

USE OF HUMAN HAIR & GLASS POWDER AS DISCRETE FIBER IN ROAD CONSTRUCTION

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of the degree of**

MASTER OF TECHNOLOGY

in

CIVIL ENGINEERING

by

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2016

DECLARATION

I, Ujjwal Mishra (11500975), hereby declare that this thesis report entitled “**USE OF HUMAN HAIR & GLASS POWDER AS DISCRETE FIBER IN ROAD CONSTRUCTION**” submitted in the partial fulfilment of the requirements for the award of degree of Master of Civil Engineering, in the School of Civil Engineering, **Lovely Professional University, Phagwara**, is my own work. This matter embodied in this report has not been submitted in part or full to any other university or institute for the award of any degree.

Date:

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CERTIFICATE

Certified that this project report entitled “**USE OF HUMAN HAIR & GLASS POWDER AS DISCRETE FIBER IN ROAD CONSTRUCTION**” submitted individually by student of School of Civil Engineering, **Lovely Professional University, Phagwara** carried out the work under my supervision for the Award of Degree. This report has not been submitted to any other university or institution for the award of any degree.

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ABSTRACT

The main purpose of my research is to evaluate various different aspects or results which are going to come after in the road construction process by using the discrete fibers as-human hair and glass powder. The main concern of our studies is about that whether after using these discrete fibers in construction of road the tensile strength is going to increase or decrease and what are the various effects which are going to be happen in the life span of the pavement whether it is going to increase or decrease due to this, and one of the main objective of the research was to do the comparison between the various effects which are going to be generate due to use of human hair as a discrete fiber in road construction and the effects which are going to be generate due to use of glass powder as a discrete fiber in road construction and we are also going to check which is the best alternative in it and which will give the most economical and reliable results in the future and whether the tensile strength is going to be affected by these materials and whether it is going to be increase or decrease and what effect it will leave in the pavement and as we know that the life span of the rigid pavement is about 15-20 years and after the increase in the tensile strength of the pavement we can increase it upto 25 years but we are mainly concerned about the flexible pavements because those have the less life time span upto 6-8 years and we are trying to increase this time span upto 12-15 years.in most of the research papers and studies we have gone through to collect the necessary information about various properties of these materials and the effect in under different situations and even whether those properties are going to be useful in our project work or not and what are the various modifications which are being required to add in our project and what will be the various equipments and the materials we are going to use in it are being described in this study so it is an short brief of the work and experiments which are going to done in further thesis project.

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CHAPTER-1

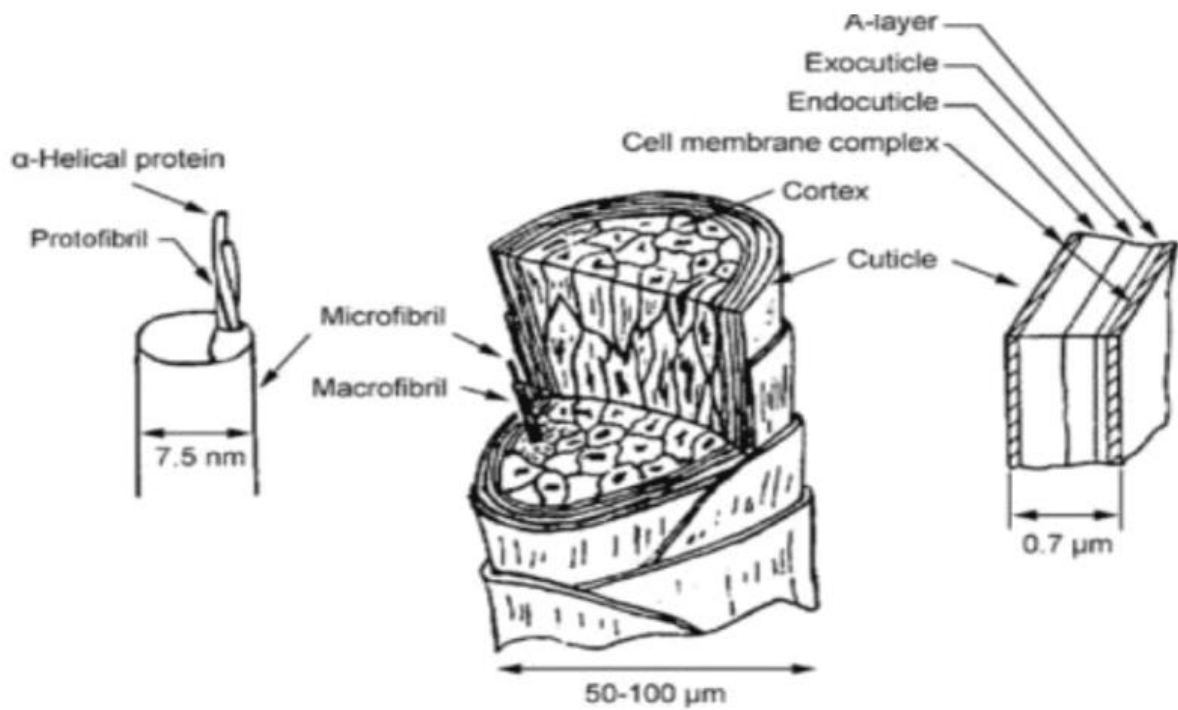
INTRODUCTION

1.1 BACKGROUND

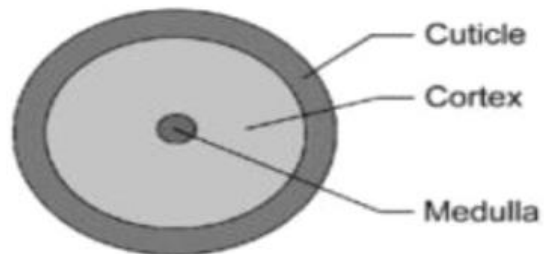
As we know that human hair is an important biological fiber among many other biological fibres which are being used from last 3000 years in composite systems in many countries like Egypt straw and clay were these fibres which are being mixed for wall construction but here due to raise in ecology risk and crisis of global energy we are going to do the study of the biological fiber i.e human hair because the various benefits of the biological fibers are that these are present in ample quantity, having non-corrosive property and also these are not harmful for human body so our thesis is only concerned about the human hair which is a filament of protein and found on skin and dermis and originates from follicles. It generally contains protein and keratins and amino acid's long chain (polymers). It generally have 20.85% oxygen, 6.36 hydrogen, 17.14% nitrogen,5% sulphur,50.65% carbon. The amino acid which exists in hair contains threonine, serine, cytosine, glutamine, arginine, leucine, valine etc.

The specific word "Hair" generally depicts 2 different structures i.e given following in detail Hair follicle, which is the part below the skin and it is called bulb when it is being pulled from the skin it maintains the cells of stem and is situated in the dermis when a hair falls out it helps it to re-grow it and also helps in skin re-growing after wound. The filamentous part which is quite hard and expands above the surface of the skin is called, the shaft. The human hair shaft's cross section can be divided into three parts:The cuticle consisting of numerous flat layers and small cells which is being overlapped on each other as shingles of roof.The cortex containing packets of keratin in cell structures that is hard like a electric rod.The medulla which is totally unorganized and also an open area which is located at center of fiber.One of the main reason behind the use of hair as the fiber in the road construction is also that it helps in strengthening the mortar and also protect it from being spalled.it also helps the pavement to be protected from any kind of the failures as it is mentioned earlier that it provides a high tensile strength to the structure which is equal to the similar tensile strength to a wire of copper having the same diameter.

Here is the diagramme of the schematic and cross section of a human hair -



Schematic of hair fiber structure



Cross section of a human hair fiber

Figure 1.1: Schematic of human hair structure and cross-section (Wei et al. [1]).

1.2 Glass powder

Glass can be defined by the following point-

- a) Translucent
- b) Transparent
- c) Amorphous solid

It is not made up by a single material it is the mixture of the various metal silicates or alkali metals.

1.2.1 History

The history of the manufacturing of the glass is very ancient. It is found by the archaeologists that first glass was made in coastal north Syria, Mesopotamia or ancient Egypt in 3500 B.C

But the actual development of the glass technology has begun in 1730 B.C in China but though it was found after the invention of metal and ceramic. Later glass has been discovered in England and named as Anglo-Saxon glass which is being used in making vessels, windows, beads and also used in jewelry.

1.2.2 Characteristics of glass

The various characteristics of glass are given following-

- 1) Glass is used in transmission of light.
- 2) Glass is used in absorption of light.
- 3) It is also used in reflection of light.
- 4) Glass is also considered as ionic liquid and it is also a good electrical insulator at high temperatures.
- 5) It is unaffected by water or air.
- 6) It is non-reactionable with any simple chemical reagent.
- 7) It is also fragile.
- 8) Glass is not having any specific melting point.
- 9) It is a colourless, diffused, stained and clear material
- 10) It is possible by fusion process to add glass pieces.

1.2.3 Types of glasses

Generally glasses are of following types-

- a) Insulating glass
- b) Safety glass
- c) Laminated safety glass
- d) Toughened safety glass
- e) Tinted glass
- f) Glass bricks
- g) Reflective glass

now we are going to discuss these types of glasses in details with their properties-

a) Insulating glass

1.it is made up by two or more types of glasses distinguished by spaces of air which is being assembled in any mill or factory.

2.it is water and moisture resistant

3.this glass is sealed hermetically by air spaces.

b) Safety glasses

it is being basically developed for the safety of the vehicles, it is of two types-

- a) laminated safety glass
- b) toughened safety glass

c) Laminated safety glasses

1.it is generally have a structure like sandwich having the layer of plastic material which is transparent like celluloid between two sheet glass.

2.the sheets are prepared by special enamel and gelatin coated.

3.with the help of specific heat and pressure special adhesion is generated.

d) Toughened safety glasses

1.these kind of glass bears a dead load which is equal to the four times of a simple glass

2.these glasses have more strength due to extra compressive stress

3.when the pre stress expanded the cracks occur

e) Tinted glass

- 1.it is made up by addition of dye in molten glass stage.
- 2.it absorbs heat and reduces heat gain of solar energy.
- 3.it is available in various colors like-green, blue, grey, bronze etc.

f) Glass bricks

- 1.these are the different units or blocks of the glass join together to work as a brick
- 2.it can be joined by the silicon sealants.
- 3.these are fire resistant also and mainly find at Indonesia, sri lanka, china etc.

g) Reflective glass

1. with the help of chemical deposition the metal coating is provide on this glass surface.
2. it is used as a solar heat and sunlight reflector.
- 3.it is also traffic hazardous and causes light pollution

1.2.4 Scope of the study :

- a) With the help of this study we are going to find out that whether these fibers are going to be more effective on flexible or rigid pavement.
- b) Generally rigid pavements time span or durability is higher than flexible one so we are mainly concerned about the use of these materials on flexible pavements.
- c) We are manly going to increase the durability of flexible pavements by using fibers like-human hair,glass powder.
- d) We are also going to perform varoius test related to this thesis which will give us the reliable data and assumptions made by us will be finally workable due to this.
- e) Mostly the life span of the flexible pavement lies between 8 to 10 years after doing this test and adding the material we are going to increse it upto 11-15 years.

1.2.5 Objectives of the study :

The main purpose of doing or making the thesis over this subject was to understand the various benefits or drawbacks to use these discrete fibers like-human hair and glass powder in the road construction. After all the test which are going to be performed in this thesis are being evaluated by the observer that what effects they are going to be leave on the surface of the pavements whether they are the flexible or rigid pavement. The one important factor which are also going to be observed by this thesis is that whether uses of these fibers are going to increase or decrease the tensile strength of the pavement. We are also going to observe that what effect will occur on the compressive strength of material when we will use the human hair or glass powder in road construction process.

a) The observer is also going to watch that whether the use of these fibers are going to result in any kind of discrepancies like-crackings or fatigue or failure of the pavements. If it takes place so we are going to check that which type of cracking occurrence are going to take place whether they are transverse cracks or shrinkage cracks.

b) In the case of crackings or pavement failures we are going to change the main constituents of the materials which were mainly used in making the materials which are going to be used in the road construction process.

c) After doing this study we will get to know that whether we are going to reduce the number of cracks or pavement failures at the right time or what will be the various measures which we are going to take as the preventive actions.

d) Here we are just going to figure out in what quantity we are going to mix these fibres with the materials so that they will make that perfect combination which can be useful to make these materials effective and useful.

e) Here we also get to know that how we are going to reduce the various stresses which are going to act on the surfaces of the pavements. Those stresses are mainly temperature stresses, warping stress or stresses due to thermal expressions.

f) We can also calculate the coefficient of those stresses with the help of which we can also get the quantity of those stresses and idea by which we are going to remove it from our construction pavements.

g) Here we are also going to know the value of pavement thickness or slab thickness by which we can get to know that what are the various required factors by which we are going to strengthen our pavement strength.

h) It will help in efficient and safe construction of pavements to avoid any hazardous situation.

1.2.6 Need of the Study :

Our basic aim behind this study is to make more improvement in the quality of soil subgrade so that there can be less pavement failures due to various temperature related situations or numerous moisture variation tendencies ,if subgrade's bearing capacity is not good then we can enhance it by adding some modifiers like discrete fibers in it by stabilization of the soil.As subgrade exists below all the layers of the road so it is considered as an important layer of road since it takes all layers load over it and can be strong enough to take all extreme road and weather conditions as well with causing any pavement failures.

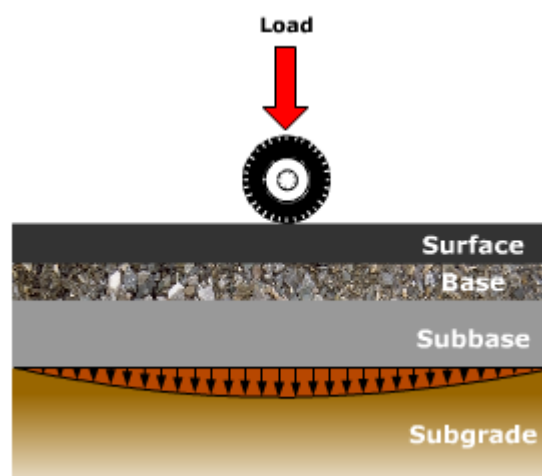


Figure 1.2: Components of flexible pavements and applied load over it

With the help of this diagramme we can easily understand that there are four different layers exist in the design of flexible pavement and subgrade is the bottom layer which should be very much strong enough to take all types of vehicular road in extreme weather condition also if we will mix the discrete fibers like Human hair and glass powder at the time of road construction in it can be the hard enough to take any kind of load at any kind of extreme hot or cold situation.

Chapter 2

Review of literature

So the purpose of writing this thesis was to conduct a suitable and meaningful study about the discrete fibers and their uses in road construction as it has been worked over this subject by many other people so we have taken some inspiration from the test papers of those scholar's study and included in our thesis

Ganiron et al. [5]

He found that if the additives of human hair is being mixed with asphalt cement mixture.it enhances the load bearing capacity of it.

Choudhry and Pandey et al. [6]

They both have done the comparison between mechanical properties of human hair fiber and polypropylene matrix and stated that composite having 3-5% of fibers of human hair shows the high flexural modulus & strength and heavy impact strength than non-reinforced polymer.

Fueghelman et al. [7]

He found that alpha-keratin fibers like-wool and human hair if we compare than we'll get the results that hair has the high tensile strength than comparison of any other fibers.

Jain and Kothari et al. [8]

They studied the various properties of human hair fiber reinforced concrete and investigates that after mixing the human hair with concrete can improves or increases it's binding properties,tensile strength,micro cracking control,compressive strength and resistance of spalling.

Renju et al. [9]

He get to know that fertility of soil gets increased after mixing of fibers of human hair by an special chemical technique.

Saxena et al. [10]

He stated that the use of the hair fiber reinforced concrete will be the most useful fiber in ecological field in coming future.

Thompson et al. [11]

He invented a composite material which is based on hair by taking various cut lengths of hair to make a mat of hair and adding with a material which is structural based to form a required composite material.

Chai et al. [12]

He studied the thermal properties of human hair and found that all properties were suitable to bind up with the soil as no thermal activity are going to take place due to this bind up and are free from all other thermal deficiencies.

Jager et al. [13]

He has used some different mathematical concepts to understand and use the human hair fiber percentage in various matrixes and also used it in enhancing the technology with technical methods as high as possible.

Gupta et al. [14]

He stated that human hair is totally a waste material and it can be utilized by various methods and has a large number of scopes of being used in various fields like in medicine, engineering and agricultural industries. Now we are going to discuss the various properties of glass which are being used in road construction to enhance the performance of the road glass is generally being used in the form of the grids of the fiber with a tack coat and various scientists and researchers have given their theory about the glass fiber which are going to be discussed below in detail :

Aldea and Darling et al.[15]

They stated that by mixing in coating of glass fiber grids increase the tensile strength of material at starting and use of polymeric coating generally improves the tendencies of interlayer bonding in comparatively with glass grid coated with emulsion.

Marks et al.[16]

He founded that how we can prevent the reflective cracking in rehab of a joined pavement of concrete after study and observation of four years he stated that if we are going to place the glass grid directly on the top of the surface of pavement of concrete then it will be more absolute or powerful rather than putting the grids of the glass between the slabs of asphalt concrete.

Bush and Brooks et al.[17]

To reduce the transverse cracks in flexible pavements they studied the five different types of reinforcement in which glass fiber grid was also included and found that it can be easily reduced by placing it on existed cracks at the top layer of surface.

Steinberg et al.[18]

He had given one assumption about the interlayer of glass grid layer that if it is not installed properly or could not be handled safely by the site workers so due to this faulty activity it can be unable to give an expected performance.

Virgili et al.[19]

He indicated that when tensile stress reach the condition of tip of the crack upto ribs of the grid then only grid of the glasses starts to work to make it more efficient where there will be high tensile stress grid should be placed their instantly.

Bondt et al.[20]

He investigated that there is a huge quality difference between the coatings of various grids of glass fibers which is market available due to this variation some initially cheaper products are less powerful and are very much vulnerable in the field of performance.

Plug and de Bondt et al.[21]

They both have concluded that in overlays of asphalt after tack coat curing periods by using the Leutner shear test observed the adhesion of reinforcement of grids of glass fibers and given the results that after the construction tack coat's shear strength increases with passage of the interval of time.

Lytton et al.[22]

He evaluated that failure of the glass grid layer reinforcement will only take place if there will be any disturbance of the bonds between the lower layer and inter layer will take place and it is going to be in the form of cracks of transverse and reflection crackings.

Bacchi and Arsenie et al.[23]

They have studied the behaviour of the fatigue in both standard bituminous mixture glass grid fiber and glass fiber grid mixed with bituminous mixture reinforced with a light polyester braided material.

Darling and Woolstencroft et al.[24]

After evaluating of two test sites about glass grids performances on both sites of evaluation constructed by the technique of deep flexible and composite pavements, results the Various harmful longitudinal and transverse cracking.

A.L Kishore et al.[25]

To make more people aware about the importance of human hair waste and it's benefits the researcher has been open a online site 'India tele-mart.com' where you can sell your cutting hair in the exchange of some cost which should be provided on the basis of the quantity of hair which you are just going to sell.

P.Mehra et al.[26]

In the well known news paper 'The Hindu' one article has been published in which researcher has been summarized the various temples where people get tonsured due to some religious practices or when there any wish got granted by the god.

Chapter 3

Research Methodology

After the detailing of literature review we will move forward toward our next chapter that will represent the methodology which has been used in doing the research work or by which we can extract the various results from our experimentation work by using this in it. Mostly two major kind of data's exists in any reserch or thesis studies which is known as first primary data, which has been taken by the reseachers by experimentation on different fields and second is secondary data which has been generated through various other sources like-news papers,journals,publications and internet as well.

Generally we are going to use waste of human hair and glass powder which is generally being dumped into soil or being burnt due to considering of it as garbage material and of no real use so by using it as a discrete fiber we are going to utilize it in such place where it has no important necessity but by using this we are going to be modify our soil strength and stability in an efficient manner easily.As it has been approved by the studies that mostly failure of the pavement originates from poor stabilized subgrade soil which has been used in the studies due to various factors like-unpredictable behaviour of traffic,temperature variation and due to change in condition of moisture in the particular soil so the Highway research board (HRB) suggested one alternate to solve the problem that if we are going to use the discrete fibers in various percentages in the soil then subgrade strength can be enhanced as well as we can make our soil stabilized by mixing of those additives and for this purpose no other expensive chemicals are required to use in it we can easily measure or check our results by using california bearing ratio (CBR) test.The testing of the CBR will be provided in details in following chapter and other experiments which are also very much necessary to the evaluation of results are also being given in that chapter in detail as well.As we know there are numerous discrete fibers are there but after studying and being suggested by our guide I have generally taken the human hair and glass powder as discrete fiber as it has not been so much used and is a fresh material for the study and reserch generally very less researchers has used these fibers in their research studies and found the results satisfactory so now we are also going to explore our knowledge area by modifying our concepts via using this in our study.

Chapter 4

Equipments and Material Used

4.1 General

We are going to use these discrete fibers in our studies than we should know what properties they have in it which can be meaningful for our research work and which can make our soil subgrade more stable and strengthen. So here are the various properties and recommended remarks of the discrete fibers which has been used in our study. First of all we are going to give the various properties of those human hair which are being used in our study.



Figure 4.1: Human Hair Fiber

Human Hair Properties	Remark
Tensile strength	About 355 Mpa
Linear density (gm/cc)	1.25–1.40
Cross-section	Circular
Length	22-25 mm

Diameter	48 μm
Elongation	1.3 times its dry weight
Friction	Geometry of cuticle and hair's physical and chemical factors are effecting factors of it.
Chemical reaction	Surface porosity of hair. Generally 80% of keratin protein is present in human hair.
Absorption	Surface tension physical process affect this

Table 4.1: Properties of human hair used in research work

And now we are going to discuss the properties of that glass powder which has been used in our research work as well as going to be added in numerous percentages in the soil to make it strengthen and stabilized.



Figure 4.2: Glass Powder

Glass Powder Properties	Remarks
Chemical Composition	1) 74.5% of SiO_2 2) 11.46% of AL_2O_3

	3) 11.52% of Na ₂ O
Tensile Strength	26-63 Mpa
Hardness	6 to 8
Softening Point	1520-1745 C
Specific Gravity	2.6 to 2.8

Table 4.2: Properties of Glass Powder used in research work

4.2 Sources of collection of Human Hair

As the study says that we are going to use the human hair and glass powder as a discrete fiber then most of the queries arises that where we are going to find out those materials in such a huge quantity and what are the main sources of those material so here we are going to tell you what are the major sources where we can find out those material easily. First of all we are going to discuss where we can find out the human hair in huge quantity.

4.2.1 Shops of the Barbers & Hair stylists or in Hair saloons

If you want the human hair in huge quantity then the primary source of this material is any barber's or hair stylist's shop or mostly in saloons as when the hair of the particular person get grow up then he is definitely going to barber's shop or in any hair saloons to cut it out, then from there you can easily get the human hair in the large amount sometimes in free also since human hair is no use and it is going to be dumped out somewhere in that shop only or at any place where it can cause problem to others so it is better to utilize them in the research work [25].

4.2.2 Some Special Temples or Religious places

In India it is being seen from years that men as well as women got tonsured in the temples due to their religious practices or it is being considered as if any wish of them is going to fulfill by the god they are going to give their hair in the particular temple. As there are so many temples exists in India where people get tonsured due to

fulfillment of their wishes by god for examples some temples are given following which has special importance of these religious work [26].

- 1) Shri Shirdi Sai temple, Situated in district Ahmednagar, Maharashtra.
- 2) Shri Kashi Vishwanath temple, Situated in Varanasi, Uttar Pradesh.
- 3) Shri Tirupati Balaji temple, Situated in Tirupati, Andhra Pradesh

So These are the examples of some temples where people due to their religious practices gives their hair.

4.2.3 Recycling waste shops

As all of us know that human hair is considered as the material of no use so people are going to throw it or dump it at different places but some people collect those hair for recycling purposes for the purpose of making toys, hair extensions or in many countries like India and China it is being used to make wigs as it is having a huge market of human hair for this purpose so we are going to take the human hair from these shops also.

Now we are going to discuss those sources from which we have collected the glass powder.

4.3 Sources of Collection of Glass powder

Numerous sources exists to collect the glass powder waste as we generally see that there are so many glass waste in being collected in the automobiles and general store shops mostly those shopkeepers are going to sell these glass waste at a good price as it is of no use of their and if they are going to be sell it to some other shopkeepers then they can recycle this waste and make it useful for in numerous ways as it can also be recyclable thing which can be used to make the various utensils, stylish glasses and soft drink bottles as well and some of it are also being used in making various bio-medical equipments which are going to be used in various medical fields efficiently.

4.3.1 From Soft drink bottles & Junk yards

The primary sources of being collection of the glass powder is from wasted soft drink bottles and the junk yards as we found many pieces of broken glasses windows from LPU and then just after collection process the glasses and bottles are properly rinsed and then being dried for 24 hours in sunlight after that these were broken down in very small sizes via hammer so that it can easily get pass through the sieve no 400 which is very much necessary to bring the glass in finer powder form and passing the material through this sieve we got our glass material into smooth powder form and now it became meaningful for our research and is going to mix in soil in powder form.

4.4 Collection sources & Properties of soil used in experimentation

In our experimentation clayey soil collected from LPU ground is going to be used in this process. At the starting of this process for taking the disturbed and undisturbed sample, the top soil is being removed and also being excavated upto the depth of 0.7m then only we can take the soil for our experimentation purpose. The various properties which soil contains is going to be measured through different experimentation in the next chapter after that we will prepare the table of properties which soil contains in it.



Figure 4.3: Clayey Soil

The particular soil is going to be used in experimentation purpose which has been collected from LPU ground and is being bring out to soil experiment lab block 57 (A).

Chapter 5

Experimentation & Results

In this chapter we are just going to complete the experimentation part which is a necessary phenomenon and generally helps us to extract the various useful results from given data and also it is useful to measure how discrete fiber human hair and glass powder is going to affect the clay soil, to the fact and to extract the values from it we have performed some tests from the help of which we could able to make fibers useful. So the tests which performed to take the readings are particle size distribution (analysis of sieve), liquid limit test, plastic limit test, shrinkage limit test, specific gravity test, compaction test and in the final step we have done California bearing ratio test (CBR) test. So these tests are going to be explain further in details:

5.1 Particle Size Distribution (Sieve Analysis)

To measure the particle's size percentages which is passed by each sieve from it's weight of soil the sieve analysis should be performed. In this process generally sieves are used having their sizes.

First pan,0.075,0.150,0.212,0.425,0.500,0.600,1.18,1.700,2.36,4.75,Mostly all sieves put into one over each other in ascending order.



Figure 5.1: Sieves

In this process the first step is for 24 hours the soil which has been collected through the ground should be dried in oven properly. After that with the help of sieve no.75 μm , it can be sieved and it's time to get that soil again oven dried so that we can take it's weight which has been noted down after this process.

The arrangement of sieves then done on material which is reweighed and it's aperture size then we shake the sieves for 10 minutes non-stop after putting the soil in it, Then for some time it has been left so that particles of soil get settled down properly and those particles which has been retained on it get again weighed and noted down with the help of which we can easily draw the graph between sizes of various sieves and passing particle size percentages as we got the measures of retained and passing percentages of soil particles.

Sieves Diameters (mm)	Retained Mass (g)	Retained Percentage (%)	Passed Percentages (%)
4.75	0	0	100
2.36	0.27	0.21	99.73
1.700	0.38	0.29	99.43
1.18	1.2	0.95	98.43
0.600	4.25	3.21	95.20
0.500	6.42	4.86	90.32
0.425	1.09	0.81	89.49
0.212	53.2	40.43	49.02
0.150	34.97	26.42	22.58
0.075	24	20.33	2.22
Pan	2.7	2.21	0.00

Table 5.1: Analysis of Particle Size Distribution

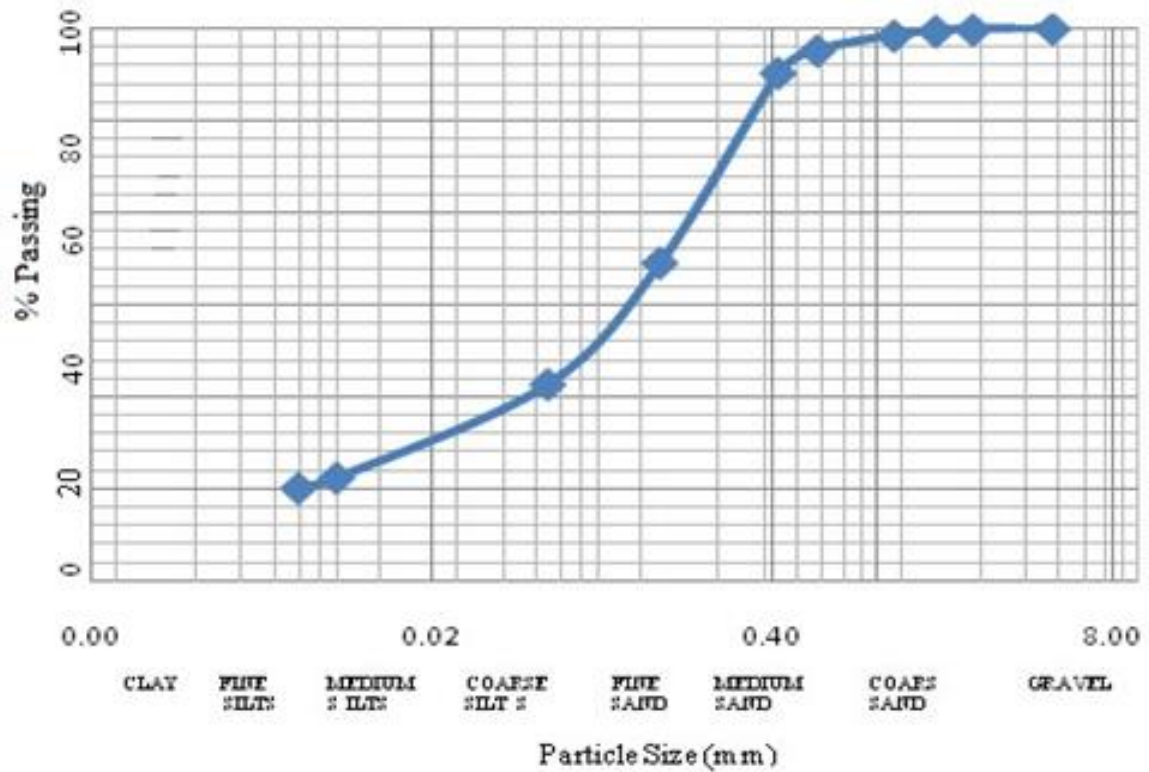


Figure 5.2: Chart of Particle Size Distribution

5.2 Specific Gravity Test

At 40°C temperature the ratio of volume of soil particles given in weight of air and to the same amount of water at same volume in weight of air is called soil sample's specific gravity.

To evaluate the specific gravity bottle should be properly get emptied then after get properly dried and take the weight of that bottle as m_1 , after putting 50 g of soil in it again the weight has been taken which is labelled as m_2 . After pouring the 1/3 part of water of it's height in real the bottle get shaken non-stop for at least five minutes. After being stable of 30 minutes it has been kept for at least one day to get fully settled as after pouring 2/3 part of water from the glass jar height, after 24 hours readings must be noted down as m_3 . At last the content present in the bottle gets removed out from it and it's present weight is then recorded as m_4 . There after with the help of following formulae we can easily evaluate Specific gravity (G_s).

$$\text{Specific Gravity } (G_s) = \frac{(m_2 - m_1)}{(m_4 - m_1) - (m_3 - m_2)}$$

Weights (g)	Test 1	Test 2	Test 3
Weight of bottle density = m1	308.7	256.3	266.5
Weight of bottle density+soil=m2	358.7	304.3	315.5
Weight of bottle density+soil+water=m3	635.3	614	623.2
Weight of bottle density+water=m4	604.3	585	592.8
Specific Gravity	2.63	2.52	2.61
Apparent Specific Gravity		2.586	

Table 5.2: Analysis of Specific Gravity (Gs)

5.3 Liquid Limit Test

The soil starts to behave like a liquid after a certain content of moisture, that content of moisture is generally known as liquid limit. This is an important Atterberg limit which can be easily evaluated by performing liquid limit test (LL). In this test first of all after passing through BS test sieve of 42 μm , we take sample of 200 g of soil, and trays made by metals are used to put this sample into it, after that we will mix the

water in certain quantity so that we can make a mix paste which contains not too much of water content and a less thick after it's preparation we put the paste in a device called Casagrande device, after that we level the arrangement properly and then with the help of grooving tool divide it simultaneously. Then we start to give blows to the arrangement so that it can become very near to that part which was divided, then we record those number of blows. To evaluate the value of moisture content we keep it's one soil portion into a jar. We generally repeat this experiment with adding different amount of distilled water in it. After 20 blows which moisture content we get from this process is generally taken as soil's particular liquid limit.



Figure 5.3: Evaluation of Liquid limit by Casagrande's experiment

It's a general outcome which has been obtained out from various researches that this will be a decrease in liquid limit with addition of Human hair and glass powder as discrete fiber in it upto a certain percentages. The various values which has been obtained from experiment is being noted down for reference and is given following in tabular form –

Test	Number Of Given blows	Weight of Wet Sample (g)	Weight of Dry Sample (g)	Value Of Moisture	Moisture Content (%)
1	50	7.9	7.1	1	11.61
2	30	9.4	7.5	2.1	26.05
3	24	10	6.4	2	29.05
4	16	8.4	6.4	4	32.28

Table 5.3: Analysis of Liquid limit (LL)

Average Moisture Content (%) = 24.74

5.4 Plastic Limit Test

When we add water in our soil sample a stage comes after that soil acts as material of plastic, that particular content of moisture is defined as plastic limit of soil and can be written as (PL).

To measure the Plastic Limit (PL), the sample which is already mixed should be brought to the proper mould after moulding with the help of our palm it should be rolled into a thread like stick shape having diameter 3 mm, at the position where stick crumbed firstly is taken as Plastic Limit (PL). After taking the values of liquid limit

we have also measured the point at where Plastic Limit exists and it is given below in form of table-

Test	Weight Of Wet Sample (g)	Weight Of Dry Sample (g)	Moisture (g)	Moisture Content (%)
1	1	0.8	0.2	11.14
2	1.6	1.5	0.2	6.77

Table 5.4: Analysis of Plastic Limit (PL)

Average Moisture Content (%) = 8.955



Figure 5.4: Evaluation of Plastic Limit (PL)

5.5 Shrinkage Limit Test

The minimum content of moisture after which in the decrease of it's value causes no changes in volume of soil is known as soil's shrinkage limit, can be indicated with the word (SL).

For the calculation of shrinkage limit generally we take a shrinkage mould and after passing a sample of clay with the sieve number 425 μm BS sieve we put that sample in the mould and then add water in a required quantity and mix it properly after that we levelled out the soil surface and keep it in oven for a whole day. After 24 hours we note down the reading of sample's length reduction and evaluate the shrinkage limit with the help of following formulae-

$$\text{Shrinkage Limit (SL)} = 1 - (\text{Oven dried specimen length} / \text{Specimen initial length}) \times 100$$



Figure 5.5: Apparatus used in Evaluation of Shrinkage Limit (SL)

Test	Initial Length (cm)	Final Length (cm)	Changes in Length (cm)	Shrinkage Limit (%)
1	12	11	1	7.12
2	12	11.2	0.94	6.77

Table 5.5: Analysis of shrinkage Limit (SL)

$$\text{Average Percentage of Shrinkage limit (\%)} = 6.945$$

5.6 Compaction Test (Standard Procter Test)

The compaction test or general standard procter test is being performed in order to obtain the value of optimum moisture content (OMC) and maximum dry density (MDD) with mixing the discrete fiber with the soil and without mixing it in the soil. The procedure with which the test can be performed easily is that first of all we take a tray and put around 3000 g of clay soil in it after being break down into particles of smaller sizes, then water is added into it in the quantity of 60 ml and then we keep the whole arrangement into a mould with making 3 layers of having thickness 50 mm for each layer after that we give 25 blows to each layer with the help of standard rammer. After doing this we scrape the layer's top surface with the help of trowel, then collar can be removed and we will go for trimming of soil by trowel as well and then we measure it's mass at weighing machine. With completion of this process two samples we have to take one from mould's bottom and another from the top and then moisture content of both will get evaluated after this the sample gets extruded from mould and break down into a loose state. We repeat this experiment upto that time when the compacted soil weight does not get fell. After whole process dry density versus moisture content graph can be plotted with the help of which optimum moisture content and maximum dry density can be calculated easily-



Figure 5.6: Compaction (Standard Procter test)

Content Of Cement (%)	Optimum moisture Content OMC (%)	Maximum Dry Density MDD (g/cm3)
0	15.23	1.864
2.5	14.39	1.877
4	13.97	1.879
5.5	13.68	1.880
7	16.39	1.857

Table 5.6: MDD & OMC values of soil-cement stabilization in compaction (standard procter) test

Content of Human hair & Glass powder (%)	Optimum moisture Content OMC (%)	Maximum Dry Density MDD (g/cm3)
0	15.23	1.864
2.5	15.39	1.891
4	16.47	1.864
5.5	18.57	1.836
7	17.74	1.838
9	16.8	1.839

Table 5.7: MDD & OMC values of soil-Human hair & Glass powder stabilization in compaction (standard procter) test

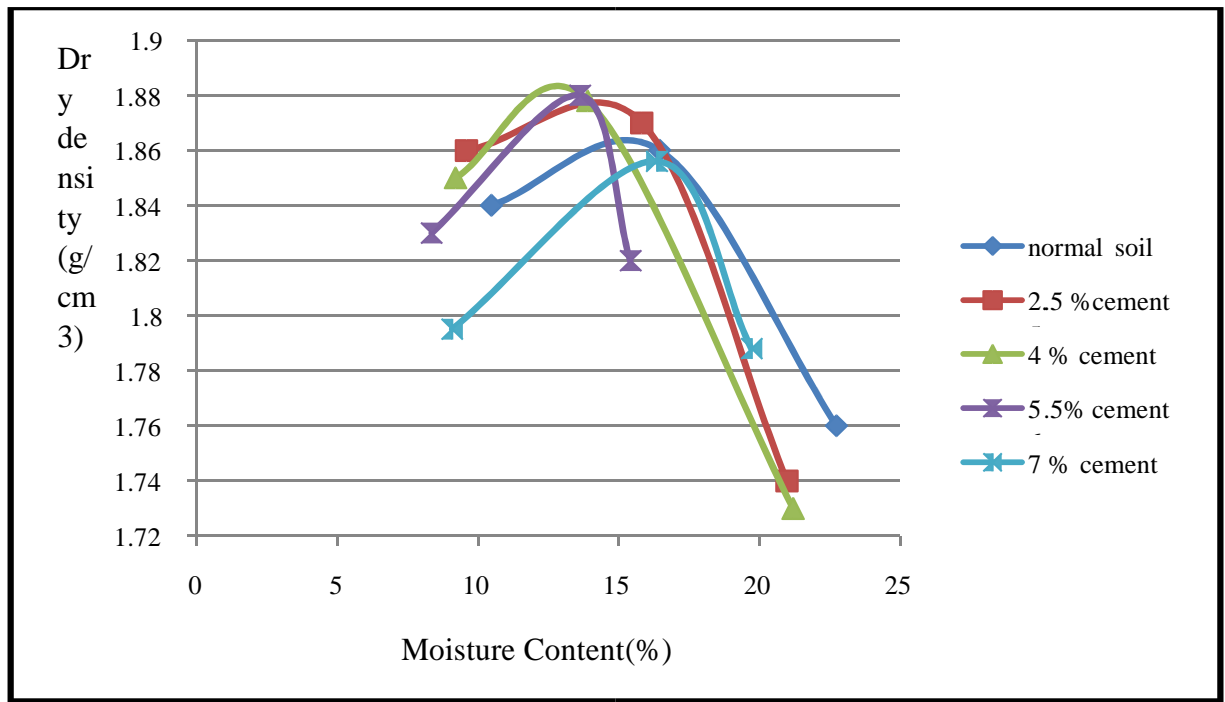


Figure 5.7: Dry density vs. Moisture content for all percentages in cement stabilization for compaction (Standard Proctor) test

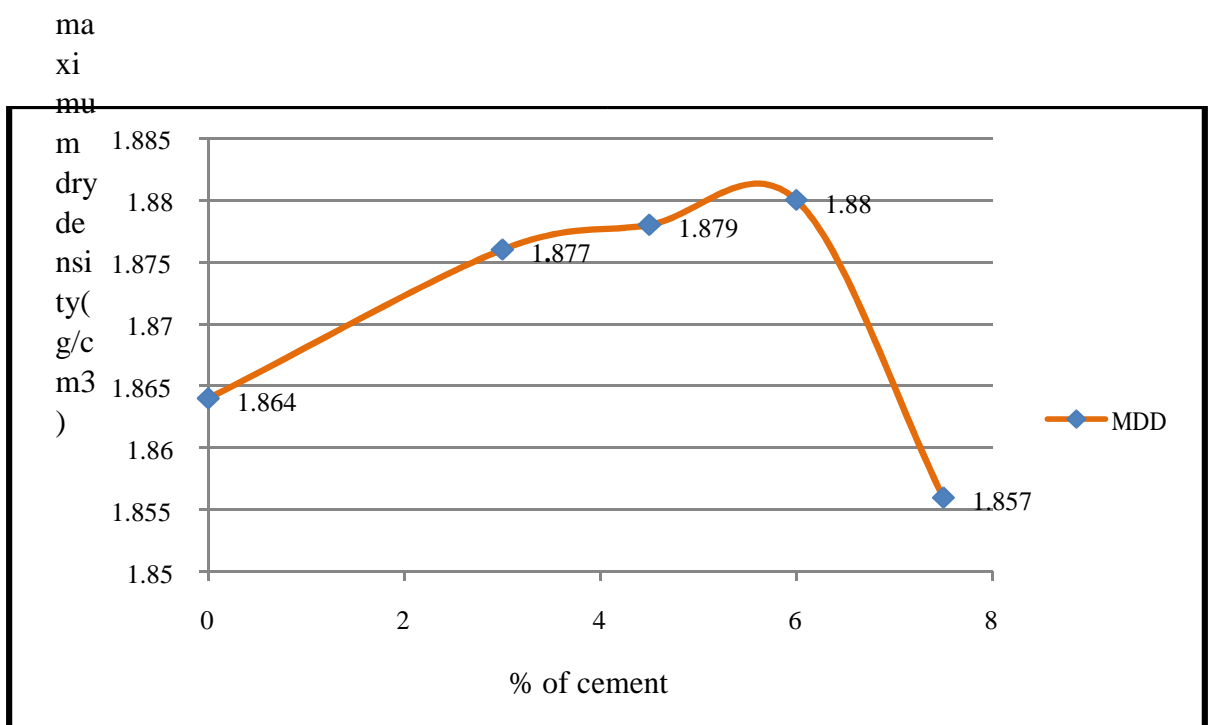


Figure 5.8: Cement content vs. Maximum dry density for compaction (standard proctor) test

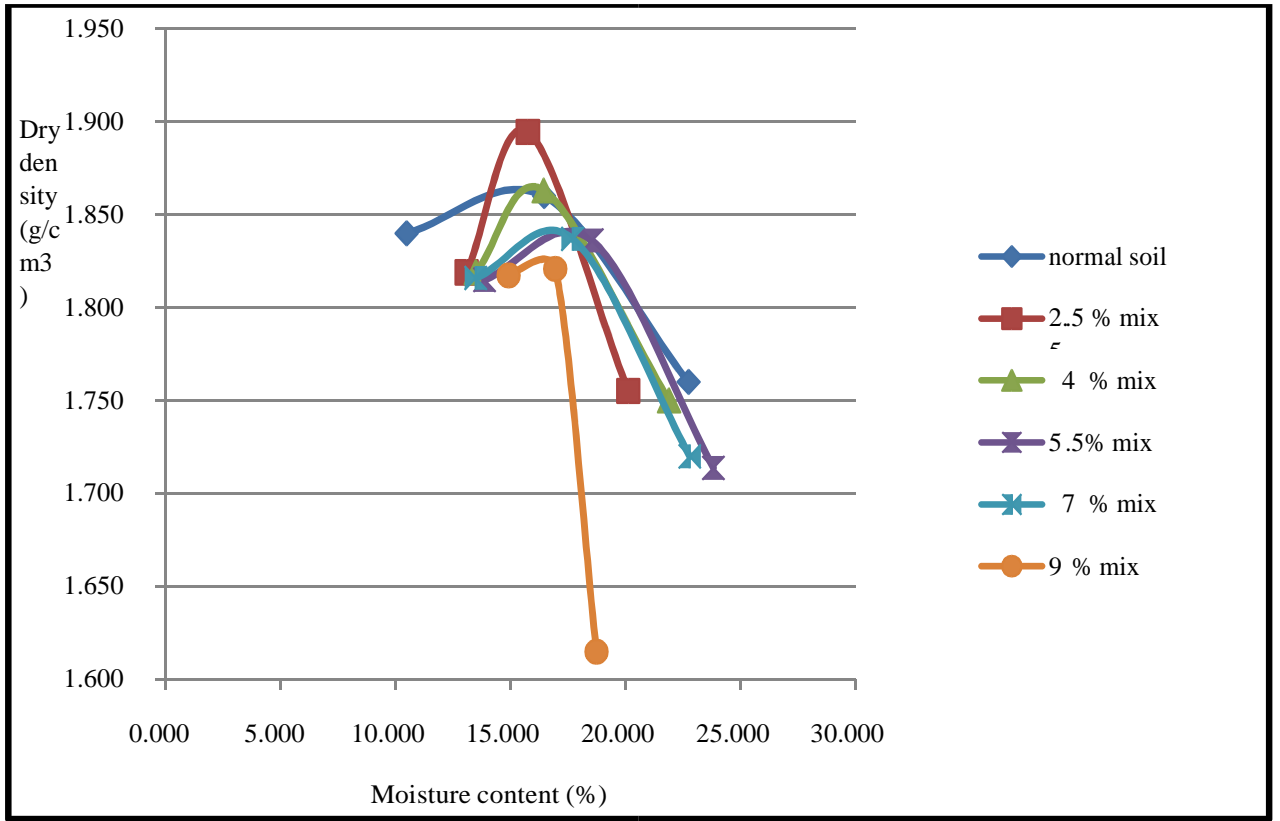


Figure 5.9: Dry Density vs. Moisture Content for all percentages in the Mix of Human hair & Glass powder stabilization for standard proctor test

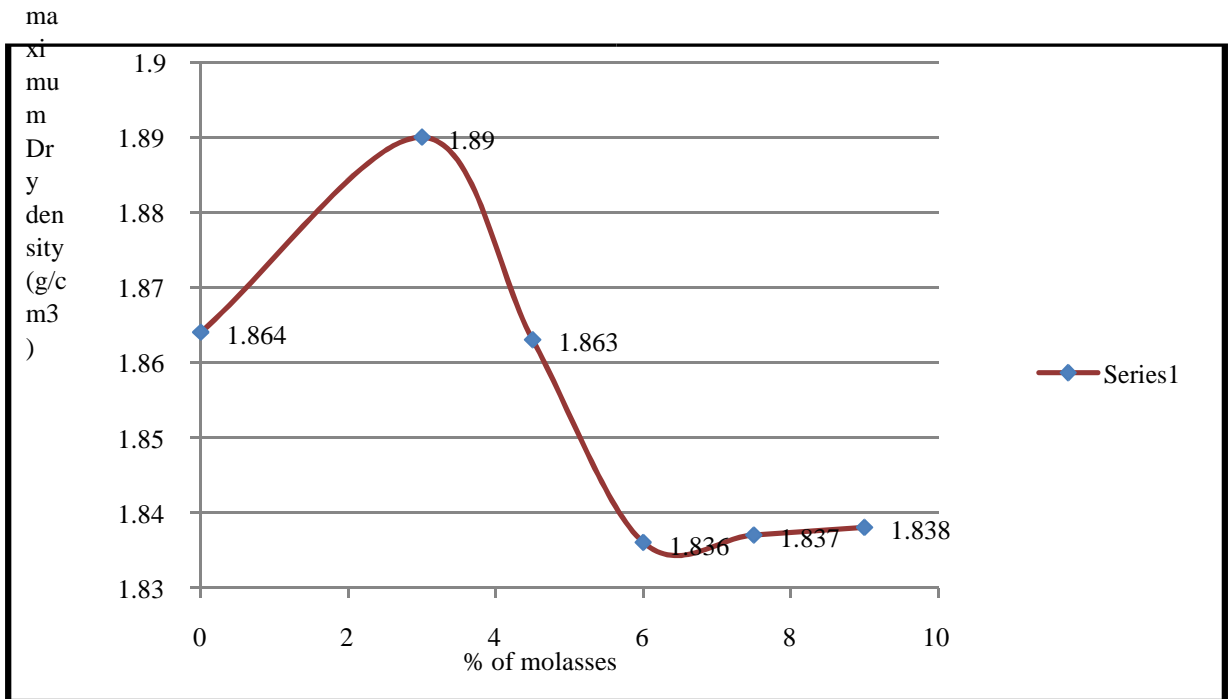


Figure 5.10: Human hair & Glass powder content vs maximum dry density in standard proctor test

5.7 California bearing ratio (CBR) test

For a design of flexible pavement generally a penetration test is carried out to measure soil's bearing capacity which is known as California bearing ratio (CBR) test. To evaluate the strength of particular soil in both un-soaked and soaked condition the soil value which is either compacted or is in natural state get compared in the form of curves in standard tests. For the penetration of a soil sample the required amount of pressure having standard area plunger which is also required the pressure in same amount for a rock material which is crushed in a standard manner can be evaluated with the help of California bearing ratio test easily [27,28].

To perform this test the proportion of equal mix which is used in compaction test is required again to calculate percentage of moisture the dry soil upto 6 kg is added in certain amount of water, then CBR moulds are used to put the soil sample in it and again it is filled in the each moulds and then compacted in three layers by giving 25 blows to each with the help of standard rammer (fall through 30 cm and weight 4.5 kg). The surface which exists in the top was levelled after scraping with compaction of third layer.

After this process to level the real or evaluated mass construction the required surcharge weight was put on surface of soil. At the rate of constant 1.25 mm/min the load was applied on surface of soil. After application of load readings of load should be noted down for both the bottom and top layer at given penetrations instantly. After completion of this penetration test at the exposed surface which is compacted also (both at bottom and top), a filter paper is being placed at that position with cover made by metal so that we can easily stop the water influence directly and put it in soaking tank for 98 hours time period. After that time period we remove it again and soaked readings which were corresponding has again noted down under same penetrations for both bottom and top surface under un-soaked condition.

Then the graph has been plotted between penetration value and load intensity with the help of obtained points a curve is drawn. The load penetration of 2.5 mm and 5 mm value were indicated as standard load percentage values respectively. Among the both whichever value will be higher that one should be considered as CBR value. With the help of following formulaes the CBR value were calculated easily and for both conditions for soaked and un soaked condition the value was calculated separately and has been given in the table form and also the graph is made for those obtained values.

CBR value (%) =

$$\frac{\text{Load at 2.5 and 5 mm penetration}}{\text{Load sustained by standard aggregate at corresponding value of penetration}} \times 100$$



Figure 5.11: Apparatus of CBR



Figure 5.12: CBR mould Soaking

Cement Content(%)	Un-soaked CBR(%)	Soaked CBR (%)
0	1.78	1.19
2.5	2.36	1.77
4	2.75	2.35
5.5	3.52	2.94
7	2.65	2.46

Table 5.8: CBR values for soil-cement stabilization in compaction (standard proctor) test for soaked and un-soaked condition

Cement Content(%)	Un-soaked CBR(%)	Soaked CBR (%)
0	1.78	1.19
2.5	2.36	1.77
4	2.55	2.26
5.5	3.45	2.36
7	2.93	2.56
9	2.75	2.17

Table 5.9: CBR values for soil-cement stabilization in compaction (standard proctor) test for soaked and un-soaked condition

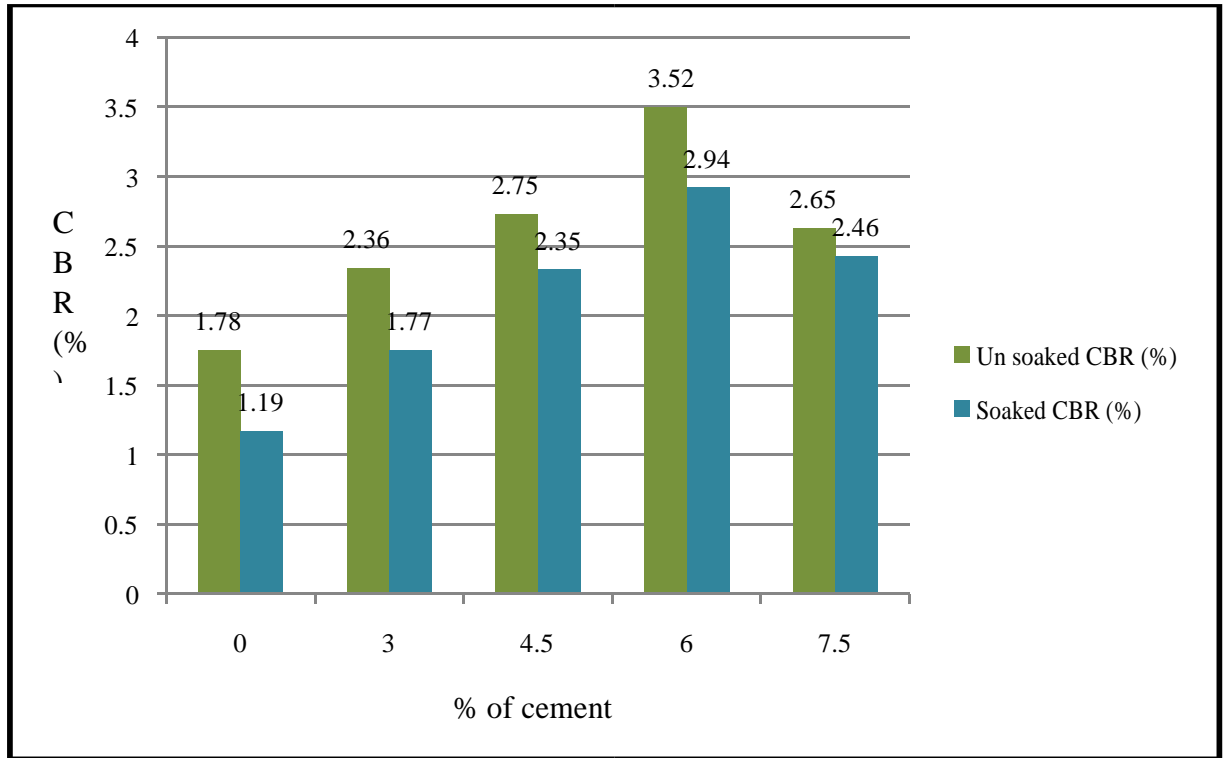


Figure 5.13: Soil-cement stabilization for Soaked and Un soaked condition in compaction (standard proctor) test

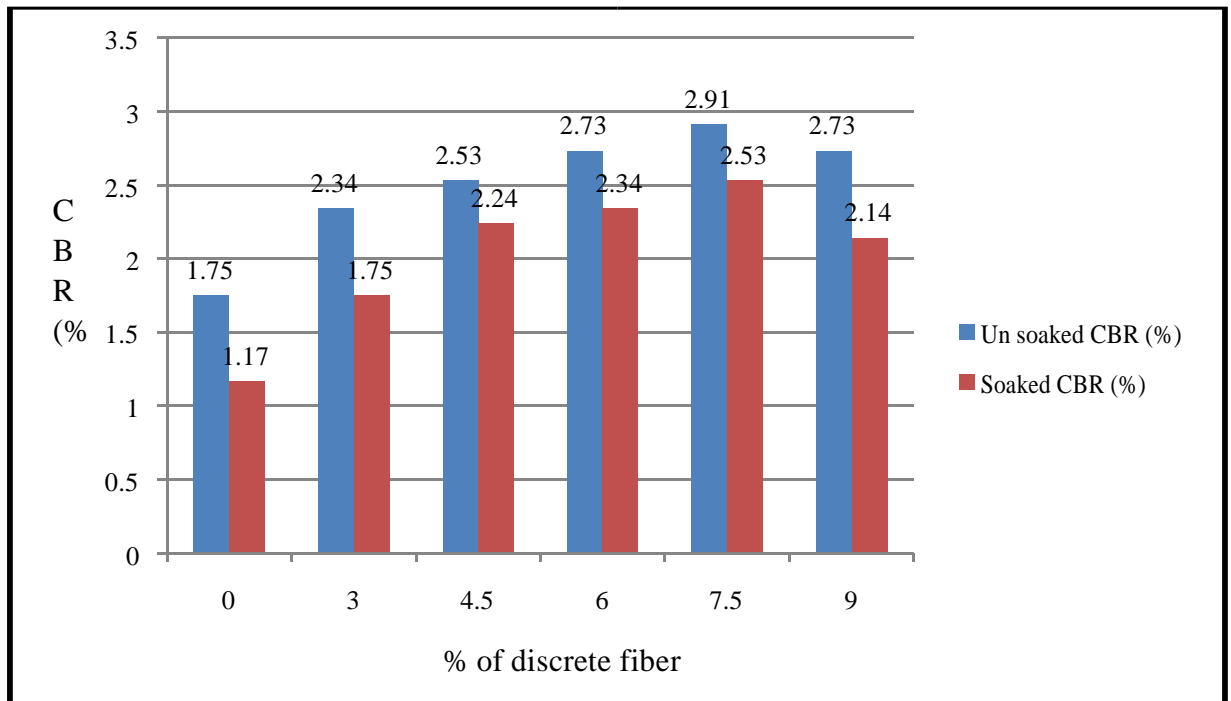


Figure 5.14: Human Hair & Glass powder-soil-cement stabilization for Soaked and Un soaked condition in compaction (standard proctor) test

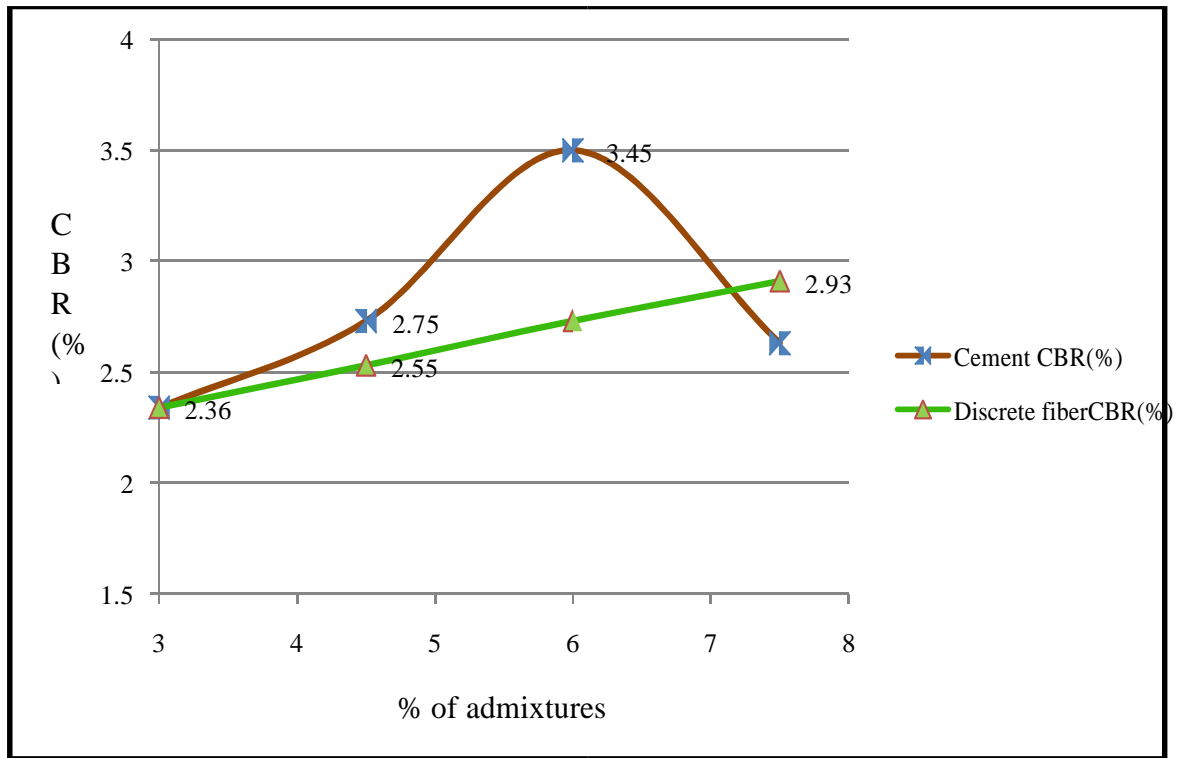


Figure 5.15: Comparison of Human Hair & Glass powder-soil-cement stabilization for Un-soaked condition in compaction (standard proctor) test

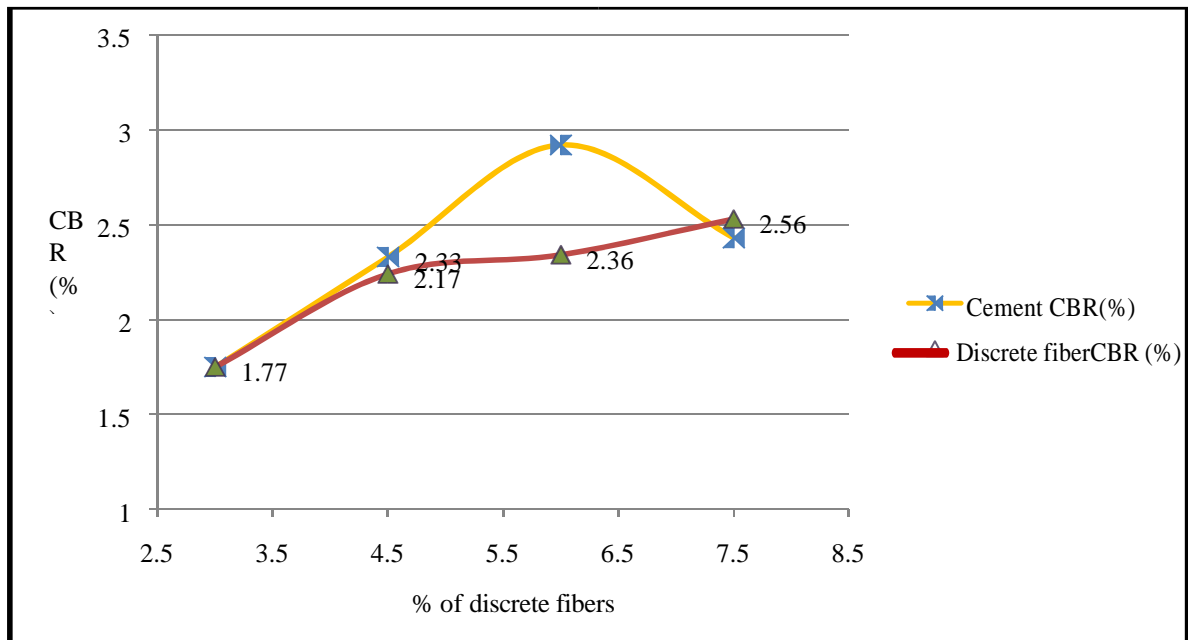


Figure 5.16: Comparison of Human Hair & Glass powder-soil-cement stabilization for Soaked condition in compaction (standard proctor) test

5.8 Flexible Pavement design by using IRC 37-2001

As we have mentioned earlier that Lovely Professional University is the given site having area of rainfall in average upto 686 mm which is according to IRC guidelines is greater than 500 mm so for pavement's total thickness can be designed according to those CBR values which are soaked.

Due many activities like- for teaching and studying purposes teachers and students come to the university and some construction work is also going in the university so mostly vehicles come due to those activities. We will take time period for pavement modification 2 years and 10 years for it's period of design life.

After that we will use 75% of distribution factor of total traffic with vehicle damage factor 1.5 having growth rate 7.5%.

$$N = \frac{365 \cdot D \cdot A \cdot F \{ (1+r)^n - 1 \}}{r}$$

$$\text{Where } A = P(1+r)^x$$

So after putting all the values in it we can simply find out the values of A as well as N which is given following:

$$A = 70(1+0.075)^2 = 80.89 \approx 81$$

$$N = \frac{365 \cdot 0.75 \cdot 81 \cdot 1.5 \{ (1+0.075)^{15} - 1 \}}{0.075}$$

$$= 875853.24 \approx 1 \text{ msa}$$

5.9 In Light compaction (standard procter test)

	CBR(%)	Total pavement thickness(mm)	Granular base (mm)	Granular sub-base (mm)	Wearing course (mm)
Normal soil	1.17	811	224	811	20PC
Soil-cement stabilization	2.94	561	224	336	20PC
Discrete fiberstabilization	2.56	604	224	379	20PC

Table 5.10: Individual layer thickness evaluation in Compaction test

Chapter 6

Conclusion

At the final stage we have reached at the conclusion that with the help of adding discrete fiber human hair & glass powder with the clay soil can modified the quality of subgrade which is an important factor in flexible pavement design according to IRC 37-2001 because the pavement thickness was 811 mm first but after experimentation it has been decreased upto 604 mm and 561 mm instantly with the stabilization of soil-cement stabilization since the values which has been obtained from California bearing ratio are very much near to the values of soil cement stabilization.

The granular sub-base material can be saved since capping layer is not provided so value get increased upto 2.56 from 1.17. With the help of stabilization maintenance work can be guarded properly. The project's overall cost of life cycle can also be reduced. By using stabilization process pavement's durability get enhanced and permeability get decreased.

With mixing of discrete fibers like human hair and glass powder there are significant positive changes we got in the clay soil. It seems that both the discrete fibers are getting the best alternatives instead of various chemical additives which are expensive as well as harmful itself, with the use of these natural discrete fibers we can save the cost as well as environment from various difficulties as it has been seen that mostly human hair having no major uses in the society so they are going either to be burnt or being dumped into some places and glass powder can be recycled and are also being used into make various types of utensils like-glass plates, cups, dishes and medicines bottles and it can be used in several fields so it is a bit expensive but further useful with the help of both we can enhance the quality of soil's subgrade for sure.

6.1 Recommendations

- a) All the above experiments should be performed to get the better results.
- b) The CBR values should be taken in both the un-soaked and soaked condition.
- c) Handling equipments & all safety measures should be taken while experimentation.

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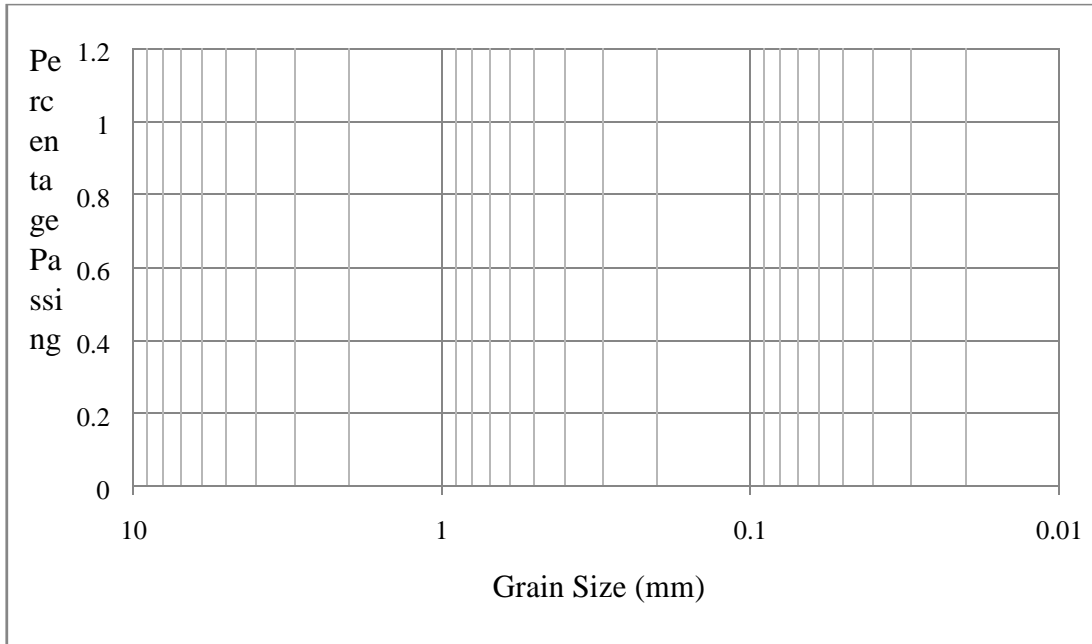
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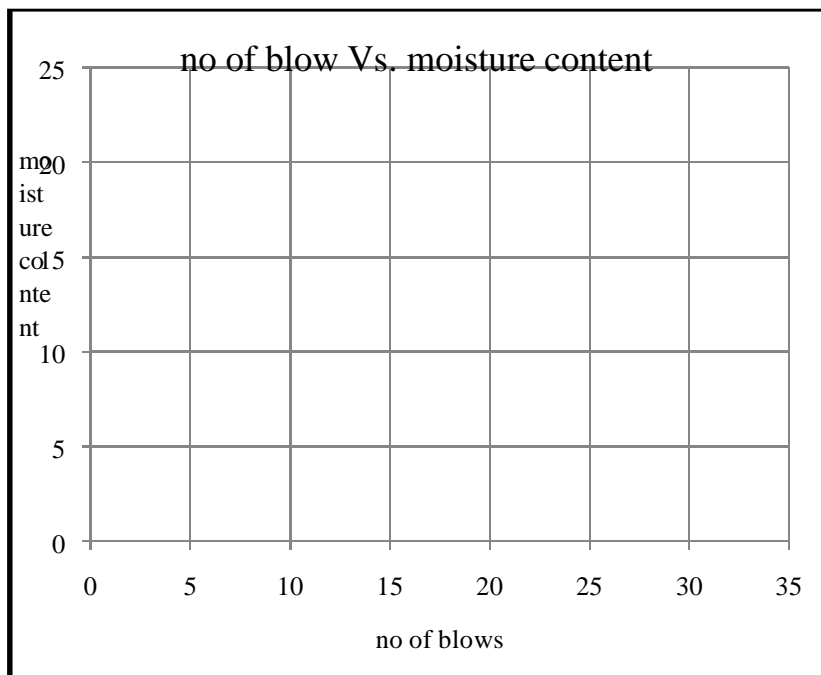
Appendix

1. Semi log graph for sieve analysis



Semi log graph for sieve analysis

2. Moisture content V/S no. of blows graph for analysis of liquid limit



For finding liquid limit

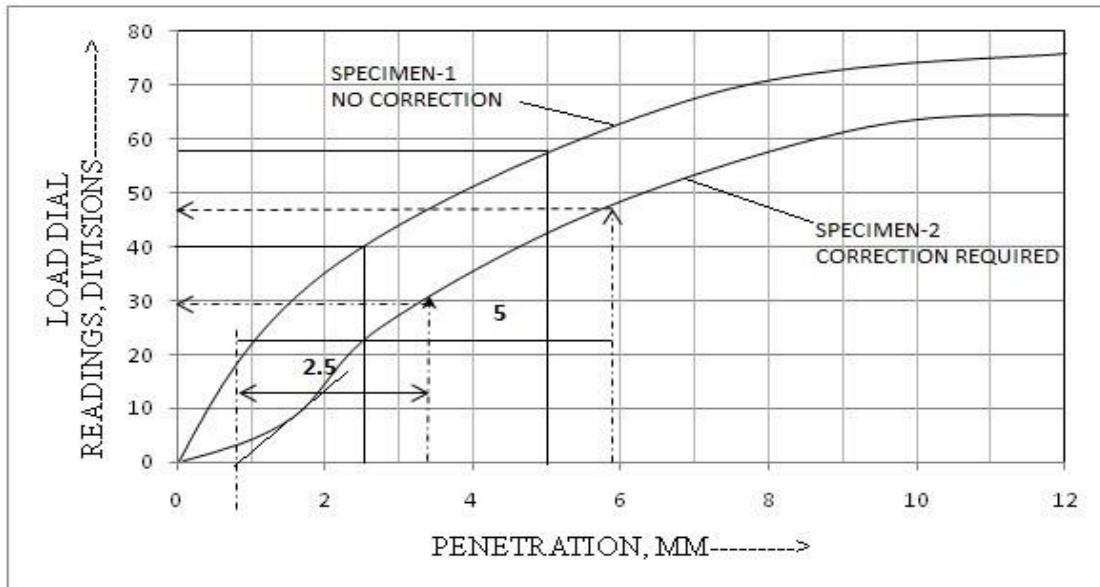
3.Observation table for California bearing ratio test

Penetration reading (mm)	Proving ring dial gauge reading	Load(kg)
0.5		
1		
1.5		
2		
2.5		
4		
5		
7.5		
10		
12.5		

4.Standard load values on crushed stone aggregates

Penetration (mm)	Standard load (kg)	Unit standard Load (kg/cm ²)
2.5	1370	70
5	2055	105
7.50	2630	134
10.0	3180	162
12.50	3600	183

5. Load penetration curve for CBR test





About Student



Myself Ujjwal Mishra, having Registration number 11500975 is the student of M.tech final year in Civil engineering from Lovely Professional University. I have completed my B.tech (Hons.)-Civil engineering from Lovely Professional University as well, The main purpose of writing this column is to provide the confirmation of completing my final thesis work on the topic “Use of Human hair & Glass Powder as discrete fibers in road construction” and to also give the information about my various publications to the examiners or evaluation panel which are given following:

(1)TITLE- “Human hair waste”, Uses & Sources: A Review.

JOURNAL NAME-International Journal of Scientific Research and Development(IJSRD),Volume-5 Issue-2 April-2017,IMPACT FACTOR:4.396

STATUS: PUBLISHED

(2)TITLE- “Human hair fiber”, a discrete fiber to improve soil subgrade strength.

JOURNAL NAME- International Journal of Innovative Research and Advanced Studies (IJIRAS),March Issue 2017,IMPACT FACTOR:3.82

STATUS: PUBLISHED

(3)TITLE- Enhancement in subgrade soil strength using Glass Powder as discrete fiber.

JOURNAL NAME- *International Research Journal of Engineering and Technology(IRJET)*,Volume-4 Issue-4 April-2017,IMPACT FACTOR:5.181

STATUS: PUBLISHED

