optimum increases shear strength more as compared to other two (Surkhi and glass).
And similarly for UCS, it can be interpreted that Surkhi at its optimum increases the strength more as compared to other two. Also for the CBR value, it can be interpreted that Addition of Surkhi at its optimum increases CBR more than other two. The application of these material depends on the type of strength required. e.g. In case of road pavements CBR can be enhanced by addition of Surkhi.

ANNEXURE 1

Experiment Reports

A. Specific Gravity of Simple Soil

$$G = \frac{W4-W1}{(W4-W1)-(W3-W2)} = 2.678$$

Sr.no.	Details	Result
1	Specific Gravity (Density Bottle)	Weight (gm)
2	W1 (empty bottle)	27
3	W2 (with water)	79
4	W3 (water + soil)	83.7
5	W4 (bottle + soil)	34.5

Table 3 Data For Specific Gravity of Simple Soil Calculations:

B. Sieve Analysis of Soil

Sieve Analysis Data Sheet							
Experiment Location:	sieve analysis Dehlan						
	Weight of Container (g):	400.0	**Weight of Container & Soil (g):**		2400g		
	Weight of Dry Sample (g):	2000g					
	Diameter (mm)	**Mass of Sieve (g)**	**Mass of Sieve & Soil (g)**	**Soil Retained (g)**	**Soil Retained (%)**	**cumulative**	**Soil Passing (%)**
Sieve Number	**10**	**370**	**435.5**	**65.5**	**3.275**	**3.275**	**96**
1	4.75	370	561.4	191.4	9.57	12.845	87.155
2	2.36	370	614.6	244.6	12.23	25.075	74.925
3	1.00	370	698.8	328.8	16.44	41.515	58.485
4	0.60	370	602.6	232.6	11.63	53.145	46.855
5	0.43	370	761.5	391.5	19.575	72.72	27.28
6	0.300	370	462	92.0	4.6	77.32	22.68
7	0.212	370	645.8	275.8	13.79	91.11	8.89
8	0.15	370	461.4	91.4	4.57	95.68	4.32
9	0.035	370	424	54.0	2.7	98.38	1.62
10	Pan	370	402.3	32.3	1.615	100	0
11							

Table 4 Data For Sieve Analysis of Simple Soil

Cu=D60/D10=6.1
Cc=(D30)^2/(D60*D10)=1.05

ANNEXURE 2

Experiment:-Direct Shear test on soil with 0.105% Plastic content.						
1.	**Stabilizer**-Plastic	**4.**	**Strain Rate**-1.25 mm/min	**7.**	**IS:2720:1986-13**	**D1**
2.	**Mould vol.**-6x6x2.5cm	**5.**	**Soil origin**- Una (H.P)	**8.**	**Fig**.-1,2	
3.	**Machine**-DST digital	**6.**	**Max Stress**-26.8 N/cm^2	**9.**	**Table**-5-6	

Shear Force(N)	**Displacement(mm)**	**Shear Stress (N/cm^2)**	**Shear Strain**
A	**vertical load**	**39.215 N/cm^2**	
224.00	1.00	14.93	0.02
375.00	4.00	25.00	0.07
390.00	7.00	26.80	0.12
380.00	10.00	25.57	0.17
Max shear stress		26.8 N/cm^2	
B	**vertical load**	**29.43 N/cm^2**	
130.00	1.00	8.67	0.02
235.00	4.00	15.67	0.07
250.00	7.00	17.94	0.12
245.00	11.00	17.47	0.18
Max shear stress		18 N/cm^2	
C	**vertical load**	**14.715 N/cm^2**	
155.00	1.00	10.33	0.02
185.00	4.00	12.33	0.07
220.00	8.00	14.67	0.13
218.00	9.00	14.53	0.15
214.00	12.00	14.27	0.20
Max shear stress		14.66 N/cm^2	

Table -5

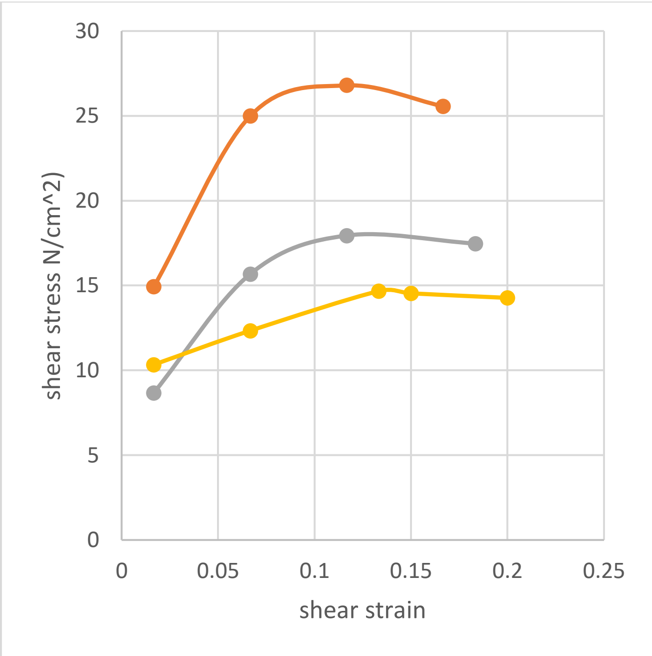


Fig.-1

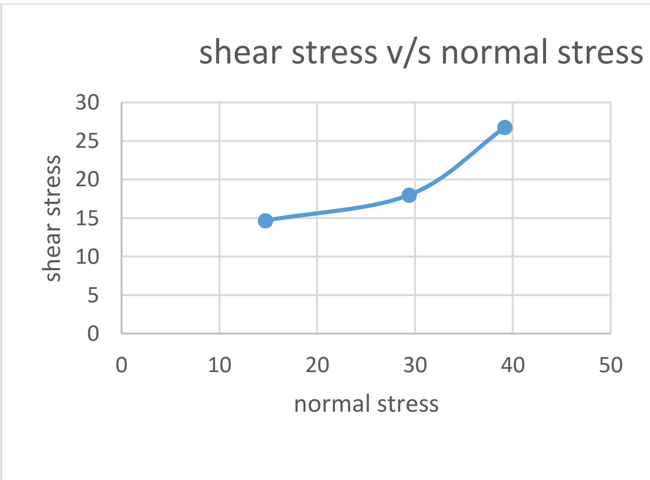


Fig.-2

Results			**Shear Strength**
1	**C**	**6 N/cm^2**	**$\tau = \sigma \tan\phi + C$**
2	**ϕ**	**28°**	**26.85 N/cm^2**

Table-6

Experiment:-Direct Shear test on soil with 0.110% Plastic content.						
1.	**Stabilizer**-Plastic	**4.**	**Strain Rate**-1.25 mm/min	**7.**	**IS:2720:1986-13**	**D2**
2.	**Mould vol.**-6x6x2.5cm	**5.**	**Soil origin**- Una (H.P)	**8.**	**Fig**.-3-4	
3.	**Machine**-DST digital	**6.**	**Max Stress**-31.83 N/cm^2	**9.**	**Table**-7-8	

Shear Force(N)	**Displacement(mm)**	**Shear Stress (N/cm^2)**	**Shear Strain**
A	**vertical load**	**39.215 N/cm^2**	
333	2	14.93	0.03
479	4	31.93	0.07
500	8	33.33	0.13
490	10	32.67	0.17
Max shear stress		33.33 N/cm^2	
B	**vertical load**	**29.43 N/cm^2**	
130.00	1.00	8.67	0.02
235.00	4.00	15.67	0.07
323	10.00	21.53	0.16
310	11.00	20.60	0.18
Max shear stress		21.53 N/cm^2	
C	**vertical load**	**14.715 N/cm^2**	
155.00	1.00	10.33	0.02
185.00	4.00	12.33	0.07
190.00	5.00	12.67	0.13
200.00	8.00	13.53	0.15
190.00	12.00	12.27	0.20
Max shear stress		13.53 N/cm^2	

Table -7

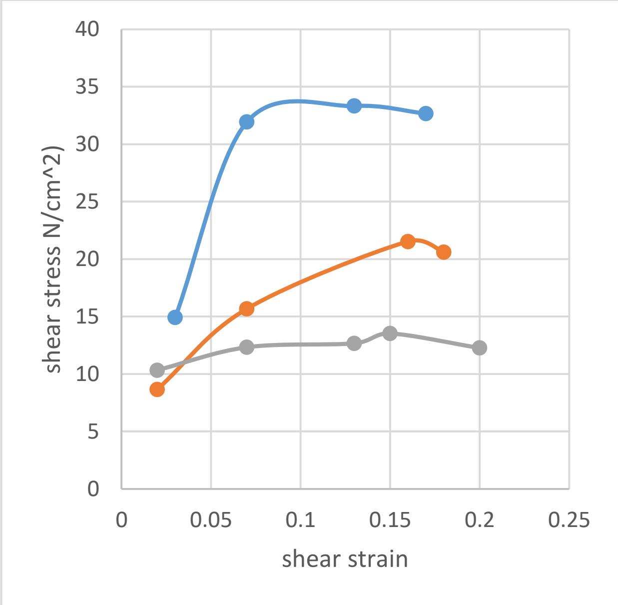


Fig-3

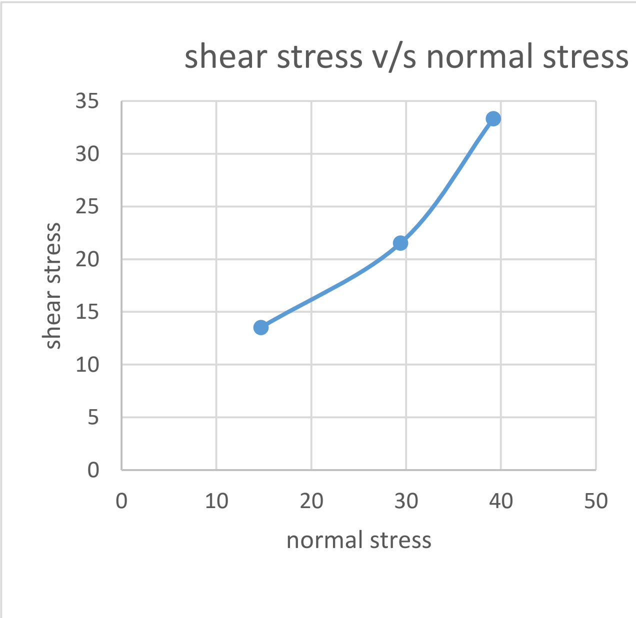


Fig.-4

Results			**Shear Strength**
1	**C**	**1.5 N/cm^2**	**ט= σ tanφ + C**
2	**φ**	**37.72°**	**31.83 N/cm^2**

Table-8

Experiment:-Direct Shear test on soil with 0.115% Plastic content.						
1.	**Stabilizer-**Plastic	**4.**	**Strain Rate-**1.25 mm/min	**7.**	**IS:2720:1986-13**	**D3**
2.	**Mould vol.-**6x6x2.5cm	**5.**	**Soil origin-** Una (H.P)	**8.**	**Fig.**-5-6	
3.	**Machine-**DST digital	**6.**	**Max Stress-**36.29 N/cm^2	**9.**	**Table-**9-10	

Shear Force(N)	**Displacement(mm)**	**Shear Stress (N/cm^2)**	**Shear Strain**
A	**vertical load**	**39.215 N/cm^2**	
333	2	14.93	0.03
479	4	31.93	0.07
532	8	36.26	0.13
525	10	35	0.17
Max shear stress		36.26 N/cm^2	
B	**vertical load**	**29.43 N/cm^2**	
130.00	1.00	8.67	0.02
235.00	4.00	15.67	0.07
365.00	10.00	24.33	0.16
355.00	11.00	23.67	0.18
Max shear stress		24.33 N/cm^2	
C	**vertical load**	**14.715 N/cm^2**	
95	1.00	6.33	0.02
120.00	4.00	8.33	0.07
127.00	5.00	8.67	0.13
175.00	8.00	11.53	0.15
144.00	12.00	9.27	0.20
Max shear stress		11.53 N/cm^2	

Table -9

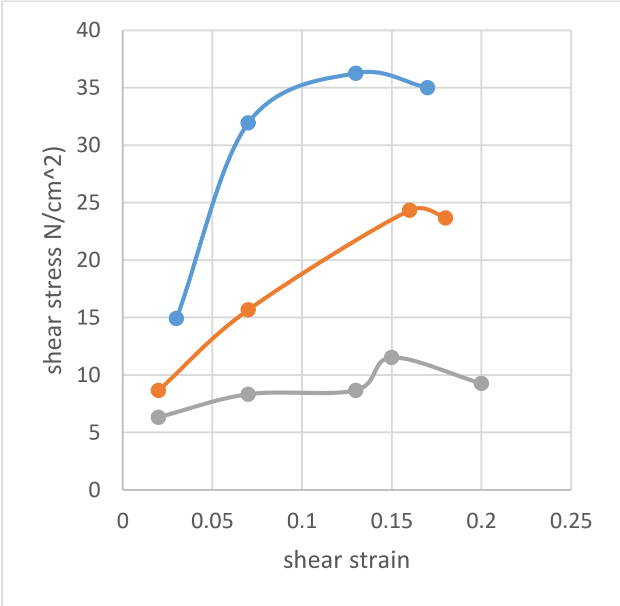


Fig-5

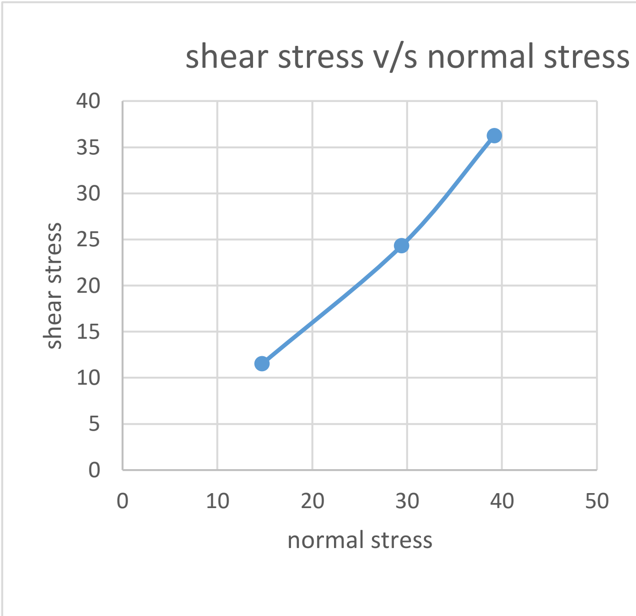


Fig.-6

Results			**Shear strength**
1	**C**	**2 N/cm^2**	**ɒ= ɕ tanɸ + C**
2	**ɸ**	**41.17°**	**36.29 N/cm^2**

Table-10

Experiment:-Direct Shear test on soil with 0.120% Plastic content.						
1.	**Stabilizer**-Plastic	**4.**	**Strain Rate**-1.25 mm/min	**7.**	**IS:2720:1986-13**	**D4**
2.	**Mould vol.**-6x6x2.5cm	**5.**	**Soil origin-** Una (H.P)	**8.**	**Fig**.-7-8	
3.	**Machine**-DST digital	**6.**	**Max Stress**-35.49N/cm^2	**9.**	**Table**-11-12	

Shear Force(N)	**Displacement(mm)**	**Shear Stress (N/cm^2)**	**Shear Strain**
A	**vertical load**	**39.215 N/cm^2**	
224	2	14.93	0.03
460	4	30.90	0.07
520	8	35	0.13
490	10	34.13	0.17
Max shear stress		35 N/cm^2	
B	**vertical load**	**29.43 N/cm^2**	
130.00	1.00	8.67	0.02
250	4.00	15.67	0.07
323	10.00	21.33	0.16
305	11.00	20.60	0.18
Max shear stress		21.33 N/cm^2	
C	**vertical load**	**14.715 N/cm^2**	
92	1.00	6.33	0.02
120	4.00	8.33	0.07
125.00	5.00	8.67	0.13
160.00	8.00	10.53	0.15
155.00	12.00	9.27	0.20
Max shear stress		10.53 N/cm^2	

Table -11

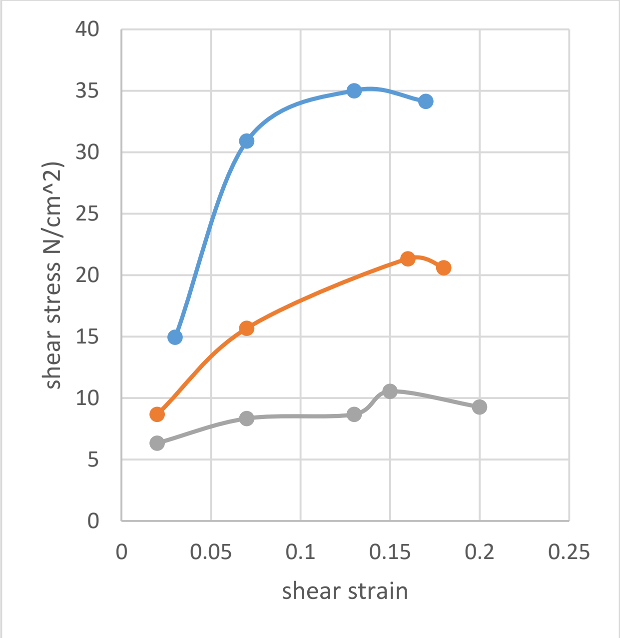


Fig-7

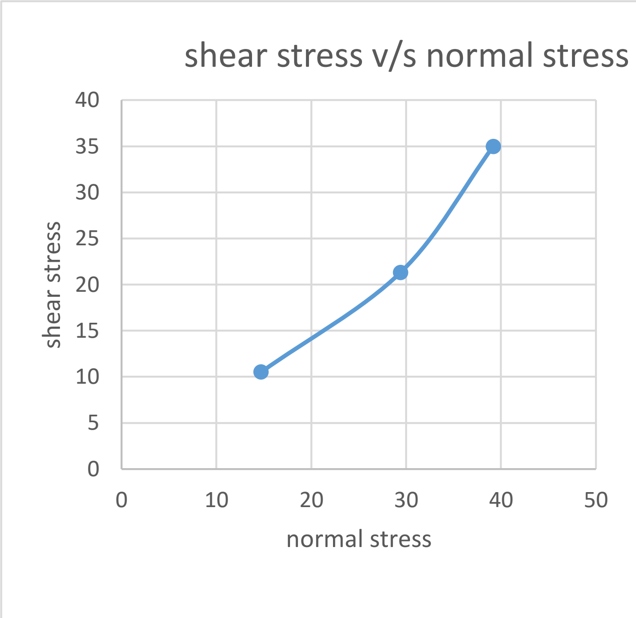


Fig.-8

Results			**Shear strength**
1	**C**	**1.5 N/cm^2**	** τ= σ tanφ + C**
2	**φ**	**40.92°**	**35.49 N/cm^2**

Table-12

Experiment:-Direct Shear test on soil with 10% Surkhi content.						
1.	**Stabilizer**-Surkhi	**4.**	**Strain Rate**-1.25 mm/min	**7.**	**IS:2720:1986-13**	**D5**
2.	**Mould vol.**-6x6x2.5cm	**5.**	**Soil origin**- Una (H.P)	**8.**	**Fig**.-9-10	
3.	**Machine**-DST digital	**6.**	**Max Stress**-22.66 N/cm^2	**9.**	**Table**-13-14	

Shear Force(N)	**Displacement(mm)**	**Shear Stress (N/cm^2)**	**Shear Strain**
A	**vertical load**	**39.215 N/cm^2**	
284	2	18.93	0.03
305	4	20.3	0.07
325	8	22.4	0.13
340	10	21.12	0.17
Max shear stress		22.4 N/cm^2	
B	**vertical load**	**29.43 N/cm^2**	
161.00	1.00	10.73	0.02
279.00	4.00	18.67	0.07
310	10.00	20.53	0.16
300	11.00	20	0.18
Max shear stress		20.53 N/cm^2	
C	**vertical load**	**14.715 N/cm^2**	
115.00	1.00	7.60	0.02
209.00	4.00	13.33	0.07
222.00	5.00	14.67	0.13
240.00	8.00	16.33	0.15
230.00	12.00	16	0.20
Max shear stress		16 N/cm^2	

Table -13

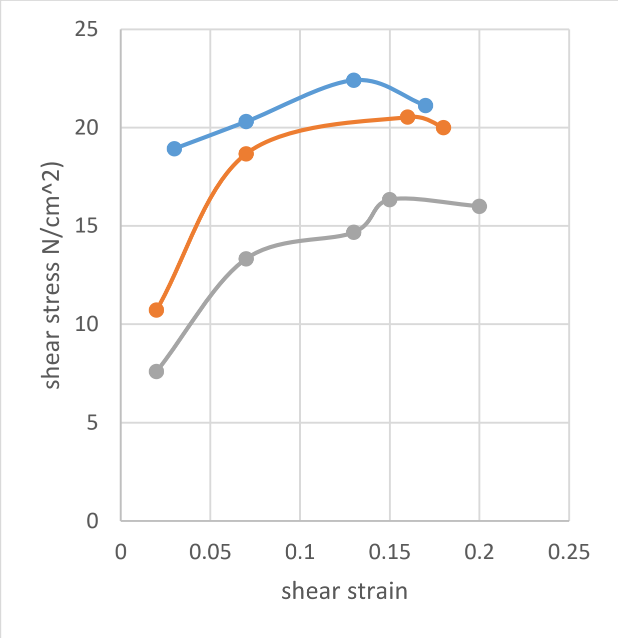


Fig-9

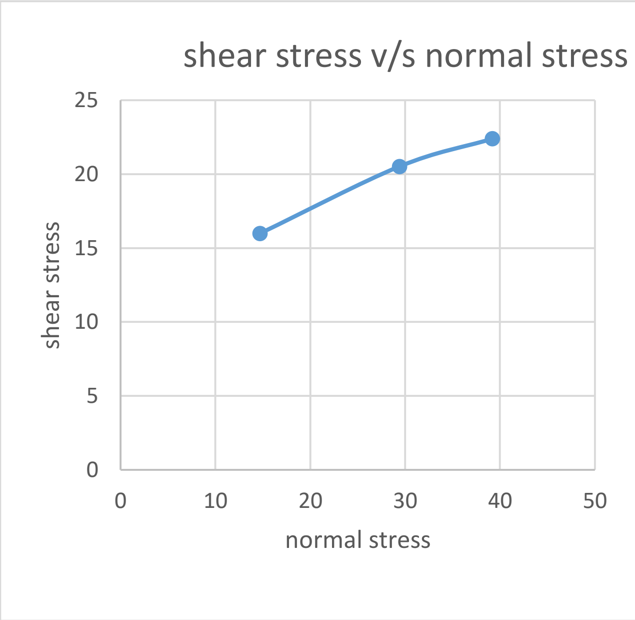


Fig.-10

Results			**Shear strength**
1	**C**	**13 N/cm^2**	**ꚍ= σ tanϕ + C**
2	**ϕ**	**13.85°**	**22.66 N/cm^2**

Table-14

Experiment:-Direct Shear test on soil with 12.50% Surkhi content.						
1.	**Stabilizer**-Surkhi	**4.**	**Strain Rate**-1.25 mm/min	**7.**	**IS:2720:1986-13**	**D6**
2.	**Mould vol.**-6x6x2.5cm	**5.**	**Soil origin**- Una (H.P)	**8.**	**Fig**.-11-12	
3.	**Machine**-DST digital	**6.**	**Max Stress**-23.67 N/cm^2	**9.**	**Table**-15-16	

Shear Force(N)	**Displacement(mm)**	**Shear Stress (N/cm^2)**	**Shear Strain**
A	**vertical load**	**39.215 N/cm^2**	
284	2	18.93	0.03
333	4	22.20	0.07
355	8	23.67	0.13
348	10	23.45	0.17
Max shear stress		23.67 N/cm^2	
B	**vertical load**	**29.43 N/cm^2**	
161.00	1.00	10.73	0.02
285	4.00	19	0.07
317	7.00	21.33	0.16
312	9.00	20.60	0.18
Max shear stress		21.33 N/cm^2	
C	**vertical load**	**14.715 N/cm^2**	
115.00	1.00	7.66	0.02
209.00	4.00	13.93	0.07
222.00	5.00	13.2	0.13
250.00	8.00	16.53	0.15
240.00	12.00	15.2	0.20
Max shear stress		16.53 N/cm^2	

Table -15

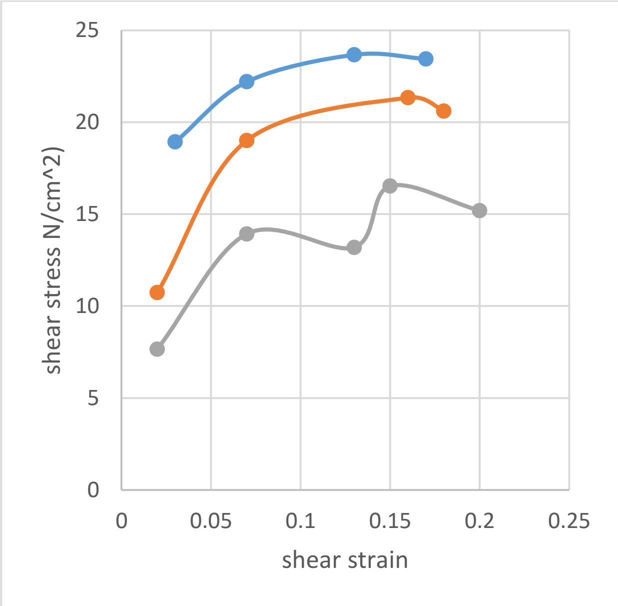


Fig-11

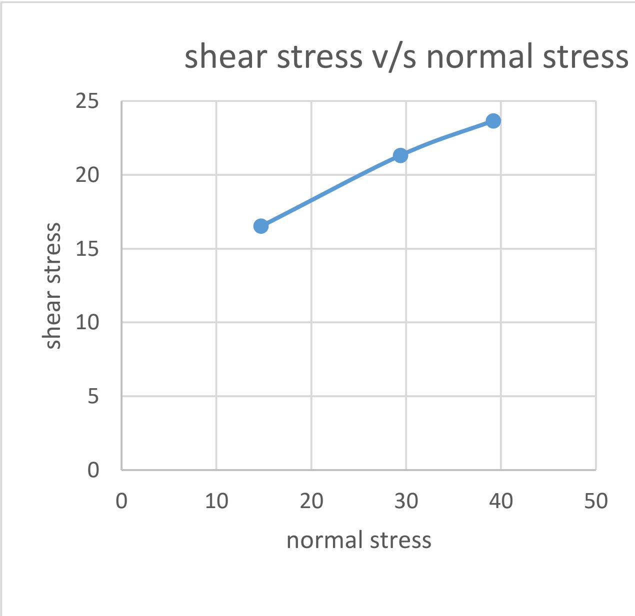


Fig.-12

Results			**Shear strength**
1	**C**	**13.1 N/cm^2**	**τ= σ tanϕ + C**
2	**ϕ**	**15.08°**	**23.66 N/cm^2**

Table-16

Experiment:-Direct Shear test on soil with 15% Surkhi content.						
1.	**Stabilizer**-Surkhi	**4.**	**Strain Rate**-1.25 mm/min	**7.**	**IS:2720:1986-13**	**D7**
2.	**Mould vol.**-6x6x2.5cm	**5.**	**Soil origin**- Una (H.P)	**8.**	**Fig**.-13-14	
3.	**Machine**-DST digital	**6.**	**Max Stress**-26.67 N/cm^2	**9.**	**Table**-17-18	

Shear Force(N)	**Displacement(mm)**	**Shear Stress (N/cm^2)**	**Shear Strain**
A	**vertical load**	**39.215 N/cm^2**	
275	2	18.33	0.03
331	4	22.01	0.07
400	6	26.67	0.1
365	8	24.33	0.13
Max shear stress		26.67 N/cm^2	
B	**vertical load**	**29.43 N/cm^2**	
160.00	1.00	10.66	0.02
275.00	4.00	18.33	0.07
360	7.00	24	0.16
342	9.00	22.8	0.18
Max shear stress		24 N/cm^2	
C	**vertical load**	**14.715 N/cm^2**	
115.00	1.00	7.33	0.02
209.00	4.00	13.93	0.07
222.00	5.00	14.7	0.13
258.00	8.00	17.63	0.15
240.00	12.00	16.00	0.20
Max shear stress		17.63 N/cm^2	

Table -17

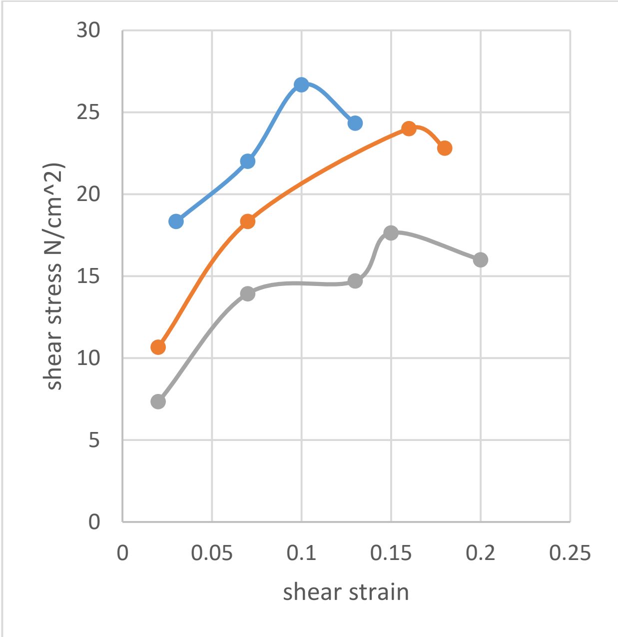


Fig-13

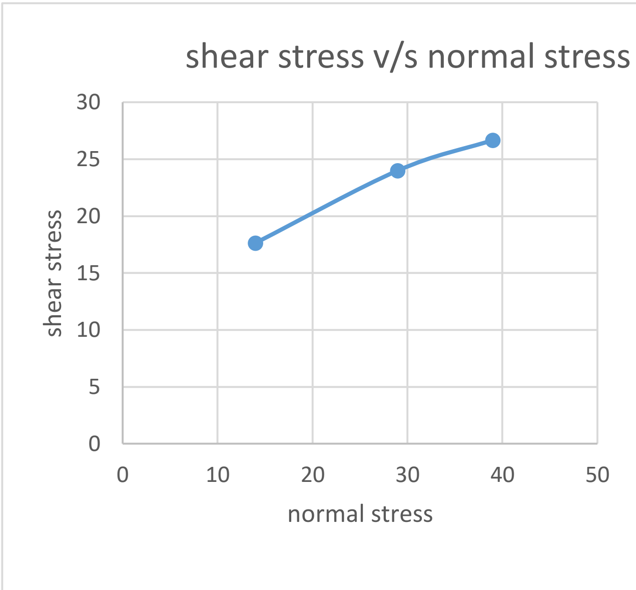


Fig.-14

Results			**Shear Strength**
1	**C**	**12 N/cm^2**	**ʋ= ϭ tanɸ + C**
2	**ɸ**	**20.51°**	**26.67 N/cm^2**

Table-18

Experiment:-Direct Shear test on soil with 17.5% Surkhi content.						
1.	**Stabilizer**-Surkhi	**4.**	**Strain Rate**-1.25 mm/min	**7.**	**IS:2720:1986-13**	**D8**
2.	**Mould vol.**-6x6x2.5cm	**5.**	**Soil origin**- Una (H.P)	**8.**	**Fig**.-15-16	
3.	**Machine**-DST digital	**6.**	**Max Stress**-30.42 N/cm^2	**9.**	**Table**-19-20	

Shear Force(N)	Displacement(mm)	Shear Stress (N/cm^2)	Shear Strain
A	**vertical load**	**39.215 N/cm^2**	
261	2	17.40	0.03
371	4	24.73	0.07
448	6	30.06	0.1
444	8	29.67	0.13
Max shear stress		30.06 N/cm^2	
B	**vertical load**	**29.43 N/cm^2**	
158.00	1.00	10.67	0.02
279.00	4.00	18.67	0.07
383	7.00	25.53	0.16
340	9.00	20.60	0.18
Max shear stress		25.53 N/cm^2	
C	**vertical load**	**14.715 N/cm^2**	
119.00	1.00	7.93	0.02
216.00	4.00	14.4	0.07
229.00	5.00	15.26	0.13
246.00	8.00	16.4	0.15
240.00	12.00	12.27	0.20
Max shear stress		16.4 N/cm^2	

Table -19

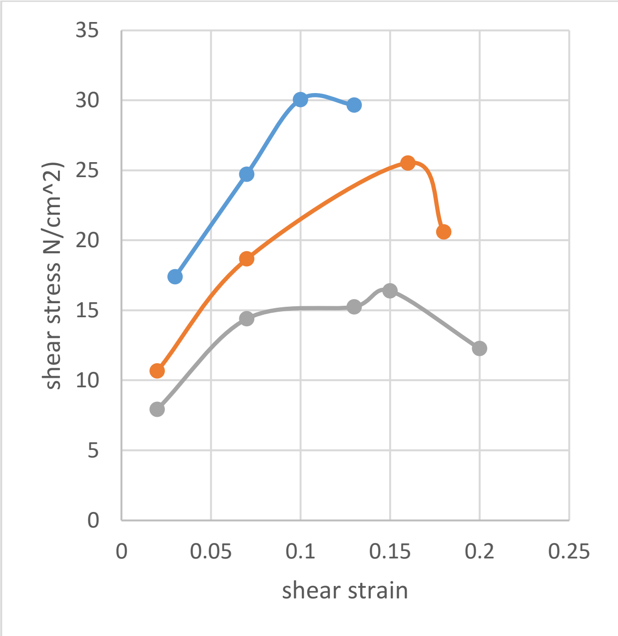


Fig-15

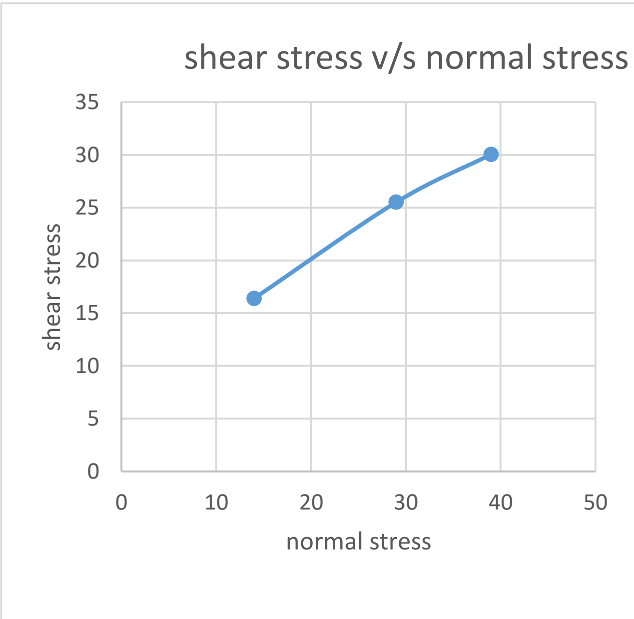


Fig.-16

Results			**Shear strength**
1	**C**	**10 N/cm^2**	** τ= σ tanϕ + C**
2	**ϕ**	**27.09°**	**30.423 N/cm^2**

Table-20

Experiment:-Direct Shear test on soil with 20% Surkhi content.						
1.	**Stabilizer**-Surkhi	**4.**	**Strain Rate**-1.25 mm/min	**7.**	**IS:2720:1986-13**	**D9**
2.	**Mould vol.**-6x6x2.5cm	**5.**	**Soil origin**- Una (H.P)	**8.**	**Fig**.-17-18	
3.	**Machine**-DST digital	**6.**	**Max Stress**-26.28 N/cm^2	**9.**	**Table**-21-22	

Shear Force(N)	**Displacement(mm)**	**Shear Stress (N/cm^2)**	**Shear Strain**
A	**vertical load**	**39.215 N/cm^2**	
164	2	10.93	0.03
345	4	23.93	0.07
375	6	25.33	0.13
365	8	24.67	0.17
Max shear stress		25.33 N/cm^2	
B	**vertical load**	**29.43 N/cm^2**	
163.00	1.00	10.67	0.02
281.00	4.00	18.67	0.07
353	7.00	23.53	0.16
340	9.00	22.60	0.18
Max shear stress		23.53 N/cm^2	
C	**vertical load**	**14.715 N/cm^2**	
115.00	1.00	10.33	0.02
175.00	4.00	12.33	0.07
190.00	5.00	12.67	0.13
210.00	8.00	13.63	0.15
190.00	12.00	12.27	0.20
Max shear stress		13.63 N/cm^2	

Table -21

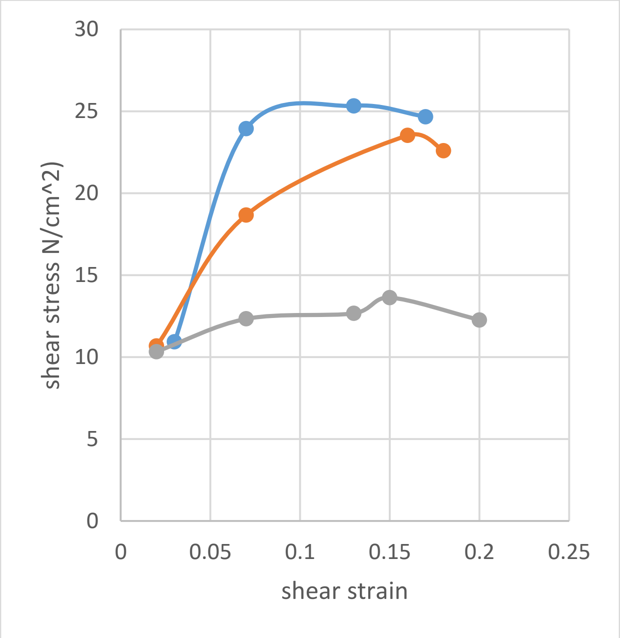


Fig-17

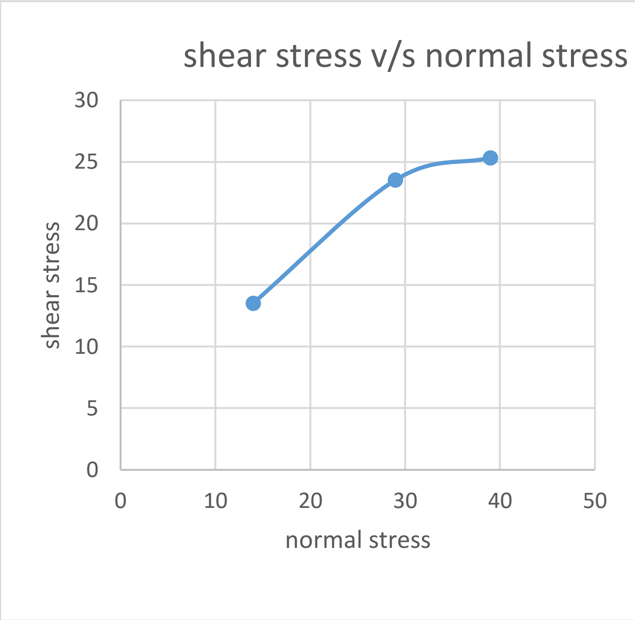


Fig.-18

Results			**Shear strength**
1	**C**	**4.9 N/cm^2**	**ᴛ= ϭ tanϕ + C**
2	**ϕ**	**28.65°**	**26.28 N/cm^2**

Table-22

Experiment:-Direct Shear test on soil with 5% Glass content.						
1.	**Stabilizer**-Glass	**4.**	**Strain Rate**-1.25 mm/min	**7.**	**IS:2720:1986-13**	**D10**
2.	**Mould vol.**-6x6x2.5cm	**5.**	**Soil origin**- Una (H.P)	**8.**	**Fig**.-19-20	
3.	**Machine**-DST digital	**6.**	**Max Stress**-27.27 N/cm^2	**9.**	**Table**-23-24	

Shear Force(N)	**Displacement(mm)**	**Shear Stress (N/cm^2)**	**Shear Strain**
A	**vertical load**	**39.215 N/cm^2**	
293	2	19.93	0.03
377	4	25.53	0.07
410	8	27.33	0.13
394	10	26.37	0.17
Max shear stress		27.33 N/cm^2	
B	**vertical load**	**29.43 N/cm^2**	
68.00	1.00	7.67	0.02
186.00	4.00	15.67	0.07
223	10.00	18.53	0.16
215	11.00	17.60	0.18
Max shear stress		18.53 N/cm^2	
C	**vertical load**	**14.715 N/cm^2**	
105.00	1.00	7.33	0.02
205.00	4.00	13.33	0.07
207.00	5.00	13.67	0.13
210.00	8.00	13.93	0.15
202.00	12.00	12.27	0.20
Max shear stress		13.93 N/cm^2	

Table -23

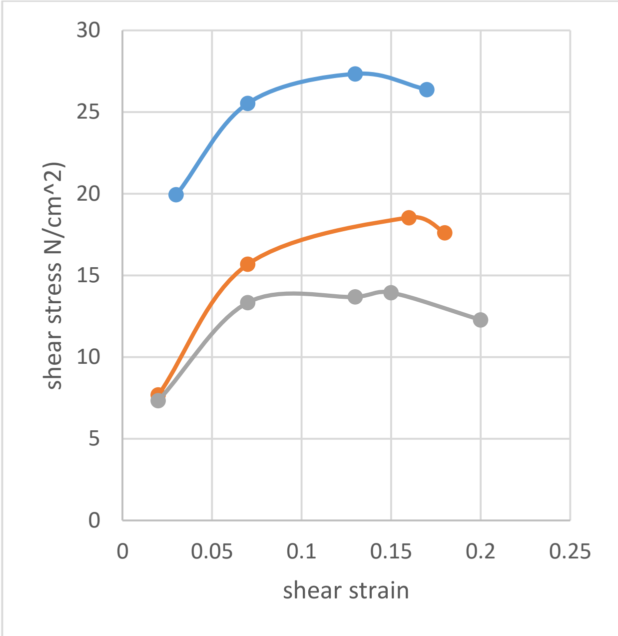


Fig-19

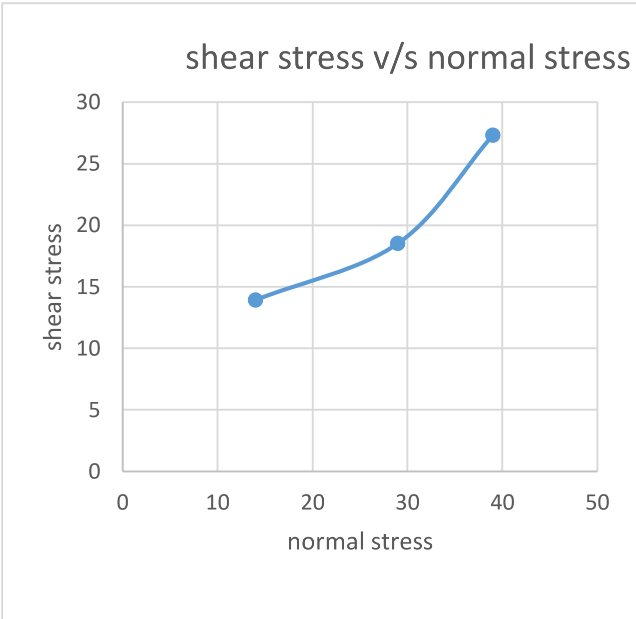


Fig.-20

Results			**Shear strength**
1	**C**	**4 N/cm^2**	**ҩ= ϭ tanϕ + C**
2	**ϕ**	**30.75°**	**27.28 N/cm^2**

Table-24

Experiment:-Direct Shear test on soil with 8% Glass content.						
1.	**Stabilizer-**Glass	**4.**	**Strain Rate-**1.25 mm/min	**7.**	**IS:2720:1986-13**	**D11**
2.	**Mould vol.-**6x6x2.5cm	**5.**	**Soil origin-** Una (H.P)	**8.**	**Fig.**-21-22	
3.	**Machine-**DST digital	**6.**	**Max Stress-**32 N/cm^2	**9.**	**Table-**25-26	

Shear Force(N)	**Displacement(mm)**	**Shear Stress (N/cm^2)**	**Shear Strain**
A	**vertical load**	**39.215 N/cm^2**	
293	2	19.93	0.03
377	4	25.93	0.07
436	8	32	0.13
400	10	31.4	0.17
Max shear stress		32 N/cm^2	
B	**vertical load**	**29.43 N/cm^2**	
153.00	1.00	10.2	0.02
259.00	4.00	17.26	0.07
355	10.00	23.53	0.16
345	11.00	20.60	0.18
Max shear stress		23.53 N/cm^2	
C	**vertical load**	**14.715 N/cm^2**	
155.00	1.00	10.33	0.02
175.00	4.00	12.33	0.07
180.00	5.00	12.67	0.13
210.00	8.00	13.53	0.15
190.00	12.00	12.27	0.20
Max shear stress		13.53 N/cm^2	

Table -25

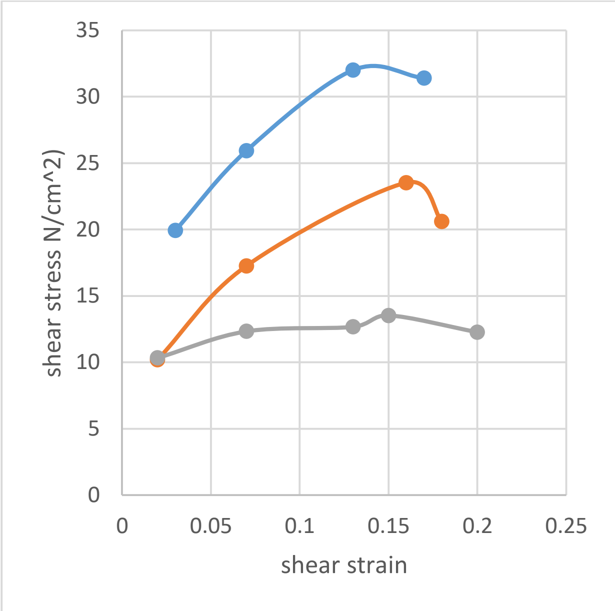


Fig-21

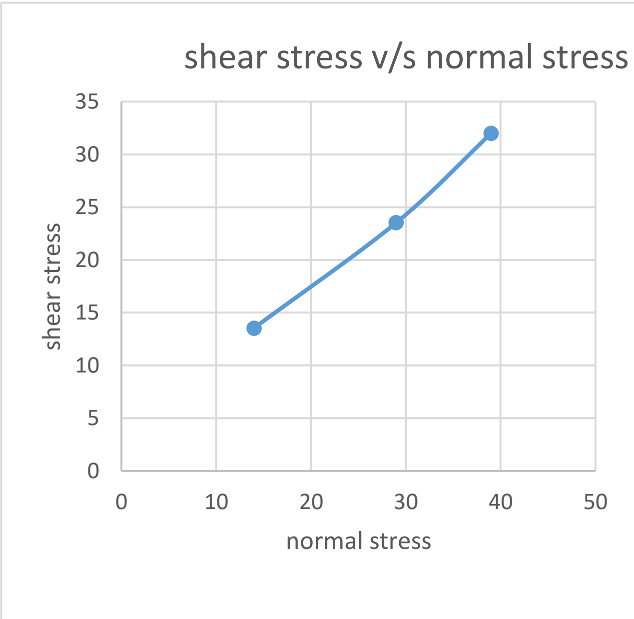


Fig.-22

Results			**Shear strength**
1	**C**	**6 N/cm^2**	**ԏ= ϭ tanϕ + C**
2	**ϕ**	**33.54°**	**31.94 N/cm^2**

Table-26

Experiment:-Direct Shear test on soil with 10% Glass content.						
1.	**Stabilizer**-Glass	**4.**	**Strain Rate**-1.25 mm/min	**7.**	**IS:2720:1986-13**	**D12**
2.	**Mould vol.**-6x6x2.5cm	**5.**	**Soil origin**- Una (H.P)	**8.**	**Fig**.-23-24	
3.	**Machine**-DST digital	**6.**	**Max Stress**-28.28 N/cm^2	**9.**	**Table**-27-28	

Shear Force(N)	Displacement(mm)	Shear Stress (N/cm^2)	Shear Strain
A	**vertical load**	**39.215 N/cm^2**	
293	2	19.53	0.03
377	4	25.13	0.07
425	8	29.43	0.13
407	10	28.37	0.17
Max shear stress		29.43 N/cm^2	
B	**vertical load**	**29.43 N/cm^2**	
154.00	1.00	10.67	0.02
258.00	4.00	15.67	0.07
333	10.00	22.53	0.16
310	11.00	20.60	0.18
Max shear stress		22.53 N/cm^2	
C	**vertical load**	**14.715 N/cm^2**	
125.00	1.00	8.33	0.02
145.00	4.00	9.33	0.07
150.00	5.00	10.67	0.13
180.00	8.00	12.53	0.15
170.00	12.00	12.27	0.20
Max shear stress		12.53 N/cm^2	

Table -27

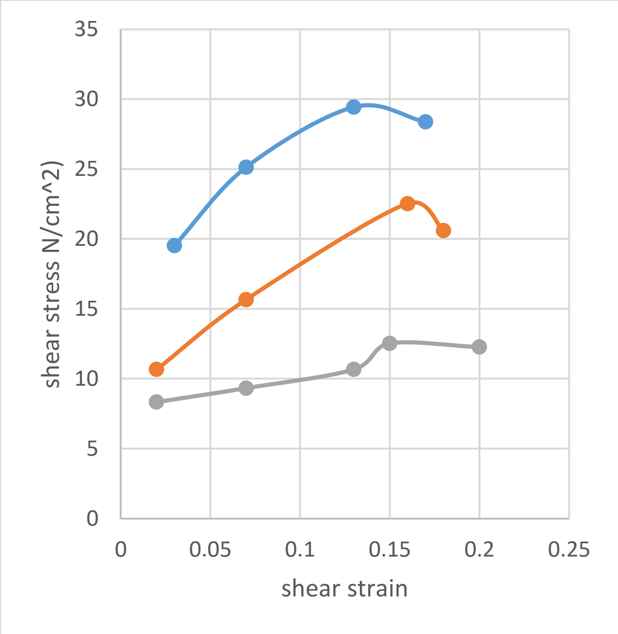


Fig-23

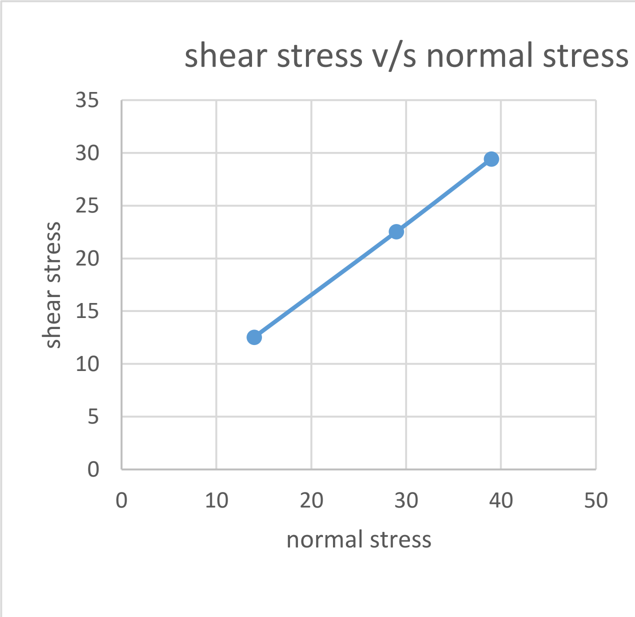


Fig.-24

Results			**Shear strength**
1	**C**	**5 N/cm^2**	**ҍ= ϭ tanф + C**
2	**ф**	**30.75°**	**28.28 N/cm^2**

Table-28

Experiment:-Direct Shear test on soil without any stabilizer						
1.	**Stabilizer**-none	**4.**	**Strain Rate**-1.25 mm/min	**7.**	**IS:2720:1986-13**	**D13**
2.	**Mould vol.**-6x6x2.5cm	**5.**	**Soil origin**- Una (H.P)	**8.**	**Fig.**-25-26	
3.	**Machine**-DST digital	**6.**	**Max Stress**-28.1 N/cm^2	**9.**	**Table**-29-30	

Shear Force(N)	**Displacement(mm)**	**Shear Stress (N/cm^2)**	**Shear Strain**
A	**vertical load**	**39.215 N/cm^2**	
284	2	14.93	0.03
400	4	16.93	0.07
525	8	20	0.13
490	10	19.50	0.17
Max shear stress		20 N/cm^2	
B	**vertical load**	**29.43 N/cm^2**	
130.00	1.00	9.67	0.02
235.00	4.00	15.67	0.07
323	10.00	17.23	0.16
310	11.00	15.25	0.18
Max shear stress		17.23 N/cm^2	
C	**vertical load**	**14.715 N/cm^2**	
145.00	1.00	10.33	0.02
175.00	4.00	12.33	0.07
190.00	5.00	12.67	0.13
200.00	8.00	13.53	0.15
190.00	12.00	12.27	0.20
Max shear stress		13.53 N/cm^2	

Table -29

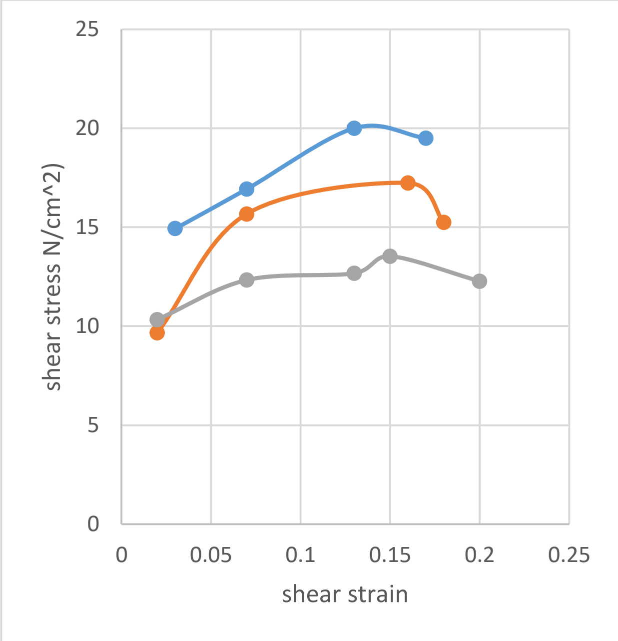


Fig-25

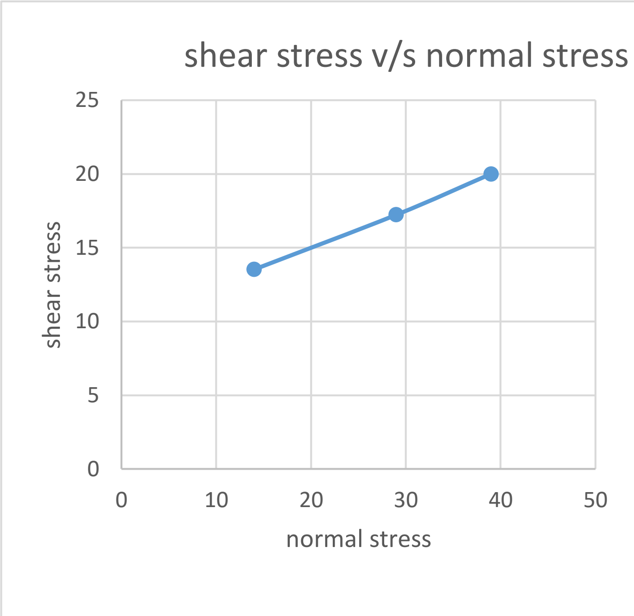


Fig.-26

Results			**Shear strength**
1	**C**	**7.5 N/cm^2**	**ҩ= ϭ tanф + C**
2	**ф**	**27.72°**	**28.1 N/cm^2**

Table-30

ANNEXURE 3

Experiment:-Standard Proctor Test using Different Stabilizing Material.				
1.	**Stabilizer-**Plastic ,Glass ,Surkhi at Different percentages			**O**
2.	**Table-**	**4.**	**Soil origin-** Una (H.P)	
3.	**Type-** Light Compaction	**5.**	**IS:2720:1980(7)**	

Table 31

Stabilizing Material	**Percentage (%)**	**OMC(%)**	**ɣd (g/cm^3)**
Plastic	0.105	19	1.67
Plastic	0.11	20	1.67
Plastic	0.115	20	1.68
Plastic	0.12	20	1.68
Surkhi	10	20	1.70
Surkhi	12.5	20	1.71
Surkhi	15	21	1.71
Surkhi	17.5	22	1.74
Surkhi	20	22	1.75
Glass	5	20	1.72
Glass	8	20	1.73
Glass	10	20	1.74
Simple Soil		19	1.65

ANNEXURE 4

Experiment:-UCS test on soil with 0.105% Plastic content.						
1.	**Stabilizer-**Plastic	**4.**	**PR Constant-**0.87 Kg/div	**7.**	**IS:2720:1991-10**	**U1**
2.	**Mould vol.-**81.656cm^3	**5.**	**Soil origin-** Una (H.P)	**8.**	**Fig.**-1-2	
3.	**Machine-**UCS digital	**6.**	**UCS-**5.54 KN/m^2	**9.**	**Table-**32	

Table-32

Proving ring readings	Dial gauge 0.02 mm/ div	Sample strain %	Axial load(N)	Corrected Area cm^2	Stress KN/m^2
2.80	20.00	0.53	24.50	86.65	2.83
3.00	40.00	1.05	26.25	87.10	3.01
3.00	60.00	1.58	26.25	87.55	3.00
3.00	80.00	2.11	26.25	88.01	2.98
3.00	100.00	2.63	26.25	88.46	2.97
3.00	120.00	3.16	26.25	88.91	2.95
3.00	140.00	3.68	26.25	89.37	2.94
3.00	160.00	4.21	26.25	89.82	2.92
3.00	180.00	4.74	26.25	90.28	2.91
3.00	200.00	5.26	26.25	90.73	2.89
3.60	220.00	5.79	31.50	91.18	3.45
5.80	240.00	6.32	50.75	91.64	5.54
5.50	260.00	6.84	48.13	92.09	5.23

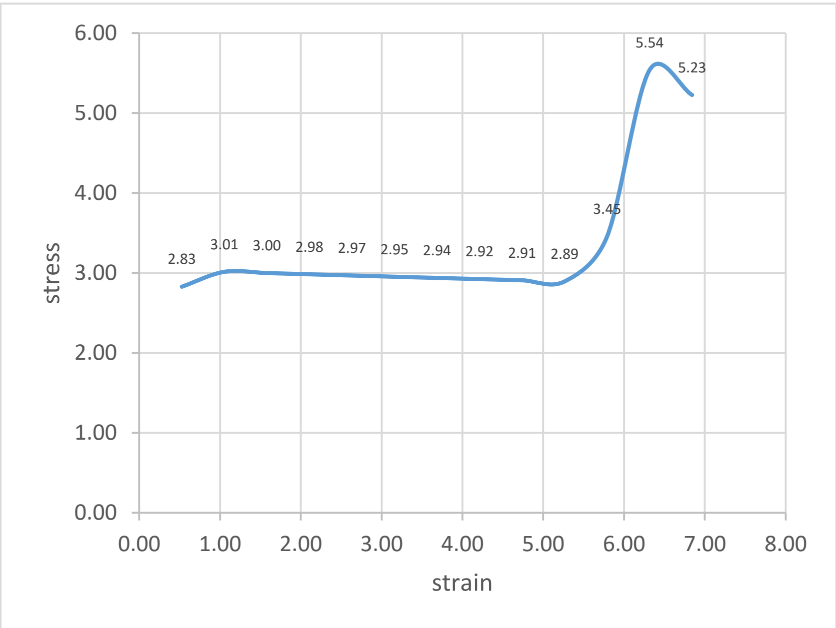


Fig-1

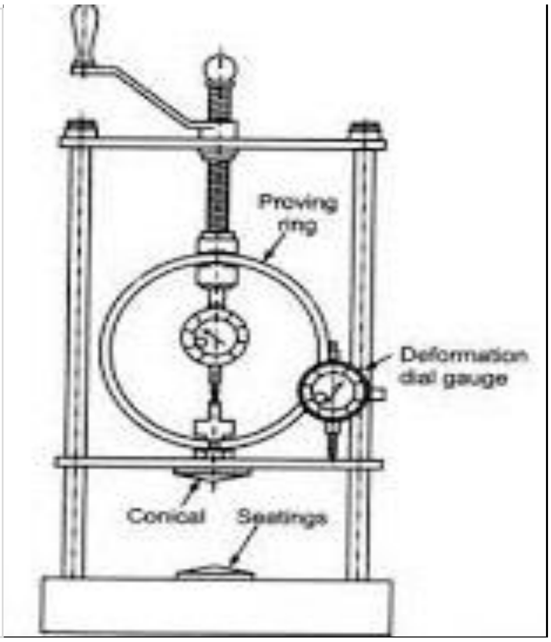


Fig-2

UNCONFINED COMPRESSIVE STRENGTH	**5.54 KN/m^2**

Experiment:-UCS test on soil with 0.110% Plastic content.						
1.	**Stabilizer**-Plastic	**4.**	**PR Constant**-0.87 Kg/div	**7.**	**IS:2720:1991-10**	**U2**
2.	**Mould vol.**-81.656cm^3	**5.**	**Soil origin**- Una (H.P)	**8.**	**Fig**.-3-4	
3.	**Machine**-UCS digital	**6.**	**UCS**-4.16 KN/m^2	**9.**	**Table**-33	

Table-33

Proving ring readings	Dial gauge 0.02 mm/ div	Sample strain %	Axial load(N)	Corrected Area cm^2	Stress KN/m^2
2.10	100.00	2.63	18.38	88.46	2.08
2.20	120.00	3.16	19.25	88.91	2.16
2.40	140.00	3.68	21.00	89.37	2.35
2.40	160.00	4.21	21.00	89.82	2.34
2.80	180.00	4.74	24.50	90.28	2.71
3.20	200.00	5.26	28.00	90.73	3.09
4.10	220.00	5.79	35.88	91.18	3.93
4.10	240.00	6.32	35.88	91.64	3.91
4.10	260.00	6.84	35.88	92.09	3.90
4.40	280.00	7.37	38.50	92.54	4.16
4.40	300.00	7.89	38.50	93.00	4.14
4.40	320.00	8.42	38.50	93.45	4.12
4.10	360.00	9.47	35.88	94.36	3.80

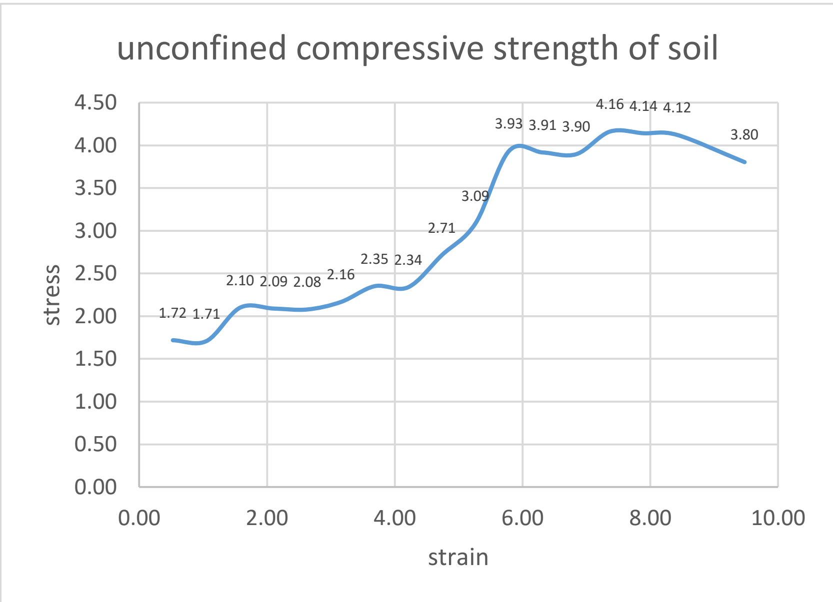


Fig-3

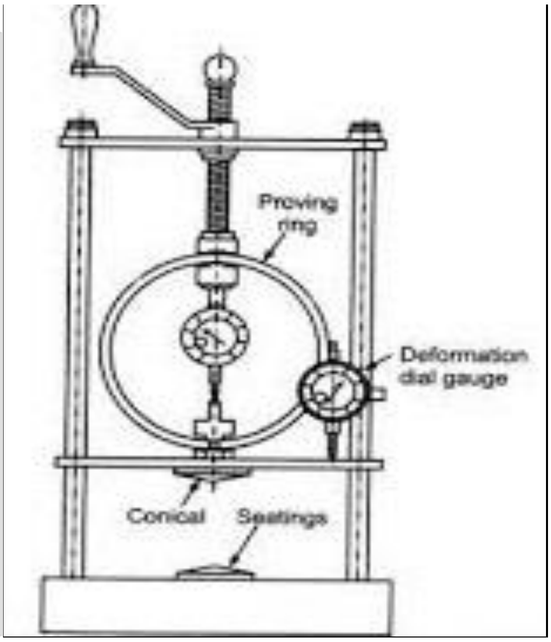


Fig-4

UNCONFINED COMPRESSIVE STRENGTH	**4.16 KN/m^2**

Experiment:-UCS test on soil with 0.115% Plastic content.						
1.	**Stabilizer**-Plastic	**4.**	**PR Constant**-0.87 Kg/div	**7.**	**IS:2720:1991-10**	**U3**
2.	**Mould vol.**-81.656cm^3	**5.**	**Soil origin**- Una (H.P)	**8.**	**Fig**.-5-6	
3.	**Machine**-UCS digital	**6.**	**UCS**-4.61KN/m^2	**9.**	**Table**-34	

Table-34

Proving ring readings	Dial gauge 0.02 mm/ div	Sample strain %	Axial load(N)	Corrected Area cm^2	Stress KN/m^2
2.20	40.00	1.05	19.25	87.10	2.21
2.50	60.00	1.58	21.88	87.55	2.50
2.50	80.00	2.11	21.88	88.01	2.49
2.50	100.00	2.63	21.88	88.46	2.47
2.90	120.00	3.16	25.38	88.91	2.85
3.40	140.00	3.68	29.75	89.37	3.33
3.40	160.00	4.21	29.75	89.82	3.31
3.60	180.00	4.74	31.50	90.28	3.49
4.30	200.00	5.26	37.63	90.73	4.15
4.80	220.00	5.79	42.00	91.18	4.61
4.80	240.00	6.32	42.00	91.64	4.58
4.80	260.00	6.84	42.00	92.09	4.56
4.40	280.00	7.37	38.50	92.54	4.16

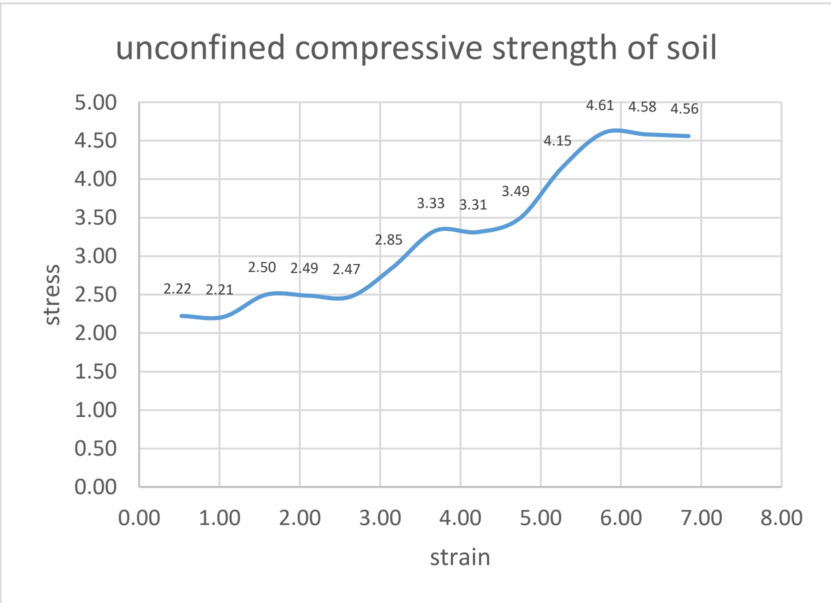


Fig-5

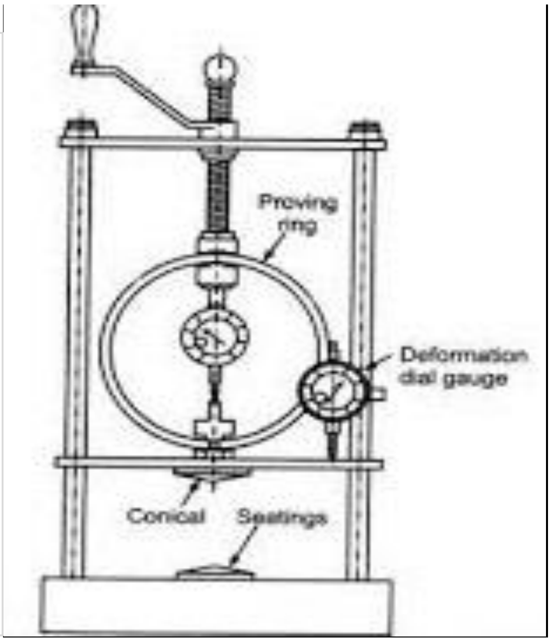


Fig-6

UNCONFINED COMPRESSIVE STRENGTH	**4.61 KN/m^2**

Experiment:-UCS test on soil with 0.120% Plastic content.						
1.	**Stabilizer**-Plastic	**4.**	**PR Constant**-0.87 Kg/div	**7.**	**IS:2720:1991-10**	**U4**
2.	**Mould vol.**-81.656cm^3	**5.**	**Soil origin**- Una (H.P)	**8.**	**Fig**.-7-8	
3.	**Machine**-UCS digital	**6.**	**UCS**-4.35 KN/m^2	**9.**	**Table**-35	

Table-35

Proving ring readings	Dial gauge 0.02 mm/ div	Sample strain %	Axial load(N)	Corrected Area cm^2	Stress KN/m^2
2.10	80.00	2.11	18.38	88.01	2.09
2.70	100.00	2.63	23.63	88.46	2.67
2.90	120.00	3.16	25.38	88.91	2.85
3.30	140.00	3.68	28.88	89.37	3.23
3.50	160.00	4.21	30.63	89.82	3.41
3.50	180.00	4.74	30.63	90.28	3.39
3.50	200.00	5.26	30.63	90.73	3.38
3.80	220.00	5.79	33.25	91.18	3.65
3.80	240.00	6.32	33.25	91.64	3.63
4.20	260.00	6.84	36.75	92.09	3.99
4.60	280.00	7.37	40.25	92.54	4.35
4.60	300.00	7.89	40.25	93.00	4.33
4.50	320.00	8.42	39.38	93.45	4.21

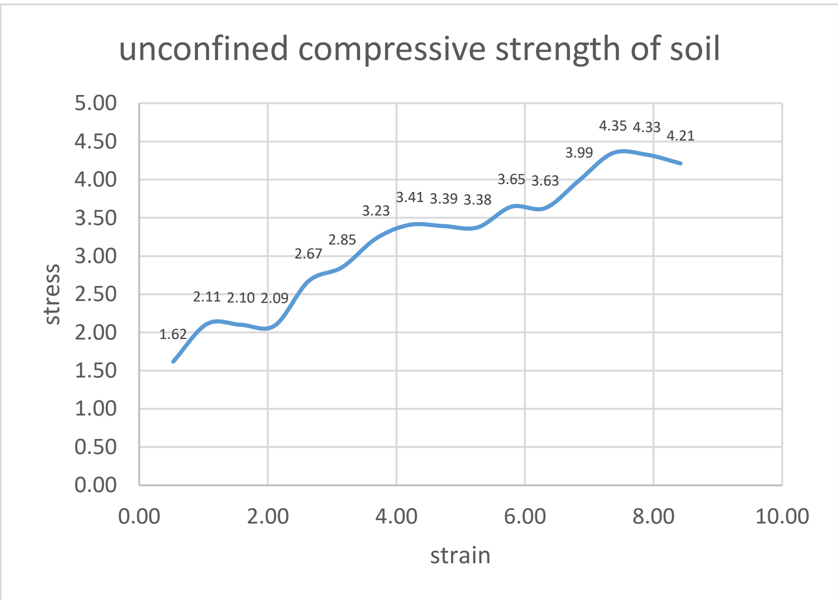


Fig -7

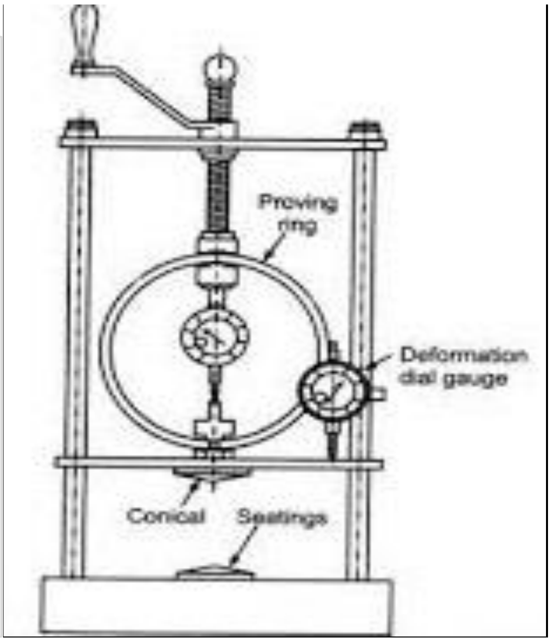


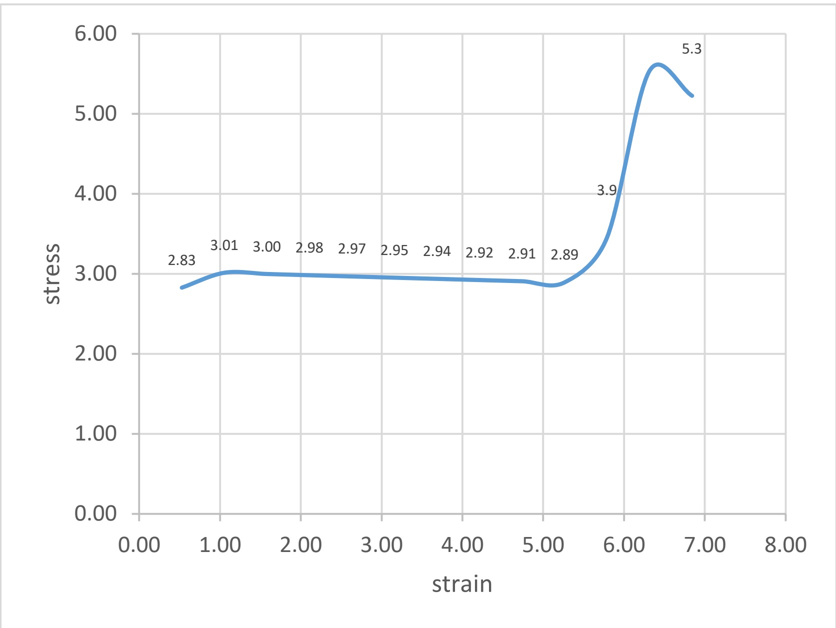
Fig-8

UNCONFINED COMPRESSIVE STRENGTH	**4.35 KN/m^2**

Experiment:-UCS test on soil with 10% Surkhi content.						
1.	**Stabilizer**-Surkhi	**4.**	**PR Constant**-0.87 Kg/div	**7.**	**IS:2720:1991-10**	**U5**
2.	**Mould vol.**-81.656cm^3	**5.**	**Soil origin**- Una (H.P)	**8.**	**Fig**.-9-10	
3.	**Machine**-UCS digital	**6.**	**UCS**-5.30 KN/m^2	**9.**	**Table**-36	

Table -36

Proving ring readings	Dial gauge 0.02 mm/ div	Sample strain %	Axial load(N)	Corrected Area cm^2	Stress KN/m^2
2.10	80.00	2.11	18.38	88.01	2.09
2.60	100.00	2.63	23.63	88.46	2.67
2.90	120.00	3.16	25.38	88.91	2.85
3.90	140.00	3.68	28.88	89.37	3.23
3.60	160.00	4.21	30.63	89.82	3.41
3.50	180.00	4.74	30.63	90.28	3.39
3.50	200.00	5.26	30.63	90.73	3.38
3.99	220.00	5.79	33.25	91.18	3.65
3.80	240.00	6.32	33.25	91.64	3.63
4.20	260.00	6.84	36.75	92.09	3.99
4.7	280.00	7.37	40.25	92.54	5.30
4.60	300.00	7.89	40.25	93.00	4.33
4.50	320.00	8.42	39.38	93.45	4.30



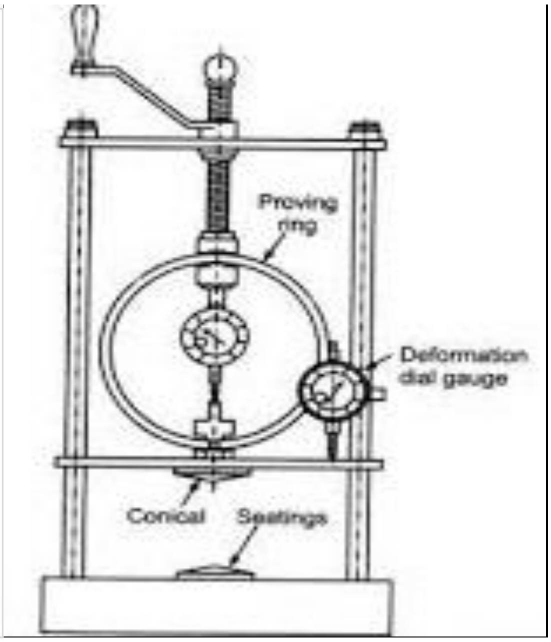


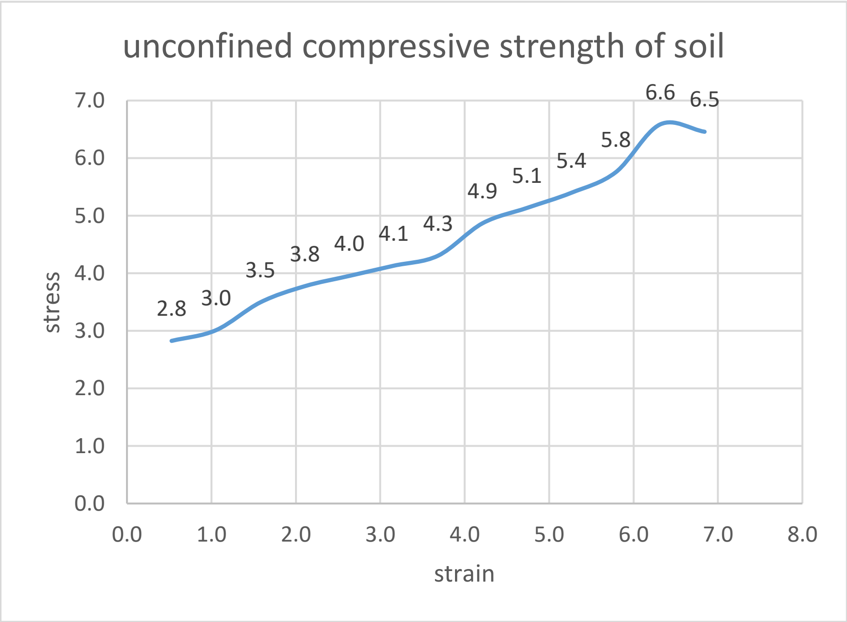
Fig-9

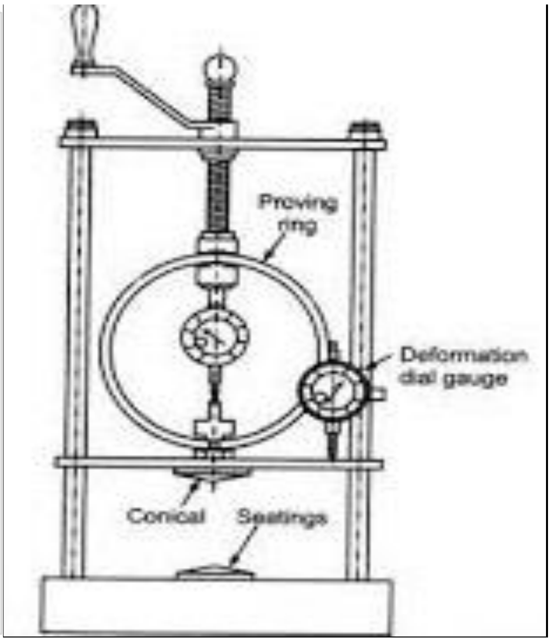
Fig-10

UNCONFINED COMPRESSIVE STRENGTH	5.30 KN/m^2

Experiment:-UCS test on soil with 12.5% Surkhi content.						
1.	**Stabilizer**-Surkhi	**4.**	**PR Constant**-0.87 Kg/div	**7.**	**IS:2720:1991-10**	**U6**
2.	**Mould vol.**-81.656cm^3	**5.**	**Soil origin**- Una (H.P)	**8.**	**Fig.**-11-12	
3.	**Machine**-UCS digital	**6.**	**UCS**-6.6 KN/m^2	**9.**	**Table**-37	

Proving ring readings	Dial gauge 0.02 mm/ div	Sample strain %	Axial load(N)	Corrected Area cm^2	Stress KN/m^2
2.8	20.00	0.5	24.5	86.65	2.8
3.0	40.00	1.1	26.3	87.10	3.0
3.5	60.00	1.6	30.6	87.55	3.5
3.8	80.00	2.1	33.3	88.01	3.8
4.0	100.00	2.6	35.0	88.46	4.0
4.2	120.00	3.2	36.8	88.91	4.1
4.4	140.00	3.7	38.5	89.37	4.3
5.0	160.00	4.2	43.8	89.82	4.9
5.3	180.00	4.7	46.4	90.28	5.1
5.6	200.00	5.3	49.0	90.73	5.4
6.0	220.00	5.8	52.5	91.18	5.8
6.9	240.00	6.3	60.4	91.64	6.6
6.8	260.00	6.8	59.5	92.09	6.5





UNCONFINED COMPRESSIVE STRENGTH	**6.6 KN/m^2**

Experiment:-UCS test on soil with 15% Surkhi content.						
1.	**Stabilizer**-Surkhi	**4.**	**PR Constant**-0.87 Kg/div	**7.**	**IS:2720:1991-10**	**U7**
2.	**Mould vol.**-81.656cm^3	**5.**	**Soil origin**- Una (H.P)	**8.**	**Fig**.-13-14	
3.	**Machine**-UCS digital	**6.**	**UCS**-9.89 KN/m^2	**9.**	**Table**-38	

Table-38

Proving ring readings	**Dial gauge 0.02 mm/ div**	**Sample strain %**	**Axial load(N)**	**Corrected Area cm^2**	**Stress KN/m^2**
1.40	20.00	0.53	12.25	86.65	1.41
2.40	40.00	1.05	21.00	87.10	2.41
5.00	60.00	1.58	43.75	87.55	5.00
9.00	80.00	2.11	78.75	88.01	8.95
10.00	100.00	2.63	87.50	88.46	9.89

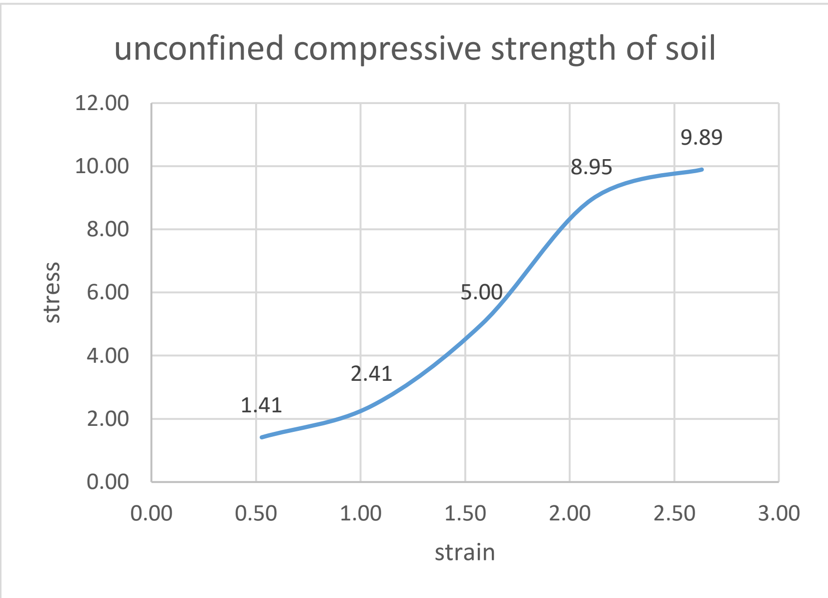


Fig-13

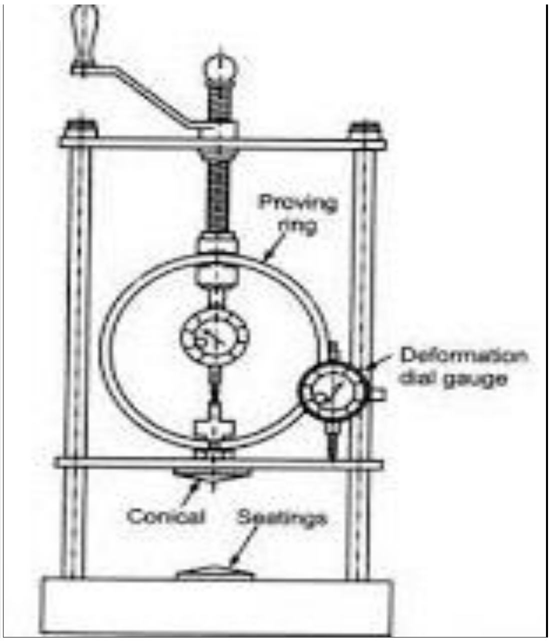


Fig-14

UNCONFINED COMPRESSIVE STRENGTH	**9.89 KN/m^2**

Experiment:-UCS test on soil with 17.5% Surkhi content.						
1.	**Stabilizer**-Surkhi	**4.**	**PR Constant**-0.87 Kg/div	**7.**	**IS:2720:1991-10**	**U8**
2.	**Mould vol.**-81.656cm^3	**5.**	**Soil origin-** Una (H.P)	**8.**	**Fig**.-15-16	
3.	**Machine**-UCS digital	**6.**	**UCS**-10.5 KN/m^2	**9.**	**Table**-39	

Table-39

Proving ring readings	Dial gauge 0.02 mm/ div	Sample strain %	Axial load(N)	Corrected Area cm^2	Stress KN/m^2
2.80	20.00	0.53	24.50	86.65	2.83
3.00	40.00	1.05	26.25	87.10	3.01
3.50	60.00	1.58	30.63	87.55	3.50
3.50	80.00	2.11	30.63	88.01	3.48
3.80	100.00	2.63	33.25	88.46	3.76
6.00	120.00	3.16	52.50	88.91	5.90
6.20	140.00	3.68	54.25	89.37	6.07
7.00	160.00	4.21	61.25	89.82	6.82
7.50	180.00	4.74	65.63	90.28	7.27
7.90	200.00	5.26	69.13	90.73	7.62
8.50	220.00	5.79	74.38	91.18	8.16
11.00	240.00	6.32	96.25	91.64	10.50
10.60	260.00	6.84	92.75	92.09	10.07

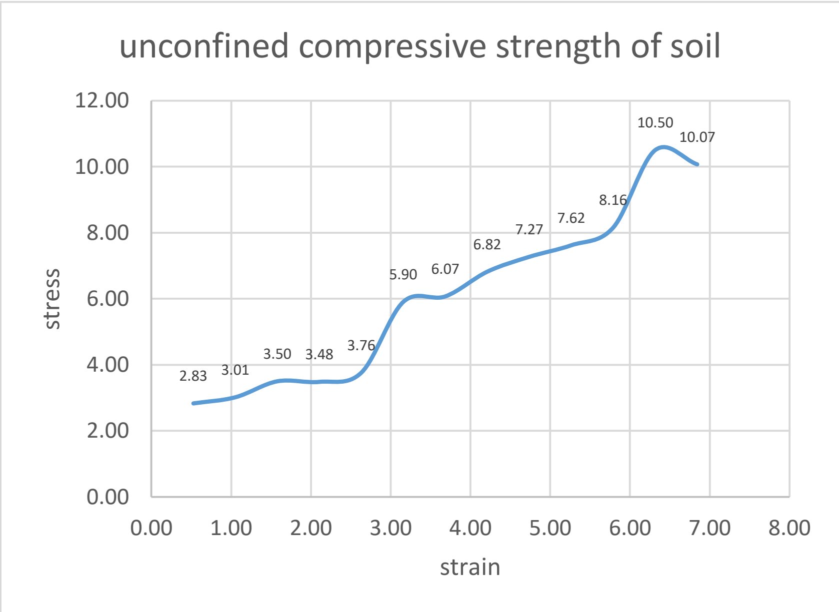


Fig-15

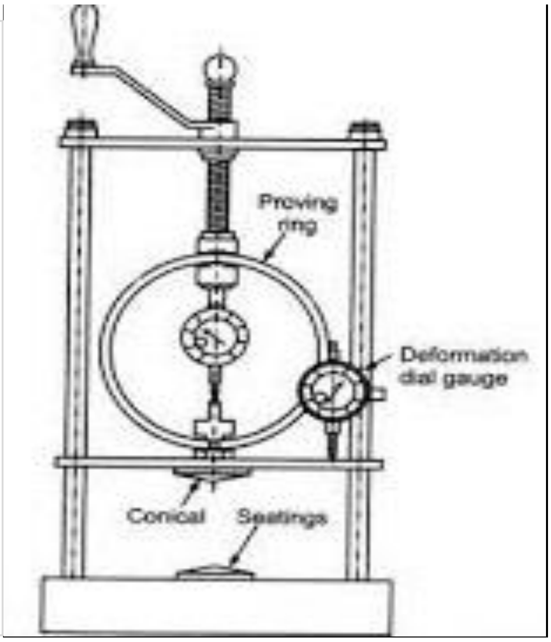


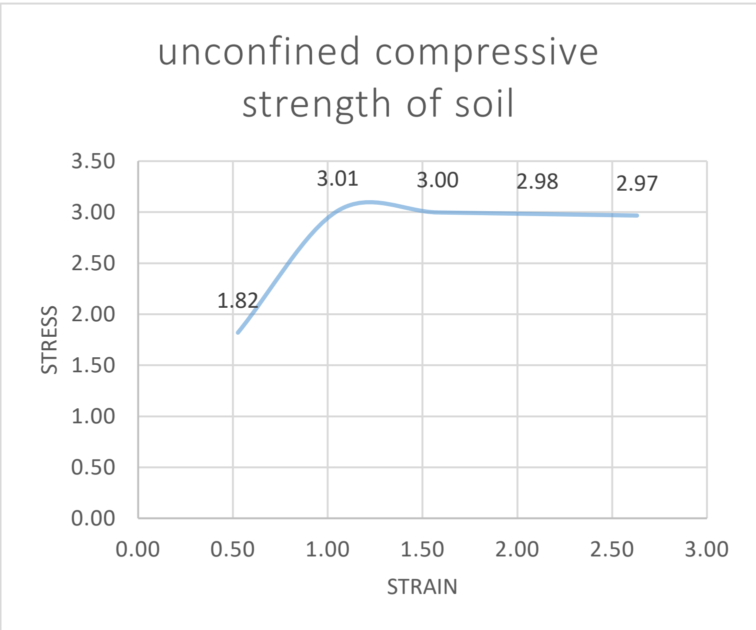
Fig-16

UNCONFINED COMPRESSIVE STRENGTH	**10.5 KN/m^2**

Experiment:-UCS test on soil with 20% Surkhi content.						
1.	**Stabilizer**-Surkhi	**4.**	**PR Constant**-0.87 Kg/div	**7.**	**IS:2720:1991-10**	**U9**
2.	**Mould vol.**-81.656cm^3	**5.**	**Soil origin**- Una (H.P)	**8.**	**Fig**.-17-18	
3.	**Machine**-UCS digital	**6.**	**UCS**-2.98 KN/m^2	**9.**	**Table**-40	

Table-40

Proving ring readings	**Dial gauge 0.02 mm/ div**	**Sample strain %**	**Axial load(N)**	**Corrected Area** cm^2	**Stress KN/m^2**
1.80	20.00	0.53	15.75	86.65	1.82
3.00	40.00	1.05	26.25	87.10	3.01
3.00	60.00	1.58	26.25	87.55	3.00
3.00	80.00	2.11	26.25	88.01	2.98
3.00	100.00	2.63	26.25	88.46	2.97



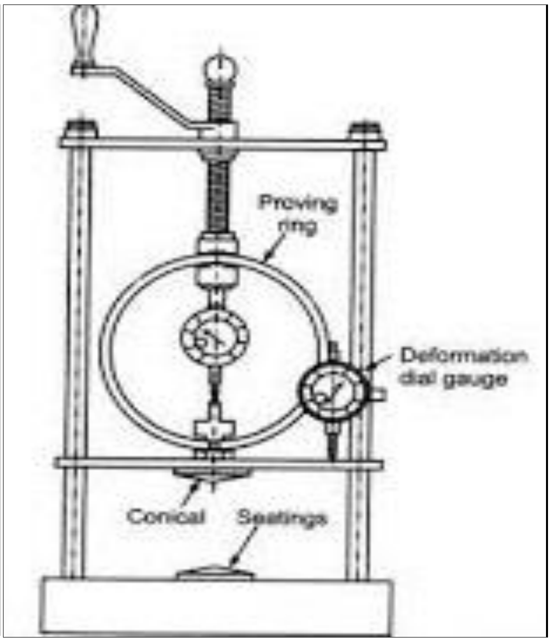


Fig-17

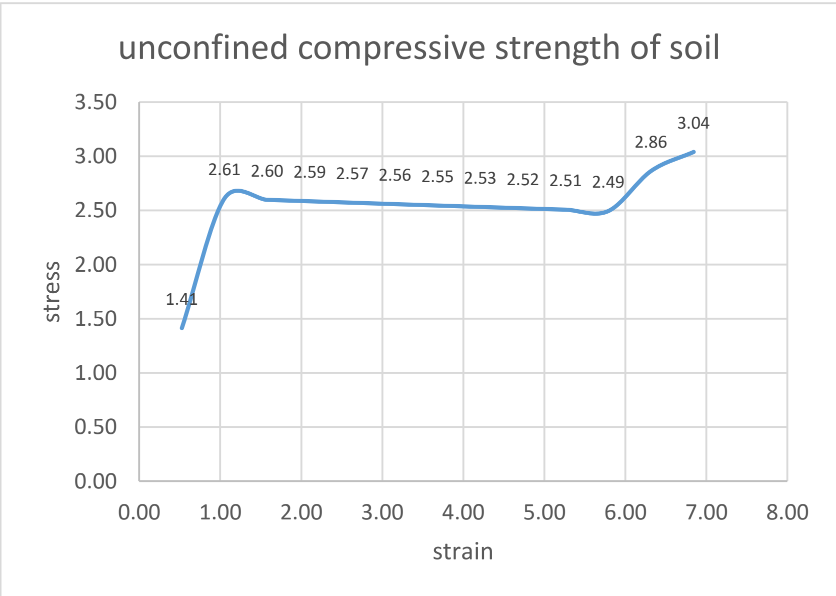
Fig-18

UNCONFINED COMPRESSIVE STRENGTH	**2.98 KN/m^2**

Experiment:-UCS test on soil with 5% Glass content.						
1.	**Stabilizer**-Glass	**4.**	**PR Constant**-0.87 Kg/div	**7.**	**IS:2720:1991-10**	**U10**
2.	**Mould vol.**-81.656cm^3	**5.**	**Soil origin**- Una (H.P)	**8.**	**Fig**.-19-20	
3.	**Machine**-UCS digital	**6.**	**UCS**-3.04 KN/m^2	**9.**	**Table-**41	

Table-41

Proving ring readings	Dial gauge 0.02 mm/ div	Sample strain %	Axial load(N)	Corrected Area cm^2	Stress KN/m^2
2.60	140.00	3.68	22.75	89.37	2.55
2.60	160.00	4.21	22.75	89.82	2.53
2.60	180.00	4.74	22.75	90.28	2.52
2.60	200.00	5.26	22.75	90.73	2.51
2.60	220.00	5.79	22.75	91.18	2.49
3.00	240.00	6.32	26.25	91.64	2.86
3.20	260.00	6.84	28.00	92.09	3.04



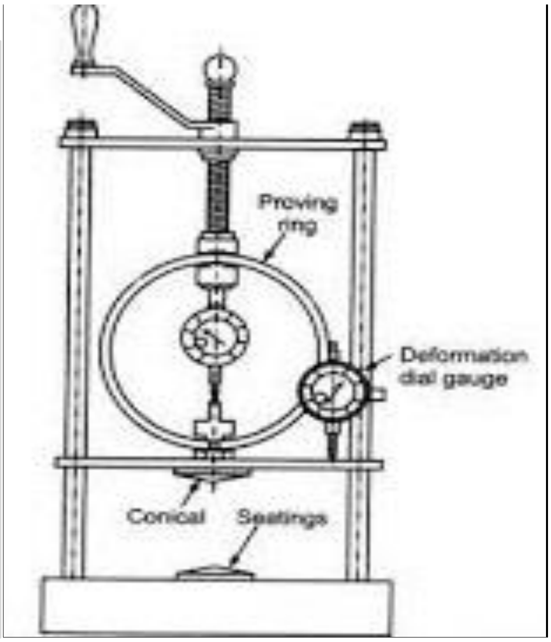


Fig-19 Fig-20

UNCONFINED COMPRESSIVE STRENGTH	**3.04 KN/m²**

Experiment:-UCS test on soil with 8% Glass content.						
1.	**Stabilizer**-Glass	**4.**	**PR Constant**-0.87 Kg/div	**7.**	**IS:2720:1991-10**	**U11**
2.	**Mould vol.**-81.656cm^3	**5.**	**Soil origin-** Una (H.P)	**8.**	**Fig**.-21-22	
3.	**Machine**-UCS digital	**6.**	**UCS**-7.4 KN/m^2	**9.**	**Table-**42	

Table-42

Proving ring readings	Dial gauge 0.02 mm/ div	Sample strain %	Axial load(N)	Corrected Area cm^2	Stress KN/m^2
3.8	40.00	1.1	33.3	8.710E+01	3.8
4.0	60.00	1.6	35.0	8.755E+01	4.0
4.4	80.00	2.1	38.5	8.801E+01	4.4
4.4	100.00	2.6	38.5	8.846E+01	4.4
4.4	120.00	3.2	38.5	8.891E+01	4.3
4.6	140.00	3.7	40.3	8.937E+01	4.5
5.0	160.00	4.2	43.8	8.982E+01	4.9
5.2	180.00	4.7	45.5	9.028E+01	5.0
5.2	200.00	5.3	45.5	9.073E+01	5.0
5.8	220.00	5.8	50.8	9.118E+01	5.6
6.4	240.00	6.3	56.0	9.164E+01	6.1
7.8	260.00	6.8	68.3	9.209E+01	7.4
7.2	280.00	7.4	63.0	9.254E+01	6.8

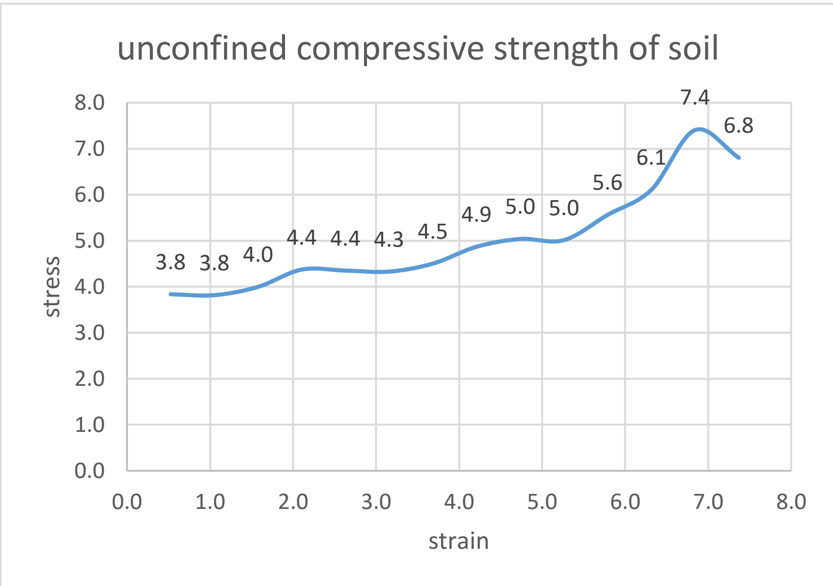


Fig-21

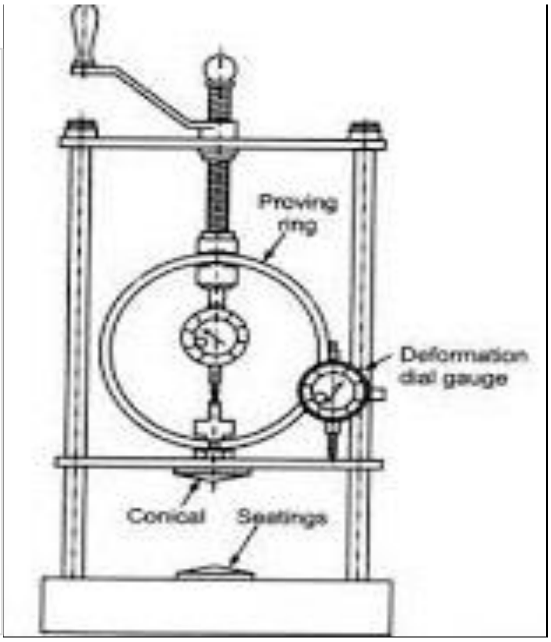


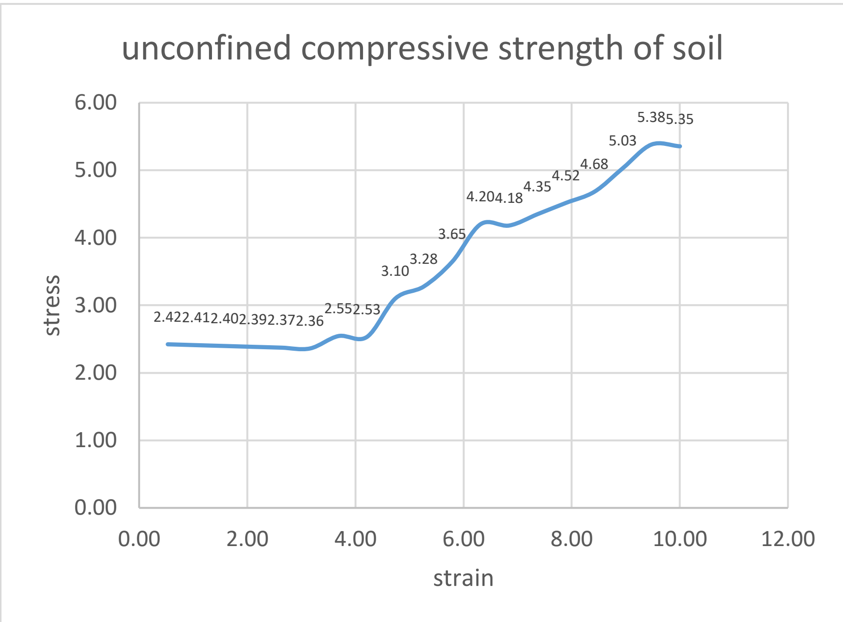
Fig-22

UNCONFINED COMPRESSIVE STRENGTH	**7.4 KN/m^2**

Experiment:-UCS test on soil with 10% Glass content.						
1.	**Stabilizer**-Glass	**4.**	**PR Constant**-0.87 Kg/div	**7.**	**IS:2720:1991-10**	**U12**
2.	**Mould vol.**-81.656cm^3	**5.**	**Soil origin**- Una (H.P)	**8.**	**Fig**.-23-24	
3.	**Machine**-UCS digital	**6.**	**UCS**-5.38 KN/m^2	**9.**	**Table**-43	

Table-43

Proving ring readings	Dial gauge 0.02 mm/ div	Sample strain %	Axial load(N)	Corrected Area cm^2	Stress KN/m^2
2.60	140.00	3.68	22.75	89.37	2.55
2.60	160.00	4.21	22.75	89.82	2.53
3.20	180.00	4.74	28.00	90.28	3.10
3.40	200.00	5.26	29.75	90.73	3.28
3.80	220.00	5.79	33.25	91.18	3.65
4.40	240.00	6.32	38.50	91.64	4.20
4.40	260.00	6.84	38.50	92.09	4.18
4.60	280.00	7.37	40.25	92.54	4.35
4.80	300.00	7.89	42.00	93.00	4.52
5.00	320.00	8.42	43.75	93.45	4.68
5.40	340.00	8.95	47.25	93.91	5.03
5.80	360.00	9.47	50.75	94.36	5.38
5.80	380.00	10.00	50.75	94.81	5.35



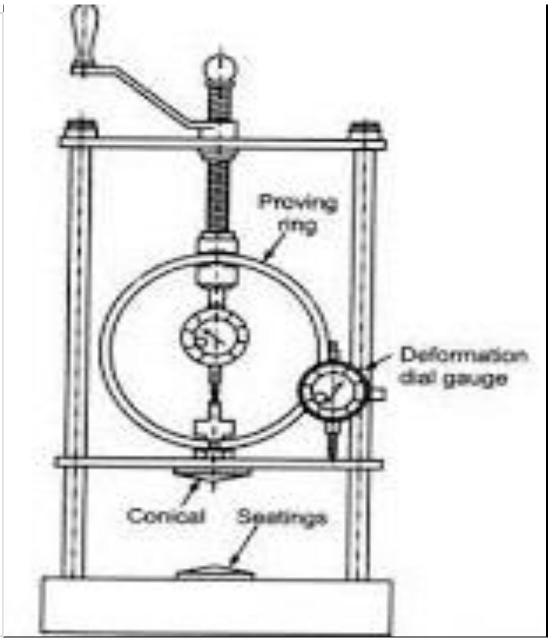


Fig-23

Fig-24

UNCONFINED COMPRESSIVE STRENGTH	**5.38 KN/m^2**

Experiment:-UCS test on soil without any stabilizer.							
1.	**Stabilizer**-none	**4.**	**PR Constant**-0.87 Kg/div	**7.**	**IS:2720:1991-10**	**U13**
2.	**Mould vol.**-81.656cm^3	**5.**	**Soil origin**- Una (H.P)	**8.**	**Fig**.-25-26	
3.	**Machine**-UCS digital	**6.**	**UCS**-2.86 KN/m^2	**9.**	**Table**-44	

Table-44

Proving ring readings	Dial gauge 0.02 mm/ div	Sample strain %	Axial load(N)	Corrected Area cm^2	Stress KN/m^2
2.10	20.00	0.53	18.38	86.65	2.12
2.10	40.00	1.05	18.38	87.10	2.11
2.20	60.00	1.58	19.25	87.55	2.20
2.20	80.00	2.11	19.25	88.01	2.19
2.20	100.00	2.63	19.25	88.46	2.18
2.30	120.00	3.16	20.13	88.91	2.26
2.30	140.00	3.68	20.13	89.37	2.25
2.30	160.00	4.21	20.13	89.82	2.24
2.40	180.00	4.74	21.00	90.28	2.33
2.60	200.00	5.26	22.75	90.73	2.51
2.60	220.00	5.79	22.75	91.18	2.49
3.00	240.00	6.32	26.25	91.64	2.86
3.00	260.00	6.84	26.25	92.09	2.85

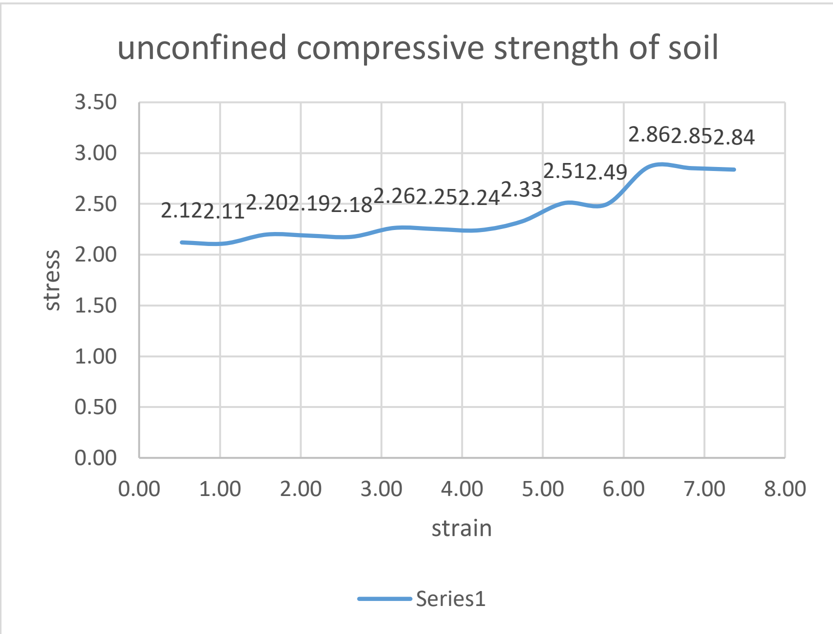


Fig-25

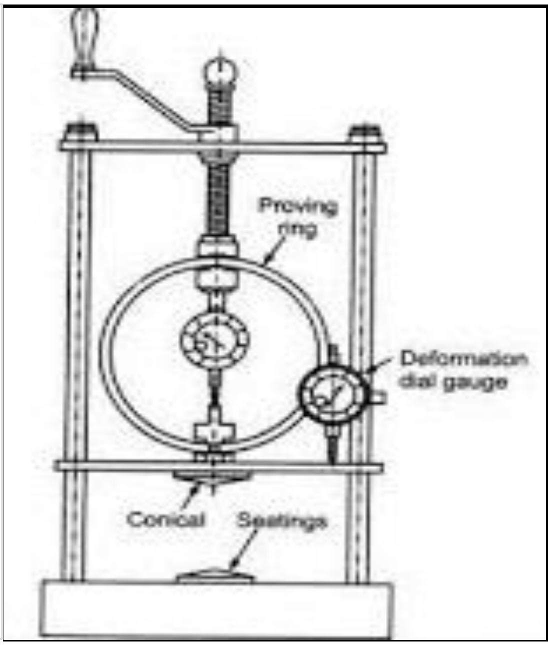
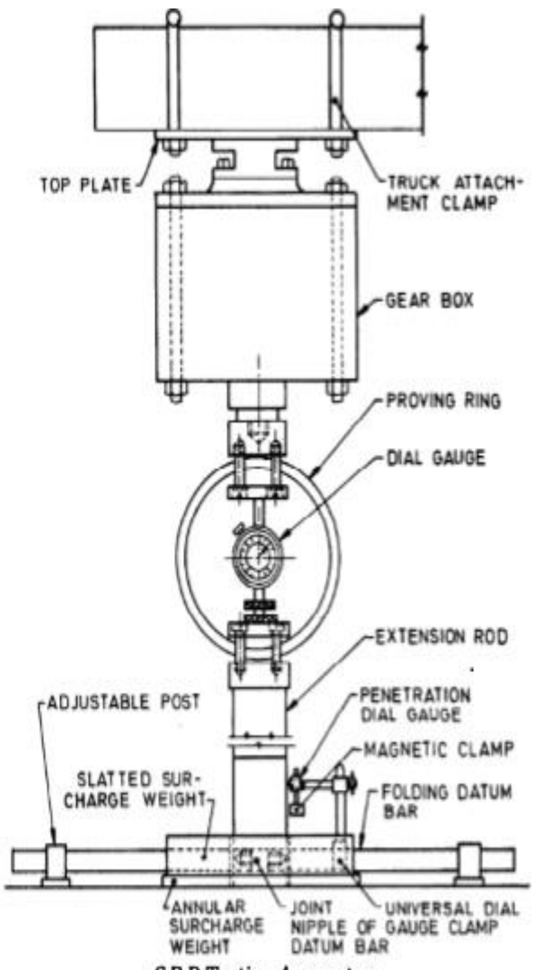


Fig-26

UNCONFINED COMPRESSIVE STRENGTH	**2.86 KN/m^2**

ANNEXURE 5

Experiment:-CBR on soil with 0.105% Plastic content.						
1.	**Stabilizer-**Plastic	**4.**	**PR Constant-8.062** Kg/div	**7.**	**IS:2720-31-1990**	**C1**
2.	**Surcharge-**2.5 Kg	**5.**	**Soil origin-** Una (H.P)	**8.**	**Fig.**-1	
3.	**Machine-**CBR machine	**6.**	**CBR- 17.7 %**	**9.**	**Table-45**	



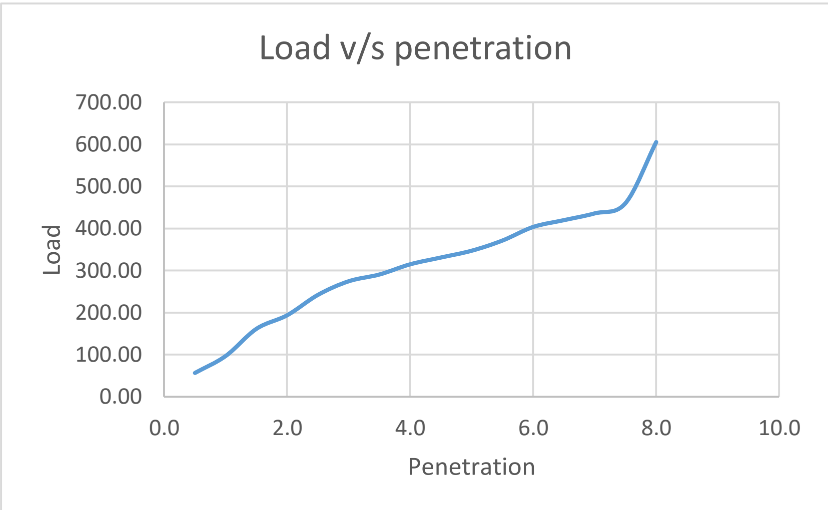
C.B.R Testing Apparatus

Plunger penetration in (mm)	Dial Gauge Reading	Corrected load(Kg)	Standard load(Kg)	CBR(%)
0.5	7.0	56.4774		
1.0	14.0	112.9548		
1.5	20.0	161.364		
2.0	24.0	193.6368		
2.5	30.0	242.046	1370.0	17.7
3.0	34.0	274.3188		
3.5	36.0	290.4552		
4.0	39.0	314.6598		
4.5	41.0	330.7962		
5.0	43.0	346.9326	2055.0	16.9
5.5	46.0	371.1372		
6.0	50.0	403.41		
6.5	52.0	419.5464		
7.0	54.0	435.6828		
7.5	57.0	459.8874		
8.0	75.0	605.115		

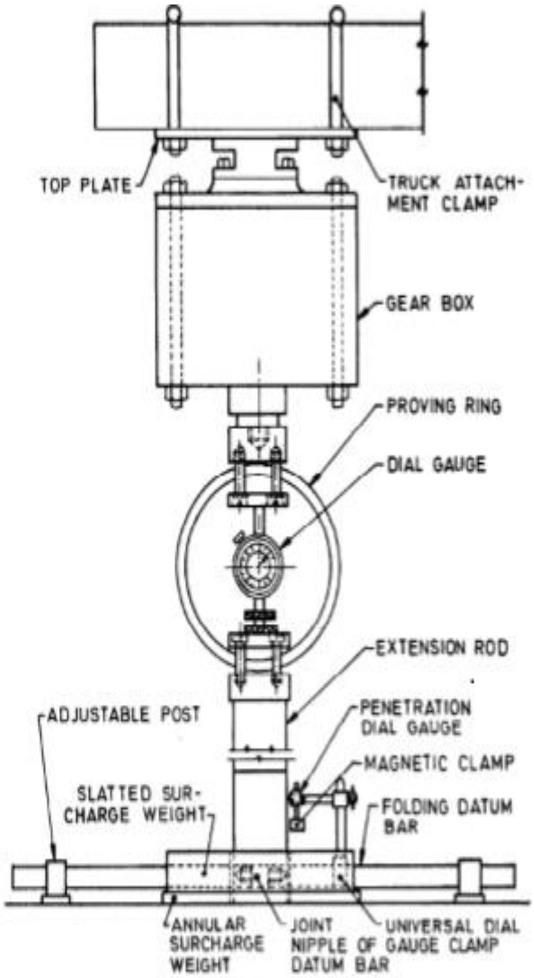
As Per IS:2720

Penetration(mm)	Unit Standard load(Kg/cm^2)	Standard load(Kgf)
2.5	70	1370
5	105	2055

CBR (%)	17.7



Experiment:-CBR on soil with 0.110% Plastic content.						
1.	**Stabilizer**-Plastic	**4.**	**PR Constant-8.06** Kg/div	**7.**	**IS:2720-31-1990**	**C2**
2.	**Surcharge**-2.5 Kg	**5.**	**Soil origin-** Una (H.P)	**8.**	**Fig.**-2	
3.	**Machine**-CBR machine	**6.**	**CBR-** 18.3 %	**9.**	**Table-**46	



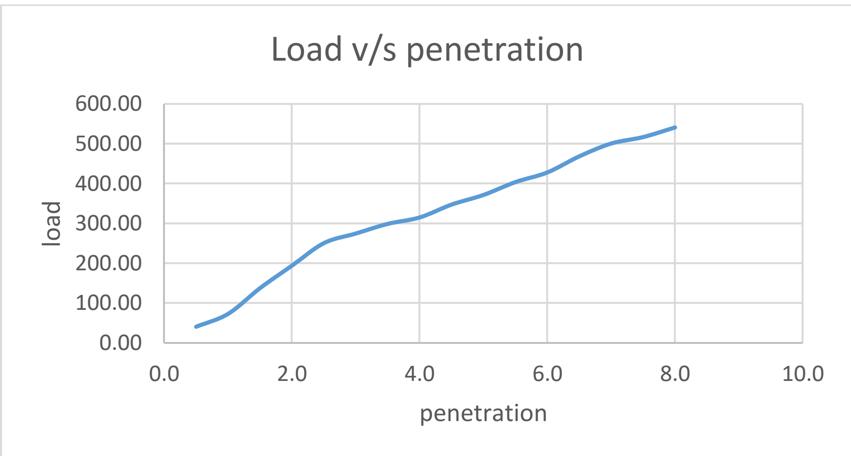
C.B.R Testing Apparatus

Plunger penetration in (mm)	Dial Gauge Reading	Corrected load(Kg)	Standard load(Kg)	CBR(%)
0.5	5	40.34		
1.0	9	72.61		
1.5	17	137.16		
2.0	24	193.64		
2.5	31	250.11	1370.0	18.3
3.0	34	274.32		
3.5	37	298.52		
4.0	39	314.66		
4.5	43	346.93		
5.0	46	371.14	2055.0	18.1
5.5	50	403.41		
6.0	53	427.61		
6.5	58	467.96		
7.0	62	500.23		
7.5	64	516.36		
8.0	67	540.57		

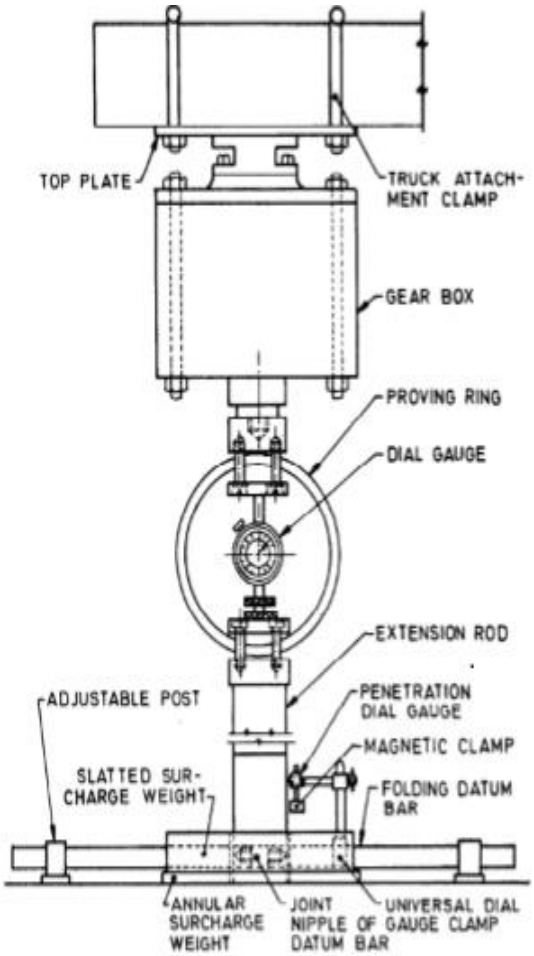
As Per IS:2720

Penetration(mm)	Unit Standard load(Kg/cm^2)	Standard load(Kgf)
2.5	70	1370
5	105	2055

CBR (%)	18.3



Experiment:-CBR on soil with 0.115% Plastic content.						
1.	**Stabilizer-**Plastic	**4.**	**PR Constant-** 8.06Kg/div	**7.**	**IS:2720-31-1990**	**C3**
2.	**Surcharge-**2.5 Kg	**5.**	**Soil origin-** Una (H.P)	**8.**	**Fig.**-3	
3.	**Machine-**CBR machine	**6.**	**CBR- 20.6 %**	**9.**	**Table-**47	



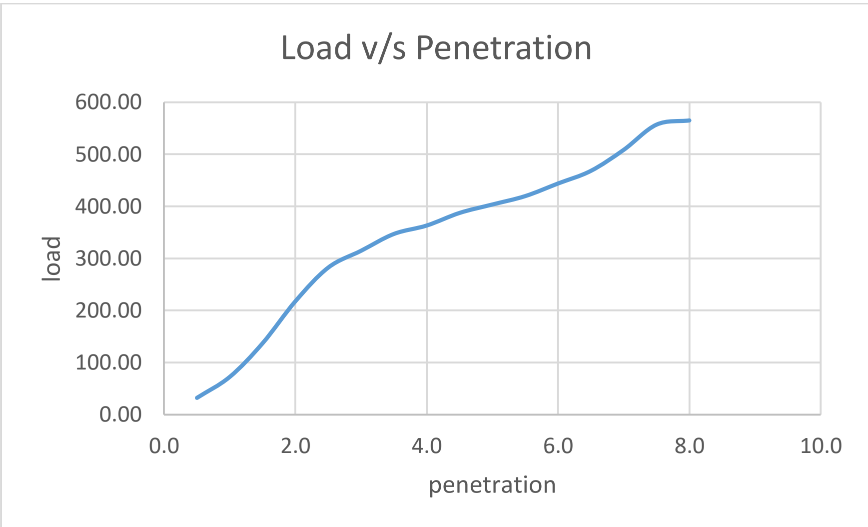
C.B.R Testing Apparatus

Plunger penetration in (mm)	Dial Gauge Reading	Corrected load(Kg)	Standard load(Kg)	CBR(%)
0.5	4	32.27		
1.0	9	72.61		
1.5	17	137.16		
2.0	27	217.84		
2.5	35	282.39	1370.0	20.6
3.0	39	314.66		
3.5	43	346.93		
4.0	45	363.07		
4.5	48	387.27		
5.0	50	403.41	2055.0	19.61
5.5	52	419.55		
6.0	55	443.75		
6.5	58	467.96		
7.0	63	508.30		
7.5	69	556.71		
8.0	70	564.77		

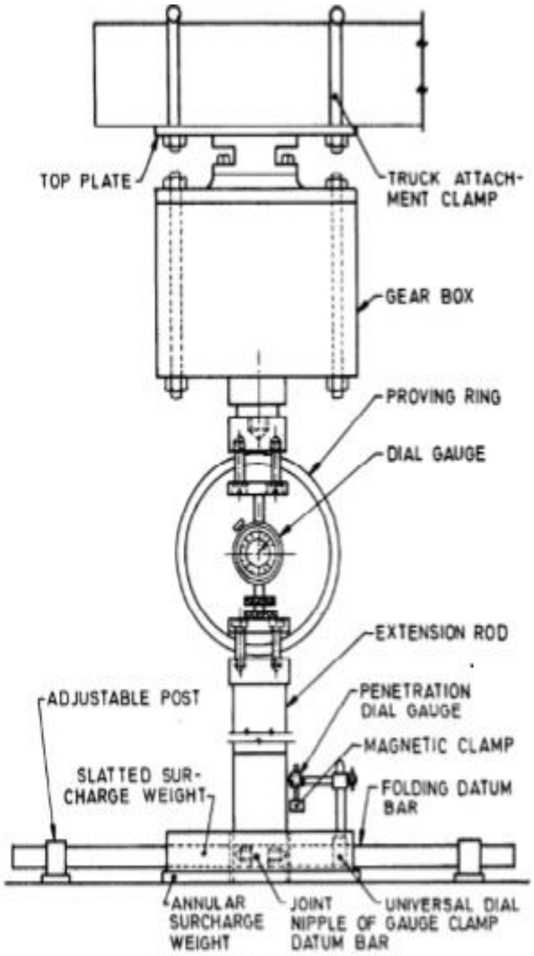
As Per IS:2720

Penetration(mm)	Unit Standard load(Kg/cm^2)	Standard load(Kgf)
2.5	70	1370
5	105	2055

CBR (%)	20.6



Experiment:-CBR on soil with 0.120% Plastic content.						
1.	**Stabilizer**-Plastic	**4.**	**PR Constant-8.06** Kg/div	**7.**	**IS:2720-31-1990**	**C4**
2.	**Surcharge**-2.5 Kg	**5.**	**Soil origin**- Una (H.P)	**8.**	**Fig**.-4	
3.	**Machine**-CBR machine	**6.**	**CBR- 20%**	**9.**	**Table**-48	



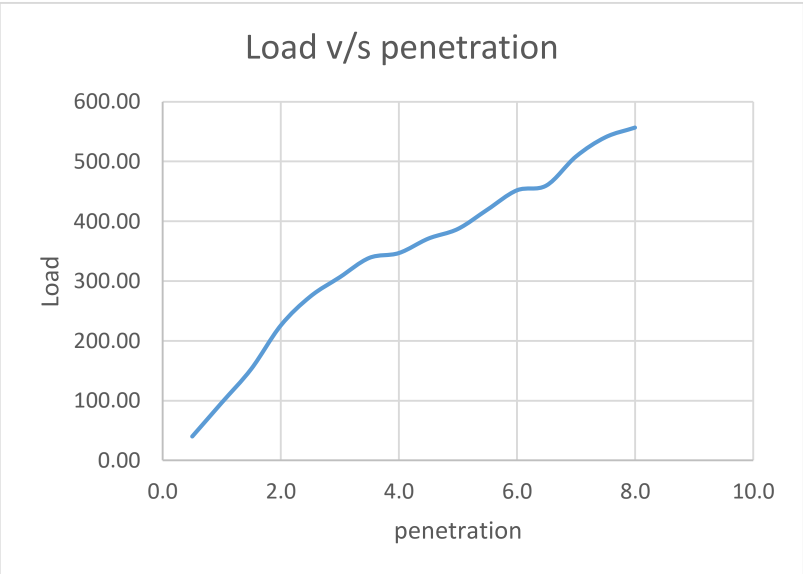
C.B.R Testing Apparatus

Plunger penetration in (mm)	Dial Gauge Reading	Corrected load(Kg)	Standard load(Kg)	CBR(%)
0.5	5	40.34		
1.0	12	96.82		
1.5	19	153.30		
2.0	28	225.91		
2.5	34	274.32	1370.0	20
3.0	38	306.59		
3.5	42	338.86		
4.0	43	346.93		
4.5	46	371.14		
5.0	48	387.27	2055.0	18.8
5.5	52	419.55		
6.0	56	451.82		
6.5	57	459.89		
7.0	63	508.30		
7.5	67	540.57		
8.0	69	556.71		

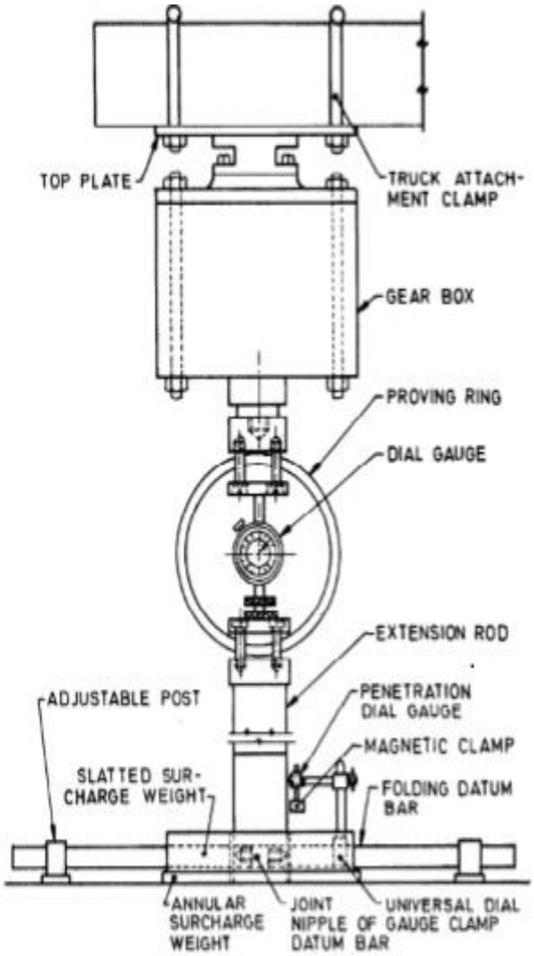
As Per IS:2720

Penetration(mm)	Unit Standard load(Kg/cm^2)	Standard load(Kgf)
2.5	70	1370
5	105	2055

CBR (%)	20



Experiment:-CBR on soil with 10% Surkhi content.						
1.	**Stabilizer**-Surkhi	**4.**	**PR Constant-8.06** Kg/div	**7.**	**IS:2720-31-1990**	**C5**
2.	**Surcharge**-2.5 Kg	**5.**	**Soil origin-** Una (H.P)	**8.**	**Fig.**-5	
3.	**Machine**-CBR machine	**6.**	**CBR- 19.41%**	**9.**	**Table-**49	



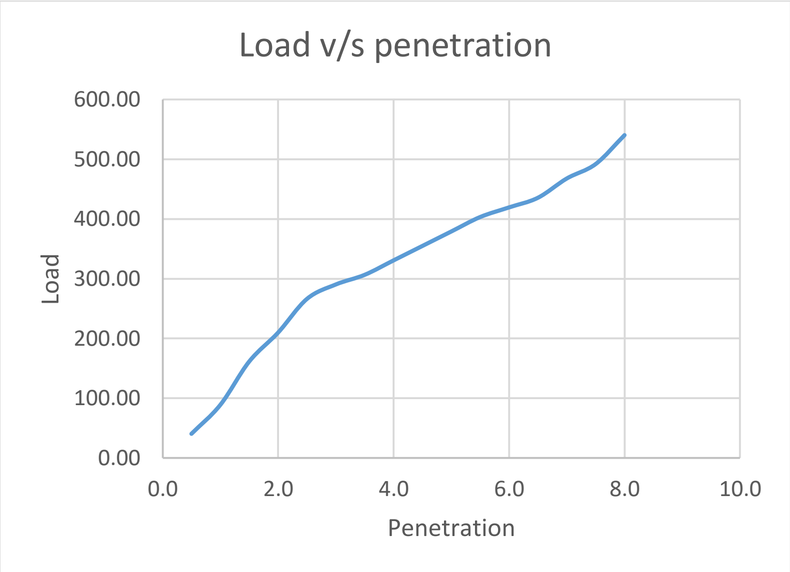
C.B.R Testing Apparatus

Plunger penetration in (mm)	Dial Gauge Reading	Corrected load(Kg)	Standard load(Kg)	CBR(%)
0.5	5	40.34		
1.0	11	88.75		
1.5	20	161.36		
2.0	26	209.77		
2.5	33	266.25	1370.0	19.41
3.0	36	290.46		
3.5	38	306.59		
4.0	41	330.80		
4.5	44	355.00		
5.0	47	379.21	2055.0	18.44
5.5	50	403.41		
6.0	52	419.55		
6.5	54	435.68		
7.0	58	467.96		
7.5	61	492.16		
8.0	67	540.57		

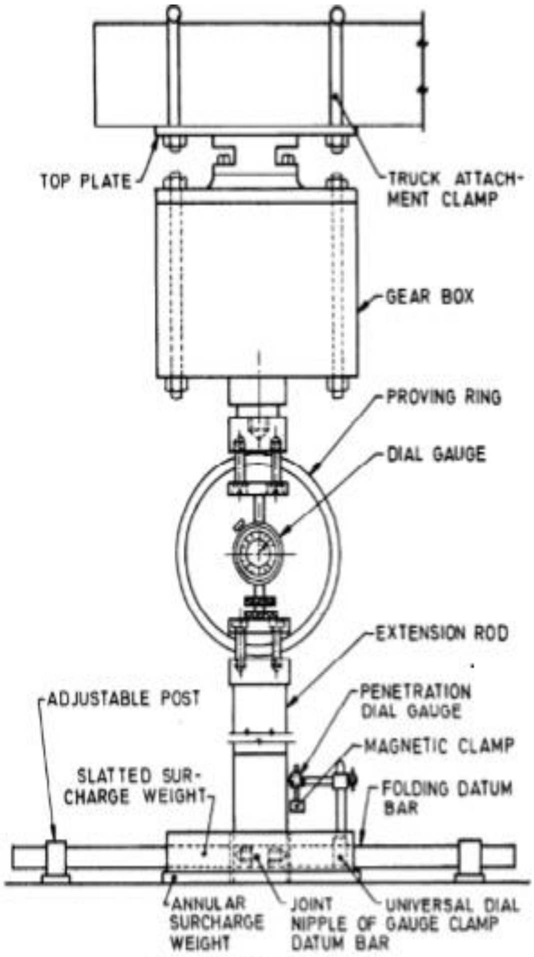
As Per IS:2720

Penetration(mm)	Unit Standard load(Kg/cm^2)	Standard load(Kgf)
2.5	70	1370
5	105	2055

CBR (%)	19.41



Experiment:-CBR on soil with 12.5% Surkhi content.						
1.	**Stabilizer**-Surkhi	**4.**	**PR Constant-8.06** Kg/div	**7.**	**IS:2720-31-1990**	**C6**
2.	**Surcharge**-2.5 Kg	**5.**	**Soil origin-** Una (H.P)	**8.**	**Fig.**-6	
3.	**Machine-**CBR machine	**6.**	**CBR- 20.58%**	**9.**	**Table-**50	



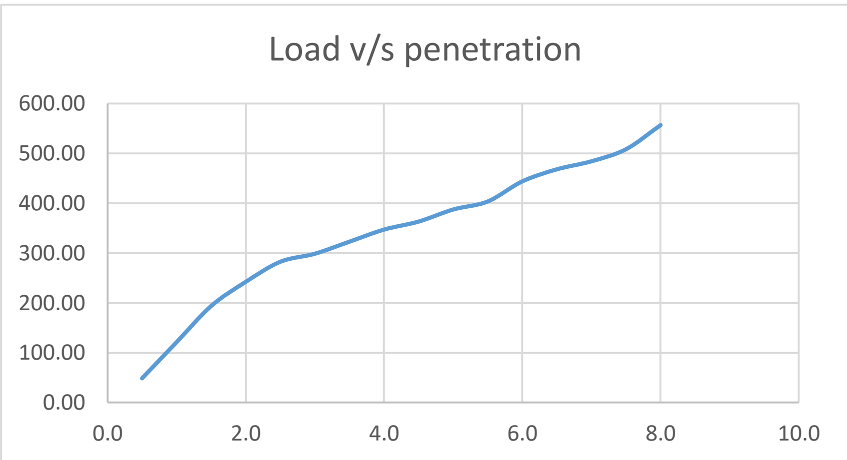
C.B.R Testing Apparatus

Plunger penetration in (mm)	Dial Gauge Reading	Corrected load(Kg)	Standard load(Kg)	CBR(%)
0.5	6	48.41		
1.0	15	121.02		
1.5	24	193.64		
2.0	30	242.05		
2.5	35	282.39	1370.0	20.58
3.0	37	298.52		
3.5	40	322.73		
4.0	43	346.93		
4.5	45	363.07		
5.0	48	387.27	2055.0	18.8
5.5	50	403.41		
6.0	55	443.75		
6.5	58	467.96		
7.0	60	484.09		
7.5	63	508.30		
8.0	69	556.71		

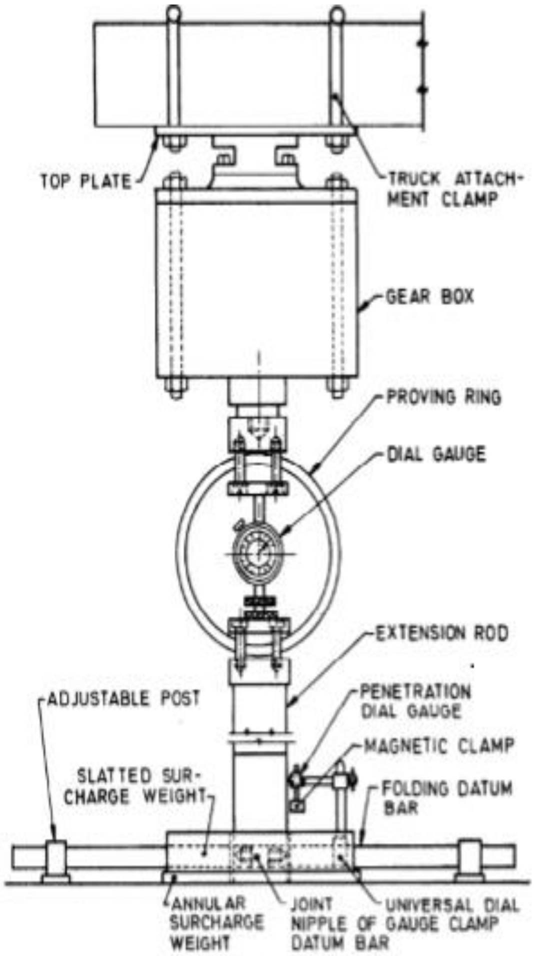
As Per IS:2720

Penetration(mm)	Unit Standard load(Kg/cm^2)	Standard load(Kgf)
2.5	70	1370
5	105	2055

CBR (%)	20.58



Experiment:-CBR on soil with 15% Surkhi content.						
1.	**Stabilizer-**Surkhi	**4.**	**PR Constant-8.06** Kg/div	**7.**	**IS:2720-31-1990**	**C7**
2.	**Surcharge-**2.5 Kg	**5.**	**Soil origin-** Una (H.P)	**8.**	**Fig.**-7	
3.	**Machine-**CBR machine	**6.**	**CBR- 21.75**	**9.**	**Table-**51	



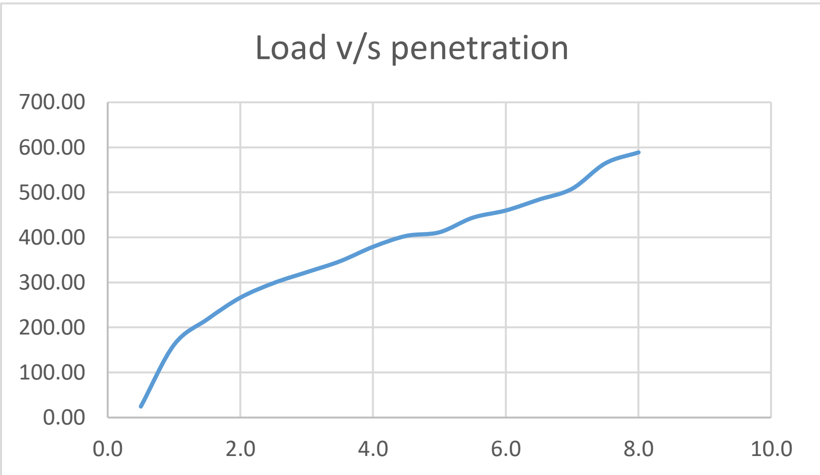
C.B.R Testing Apparatus

Plunger penetration in (mm)	Dial Gauge Reading	Corrected load(Kg)	Standard load(Kg)	CBR(%)
0.5	3	24.20		
1.0	20	161.36		
1.5	27	217.84		
2.0	33	266.25		
2.5	37	298.52	1370.0	21.75
3.0	40	322.73		
3.5	43	346.93		
4.0	47	379.21		
4.5	50	403.41		
5.0	51	411.48	2055.0	20
5.5	55	443.75		
6.0	57	459.89		
6.5	60	484.09		
7.0	63	508.30		
7.5	70	564.77		
8.0	73	588.98		

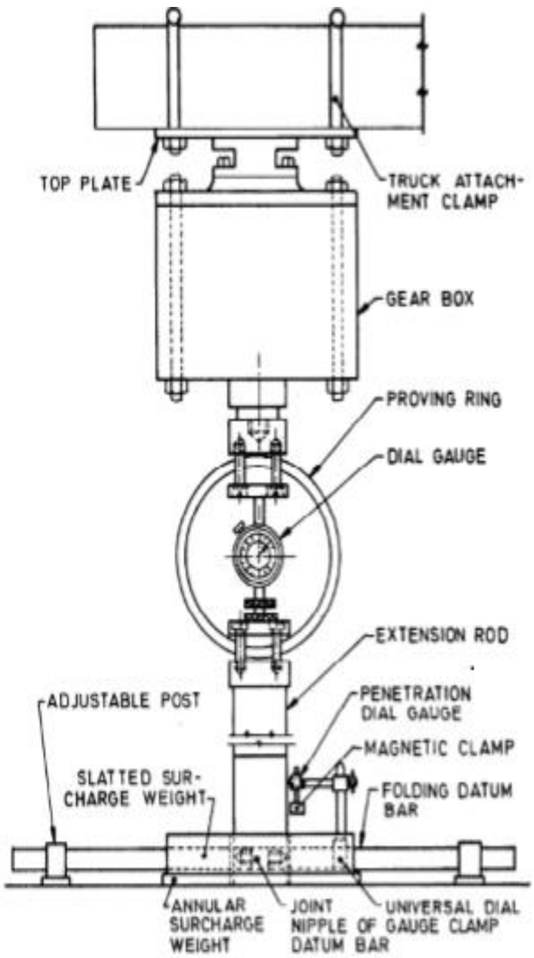
As Per IS:2720

Penetration(mm)	Unit Standard load(Kg/cm^2)	Standard load(Kgf)
2.5	70	1370
5	105	2055

CBR (%)	21.75



Experiment:-CBR on soil with 17.5% Surkhi content.						
1.	**Stabilizer**-Surkhi	**4.**	**PR Constant-** 8.06 Kg/div	**7.**	**IS:2720-31-1990**	**C8**
2.	**Surcharge**-2.5 Kg	**5.**	**Soil origin-** Una (H.P)	**8.**	**Fig.**-8	
3.	**Machine**-CBR machine	**6.**	**CBR- 24.1%**	**9.**	**Table-**52	



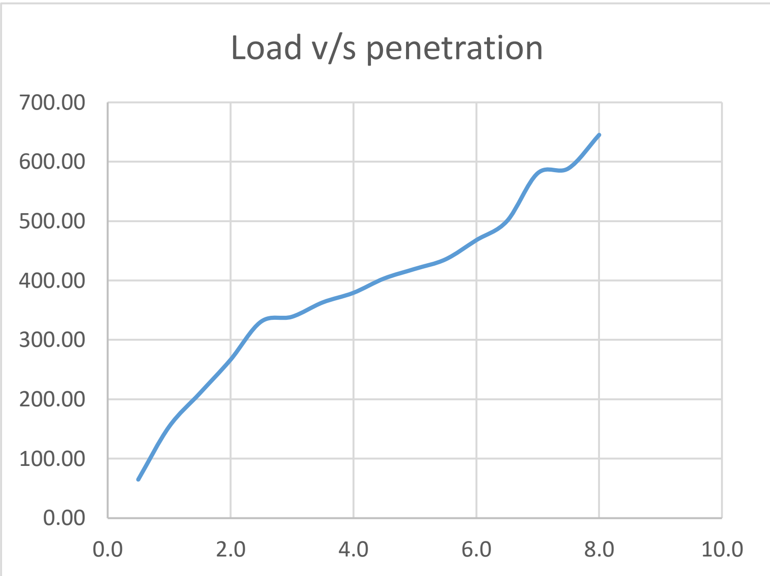
C.B.R Testing Apparatus

Plunger penetration in (mm)	Dial Gauge Reading	Corrected load(Kg)	Standard load(Kg)	CBR(%)
0.5	8	64.55		
1.0	19	153.30		
1.5	26	209.77		
2.0	33	266.25		
2.5	41	330.80	1370.0	24.1
3.0	42	338.86		
3.5	45	363.07		
4.0	47	379.21		
4.5	50	403.41		
5.0	52	419.55	2055.0	20.43
5.5	54	435.68		
6.0	58	467.96		
6.5	62	500.23		
7.0	72	580.91		
7.5	73	588.98		
8.0	80	645.46		

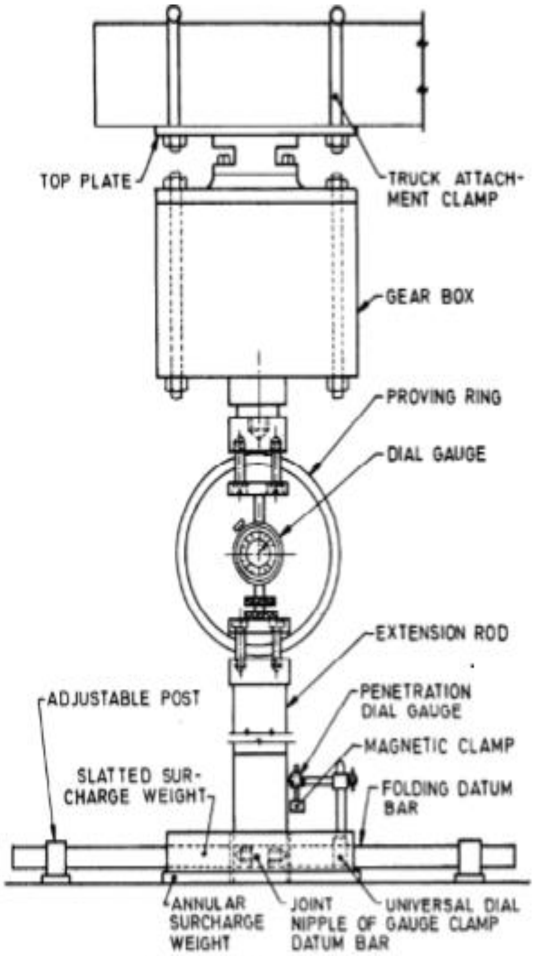
As Per IS:2720

Penetration(mm)	Unit Standard load(Kg/cm^2)	Standard load(Kgf)
2.5	70	1370
5	105	2055

CBR (%)	24.1

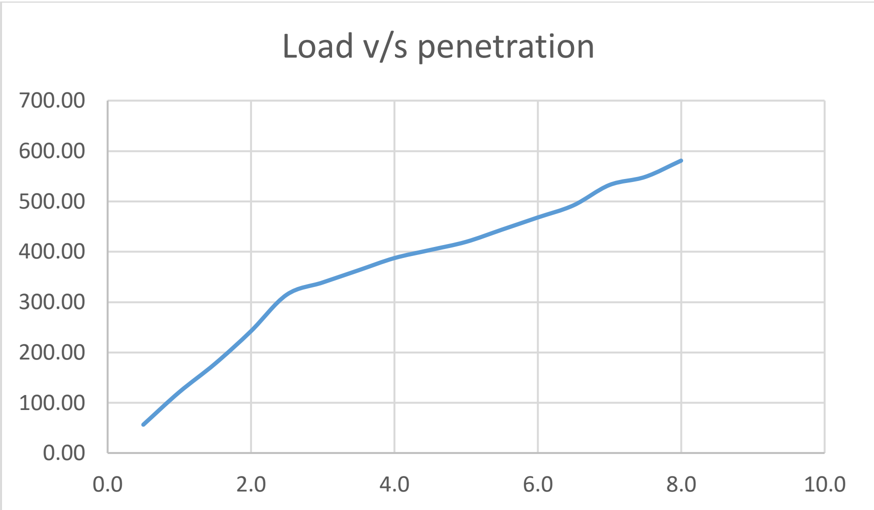


Experiment:-CBR on soil with 20% Surkhi content.						
1.	**Stabilizer**-Surkhi	**4.**	**PR Constant-8.06** Kg/div	**7.**	**IS:2720-31-1990**	**C9**
2.	**Surcharge**-2.5 Kg	**5.**	**Soil origin-** Una (H.P)	**8.**	**Fig**.-9	
3.	**Machine**-CBR machine	**6.**	**CBR- 22.96 %**	**9.**	**Table-**53	



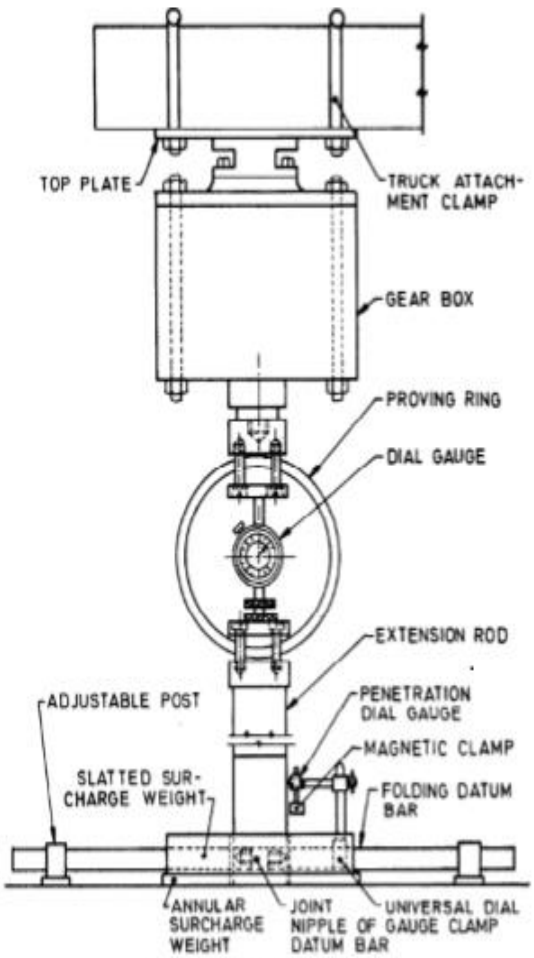
C.B.R Testing Apparatus

Plunger penetration in (mm)	Dial Gauge Reading	Corrected load(Kg)	Standard load(Kg)	CBR(%)
0.5	7	56.48		
1.0	15	121.02		
1.5	22	177.50		
2.0	30	242.05		
2.5	39	314.66	1370.0	22.96
3.0	42	338.86		
3.5	45	363.07		
4.0	48	387.27		
4.5	50	403.41		
5.0	52	419.55	2055.0	20.38
5.5	55	443.75		
6.0	58	467.96		
6.5	61	492.16		
7.0	66	532.50		
7.5	68	548.64		
8.0	72	580.91		
As Per IS:2720				
Penetration(mm)	Unit Standard load(Kg/cm^2)	Standard load(Kgf)		
2.5	70	1370		
5	105	2055		



CBR (%)	22.96

Experiment:-CBR on soil with 5% Glass content.						
1.	**Stabilizer**-Glass	**4.**	**PR Constant-** 8.06Kg/div	**7.**	**IS:2720-31-1990**	**C10**
2.	**Surcharge**-2.5 Kg	**5.**	**Soil origin-** Una (H.P)	**8.**	**Fig**.-10	
3.	**Machine**-CBR machine	**6.**	**CBR- 19.41%**	**9.**	**Table-**54	

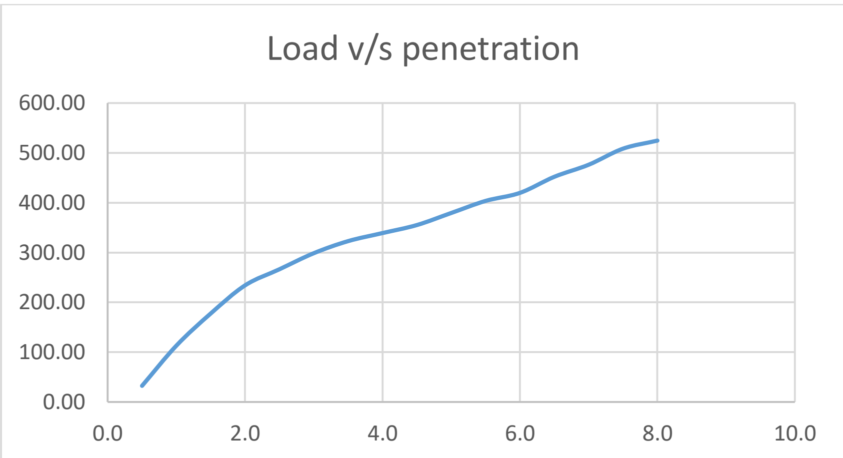


C.B.R Testing Apparatus

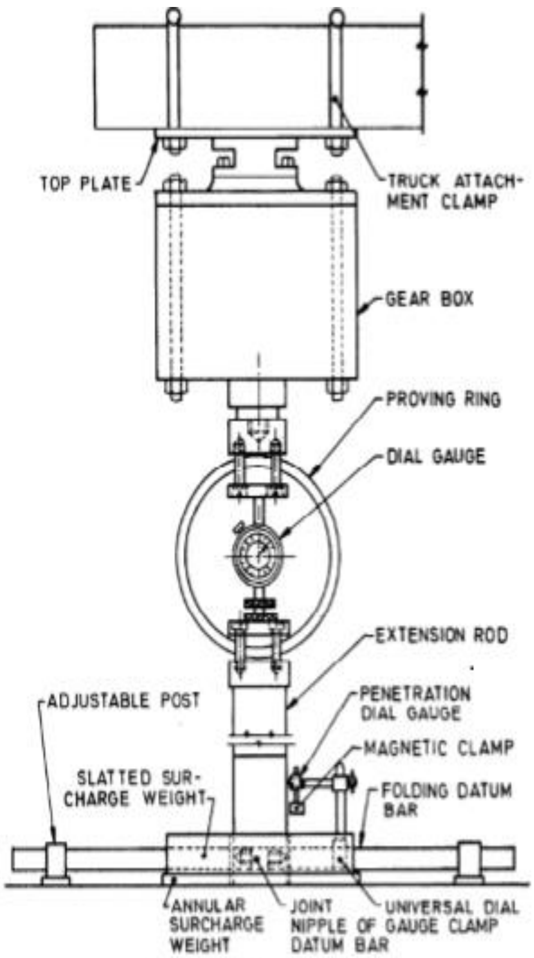
Plunger penetration in (mm)	Dial Gauge Reading	Corrected load(Kg)	Standard load(Kg)	CBR(%)
0.5	4	32.27		
1.0	14	112.95		
1.5	22	177.50		
2.0	29	233.98		
2.5	33	266.25	1370.0	19.41
3.0	37	298.52		
3.5	40	322.73		
4.0	42	338.86		
4.5	44	355.00		
5.0	47	379.21	2055.0	18.44
5.5	50	403.41		
6.0	52	419.55		
6.5	56	451.82		
7.0	59	476.02		
7.5	63	508.30		
8.0	65	524.43		

As Per IS:2720		
Penetration(mm)	Unit Standard load(Kg/cm^2)	Standard load(Kgf)
2.5	70	1370
5	105	2055

CBR (%)	19.41



Experiment:-CBR on soil with 8% Glass content.						
1.	**Stabilizer**-Glass	**4.**	**PR Constant-** 8.06 Kg/div	**7.**	**IS:2720-31-1990**	**C11**
2.	**Surcharge**-2.5 Kg	**5.**	**Soil origin-** Una (H.P)	**8.**	**Fig.**-11	
3.	**Machine**-CBR machine	**6.**	**CBR- 23**	**9.**	**Table-**55	



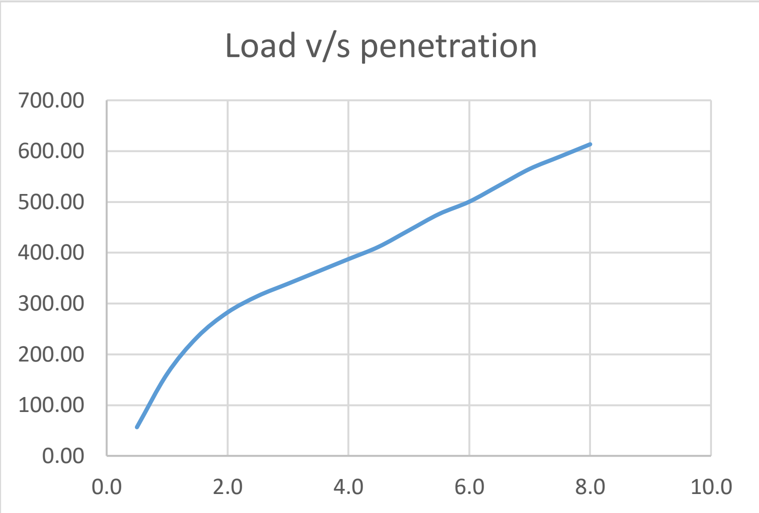
C.B.R Testing Apparatus

Plunger penetration in (mm)	Dial Gauge Reading	Corrected load(Kg)	Standard load(Kg)	CBR(%)
0.5	7	56.48		
1.0	20	161.36		
1.5	29	233.98		
2.0	35	282.39		
2.5	39	314.66	1370.0	23
3.0	42	338.86		
3.5	45	363.07		
4.0	48	387.27		
4.5	51	411.48		
5.0	55	443.75	2055.0	21.55
5.5	59	476.02		
6.0	62	500.23		
6.5	66	532.50		
7.0	70	564.77		
7.5	73	588.98		
8.0	76	613.18		

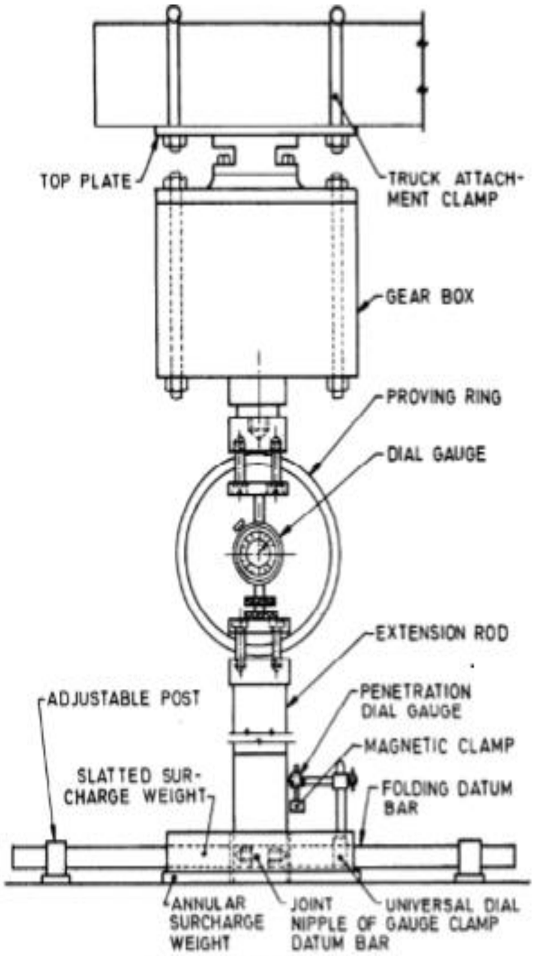
As Per IS:2720

Penetration(mm)	Unit Standard load(Kg/cm^2)	Standard load(Kgf)
2.5	70	1370
5	105	2055

CBR (%)	23



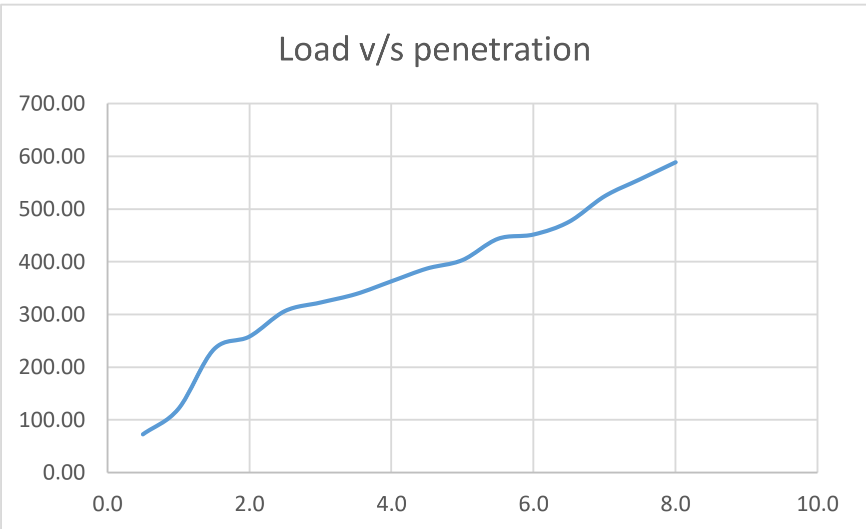
Experiment:-CBR on soil with 10% Glass content.						
1.	**Stabilizer**-Glass	**4.**	**PR Constant**- 8.06Kg/div	**7.**	**IS:2720-31-1990**	**C12**
2.	**Surcharge**-2.5 Kg	**5.**	**Soil origin**- Una (H.P)	**8.**	**Fig**.-12	
3.	**Machine**-CBR machine	**6.**	**CBR- 22.4 %**	**9.**	**Table**-56	



C.B.R Testing Apparatus

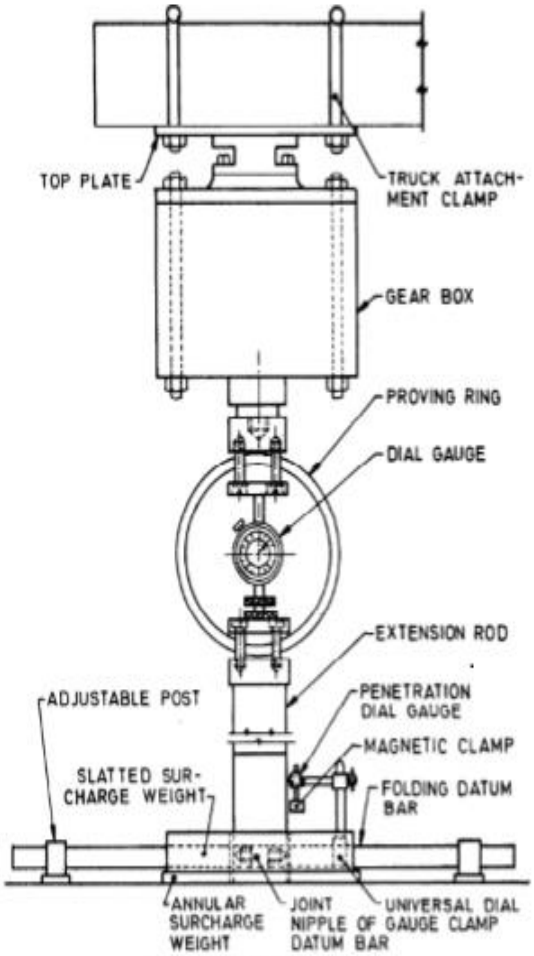
Plunger penetration in (mm)	Dial Gauge Reading	Corrected load(Kg)	Standard load(Kg)	CBR(%)
0.5	9	72.61		
1.0	15	121.02		
1.5	29	233.98		
2.0	32	258.18		
2.5	38	306.59	1370.0	22.4
3.0	40	322.73		
3.5	42	338.86		
4.0	45	363.07		
4.5	48	387.27		
5.0	50	403.41	2055.0	19.6
5.5	55	443.75		
6.0	56	451.82		
6.5	59	476.02		
7.0	65	524.43		
7.5	69	556.71		
8.0	73	588.98		

As Per IS:2720		
Penetration(mm)	Unit Standard load(Kg/cm^2)	Standard load(Kgf)
2.5	70	1370
5	105	2055



CBR (%)	22.4

Experiment:-CBR on soil without any stabilizer.						
1.	**Stabilizer**-None	**4.**	**PR Constant-** 8.06Kg/div	**7.**	**IS:2720-31-1990**	**C13**
2.	**Surcharge**-2.5 Kg	**5.**	**Soil origin-** Una (H.P)	**8.**	**Fig**.-13	
3.	**Machine**-CBR machine	**6.**	**CBR- 18.8%**	**9.**	**Table-**57	



C.B.R Testing Apparatus

Plunger penetration in (mm)	Dial Gauge Reading	Corrected load(Kg)	Standard load(Kg)	CBR(%)
0.5	6.0	48.4		
1.0	12.0	96.8		
1.5	19.0	153.3		
2.0	25.0	201.7		
2.5	32.0	258.2	1370.0	18.8
3.0	35.0	282.4		
3.5	38.0	306.6		
4.0	42.0	338.9		
4.5	43.0	346.9		
5.0	47.0	379.2	2055.0	18.5
5.5	55.0	443.8		
6.0	60.0	484.1		
6.5	63.0	508.3		
7.0	68.0	548.6		
7.5	71.0	572.8		
8.0	75.0	605.1		

As Per IS:2720		
Penetration(mm)	Unit Standard load(Kg/cm^2)	Standard load(Kgf)
2.5	70	1370
5	105	2055

CBR (%)	18.8