ASSESSMENT OF CURED AND UNCURED STRENGTH OF LEATHER WASTE STABILISED EXPANSIVE SOIL

A

PROJECT REPORT

Submitted in partial fulfilment of the requirements for the Degree

of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

Under the supervision

of

Mr. Chandra Pal Gautam

(Assistant Professor)

and

Mr. Niraj Singh Parihar

(Assistant Professor)

by

SOURAV SINGH [161608]

CHAHAT GARG [161647]

to

DEPARTMENT OF CIVIL ENGINEERING JAYPEE

UNIVERSITY OF INFORMATION TECHNOLOGY

WAKNAGHAT, SOLAN – 173234 HIMACHAL PRADESH,

INDIA

MAY 2020.

STUDENT'S DECLARATION

I hereby declare that the work presented in the project report entitled **"Assessment of Cured and Uncured Strength of Leather Waste Stabilised Expansive Soil"** submitted for partial fulfilment of requirements for the Degree of bachelor of Technology in Civil Engineering at **Jaypee University Of Information Technology, Wakhnaghat** is an authentic record of my work carried out under the supervision of **Mr. Chandra Pal Gautam** and **Mr. Niraj Singh Parihar.** This work has not been submitted elsewhere for the reward of any other degree/diploma. I am fully responsible for the contents of my project report.

Sourav Singh
161602

Chahat Garg
161647

Department of Civil Engineering

Jaypee University of Information Technology, Wakhnaghat, India.

Date: 29 May 2020

CERTIFICATE

This is to certify that the work which is being presented in the project report titled **“ Assessment of Cured and Uncured Strength of Leather Waste Stabilised Expansive Soil ”** in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology in Civil Engineering submitted to the Department of Civil Engineering, **Jaypee University of Information Technology, Waknaghat** is an authentic record of work carried out by **Sourav Singh (161608) and Chahat Garg (161647)** during a period from August, 2019 to May, 2020 under the supervision of **Mr. Chandra Pal Gautam** and **Mr. Niraj Singh Parihar,** Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat.

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

Date: 29 May 2020

Signature of Supervisor		Signature of HOD
Mr. Chandra Pal Gautam	Mr. Niraj Singh Parihar	Dr. Ashok Kumar Gupta
Assistant Professor	Assistant Professor	Professor and Head of Dept
Dept. of Civil Engg.	Dept. of Civil Engg.	Dept. of Civil Engg.
JUIT, Wakhnaghat	JUIT, Wakhnaghat	JUIT, Wakhnaghat

Signature of External Examiner

ACKNOWLEDGEMENT

In performing our project, we had to take the help and guidelines of some respected persons, who deserve our greatest gratitude. The completion of this project report gives us much pleasure. We would like to show our gratitude **to Mr. Chandra Pal Gautam Assistant Professor** and **Mr. Niraj Singh Parihar Assistant Professor** for giving us the guideline for project throughout numerous consultations. We would like to extent our deepest gratitude to all those who have directly and indirectly guided us in writing this report.

We also thank **Dr. Ashok Kumar Gupta, Professor and Head of Department**, Department of Civil Engineering, Jaypee University of Information Technology, for consent to include copyrighted pictures as a part of our report.

We also thank **Mr. Jaswinder Deswal and Mr. Itesh Singh**, Technical and laboratory, Department of Civil Engineering, Jaypee University of Information Technology, for providing us with all the facilities, necessary components and excellent working conditions required to complete the project. We thank all the people for their help directly and indirectly to complete our project.

SOURAV SINGH (161608)

CHAHAT GARG (161647)

ABSTRACT

Black cotton soil carry a threat to the civil engineers throughout the world as it has high potential for shrinkage and swelling under differing moisture content as they contain montmorillonite clay mineral. In essence black cotton soil bear a very low bearing capacity due to its peculiar characteristics of swelling and shrinkage.

Reuse of any by-product in stabilization of soil can help in both environmental and engineering favour. The need to cut down the expense of waste disposal and burgeoning expense of soil stabilizers has asked an investigation into the stabilizing capability of industrial leather waste in black cotton soil.

In this project untanned leather waste incinerated at different temperatures is worn to improve black cotton soil peculiar properties, this leather waste contains lime in good extent which is directly dumped in landfills. This lime can be useful in the formation of CSH gel in the soil mix and which can be employed to stabilize using lime content present in leather waste. And while same untanned leather waste incinerated at high temperatures can also help in stabilization due to same CSH gel formation properties.

Keywords: Black cotton soil, leather waste, untanned leather waste, CSH gel montmorillonite clay mineral.

CONTENTS

LIST OF ACRONYMS & ABBREVATIONS

Serial no.	Acronyms & Abbreviations	Description
1.	BCS	Black cotton soil
5.	CBR	California Bearing Ratio
3.	MDD	Maximum dry density
4.	OMC	Optimum moisture content
2.	UCS	Unconfined compression test
6.	UT	Untanned

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

1.1 General introduction

The expansive soils are well known throughout the world. India acquire a broad availability of expansive soil which is commonly known as Black Cotton soil (BCS), present in a broad area of 0.8 million square kilometre, which is nearly about 20% of total land area of India. In India, they are primarily found in the states of Maharashtra, Gujarat, eastern units of Madhya Pradesh, southern units of Uttar Pradesh, Karnataka and Andhra Pradesh.

Black cotton soil are expansive clayey soil from grey to dark black in color with a high potential for shrinkage and swelling under differing moisture content as they contain montmorillonite clay mineral. Swelling attribute and shrinkage attribute of black cotton soil leads to differential settlement which results in serious damage of foundations, buildings, an upheaval of floors and pavements, and bursting of pipes etc.

The foundation construction for structure on black cotton soil possesses a serious threat to the civil engineers all over the world. The undesirable characteristics of swelling and shrinking should be improved using a suitable stabilization approach. Stabilization concerns the methods for improvinging the properties of black cotton to enhance its engineering attributes and property.

Fig. 1.1 Black cotton soil in naturally dry state.

Leather industry waste reside to be one of the high polluting industries in developing economies because of generation of a large amount of waste in the form of solids, liquids and gases. The global tanning industry produces around 6 million tonnes of solid waste per year. About 90% of tannery in world involves the basic chromium tannage as material because of its excellent properties.

Heavy metals such as chromium (+III) and chromium (+IV) have been contemplated lethal in nature. And are very rich influents from leather waste.

Leather tannery wastes are differentiated in to 3 grades:

- Wastes taken away from untanned skins (trimming and fleshing waste).
- Wastes taken away from tanned leather (Shaving waste and buffing dust).
- Wastes taken away from dyed and finished leather (trimming from the leather).

Fig. 1.2 Open burning of leather waste.

Black cotton soil is treated as very poor type of soil because of its very low bearing capacity and high swelling and shrinkage characteristics. With increasing cost of stabilizers and commitment to safeguard our environment from deterioration because of these highly toxic waste dumped straight into the landfills. These wastes with heavy metals should be worn for both environmental and engineering prosperity. The heavy metals that are present can be worn with the high capacity of cation exchange characteristics of black cotton soil which can stabilise it to strengthen it and reduce its peculiar characteristics of swelling and shrinkage under proper curing condition.

CHAPTER 2

LITERATURE REVIEW

2.1 General

This examination is about the great success in development of effect of silica and lime on the black cotton soil and the occurrence of CSH gel formation. The effect of curing as it enhances the quality advancement of soil in various stages and the properties of the tannery leather waste. Therefore, several studies have been conducted for modifying the strength of black cotton soil using different modifiers under normal condition and cured condition.

2.2 Literature Survey:

- **Vigneshwar et al. (2017) [1]** recognized the importance of soil stabilization as one of the major essence for the development of road pavements and the foundations constructions. This stabilization can be achieved by various waste materials such as fly ash, rice husk ash, quarry dust, pond ash dust etc. The prime intention of this investigation is to investigate the impact of quarry dust which is gotten during quarrying process. The quarry ash was used in a stepped manner of 10%, 20%, 30%, 40%, and 50%. Even though being an expensive test for soil he defined Tri-Axial test as a prime indicator for his results as it has all control over the drainage conditions and stress distribution is uniform on the failure surface. The main objective is to study the triaxial behaviour of soil blended in with shifted volumetric extents of quarry dust. The triaxial test was led on cylindrical shaped samples of 76mm x 38mm with three principal stresses were applied on the example out of which two were applied by water pressure and the deviator stress was applied by a loading ram form the top of the sample. And plotting of deviator stress versus axial strain was done. Upon mixing of soil with quarry dust, the quarry dust imparts the plasticity to the soil mix. The quarry particles are flocullant in nature and gotten dispersive at the blend of half, which leads to the pseudo cohesion in the soil mix. From triaxial graph it is evident that there was an increase in friction angle and the cohesion with the increase of quarry dust percentage in the mix.

- **Mohammed et al. (2014) [2]** observed the overall execution of two soils in holding the substantial metal particles in the wake of altering them with reasonable lattices was been assessed. Black cotton soil of Belgaum and red soil of Bangalore were blended in with various rates of lime. The BCS with 6% lime has adsorbed the greatest which is trailed by BCS with 3% lime. At higher concentration, the vitality adsorption is higher and further more adsorption of vitality happens than normal and hence it is more favourable in strength parameter. The exploratory outcomes connected well with experimental and active models Recreation utilizing speciation programming Visual minteq gave new impetus into the lead of these blends at various pH levels. It is proposed that BCS lime blend be utilized as a channel material and Red soil lime mix as the standard liner material to tighten picked significant metals for instance, copper and chromium in a cutting edge modern landfill.

- **Mehta et al. (2014) [3]** In this examination Soil contains a high content of clayey soil Thus is similar to black cotton soil. It has a very high value of plastic and liquid limit, so we can't utilize legitimately for the development of highway pavement construction. A very less value of California bearing ratio (C.B.R) was obtained after the trial and high value of swelling which results in no stabilization. So, Soil was needed to be stabilised which further results in increment of strength and decrease in plastic and liquid limit value. Lime is utilized as a modifier in high plastic soils and grants binding activity even in granular soil, be that as it may, is successfully utilized in expansive soils. CBR test as a prime pointer to the solidarity strength to the soil. Some mechanical properties of clayey sands were inspected and the conduct of these materials was communicated in straight forward numerical conditions dependent on assessment conclusion on soil that was given from the Northern territories of India. As indicated by the outcomes, it is perceptible that lime-balanced out materials with high mud substance are progressively fragile that others. Though expansion of lime gives great outcome and can be utilized for huge tasks.

- **Di Sante et al. (2014) [4]** A prompt wetting of blend fulfill an all the more deliberate improvement of soil–lime concoction responses. If correlated with the sample cured in unsaturated conditions and pozzolanic response items, ensure an enormous improvement in the compressibility paying little mind to the curing conditions. pH estimations were seen as a valuable and adequate technique to distinguish times-important to acquire a lime modified soil or a lime stabilized out soil. This strategy source additionally helpful data for a legitimate interpretation of compression and permeability tests. 7 days curing in varied conditions profoundly influence the hydraulic conductivity value which decreases with time.

- **Alebel Abebe Belay et al. (2010) [5]** studied about Cr and stated that Cr is exceptionally harmful and cancer-causing to individuals and condition. It is visible that chromium is harmful to human wellbeing, creatures and the environmental conditions. The treatment processes were either inefficient, difficult, requires a very high energy and ask for a very high cost and is only available to several parts of the world due to heavy technologies and a very high manpower demand. Diverse treatment alternatives were assessed to forestall outcomes however neither of them had the option to treat it 100%.

- **Basha et al. (2005) [6]** stated that replacement of natural soils, aggregates, and cement with solid industrial by-product is exceptionally alluring. Burnt agricultural by-product, rice husk, as a material is used for stabilizing the soil and from the viewpoint of plasticity, compaction and strength characteristics, and economy, addition of 6–8% cement and 10–15% rice husk ash is suggested as an ideal content. Cement and rice husk ash reduces the plasticity of the soil. The maximum dry density diminishes with increment in content of cement with soil. The rice husk ash enhances the uncompressive strength of the soil by a considerable margin. Addition of rice husk ash leaded to fewer requirements to get the necessary quality when contrasted with soil fixed with addition of cement enhanced the California bearing ratio value (CBR) while addition of rice husk ash enhanced the CBR value in the order of multiplication. Rice husk ash blended with soil can enhance strength individually as well as with addition of cement and can cut down some construction cost in developing countries.

- **Sudhakar M. Rao and P. Shivananda (2005) [7]** studied the lime alteration reactions happen from the substitution of replaceable particles of the soil with calcium particles discharged by lime. The expanded interchangeable calcium ions fixation builds the flocculation of earthy clayey particles and reconstruct the plastic soil into a granular and lower plastic material. and the conditions pozzolanic activities initiates following 1 day of relieving at 25deg C in contrast with 7 days required at 11.5deg. This result also hints that strength development will be quicker in hot temperatures as compared to cold temperatures which resulted from pozzolanic activity.

- **Zalihe Nalbantogolu et al. (2004) [8]** At the point when lime and fly ash are included into soil, a quick hydration process was happened and a synchronous cation trade that flocculates the soil into bigger protuberances. This resulted in increase in strength and reduction of swelling and swelling properties. After the fly ash treatment there is powerful increment in plasticity of both soils. Both soil crossed the A line from clayey locale area to silty area. There is decrease in swelling pressure of both the soils which indicated swelling is prevented in small swelling pressure values. There was reduction in cation exchange capacity value after the fly ash treatment which results in change in mineralogy and develops a new inferior mineralogy. This new mineralogy develops the soils in to more granular due to pozzolanic reactions which further resulted in low water absorption by the soil. Usage of fly ash as a stabilizer for the soil seems by all accounts to be one of the numerous practice responses for taking care of the fly ash waste issue. Since there is parcel dynamically fly ash that is disposed of rather if any use, utilizing fly ash would have impressive natural advantages in diminishing land water and air contamination.

- **Dermatas et al. (2003) [9]** The expansion of quicklime and fly ash to soils viably decreased overwhelming metal leach ability. Fly ash increases pH region for every substantial metal tried, improves pressure strain properties, their reuse is available construction materials. There is a demand to expand the utilization of fly ash and other mechanical side output so as to abstain from expanding removal costs. The pozzolanic nature of fly ash and other industrial waste products can be effectively utilized in the many range of the construction projects. The use of fly ash in the quicklime sulphate treatment gives a very high strength, resistant to swelling, monolithic solids and the strength is of similar level to that of the concrete products. The main potential dilemma regarding the treatment process is the arrangement of mineral ettringite during the reactions. As ettringite when comes in contact with the water can further results in swelling which leads to loss of strength and physical deterioration of the solids that is treated. Moreover, in the nearness of fly ash reaction by products the cohesive force produced can overcome ettringite produced swelling. Regarding substantial metal discharge, the usage of fly ash was legitimately liable for the viable immobilization of both lead and hexavalent chromium. Furthermore, it further improved trivalent chromium immobilization.

- **Osinubi et al. (2001) [10]** investigate about the locust bean ash with ordinary Portland cement in soil and obtained that replacement of 50% cement by the ash could be employed for the treatment of the soil to achieve a needed sub-base material, thereby reducing the quantity (of cement) needed for stabilization. The preliminary examination for Nigerian expansive soil which is also refer as black cotton soil shoed that it fit in AASTHO classification of soil as A-7-6 (13). The soil was penniless to be used for any of the engineering purpose. Ordinary Portland cement was used with locust bean ash in a stepwise manner in increasing concentration form 0 to 8% each by dry weight of the soil which was used in stabilization of black cotton soil. Compaction was done using British standard light energy and the assessment of resulting strength was based upon three criteria that was Unconfined compressive strength UCS , California bearing ratio CBR and durability. These three values were compared on the basis of curing periods of 7, 14 and 28 days. In terms of UCS and CBR the maximum obtained result was from 6% Ordinary Portland cement and 6% locust bean ash blend. And the durability in terms of loss in strength resistance increase from 13% to 58%. The strength and durability further increases with the curing period that shows there will be decrease in cement quantity for the construction of pavements over the expansive soils.

2.3 Summary of literature review:

- When lime and silica are included into the soil, this prompts movement of hydration process all the way more quickly. The reaction procedure Calcium Silicate Hydrates that is repetitive for long term strength increases in soil.
- While curing of soil at higher ambient temperatures helps in accelerating the progress of lime-soil reactions and retarded at low temperature.
- An immediate wetting of soil while curing enhances a uniform development of soil lime chemical reactions, not any detection of non-reactive zones.
- Black cotton soil (BCS) when blend with the lime is superior material when the same is correlated with red soil lime blend. BCS lime blend can be worn as a filter material and Red soil lime blend can be further used as the main liner material in construction.
- The triaxial test was led on cylindrical shaped samples of 76mm x 38mm with three principal stresses were applied on the example out of which two were applied by water pressure and the deviator stress was applied by a loading ram form the top of the sample.

CHAPTER 3

OBJECTIVES

- To assess the immediate change in unconfined compressive strength of soil with addition of untanned and untanned waste incinerated at 600 celcius waste.
- To determine the improvement in strength of the soil mix with untanned and untanned waste incinerated at controlled temperature of 600 celcius with respect to curing period.
- To determine the change in shear strength parameters of the soil with respect to cured and uncured specimen using open burned untanned and untanned waste incinerated at controlled temperature of 600 celcius leather waste ash which is used as an additive.

- To determine the optimum content of untanned and untanned waste incinerated at controlled temperature of 600 celcius leather waste ash as an added substance for the stabilisation of black cotton soil under the appropriate curing.

So as to accomplish the above mentioned objectives, experiments such as proctor, tri-axial test and unconfined compressive strength triaxial test, were performed initially on black cotton soil and after that by stepwise mixing +2%, +4%, +6%, +8% and +10% of waste by the weight of soil under proper curing condition using jute bags were performed.

Their compaction behaviour and their variation of strength was analysed and how it varies with the addition of waste ash was reviewed.

CHAPTER 4

MATERIALS

4.1 Black cotton Soil

4.1.1 General characteristics

The Black cotton soil (BCS) contains a high level of clay, which is basically montmorillonite in structure and dull blackish to greyish in shading. The clay mineral montmorillonite is primarily subjected for expansive qualities of the soil. Black cotton soil expands during rainy season and shrinks during the dry season causing deep cracks into the soil. In essence the black cotton soil possesses extremely low bearing limit and high swelling and shrinkage qualities. In light of its particular qualities, it brings about a poor establishment material to be utilized for development of foundations, structures, subgrade, and so forth.

4.1.2 Procurement

In India, they are primarily found in the states of Maharashtra, Gujarat, eastern units of Madhya Pradesh, southern units of Uttar Pradesh, Karnataka and Andhra Pradesh.
The Black cotton soil employed in this activity has been retrieved from District Gunna of Madhya Pradesh state.

Fig. 4.1 Black cotton soil in Oven dried state.

4.2 Leather waste

The leather waste employed in this project to being used as stabilizer to strengthen black cotton soil and to lesser its swelling and shrinkage was of both the types i.e., untanned (type IV) and leather waste (type IV).

Untanned leather waste is rich in calcium and in lime concentration which are procured after the tanning process from the leather industry.

4.2.1 Procurement

The waste procured in this venture is of pre-fleshing type and lime-fleshing type wastes which is fetched from Leather Industry Complex, Kapurthala, Punjab.

4.2.2 Preparation of untanned leather waste ash for experiment

- The retrieved untanned leather waste was right off air dried and then oven dried to clear out from any kind of dampness and water content which were present initially.
- Then waste was burned in open condition and fire was onset at a temperature of 350 degrees Celsius, later pulverised and then converted into very fine size powdered form.
- Then fine powdered ash passing through 450-micron sieve is then collected in air-tight container.

Fig 4.2 Untanned LW before open burning.

Fig 4.3 Untanned LW ash after burning and passing 425-micron sieve.

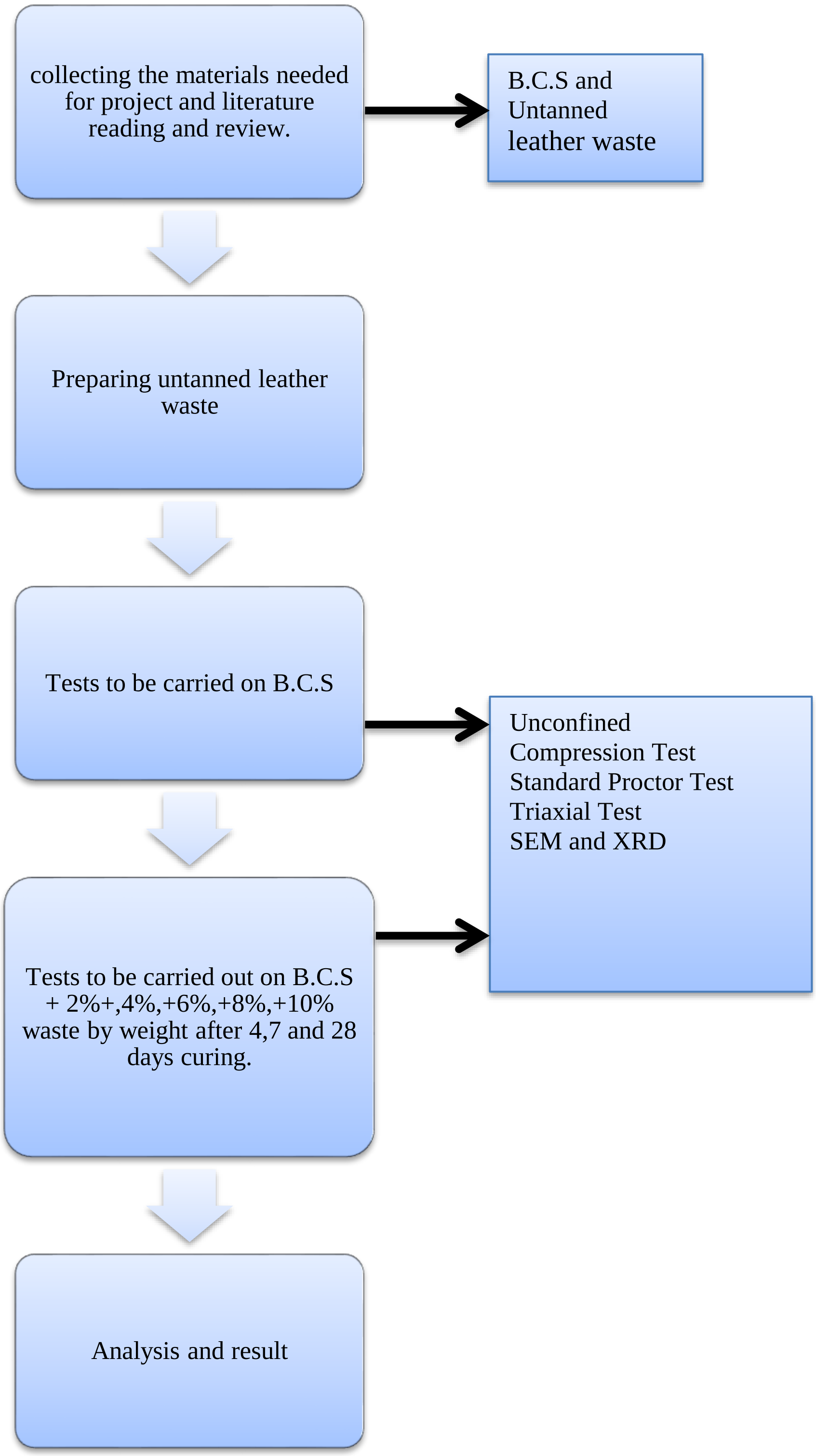
4.2.3 Preparation of untanned leather waste ash incinerated at 600 degrees for experiment

- The retrieved untanned leather waste was air and oven dried to clear out from any kind of dampness and water content which were present initially.
- Then waste was burned in open condition and fire was onset at a temperature of 350 degrees Celsius and was then incinerated at controlled temperature of 600 degrees Celsius to burn organic, later pulverised and then converted into very fine size powdered form..
- Then fine powder ash passing through 450-micron sieve is then collected in air-tight container.

CHAPTER 5

TESTING METHODOLOGY

5.1 Work Plan



5.2 Testing Methodology

5.2.1 Standard Proctor Test

Materials Requisite:

1. Weighing machine
2. Rammer (2.5kg weight)
3. Standard proctor mould (944cc capacity)

Procedure to be followed:

- A dried soil of 5kg quantity was taken and was further blended in with an adequate measure of water with appropriate water content.
- Then without base and collar proctor mould was weighed. Afterwards with the base and collar, later soil was filled in type of three layers and 25 uniformly distributed blows were given to each layer.
- By using straight edge, sample was trimmed and the surface was levelled.
- Sensitive electronic balance was used to weigh.
- To determine the bulk density; the compacted soil weight was to be divided by the volume of the proctor mould.
- And little sample was put in oven to determine water content and calculation was done for water content.
- Continue the process till the weight start decreasing.

Fig. 5.2. Proctor Apparatus and Rammer.

5.2.2 Unconfined Compressive Test

Materials Requisite:

1. Weighing machine
2. Rammer (2.5kg weight)
3. Standard proctor mould (944cc capacity)
4. UCS tester machine
5. Sample extractor

Procedure to be followed:

- The soil was compacted using proctor at OMC to provide same level of compaction energy for samples.
- UCS sampler was then embedded into the compacted soil mould.
- Sampler was taken out cautiously and was cut from both the ends to prepare a levelled surface.
- Sample was cut into the desired dimensions.
- Afterwards sample was placed at the loading plate of the UCS machine.
- The readings were carefully observed from the screen till it became constant and initiate revere loading condition.
- The process was repeated after the soil was cured for 4, 7 and 28 days respectively.

Fig. 5.2.2 Unconfined compressive strength tester.

Fig 5.2.3 Extraction of sampler tube from proctor mould.

Fig 5.2.4 An UCS Sample failed while testing.

5.2.3 Tri-Axial Test

Materials Requisite:

1. Weighing machine
2. Rammer (2.5kg weight)
3. Standard proctor mould (944cc capacity)
4. Tri-axial testing machine
5. Sample extractor

Procedure to be followed:

- Place the specimen on the base. Spot the elastic membrane layer around the specimen, using the mould by applying suction. Seal it at the cap and base with rubber at each end. Tuck the membrane upward to cover the rings or bands
- Wrap the tubes around the specimen and insert the loading cap in the membrane. Secure the membrane with the rubber bands, than pull down the membrane to cover the rings.
- Place the chamber in position in the pivotal axial stacking loading machine. Bring the hub load cylinder into contact with the specimen top a few times to allow legitimate seating and arrangement of cylinder with the top.
- Axial loading device should be aligning with care, the axial load estimating devise, and the tri-hub chamber to forestall the use of a lateral force to the situation during testing.
- Connect the weight keep up and estimation devise and adjust the cylinder to the chamber.
- Rotate the fasteners to bring the piston closer to the chamber. Apparatus should be at same level.
- Before allowing water into the chamber, release the pressure from the water instrument. Open the necessary valves to allow the free passage of water into the chamber. Modify the weight keep up and estimation devise to the ideal chamber pressure and apply the strain to the chamber liquid.
- The lapsed time reach maximum deviator stress will be approximately 10 to 20 minutes. Record load and deformation values accordingly. After culmination of the test, expel the test specimen from the glass chamber and afterward place the soil into electric oven to decide the water content of the test specimen.

Fig. 5.2.5 Tri-axial testing Machine.

CHAPTER 6

RESULT AND DISSCUSSIONS

6.1 Test performed on BCS

6.1.1 Optimum moisture content

OMC is the moisture content at which a maximum dry density s accomplished after a given compaction exertion. For determining maximum strength of a soil, the soil should be compacted at OMC. OMC is access by sketching graph between dry density and moisture content of the compacted soil and is obtained using Standard Proctor Method.

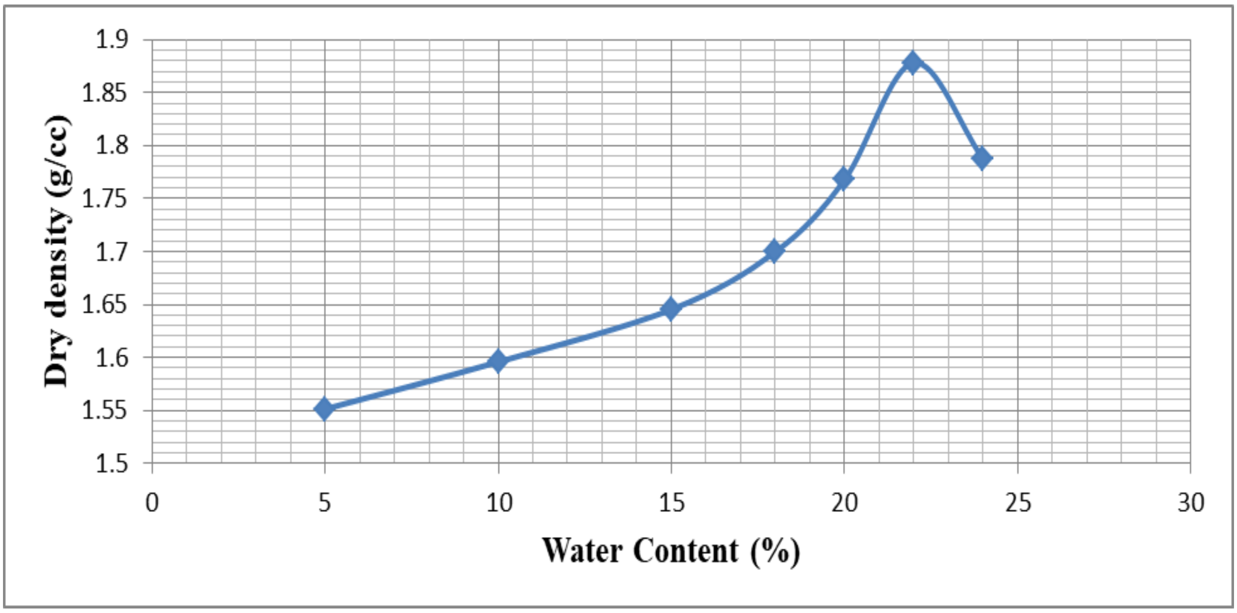


Fig.6.1.1 Compaction curve for plain black cotton soil.

The Maximum dry density of plain BCS is determined from graph as 1.88g/cc corresponding to the O.M.C of 21.8%. (Annexure 1.1).

6.1.2 Unconfined compressive test

UCS measures the unconsolidated undrained shear strength of soil sample under unconfined condition. Unconfined compressive strength is a test where lateral confining pressure equal to zero i.e., only uniaxial stress is determined.

The load obtained was 0.13 KN which is corresponds to displacement of 4.22 mm. After calculating the unconfined compressive strength was obtained as 112 KN/m^2**.**

6.2 Test Performed on BCS + Untanned leather waste ash

6.2.1 Optimum moisture content

Standard proctor test was performed on the BCS soil +2%, + 4% , +6 %, +8%, +10% untanned leather waste ash. And the MDD is determined from the graph of dry density and water content for varied ash content.

6.2.1.1 Maximum dry density variation with varied untanned leather waste ash content and water content.

Waste %age (%)	Maximum Dry Density (g/cc)
0%	1.88
2%	1.92
4%	1.93
6%	1.98
8%	1.84
10%	1.75

Table1 Maximum dry density variation with varied untanned leather waste ash content.

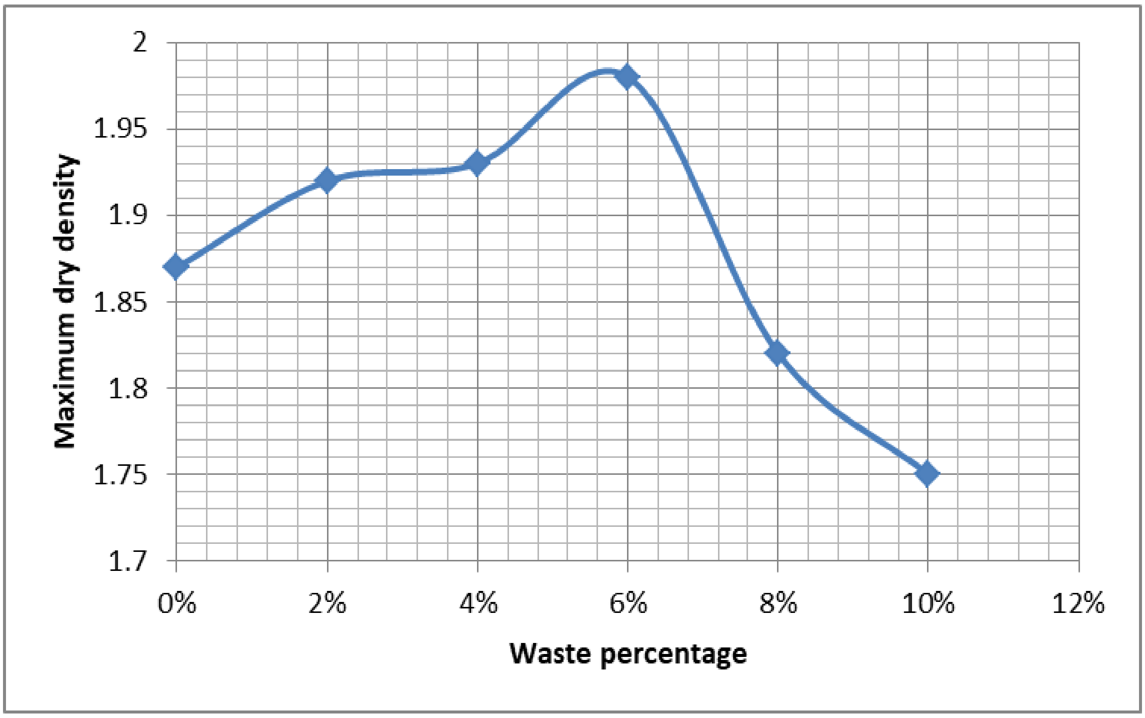


Fig.6.2.1.1 Maximum dry density variation with varied untanned leather waste ash content.

As the waste content was increased the maximum dry density first increases up to 6% and then decreases. The increase till 6% was probably because of agglomeration and flocculation which leads to decrease in volume and have resulted in increase in density. And afterwards 6% it decreases because of exaggerated contact of waste ash that resulted in decrease of density. (Annexure 1.2.1)

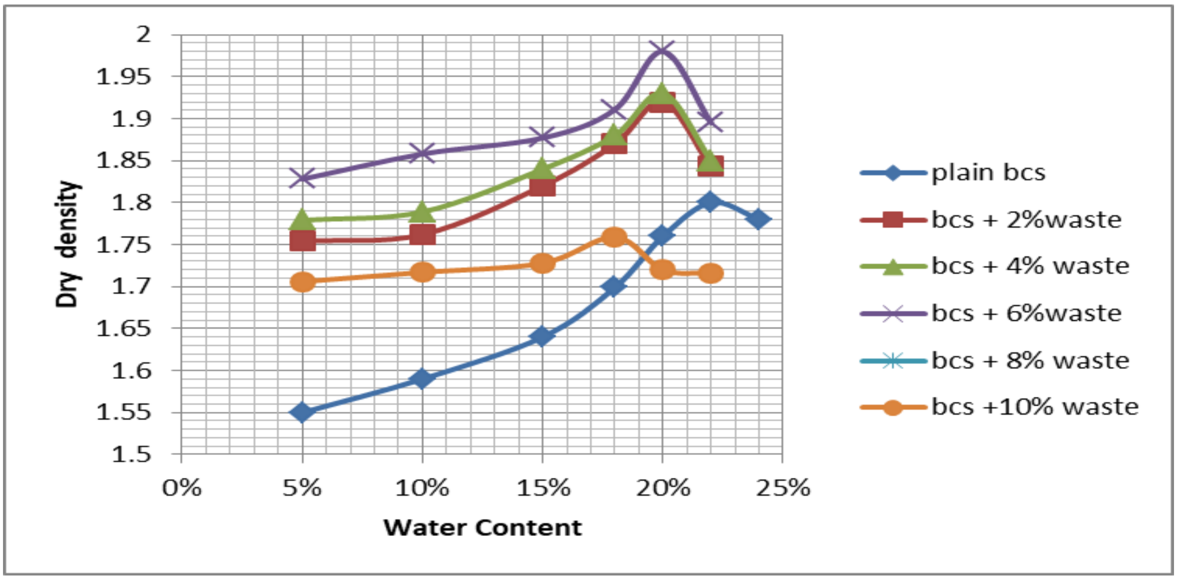


Fig.6.2.1.2 Maximum dry density variation with water content.

6.2.2 Unconfined compressive strength

BCS + 2%, +4%, + 6%, + 8%, +10% untanned leather waste is mixed and unconfined compressive strength is determined for 0, 4, 7, 28 days of curing using jute bags.

BCS + 2% Untanned leather waste ash (0days curing)

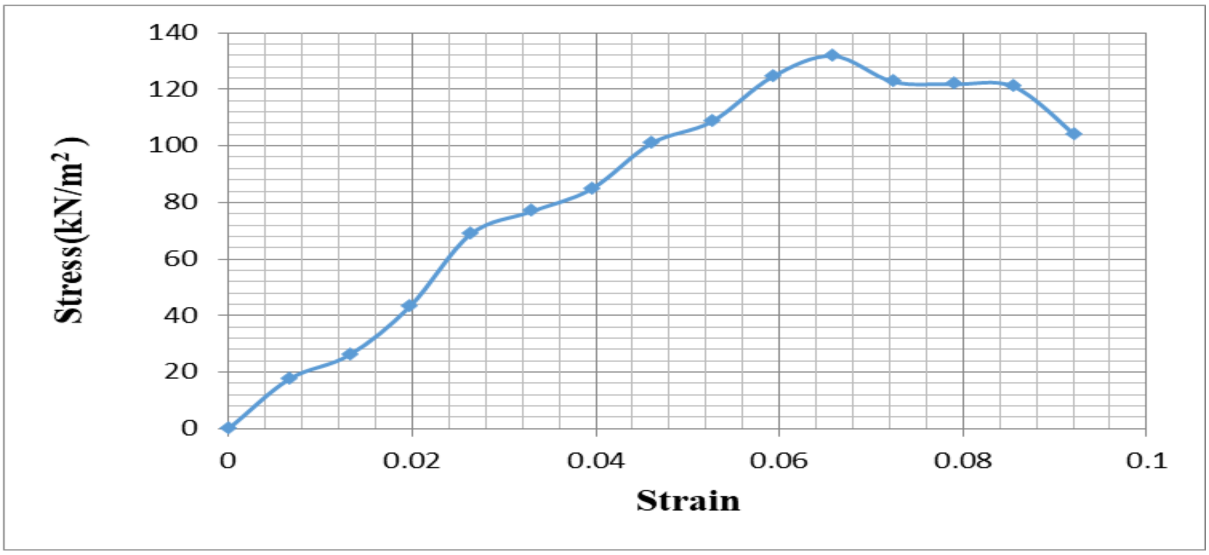


Fig. 6.2.1 Stress-Strain curve BCS + 2% untanned leather waste ash after 0 days of curing.

The Compressive strength of BCS + 2% untanned leather waste ash after 0 days of curing= 131.8 kN/m^2 (Annexure 1.3.1).

BCS + 2% Untanned leather waste ash (4days curing)

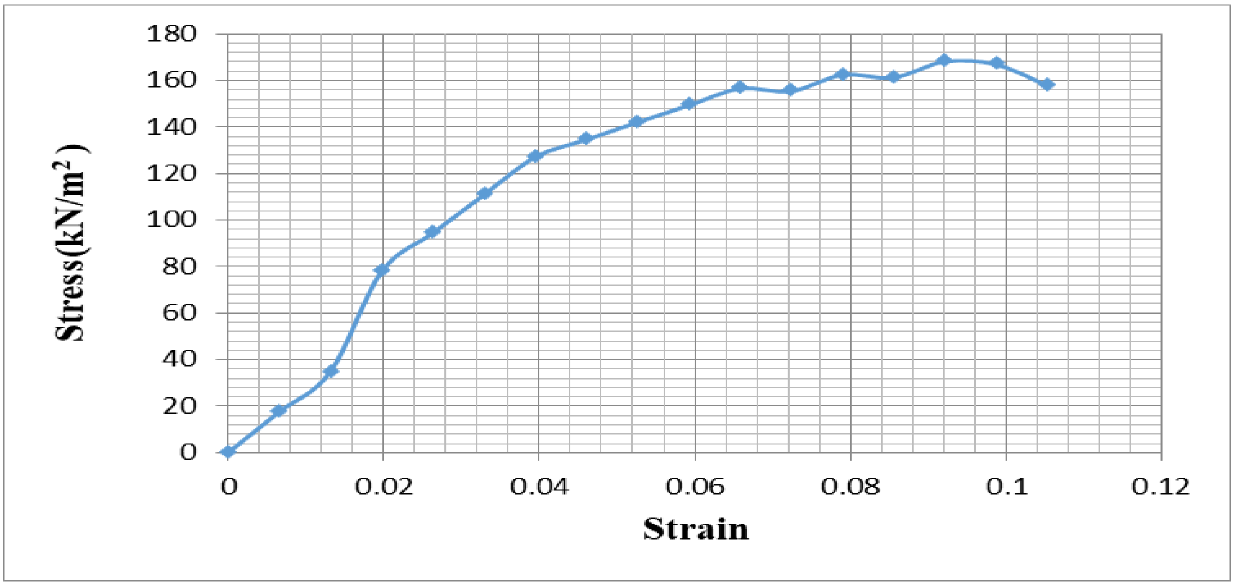


Fig. 6.2.2 Stress-Strain curve BCS + 2% untanned leather waste ash after 4 days of curing.

The Compressive strength of BCS + 2% untanned leather waste ash after 4 days of curing= 168.1 kN/m^2 (Annexure 1.3.2).

BCS + 2% Untanned leather waste ash (7days curing)

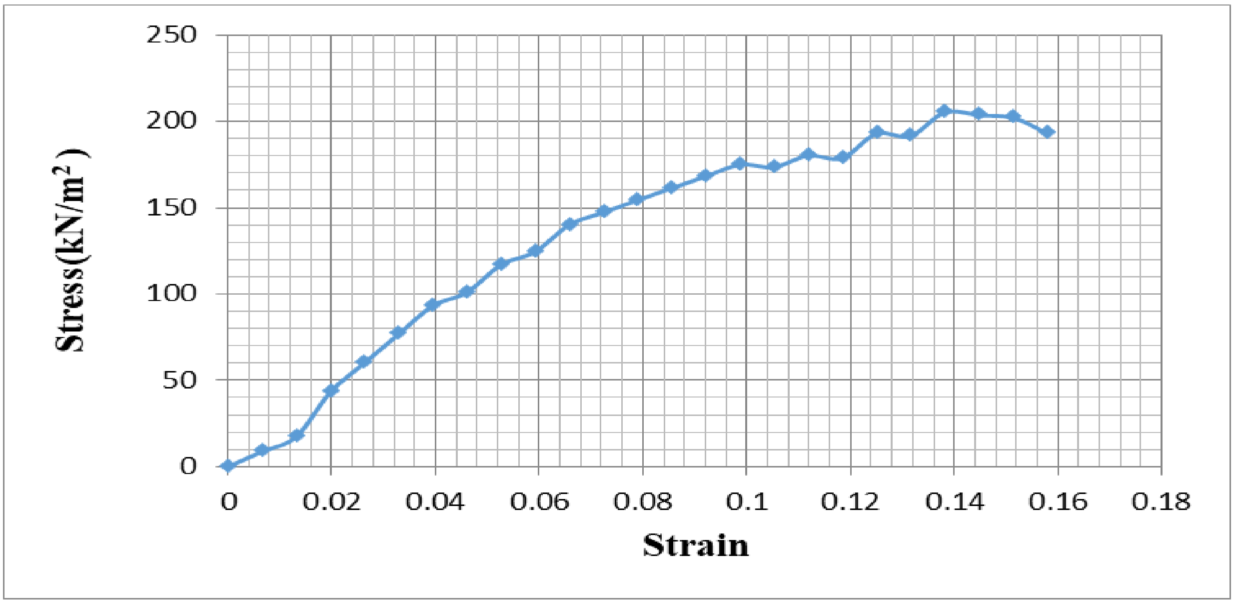


Fig. 6.2.3 Stress-Strain curve BCS + 2% untanned leather waste ash after 7 days of curing.

The Compressive strength of BCS + 2% untanned leather waste ash after 7 days of curing= 205.1 kN/m^2 (Annexure 1.3.3).

BCS + 2% Untanned leather waste ash (28 days curing)

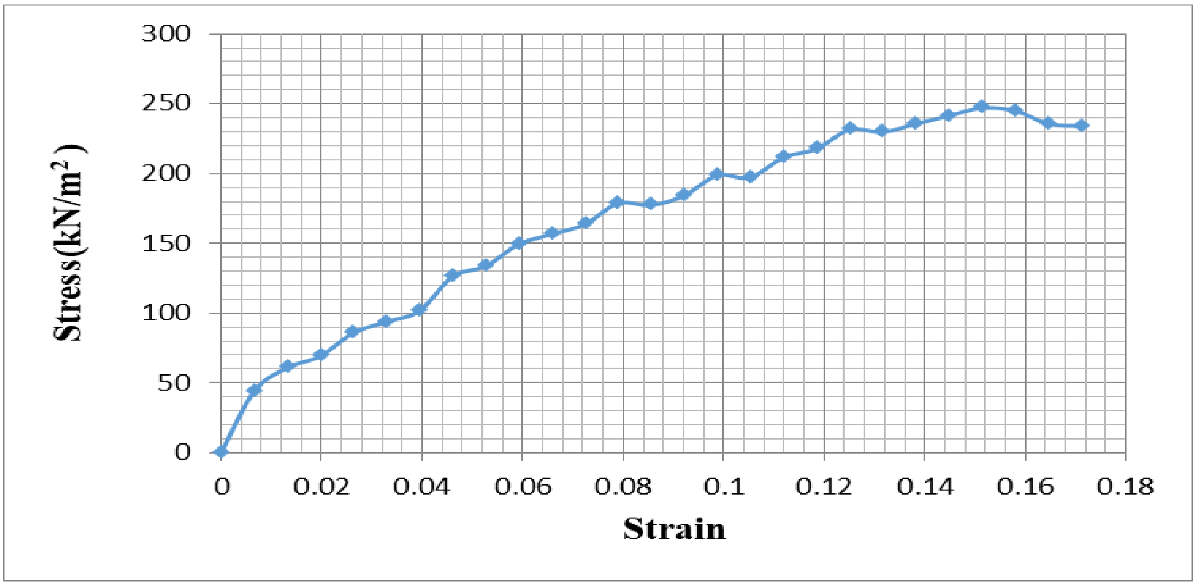


Fig. 6.2.4 Stress-Strain curve BCS + 2% untanned leather waste ash after 28 days of curing.

The Compressive strength of BCS + 2% untanned leather waste ash after 28 days of curing= 246.9 kN/m^2 (Annexure 1.3.4).

BCS + 4% Untanned leather waste ash (0days curing)

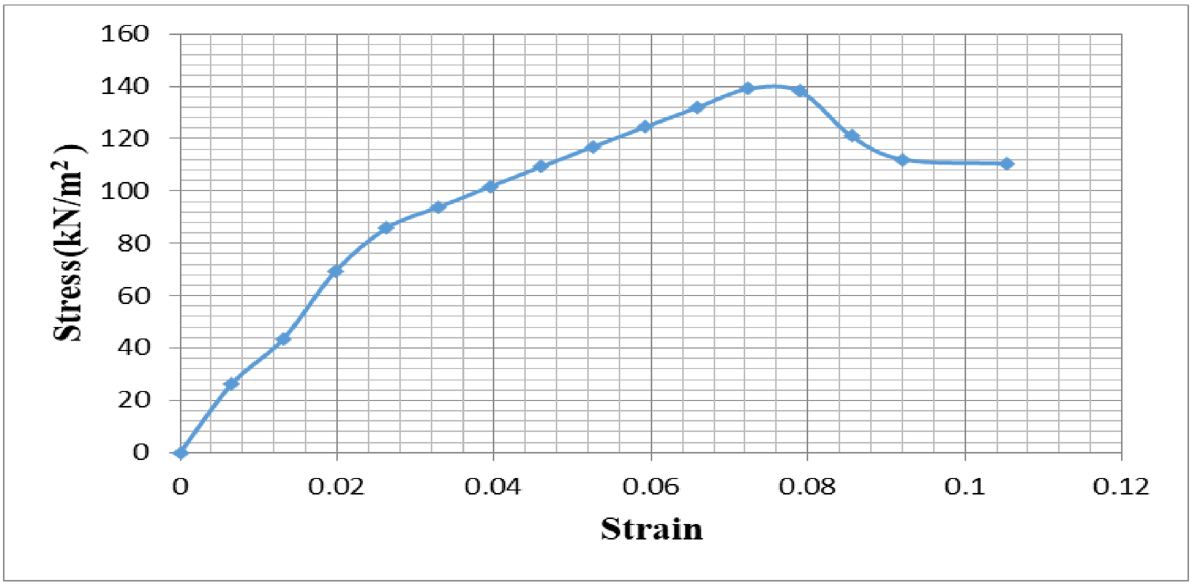


Fig. 6.2.5 Stress-Strain curve BCS + 4% untanned leather waste ash after 0 days of curing.

The Compressive strength of BCS + 4% untanned leather waste ash after 0 days of curing= 139.0 kN/m^2 (Annexure 1.3.5).

BCS + 4% Untanned leather waste ash (4days curing)

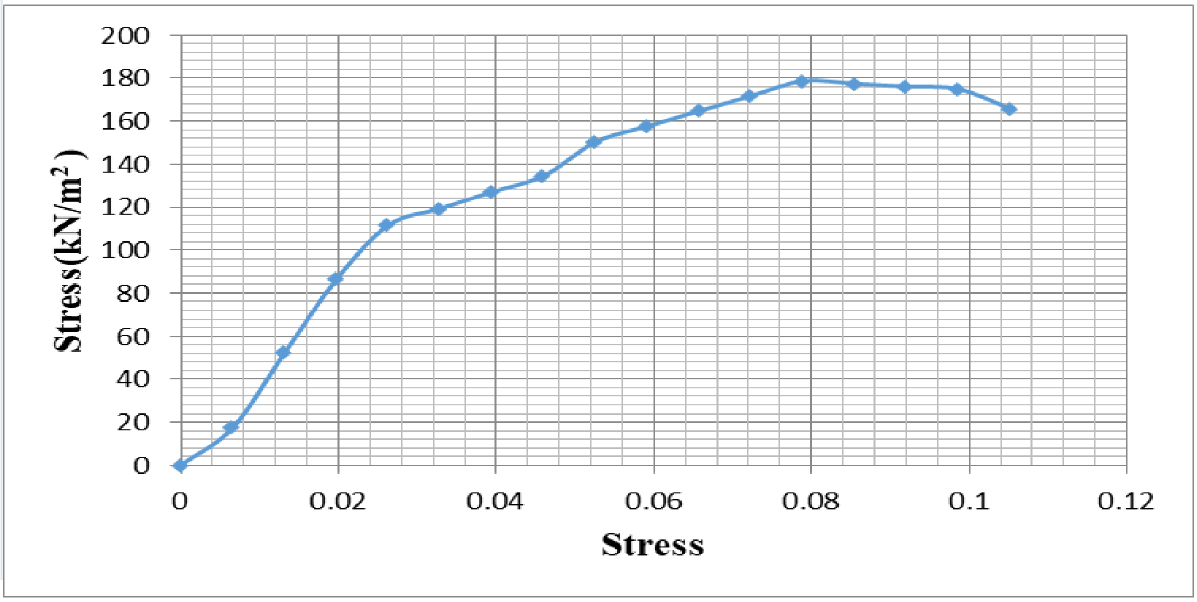


Fig. 6.2.6 Stress-Strain curve BCS + 4% untanned leather waste ash after 4 days of curing.

The Compressive strength of BCS + 4% untanned leather waste ash after 4 days of curing= 178.6 kN/m2. (Annexure 1.3.6).

BCS + 4% Untanned leather waste ash (7 days curing)

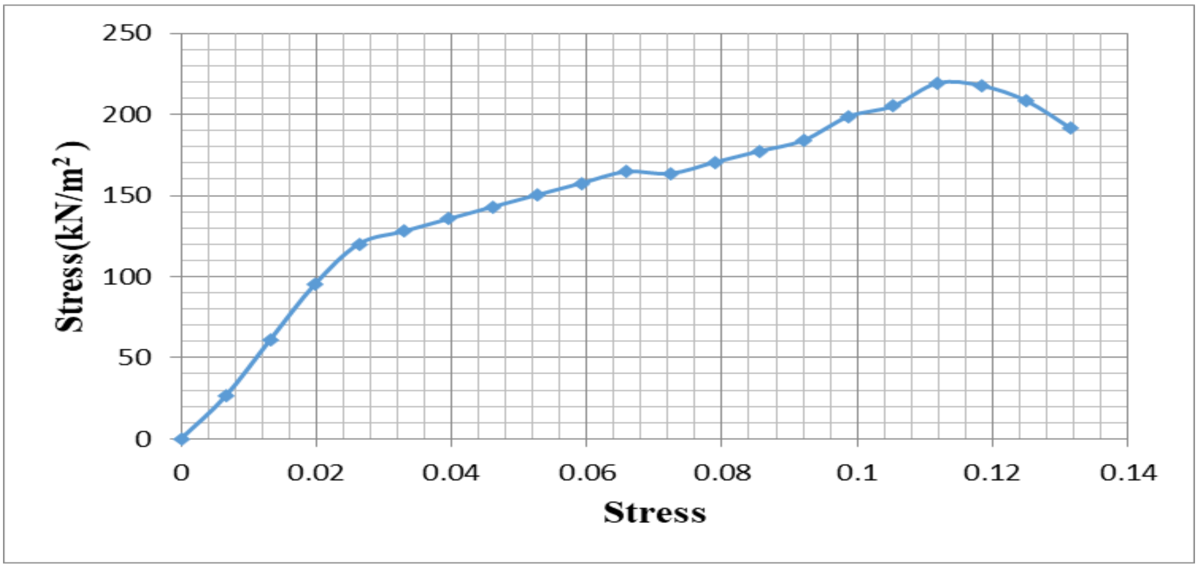


Fig. 6.2.7 Stress-Strain curve BCS + 4% untanned leather waste ash after 7 days of curing.

The Compressive strength of BCS + 4% untanned leather waste ash after 7 days of curing= 219.2 kN/m2. (Annexure 1.3.7).

BCS + 4% Untanned leather waste ash (28 days curing)

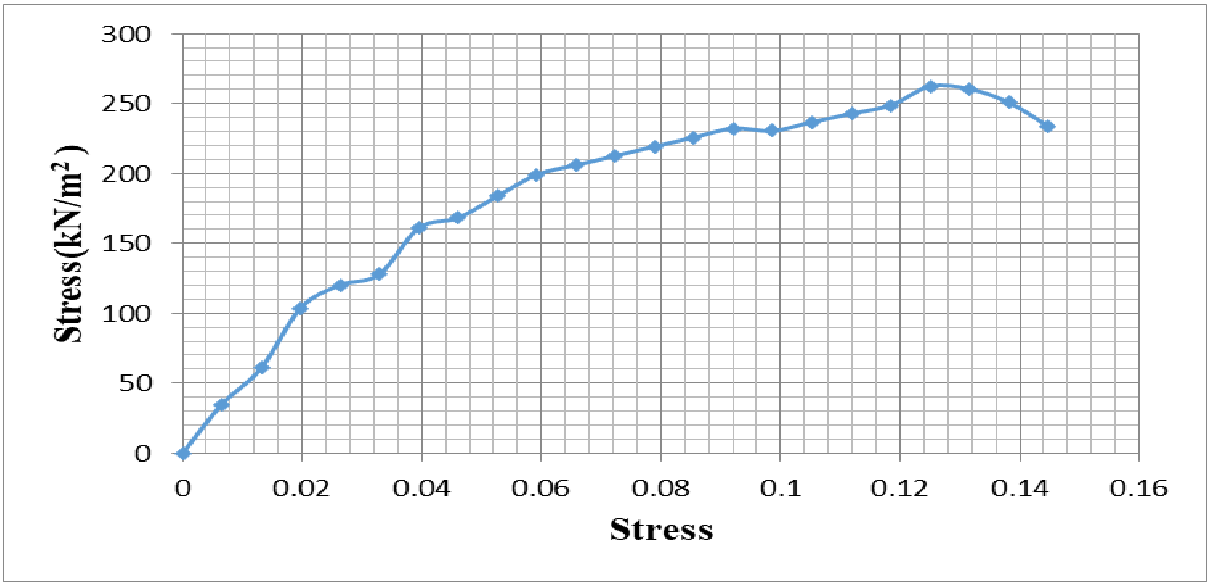


Fig. 6.2.8 Stress-Strain curve BCS + 4% untanned leather waste ash after 28 days of curing.

The Compressive strength of BCS + 4% untanned leather waste ash after 28 days of curing= 262.31 kN/m2. (Annexure 1.3.8).

BCS + 6% Untanned leather waste ash (0days curing)

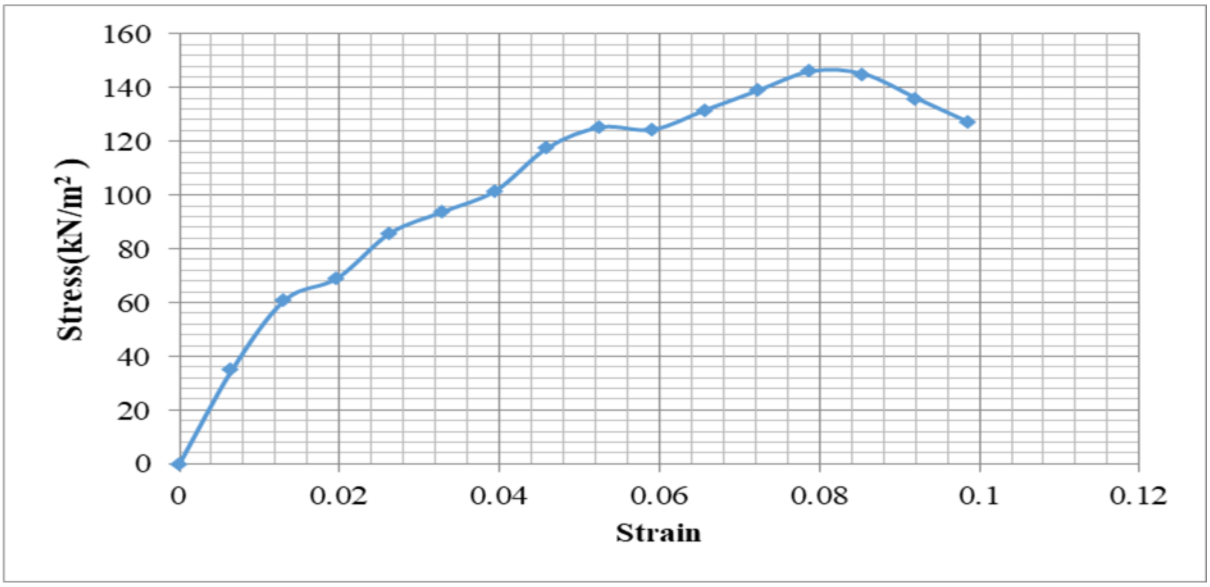


Fig. 6.2.9 Stress-Strain curve BCS + 6% untanned leather waste ash after 0 days of curing.

The Compressive strength of BCS + 6% untanned leather waste ash after 0 days of curing= 146.1 kN/m^2 (Annexure 1.3.9).

BCS + 6% Untanned leather waste ash (4days curing)

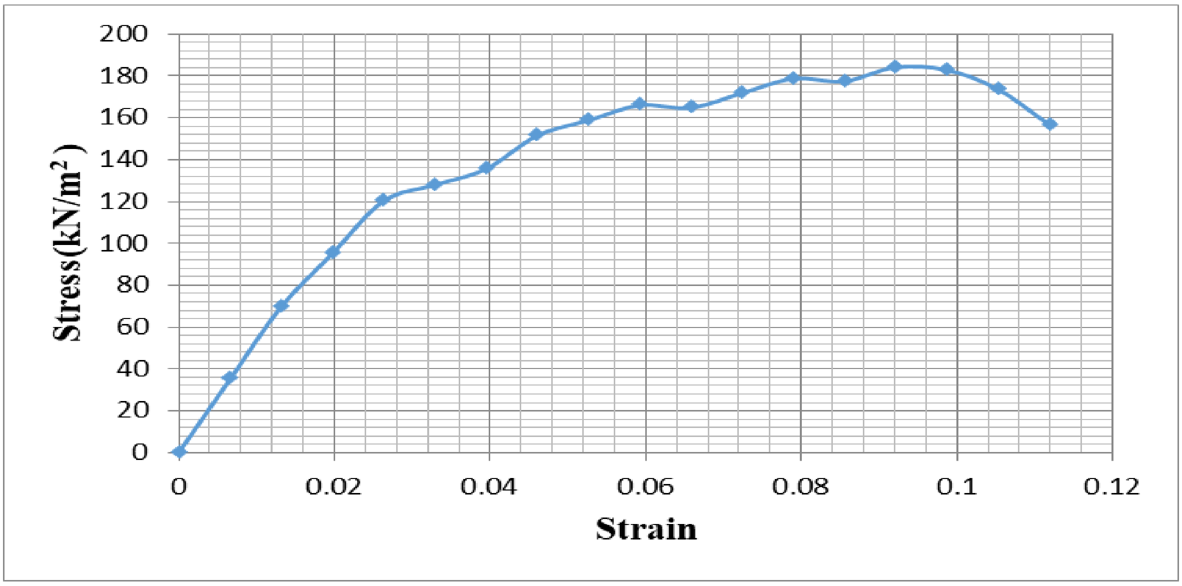


Fig. 6.2.10 Stress-Strain curve BCS + 6% untanned leather waste ash after 4 days of curing.

The Compressive strength of BCS + 6% untanned leather waste ash after 4 days of curing= 184.1 kN/m^2 (Annexure 1.3.10).

BCS + 6% Untanned leather waste ash (7days curing)

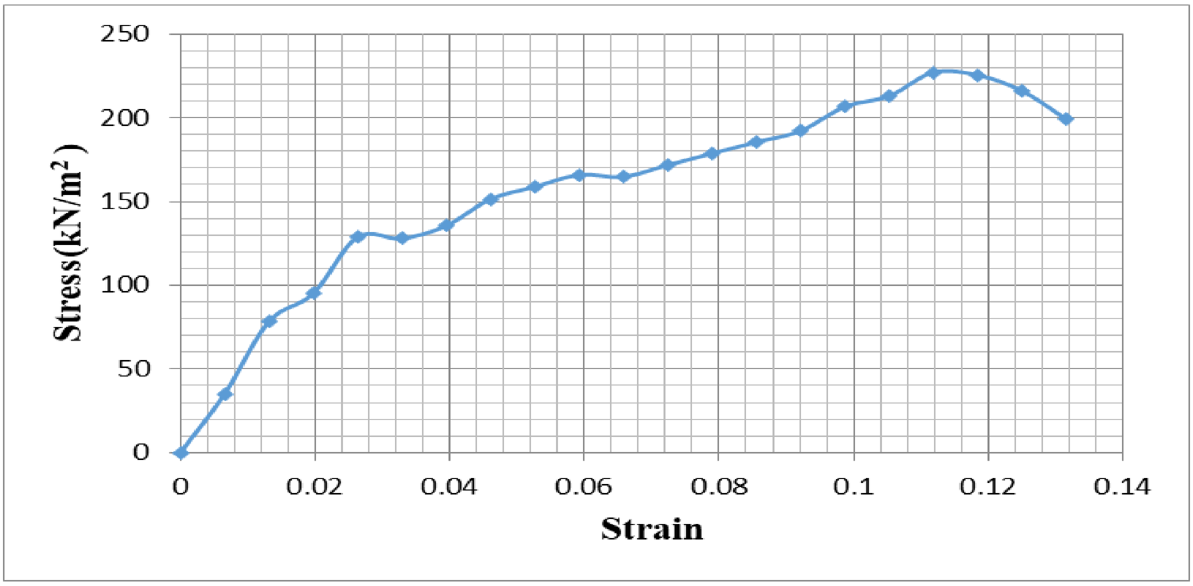


Fig. 6.2.11 Stress-Strain curve BCS + 6% untanned leather waste ash after 7days of curing.

The Compressive strength of BCS + 6% untanned leather waste ash after 7 days of curing= 227.1 kN/m^2 (Annexure 1.3.11).

BCS + 6% Untanned leather waste ash (28days curing)

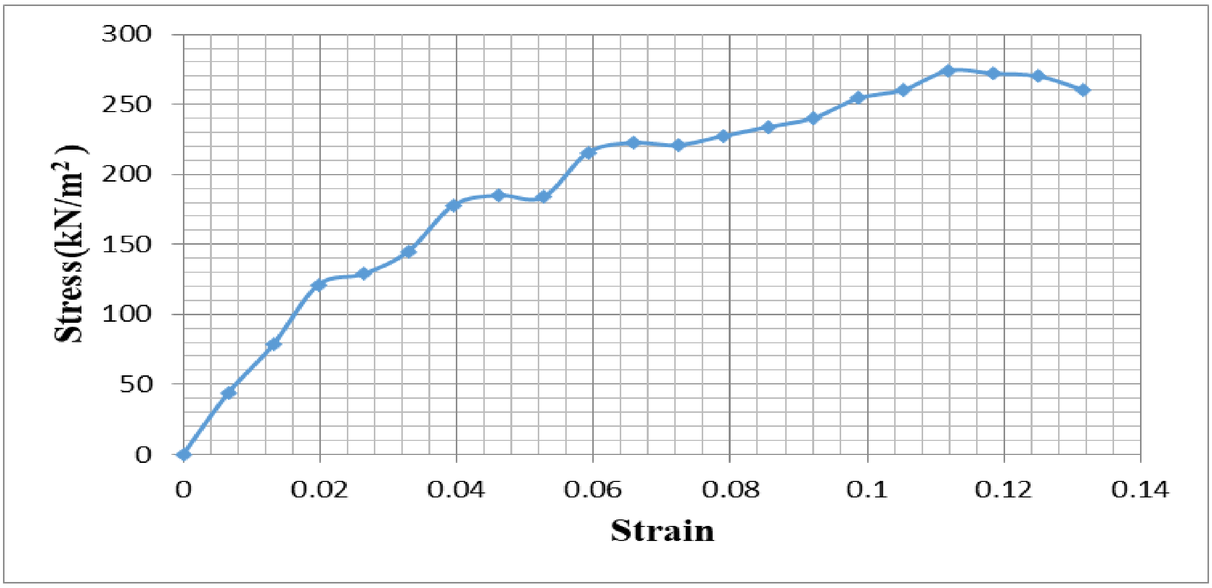


Fig. 6.2.12 Stress-Strain curve BCS +6% untanned leather waste ash after 28days of curing.

The Compressive strength of BCS + 6% untanned leather waste ash after 28 days of curing= 279.8 kN/m^2 (Annexure 1.3.12).

BCS + 8% Untanned leather waste ash (0 days curing)

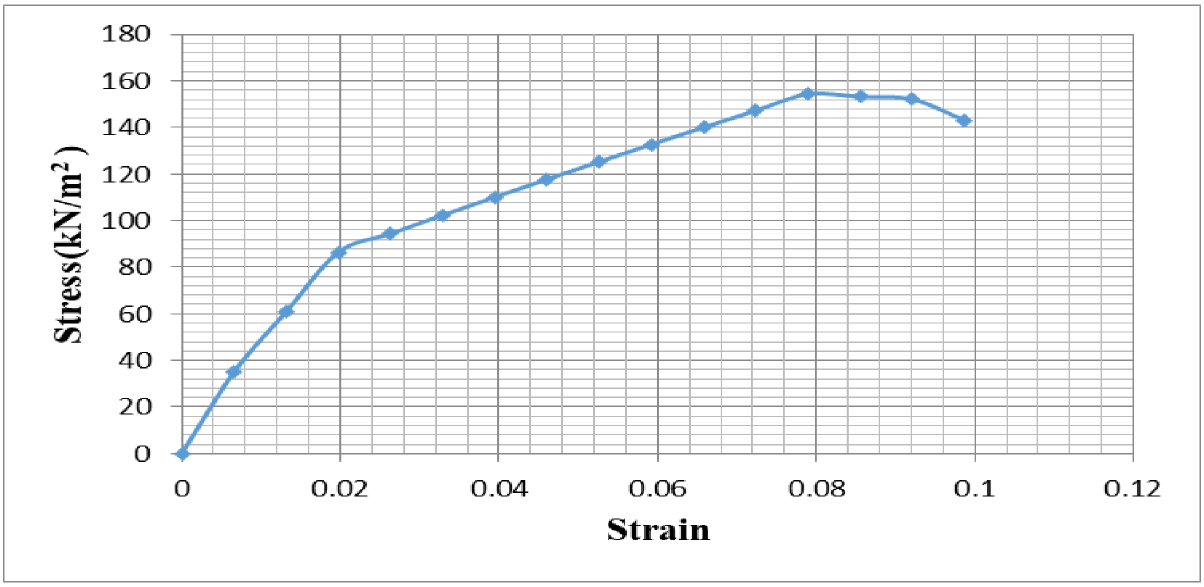


Fig. 6.2.13 Stress-Strain curve BCS + 8% untanned leather waste ash after 0 days of curing.

The Compressive strength of BCS + 8% untanned leather waste ash after 0 days of curing= 154.1 kN/m^2 (Annexure 1.3.13).

BCS + 8% Untanned leather waste ash (4days curing)

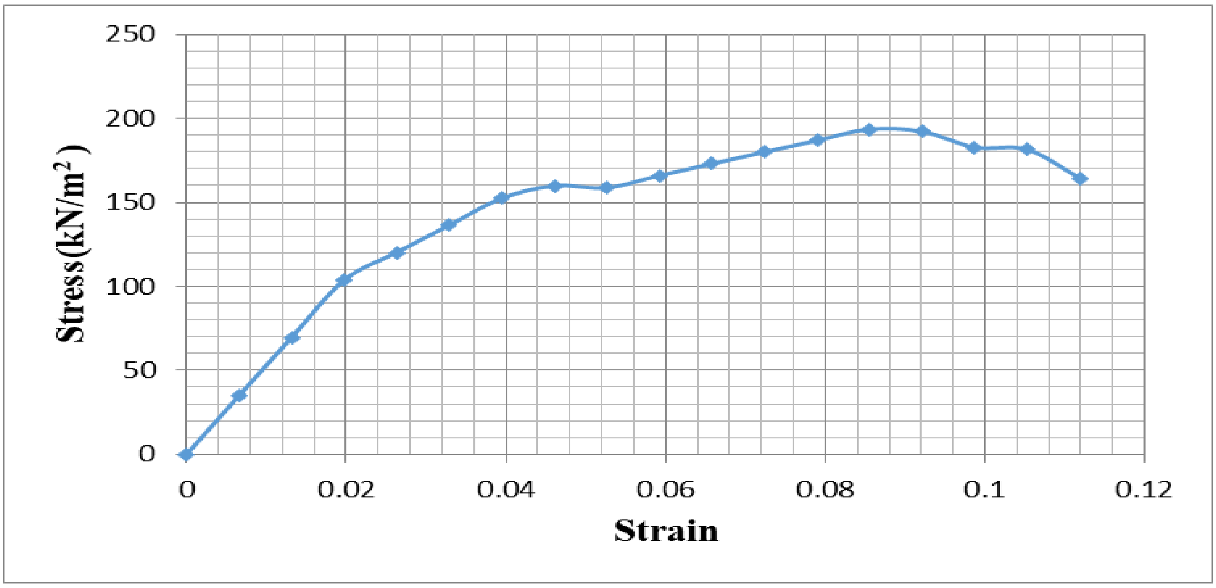


Fig. 6.2.14 Stress-Strain curve BCS + 8% untanned leather waste ash after 4 days of curing.

The Compressive strength of BCS + 8% untanned leather waste ash after 4 days of curing= 193.5 kN/m^2 (Annexure 1.3.14).

BCS + 8% Untanned leather waste ash (7days curing)

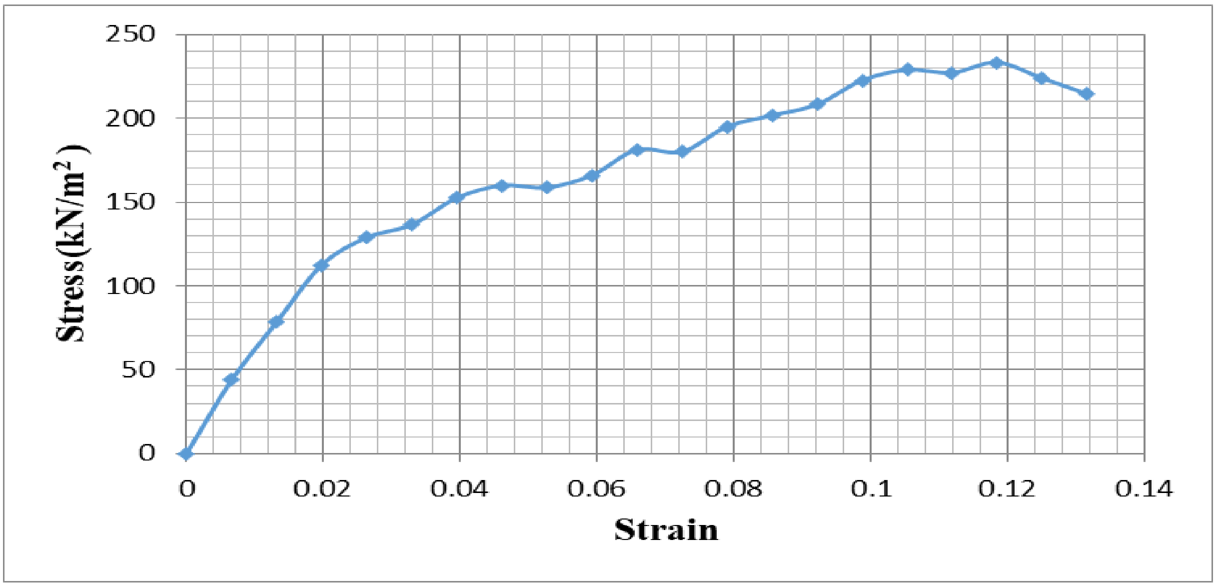


Fig. 6.2.15 Stress-Strain curve BCS + 8% untanned leather waste ash after 7 days of curing.

The Compressive strength of BCS + 8% untanned leather waste ash after 7 days of curing= 233.1 kN/m^2 (Annexure 1.3.15).

BCS + 8% Untanned leather waste ash (28days curing)

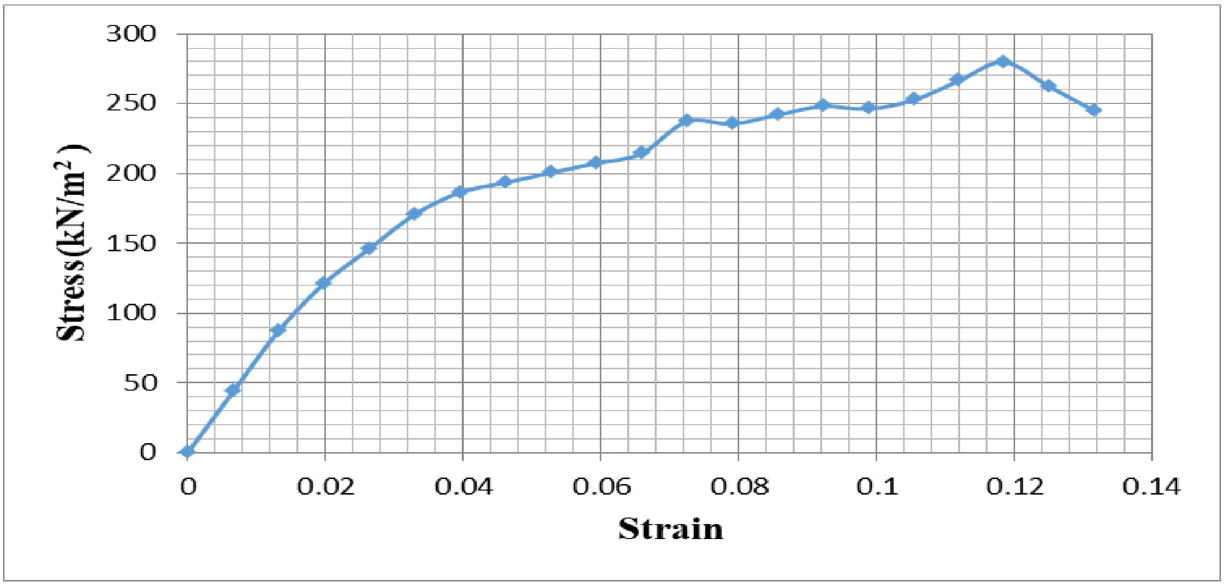


Fig. 6.2.15 Stress-Strain curve BCS + 8% untanned leather waste ash after 28 days of curing.

The Compressive strength of BCS + 8% untanned leather waste ash after 28 days of curing= 279.8 kN/m^2 (Annexure 1.3.16).

BCS + 10% Untanned leather waste ash (0 days curing)

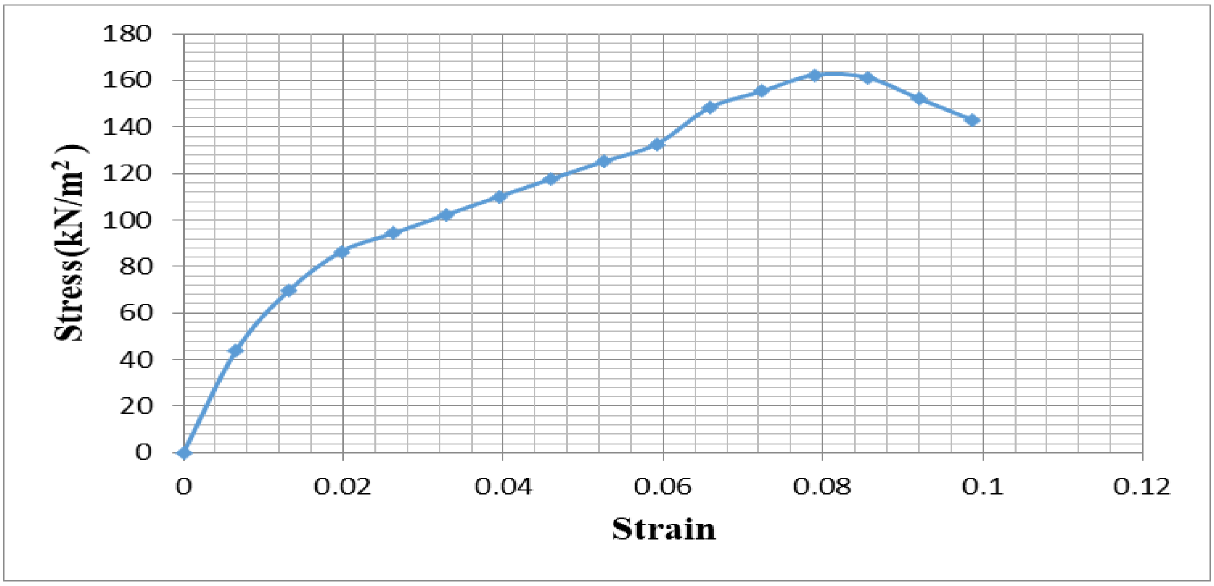


Fig. 6.2.17 Stress-Strain curve BCS + 10% untanned leather waste ash after 0 days of curing.

The Compressive strength of BCS + 10% untanned leather waste ash after 0 days of curing= 162.42 kN/m^2 (Annexure 1.3.17).

BCS + 10% Untanned leather waste ash (4days curing)

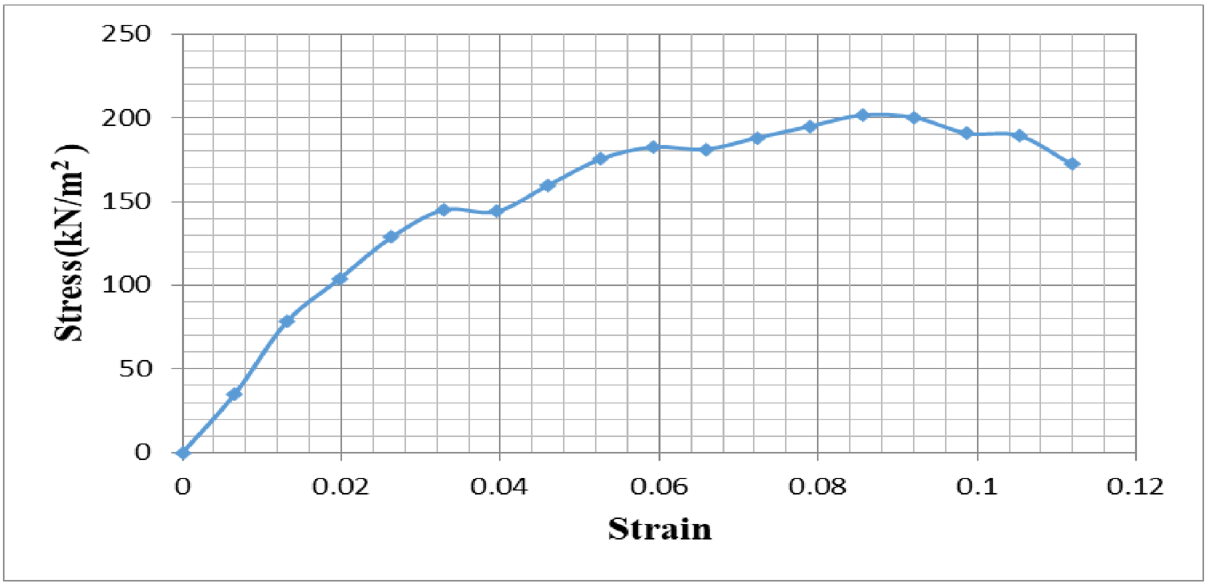


Fig. 6.2.18 Stress-Strain curve BCS + 10% untanned leather waste ash after 4 days of curing.

The Compressive strength of BCS + 10% untanned leather waste ash after 4 days of curing= 201.5 kN/m^2 (Annexure 1.3.18).

BCS + 10% Untanned leather waste ash (7days curing)

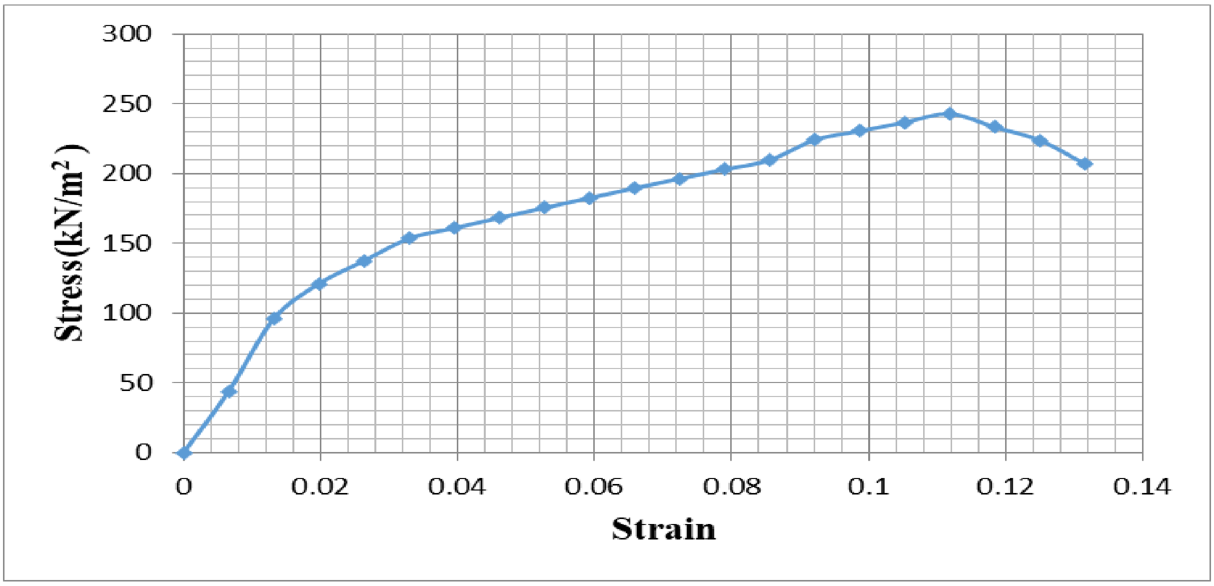


Fig. 6.2.19 Stress-Strain curve BCS + 10% untanned leather waste ash after 7 days of curing.

The Compressive strength of BCS + 10% untanned leather waste ash after 7 days of curing= 242.7 kN/m^2 (Annexure 1.3.19).

BCS + 10% Untanned leather waste ash (28days curing)

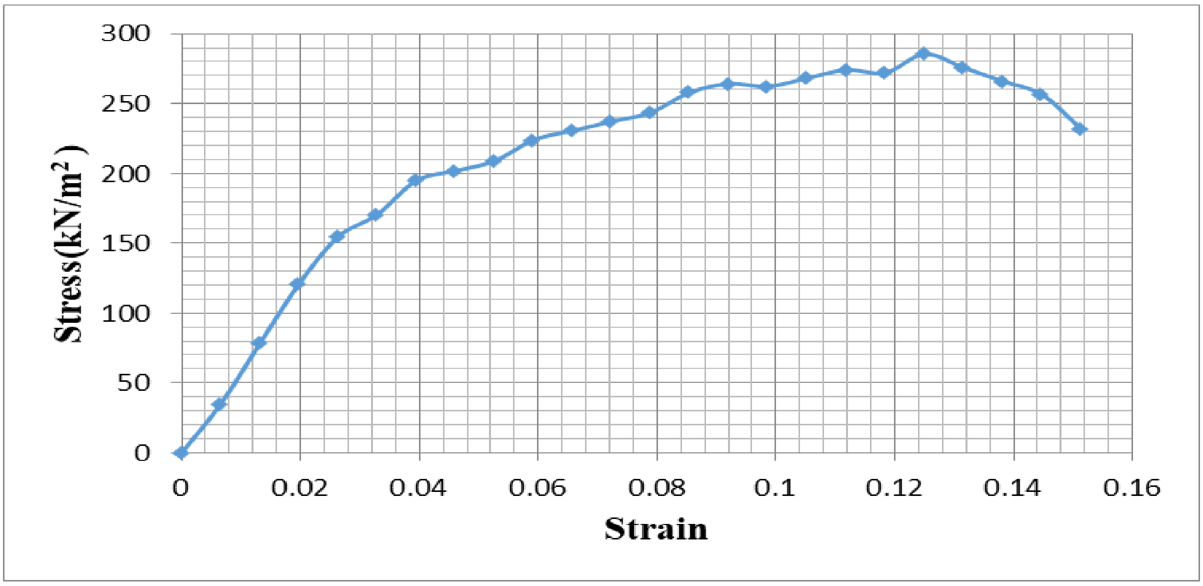


Fig. 6.2.19 Stress-Strain curve BCS + 10% untanned leather waste ash after 28 days of curing.

The Compressive strength of BCS + 10% untanned leather waste ash after 28 days of curing= 285.46 kN/m^2 (Annexure 1.3.20).

6.2.2.1 Variation of UCS of BCS with varied untanned leather waste ash content.

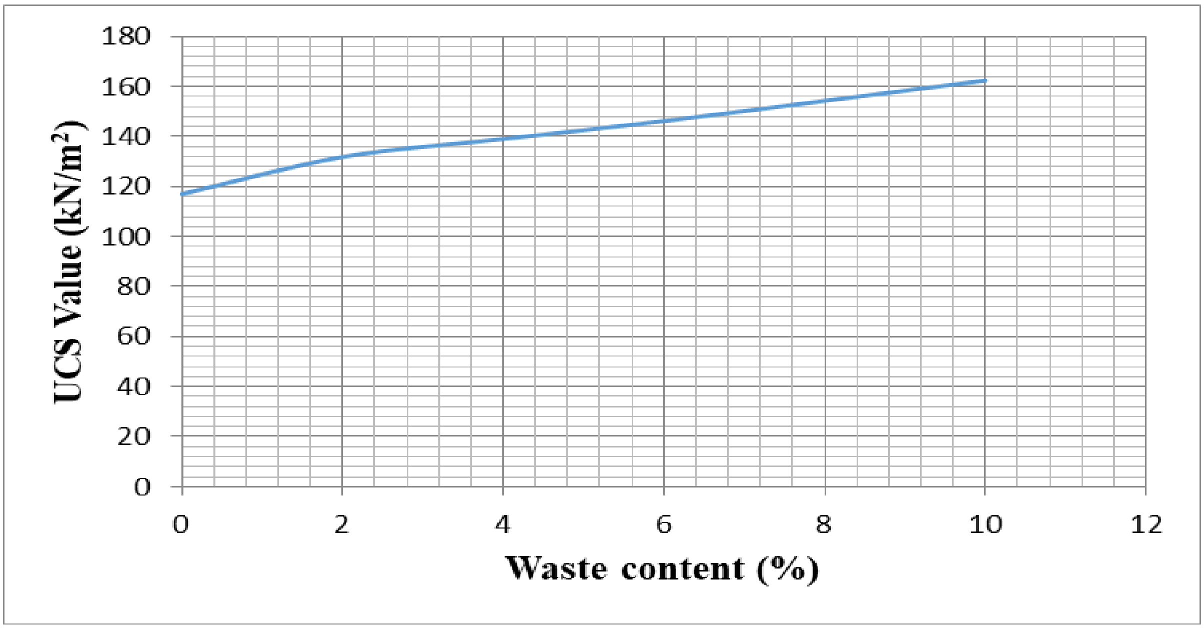


Fig. 6.2.2.1 Variation of UCS of BCS with varied untanned leather waste ash content.

6.2.2.2 Variation of UCS of BCS with varied Untanned leather waste ash after 4 days of curing.

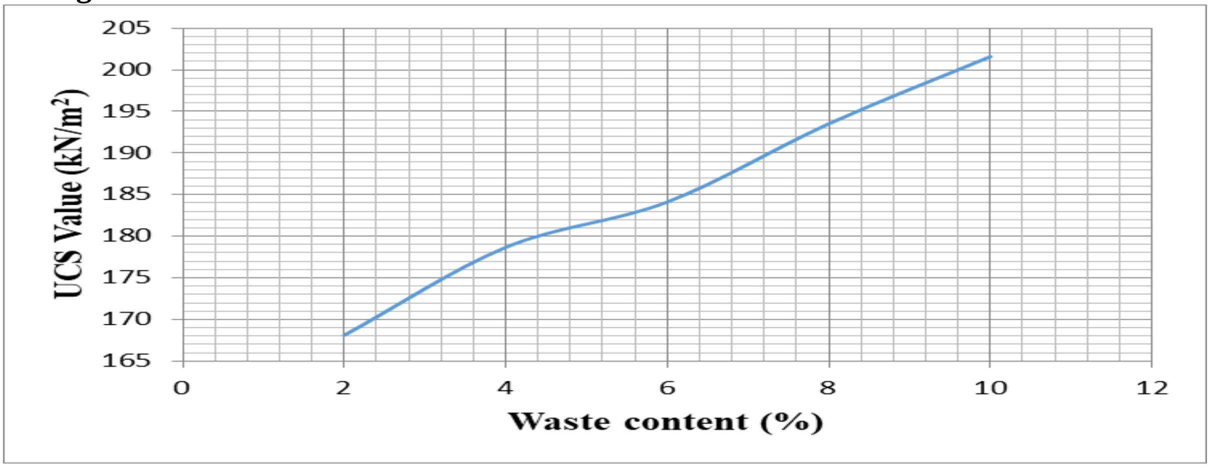


Fig. 6.2.2.2 Variation of UCS of BCS with varied untanned leather waste ash after 4 days of curing.

6.2.2.3 Variation of UCS of BCS with varied Untanned leather waste ash after 7 days of curing

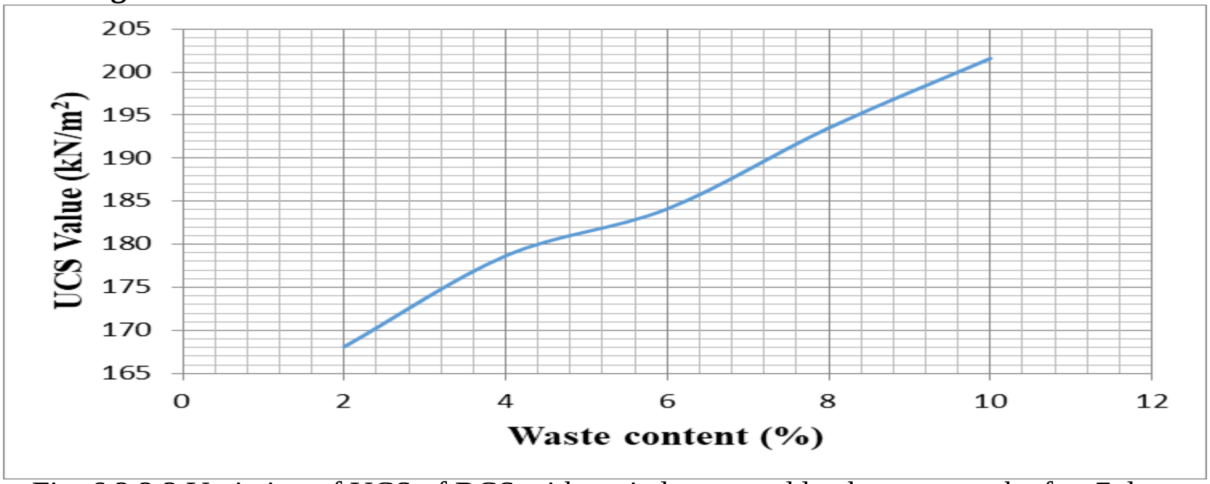


Fig. 6.2.2.3 Variation of UCS of BCS with varied untanned leather waste ash after 7 days of curing.

6.2.2.3 Variation of UCS of BCS with varied Untanned leather waste ash after 28 days of curing

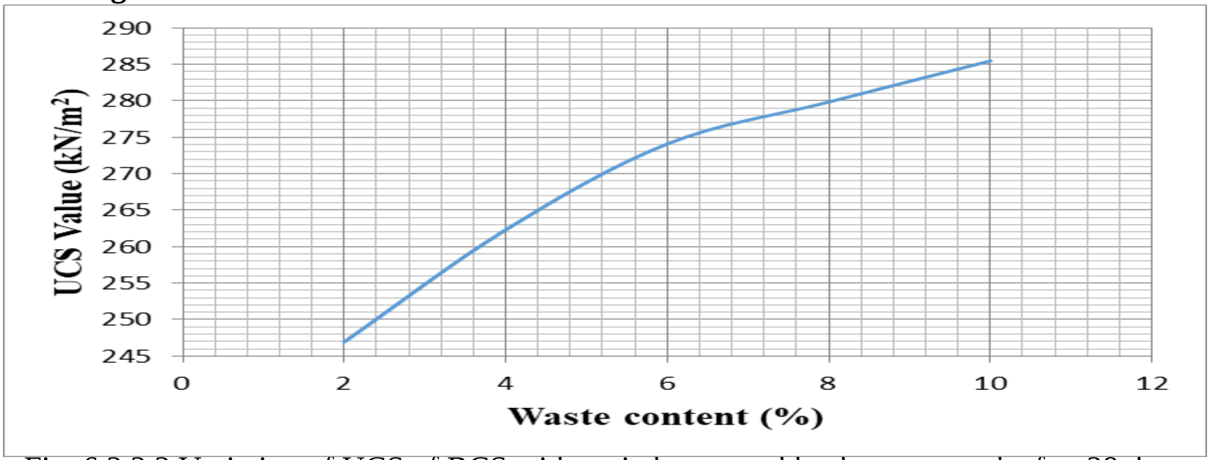


Fig. 6.2.2.3 Variation of UCS of BCS with varied untanned leather waste ash after 28 days of curing.

6.2.3 Shear strength parameters

6.2.3.1 Plain Black Cotton Soil

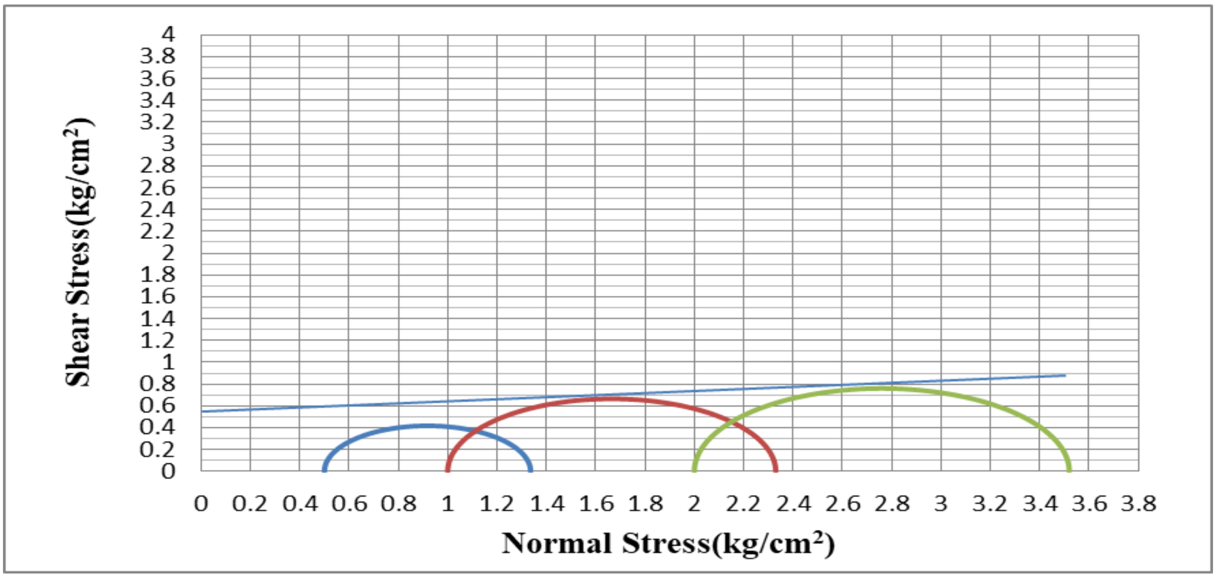


Fig.6.2.3.1 Mohr circle of plain black cotton soil

The Cohesion Value (c) for the plain black cotton soil= .544 kg/cm^2
The friction angle (phi) for the black cotton soil = 5 degrees (Annexure 1.4.1)

6.2.3.2 Black Cotton Soil + 2% Untanned leather waste ash

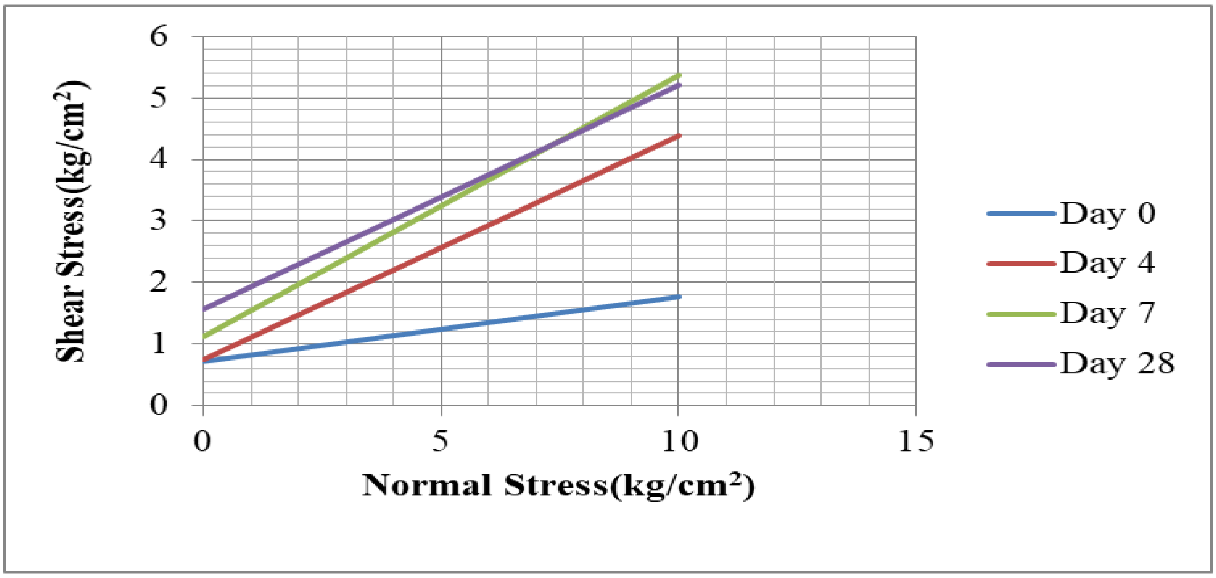


Fig.6.2.3.2 Mohr-coulomb failure envelope of Black Cotton Soil + 2% Untanned leather waste ash after curing of 0, 4, 7, 28 days.

0 Days curing

The Cohesion Value (c) for the plain black cotton soil= .72 kg/cm^2
The friction angle (phi) for the black cotton soil = 6 degrees (Annexure 1.4.2)

4 days curing

The Cohesion Value (c) for the plain black cotton soil= .75 kg/cm^2

The friction angle (phi) for the black cotton soil = 20 degrees (Annexure 1.4.3)

7days curing

The Cohesion Value (c) for the plain black cotton soil= 1.125 kg/cm^2

The friction angle (phi) for the black cotton soil = 23 degrees (Annexure 1.4.4)

28 days curing

The Cohesion Value (c) for the plain black cotton soil= 1.571 kg/cm^2

The friction angle (phi) for the black cotton soil = 20 degrees (Annexure 1.4.5)

6.2.3.3 Black Cotton Soil + 4% Untanned leather waste ash

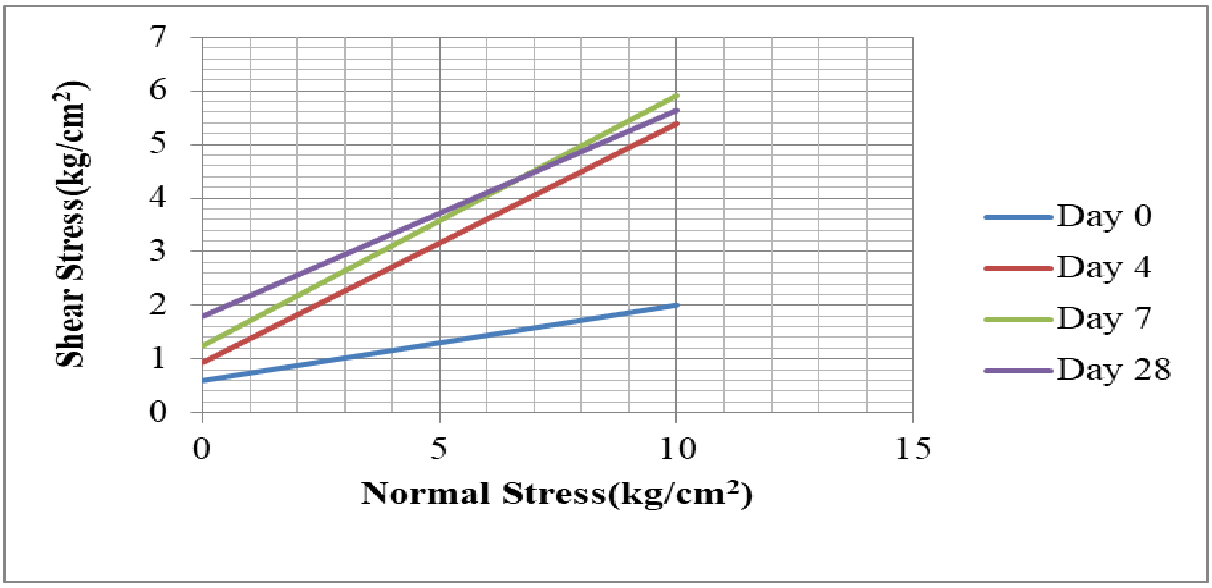


Fig.6.2.3.3 Mohr-coulomb failure envelope of Black Cotton Soil + 4% Untanned leather waste ash after curing of 0, 4, 7, 28 days.

0 Days curing

The Cohesion Value (c) for the plain black cotton soil= .6 kg/cm^2

The friction angle (phi) for the black cotton soil = 8 degrees (Annexure 1.4.6)

4 days curing

The Cohesion Value (c) for the plain black cotton soil= .9375 kg/cm^2

The friction angle (phi) for the black cotton soil = 24 degrees (Annexure 1.4.7)

7days curing

The Cohesion Value (c) for the plain black cotton soil= 1.25 kg/cm^2

The friction angle (phi) for the black cotton soil = 25 degrees (Annexure 1.4.8)

28 days curing

The Cohesion Value (c) for the plain black cotton soil= 1.8 kg/cm^2

The friction angle (phi) for the black cotton soil = 21 degrees (Annexure 1.4.9)

6.2.3.4 Black Cotton Soil + 6% Untanned leather waste ash

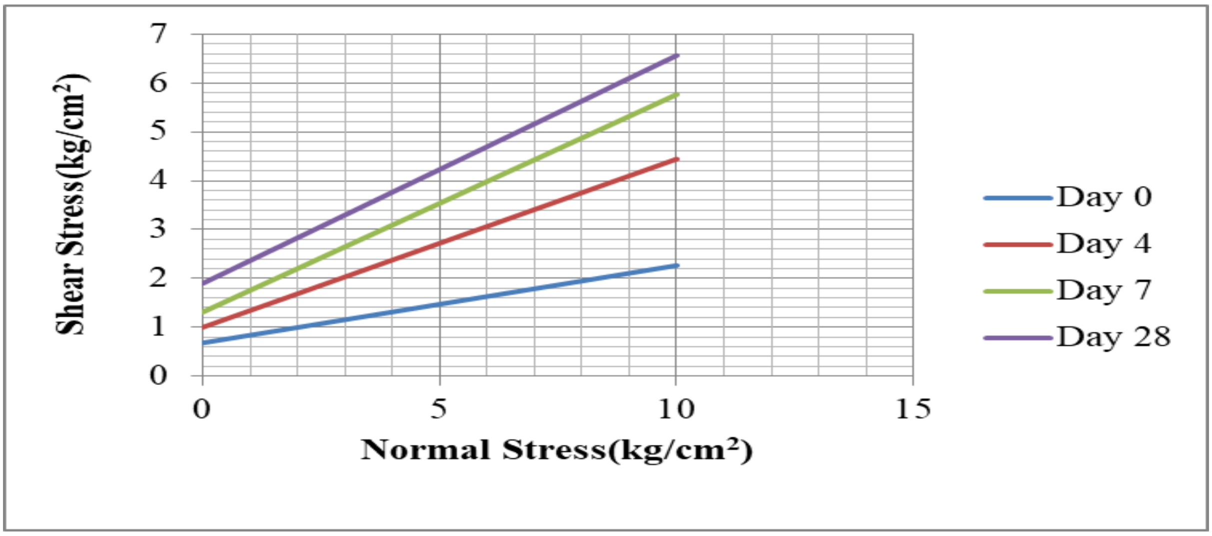


Fig.6.2.3.4 Mohr-coulomb failure envelope of Black Cotton Soil + 6% Untanned leather waste ash after curing of 0, 4, 7, 28 days.

0 Days curing

The Cohesion Value (c) for the plain black cotton soil= .681 kg/cm^2

The friction angle (phi) for the black cotton soil = 9 degrees (Annexure 1.4.10)

4 days curing

The Cohesion Value (c) for the plain black cotton soil= 1.0 kg/cm^2

The friction angle (phi) for the black cotton soil = 19 degrees (Annexure 1.4.11)

7days curing

The Cohesion Value (c) for the plain black cotton soil= 1.3125 kg/cm^2

The friction angle (phi) for the black cotton soil = 24 degrees (Annexure 1.4.12)

28 days curing

The Cohesion Value (c) for the plain black cotton soil= 1.91 kg/cm^2

The friction angle (phi) for the black cotton soil = 25 degrees (Annexure 1.4.13)

6.2.3.5 Black Cotton Soil + 8% Untanned leather waste ash

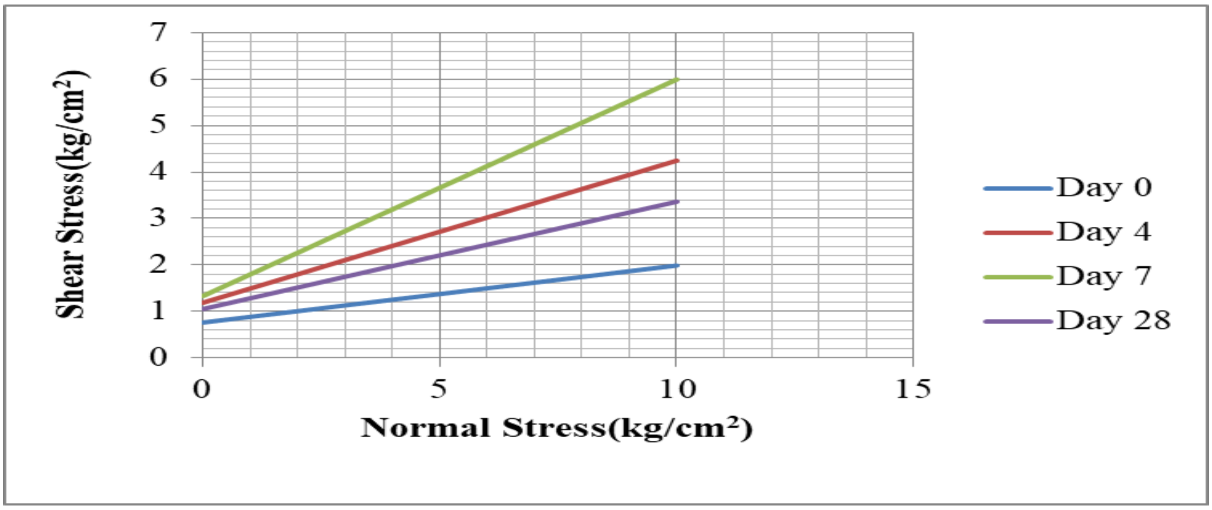


Fig.6.2.3.5 Mohr-coulomb failure envelope of Black Cotton Soil + 8% Untanned leather waste ash after curing of 0, 4, 7, 28 days.

0 Days curing

The Cohesion Value (c) for the plain black cotton soil= .76 kg/cm^2
The friction angle (phi) for the black cotton soil = 7 degrees (Annexure 1.4.14)

4 days curing

The Cohesion Value (c) for the plain black cotton soil= 1.1875 kg/cm^2
The friction angle (phi) for the black cotton soil = 17 degrees (Annexure 1.4.15)

7days curing

The Cohesion Value (c) for the plain black cotton soil= 1.33 kg/cm^2
The friction angle (phi) for the black cotton soil = 25 degrees (Annexure 1.4.16)

28 days curing

The Cohesion Value (c) for the plain black cotton soil= 1.052 kg/cm^2
The friction angle (phi) for the black cotton soil = 13 degrees (Annexure 1.4.17)

6.2.3.6 Black Cotton Soil + 10% Untanned leather waste ash

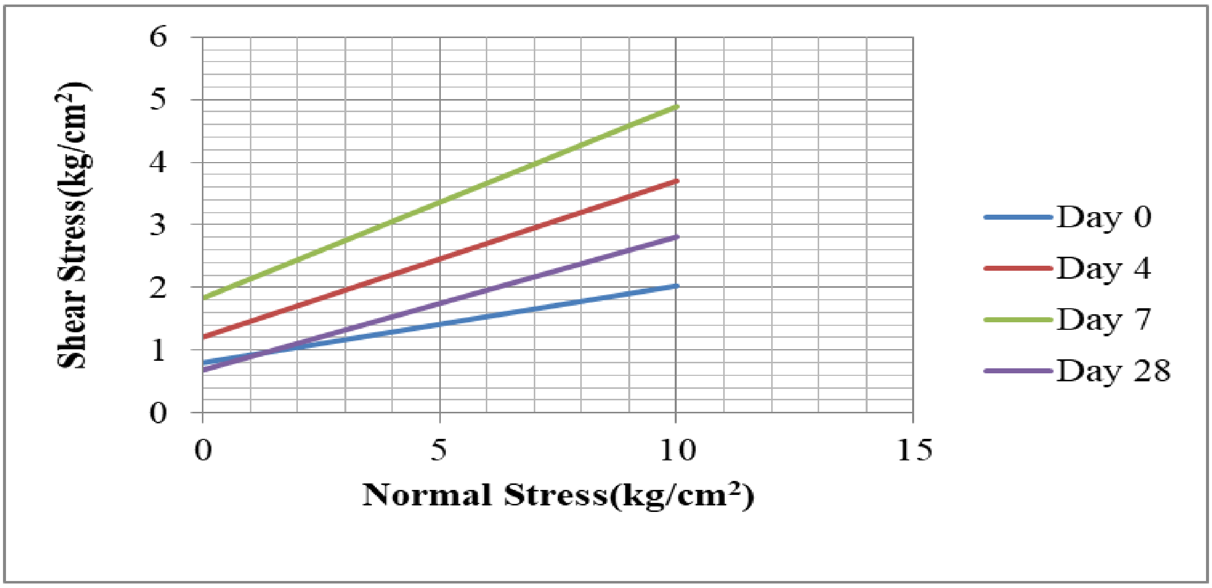


Fig.6.2.3.6 Mohr-coulomb failure envelope of Black Cotton Soil + 10% Untanned leather waste ash after curing of 0, 4, 7, 28 days.

0 Days curing

The Cohesion Value (c) for the plain black cotton soil= .8 kg/cm^2
The friction angle (phi) for the black cotton soil = 7 degrees (Annexure 1.4.18)

4 days curing

The Cohesion Value (c) for the plain black cotton soil= 1.30 kg/cm^2
The friction angle (phi) for the black cotton soil = 14 degrees (Annexure 1.4.19)

7days curing

The Cohesion Value (c) for the plain black cotton soil= 1.833 kg/cm^2
The friction angle (phi) for the black cotton soil = 17 degrees (Annexure 1.4.20)

28 days curing

The Cohesion Value (c) for the plain black cotton soil= .684 kg/cm^2
The friction angle (phi) for the black cotton soil = 12 degrees (Annexure 1.4.21)

6.2.3.7 Comparison of c and phi value on the basis of percentages and curing periods in tabular form.

Percentage ⟶		**2%**	**4%**	**6%**	**8%**	**10%**
	Days ↓					
Frictional angle(phi)	**0**	6	8	9	7	8
Cohesion value (c)		0.72	0.6	0.681	0.76	0.8
Frictional angle(phi)	**4**	20	24	19	17	14
Cohesion value (c)		0.75	0.9375	1	1.1875	1.30
Frictional angle(phi)	**7**	23	25	24	25	17
Cohesion value (c)		1.125	1.25	1.3125	1.33	1.833
Frictional angle(phi)	**28**	20	21	25	13	12
Cohesion value (c)		1.571	1.8	1.9	1.052	0.684

Fig 6.2.3.7 Comparison of c and phi value on the basis of percentages and curing periods in tabular form.

CHAPTER 7

CONCLUSIONS

- The value of MDD increases up to 6% waste ash of initial MDD from the value of 1.8g/cc for plain black cotton soil to 1.98g/cc for 6% waste ash with black cotton soil and afterwards there is a decrease in the value of MDD.

- After completion of 28 days of curing, all the soil samples showed an excellent result in terms of unconfined compressive strength. On addition of additive the value increase from 112kN/m^2 to 285 kN/m^2, that is approximately 170 % increase in strength taken above plain black cotton soil.

- By considering the above graph trends of unconfined compressive strength the optimum content of untanned leather waste ash can be used as an additive to stabilize black cotton soil is 6% to 8% on the curing of 7 days period as compared to 28 days.

- In case of shear strength parameters, the cohesive strength increases from 0.544 kg/cm^2 (5.34 kN/cm^2) to 1.91 kg/cm^2 (18.74 kN/cm^2) for the waste percentage of 6% as an additive. The friction angle (phi) increases from 5 degrees to maximum of 25 degrees for the same percentage of waste as an additive that is 6% leather waste ash.

- On the basis of curing days the 7 days of curing show more prominent results than that of the 28 days curing period in enhancing the shear strength parameter.

- From the above conclusions including maximum dry density, unconfined compressive strength and the shear strength parameters, **the optimum percentage for leather waste ash addition as additive in black cotton soil is 6%.**

FUTURE RECOMANDATIONS

- The other type of leather waste that is tanned leather waste can also be employed with proper curing periods for the stabilisation of the black cotton soil as it contains a large amount of heavy metals such as chromium (+III) and chromium (+IV) .

- The same untanned leather waste can be thermally treated at higher temperature of 800 degrees Celsius to obtain better results using the proper curing conditions.

- More superior technique for the improvement of curing conditions can be employed with same untanned waste ash and tanned waste ash.

REFERENCES

1. Basha E.A; Hashim R; Mahmud H.B.; Muntohar A.S. (2005) "Stabilization of residual soil with rice husk ash and cement" Construction and Building Materials Vol 19; pp. 448–453.
2. Belay Abebe Alebel (2010) "Impacts of chromium from tannery effluent and evaluation for alternative treatment options". Journal of Environmental Protection, Vol 21, pp.203-226.
3. Dermatas Dimitris; Meng Xiaoguang (2003)"Utilization of fly ash for stabilization/solidification of heavy metal contaminated soils" Engineering Geology, Vol 70; pp. 377–394.
4. I.S. code 2720 (Part viii)-1965, determination of maximum dry density and optimum water content.
5. I.S: 2720 (Part VII)-1980: "Indian standard for determination of water content- Dry density relationship using light compaction", Bureau of Indian Standards Publications, New Delhi.
6. Mehta S Kavish.; Sonecha J .Rutvij; Daxini D. Parth; Ratanpara B. Parth; Miss Gaikwad S Kapilani (2014) "Analysis of Engineering Properties of Black Cotton Soil & Stabilization Using By Lime". International Journal of Engineering research and Applications, 4(5), pp.25-32.
7. Mohammed Syed Abu Sayeed; Moghal Arif Ali Baig (2014) "Soils amended with admixtures as stabilizing agent to retain heavy metals" Geo-Congress 2014 Technical Paper, Vol 234; pp. 2216-2225.
8. Nalbantogolu Zalihe (2004) "Effectiveness of Class C fly ash as an expansive soil stabilizer".Construction and Building Materials, Vol 18, pp.377-381.
9. Osinubi J. K.; Oyelakin A. M; Eberemu O.A(2001) Improvement of Black Cotton Soil with Ordinary Portland Cement - Locust Bean Waste Ash Blend. Electronic Journal of Geotechnical Engineering; pp. 619-627.
10. Rao M. Sudhakar; Shivananda. P (2005) "Role of curing temperature in progress of lime-soil reactions". Geotechnical and Geological Engineering Vol 23; pp. 79–85.
11. Sante Di Marta; Fratalocchi Evelina; Mazzieri Francesco; Pasqualini Erio (2014) "Time of reactions in a lime treated clayey soil and influence of curing conditions on its microstructure and behaviour". Applied Clay Science, 99(10), pp.100–109.
12. Vigneshwar S.K; Vigneshwar G ; Gobinath S; Thirumalai. R; Dr. Bubu Suresh.S(2017) "Triaxial Behaviour of Stabilized Soil by Quarry Dust". International Journal of Innovative Research in Science,Engineering and Technology, Vol. 6, pp.273-287.

ANNEXURE

Annexure 1.1

Weight of mould + base plate	Mould+soil + base plate	Water Content	Weight of compacted soil	Bulk density	Dry density
(g)	(g)	(%)	(g)	(g/cc)	(g/cc)
3708	5247.3	5	1539.3	1.628888889	1.551322751
3708	5366.8	10	1658.8	1.755343915	1.595767196
3708	5496	15	1788	1.892063492	1.645272602
3708	5603.2	18	1895.2	2.005502646	1.699578513
3708	5712.5	20	2004.5	2.121164021	1.767636684
3708	5873.3	22	2165.3	2.291322751	1.878133403
3708	5802.7	24	2094.7	2.216613757	1.787591739

Table 2 Standard proctor for plain black cotton soil.

Annexure 1.2

Water Content	plain bcs	2%	4%	6%	8%	10%
5%	1.55	1.754	1.779	1.828	1.726	1.706
10%	1.59	1.762	1.789	1.858	1.737	1.717
15%	1.64	1.82	1.84	1.877	1.785	1.728
18%	1.699	1.87	1.88	1.911	1.821	1.759
20%	1.76	1.92	1.93	1.98	1.74	1.72
22%	1.8	1.843	1.85	1.895	1.738	1.716

Table 3 Variation of dry density with water content

Annexure 1.3.1

Displacement	Load	Strain	Corrected area	Stress
0	0	0	1134.115	0
0.5	0.02	0.006579	1141.625695	17.51888
1	0.03	0.013158	1149.236533	26.10429
1.5	0.05	0.019737	1156.94953	43.2171
2	0.08	0.026316	1164.766757	68.68328
2.5	0.09	0.032895	1172.69034	76.7466
3	0.1	0.039474	1180.722466	84.69391
3.5	0.12	0.046053	1188.865379	100.9366
4	0.13	0.052632	1197.121389	108.5938
4.5	0.15	0.059211	1205.492867	124.4304
5	0.16	0.065789	1213.982254	131.7976
5.5	0.15	0.072368	1222.592057	122.6901
6	0.15	0.078947	1231.324857	121.82
6.5	0.15	0.085526	1240.183309	120.9499
7	0.13	0.092105	1249.170145	104.0691

Table 4 UCS of BCS + 2% untanned leather waste ash after 0 days of curing.

Annexure 1.3.2

Displacement	Load	Strain	Corrected area	Stress
0	0	0	1134.115	0
0.5	0.02	0.006578947	1141.625695	17.51887688
1	0.04	0.013157895	1149.236533	34.80571566
1.5	0.09	0.019736842	1156.94953	77.79077449
2	0.11	0.026315789	1164.766757	94.43950848
2.5	0.13	0.032894737	1172.69034	110.8562044
3	0.15	0.039473684	1180.722466	127.0408621
3.5	0.16	0.046052632	1188.865379	134.5821005
4	0.17	0.052631579	1197.121389	142.0073199
4.5	0.18	0.059210526	1205.492867	149.3165202
5	0.19	0.065789474	1213.982254	156.5097014
5.5	0.19	0.072368421	1222.592057	155.4075204
6	0.2	0.078947368	1231.324857	162.4266731
6.5	0.2	0.085526316	1240.183309	161.2664825
7	0.21	0.092105263	1249.170145	168.1116066
7.5	0.21	0.098684211	1258.288175	166.8934066
8	0.2	0.105263158	1267.540294	157.785911

Table 5 UCS of BCS + 2% untanned leather waste ash after 4 days of curing.

Annexure 1.3.3

Displacement	Load	Strain	Corrected area	Stress
0	0	0	1134.115	0
0.5	0.01	0.006578947	1141.625695	8.75943844
1	0.02	0.013157895	1149.236533	17.40285783
1.5	0.05	0.019736842	1156.94953	43.21709694
2	0.07	0.026315789	1164.766757	60.09786903
2.5	0.09	0.032894737	1172.69034	76.74660302
3	0.11	0.039473684	1180.722466	93.1632989
3.5	0.12	0.046052632	1188.865379	100.9365754
4	0.14	0.052631579	1197.121389	116.9472046
4.5	0.15	0.059210526	1205.492867	124.4304335
5	0.17	0.065789474	1213.982254	140.034996
5.5	0.18	0.072368421	1222.592057	147.2281772
6	0.19	0.078947368	1231.324857	154.3053394
6.5	0.2	0.085526316	1240.183309	161.2664825
7	0.21	0.092105263	1249.170145	168.1116066
7.5	0.22	0.098684211	1258.288175	174.8407116
8	0.22	0.105263158	1267.540294	173.5645021
8.5	0.23	0.111842105	1276.929481	180.1195785
9	0.23	0.118421053	1286.458806	178.7853594
9.5	0.25	0.125	1296.131429	192.8816743
10	0.25	0.131578947	1305.950606	191.4314361
10.5	0.27	0.138157895	1315.919695	205.1796938
11	0.27	0.144736842	1326.042154	203.6134366
11.5	0.27	0.151315789	1336.32155	202.0471794
12	0.26	0.157894737	1346.761563	193.0557028

Table 6 UCS of BCS + 2% untanned leather waste ash after 7 days of curing.

Annexure 1.3.4

Displacement	Load	Strain	Corrected area	Stress
0	0	0	1134.115	0
0.5	0.05	0.006578947	1141.625695	43.79719
1	0.07	0.013157895	1149.236533	60.91
1.5	0.08	0.019736842	1156.94953	69.14736
2	0.1	0.026315789	1164.766757	85.8541
2.5	0.11	0.032894737	1172.69034	93.8014
3	0.12	0.039473684	1180.722466	101.6327
3.5	0.15	0.046052632	1188.865379	126.1707
4	0.16	0.052631579	1197.121389	133.6539
4.5	0.18	0.059210526	1205.492867	149.3165
5	0.19	0.065789474	1213.982254	156.5097
5.5	0.2	0.072368421	1222.592057	163.5869
6	0.22	0.078947368	1231.324857	178.6693
6.5	0.22	0.085526316	1240.183309	177.3931
7	0.23	0.092105263	1249.170145	184.1222
7.5	0.25	0.098684211	1258.288175	198.6826
8	0.25	0.105263158	1267.540294	197.2324
8.5	0.27	0.111842105	1276.929481	211.4447
9	0.28	0.118421053	1286.458806	217.6517
9.5	0.3	0.125	1296.131429	231.458
10	0.3	0.131578947	1305.950606	229.7177
10.5	0.31	0.138157895	1315.919695	235.5767
11	0.32	0.144736842	1326.042154	241.3196
11.5	0.33	0.151315789	1336.32155	246.9466
12	0.33	0.157894737	1346.761563	245.0322
12.5	0.32	0.164473684	1357.365984	235.7507
13	0.32	0.171052632	1368.13873	233.8944

Table 7 UCS of BCS + 2% untanned leather waste ash after 28 days of curing.

Annexure 1.3.5

Displacement	Load	Strain	Corrected area	Stress
0	0	0	1134.115	0
0.5	0.03	0.006578947	1141.626	26.27832
1	0.05	0.013157895	1149.237	43.50714
1.5	0.08	0.019736842	1156.95	69.14736
2	0.1	0.026315789	1164.767	85.8541
2.5	0.11	0.032894737	1172.69	93.8014
3	0.12	0.039473684	1180.722	101.6327
3.5	0.13	0.046052632	1188.865	109.348
4	0.14	0.052631579	1197.121	116.9472
4.5	0.15	0.059210526	1205.493	124.4304
5	0.16	0.065789474	1213.982	131.7976
5.5	0.17	0.072368421	1222.592	139.0488
6	0.17	0.078947368	1231.325	138.0627
6.5	0.15	0.085526316	1240.183	120.9499
7	0.14	0.092105263	1249.17	112.0744
7.5	0.14	0.105263158	1267.54	110.4501

Table 8 UCS of BCS + 4% untanned leather waste ash after 0 days of curing.

Annexure 1.3.6

Displacement	Load	Strain	Corrected area	Stress
0	0	0	1134.115	0
0.5	0.02	0.006578947	1141.625695	17.51888
1	0.06	0.013157895	1149.236533	52.20857
1.5	0.1	0.019736842	1156.94953	86.43419
2	0.13	0.026315789	1164.766757	111.6103
2.5	0.14	0.032894737	1172.69034	119.3836
3	0.15	0.039473684	1180.722466	127.0409
3.5	0.16	0.046052632	1188.865379	134.5821
4	0.18	0.052631579	1197.121389	150.3607
4.5	0.19	0.059210526	1205.492867	157.6119
5	0.2	0.065789474	1213.982254	164.7471
5.5	0.21	0.072368421	1222.592057	171.7662
6	0.22	0.078947368	1231.324857	178.6693
6.5	0.22	0.085526316	1240.183309	177.3931
7	0.22	0.092105263	1249.170145	176.1169
7.5	0.22	0.098684211	1258.288175	174.8407
8	0.21	0.105263158	1267.540294	165.6752

Table 9 UCS of BCS + 4% untanned leather waste ash after 4 days of curing.

Annexure 1.3.7

Displacement	Load	Strain	Corrected area	Stress
0	0	0	1134.115	0
0.5	0.03	0.006579	1141.626	26.27832
1	0.07	0.013158	1149.237	60.91
1.5	0.11	0.019737	1156.95	95.07761
2	0.14	0.026316	1164.767	120.1957
2.5	0.15	0.032895	1172.69	127.911
3	0.16	0.039474	1180.722	135.5103
3.5	0.17	0.046053	1188.865	142.9935
4	0.18	0.052632	1197.121	150.3607
4.5	0.19	0.059211	1205.493	157.6119
5	0.2	0.065789	1213.982	164.7471
5.5	0.2	0.072368	1222.592	163.5869
6	0.21	0.078947	1231.325	170.548
6.5	0.22	0.085526	1240.183	177.3931
7	0.23	0.092105	1249.17	184.1222
7.5	0.25	0.098684	1258.288	198.6826
8	0.26	0.105263	1267.54	205.1217
8.5	0.28	0.111842	1276.929	219.276
9	0.28	0.118421	1286.459	217.6517
9.5	0.27	0.125	1296.131	208.3122
10	0.25	0.131579	1305.951	191.4314

Table 10 UCS of BCS + 4% untanned leather waste ash after 7 days of curing.

Annexure 1.3.8

Displacement	Load	Strain	Corrected area	Stress
0	0	0	1134.115	0
0.5	0.04	0.006579	1141.626	35.03775
1	0.07	0.013158	1149.237	60.91
1.5	0.12	0.019737	1156.95	103.721
2	0.14	0.026316	1164.767	120.1957
2.5	0.15	0.032895	1172.69	127.911
3	0.19	0.039474	1180.722	160.9184
3.5	0.2	0.046053	1188.865	168.2276
4	0.22	0.052632	1197.121	183.7742
4.5	0.24	0.059211	1205.493	199.0887
5	0.25	0.065789	1213.982	205.9338
5.5	0.26	0.072368	1222.592	212.6629
6	0.27	0.078947	1231.325	219.276
6.5	0.28	0.085526	1240.183	225.7731
7	0.29	0.092105	1249.17	232.1541
7.5	0.29	0.098684	1258.288	230.4718
8	0.3	0.105263	1267.54	236.6789
8.5	0.31	0.111842	1276.929	242.7699
9	0.32	0.118421	1286.459	248.7448
9.5	0.34	0.125	1296.131	262.3191
10	0.34	0.131579	1305.951	260.3468
10.5	0.33	0.138158	1315.92	250.7752
11	0.31	0.144737	1326.042	233.7784

Table 11 UCS of BCS + 4% untanned leather waste ash after 28 days of curing.

Annexure 1.3.9

Displacement	Load	Strain	Corrected area	Stress
0	0	0	1134.115	0
0.5	0.04	0.006579	1141.626	35.03775
1	0.07	0.013158	1149.237	60.91
1.5	0.08	0.019737	1156.95	69.14736
2	0.1	0.026316	1164.767	85.8541
2.5	0.11	0.032895	1172.69	93.8014
3	0.12	0.039474	1180.722	101.6327
3.5	0.14	0.046053	1188.865	117.7593
4	0.15	0.052632	1197.121	125.3006
4.5	0.15	0.059211	1205.493	124.4304
5	0.16	0.065789	1213.982	131.7976
5.5	0.17	0.072368	1222.592	139.0488
6	0.18	0.078947	1231.325	146.184
6.5	0.18	0.085526	1240.183	145.1398
7	0.17	0.092105	1249.17	136.0903
7.5	0.16	0.098684	1258.288	127.1569

Table 12 UCS of BCS + 6% untanned leather waste ash after 0 days of curing.

Annexure 1.3.10

Displacement	Load	Strain	Corrected area	Stress
0	0	0	1134.115	0
0.5	0.04	0.006579	1141.626	35.03775
1	0.08	0.013158	1149.237	69.61143
1.5	0.11	0.019737	1156.95	95.07761
2	0.14	0.026316	1164.767	120.1957
2.5	0.15	0.032895	1172.69	127.911
3	0.16	0.039474	1180.722	135.5103
3.5	0.18	0.046053	1188.865	151.4049
4	0.19	0.052632	1197.121	158.7141
4.5	0.2	0.059211	1205.493	165.9072
5	0.2	0.065789	1213.982	164.7471
5.5	0.21	0.072368	1222.592	171.7662
6	0.22	0.078947	1231.325	178.6693
6.5	0.22	0.085526	1240.183	177.3931
7	0.23	0.092105	1249.17	184.1222
7.5	0.23	0.098684	1258.288	182.788
8	0.22	0.105263	1267.54	173.5645
8.5	0.2	0.111842	1276.929	156.6257

Table 13 UCS of BCS + 6% untanned leather waste ash after 4 days of curing.

Annexure 1.3.11

Displacement	Load	Strain	Corrected area	Stress
0	0	0	1134.115	0
0.5	0.04	0.006579	1141.626	35.03775
1	0.09	0.013158	1149.237	78.31286
1.5	0.11	0.019737	1156.95	95.07761
2	0.15	0.026316	1164.767	128.7811
2.5	0.15	0.032895	1172.69	127.911
3	0.16	0.039474	1180.722	135.5103
3.5	0.18	0.046053	1188.865	151.4049
4	0.19	0.052632	1197.121	158.7141
4.5	0.2	0.059211	1205.493	165.9072
5	0.2	0.065789	1213.982	164.7471
5.5	0.21	0.072368	1222.592	171.7662
6	0.22	0.078947	1231.325	178.6693
6.5	0.23	0.085526	1240.183	185.4565
7	0.24	0.092105	1249.17	192.1276
7.5	0.26	0.098684	1258.288	206.6299
8	0.27	0.105263	1267.54	213.011
8.5	0.29	0.111842	1276.929	227.1073
9	0.29	0.118421	1286.459	225.425
9.5	0.28	0.125	1296.131	216.0275
10	0.26	0.131579	1305.951	199.0887

Table 14 UCS of BCS + 6% untanned leather waste ash after 7 days of curing.

Annexure 1.3.12

Displacement	Load	Strain	Corrected area	Stress
0	0	0	1134.115	0
0.5	0.04	0.006578947	1141.625695	35.03775376
1	0.09	0.013157895	1149.236533	78.31286022
1.5	0.14	0.019736842	1156.94953	121.0078714
2	0.18	0.026315789	1164.766757	154.5373775
2.5	0.2	0.032894737	1172.69034	170.5480067
3	0.23	0.039473684	1180.722466	194.7959886
3.5	0.24	0.046052632	1188.865379	201.8731508
4	0.25	0.052631579	1197.121389	208.8342939
4.5	0.27	0.059210526	1205.492867	223.9747802
5	0.28	0.065789474	1213.982254	230.6458757
5.5	0.29	0.072368421	1222.592057	237.2009522
6	0.3	0.078947368	1231.324857	243.6400096
6.5	0.32	0.085526316	1240.183309	258.0263721
7	0.33	0.092105263	1249.170145	264.1753818
7.5	0.33	0.098684211	1258.288175	262.2610675
8	0.34	0.105263158	1267.540294	268.2360487
8.5	0.35	0.111842105	1276.929481	274.0950108
9	0.35	0.118421053	1286.458806	272.0646774
9.5	0.37	0.125	1296.131429	285.4648779
10	0.36	0.131578947	1305.950606	275.661268

Table 15 UCS of BCS + 6% untanned leather waste ash after 28 days of curing.

Annexure 1.3.13

Displacement	Load	Strain	Corrected area	Stress
0	0	0	1134.115	0
0.5	0.04	0.006579	1141.626	35.03775
1	0.07	0.013158	1149.237	60.91
1.5	0.1	0.019737	1156.95	86.43419
2	0.11	0.026316	1164.767	94.43951
2.5	0.12	0.032895	1172.69	102.3288
3	0.13	0.039474	1180.722	110.1021
3.5	0.14	0.046053	1188.865	117.7593
4	0.15	0.052632	1197.121	125.3006
4.5	0.16	0.059211	1205.493	132.7258
5	0.17	0.065789	1213.982	140.035
5.5	0.18	0.072368	1222.592	147.2282
6	0.19	0.078947	1231.325	154.3053
6.5	0.19	0.085526	1240.183	153.2032
7	0.19	0.092105	1249.17	152.101
7.5	0.18	0.098684	1258.288	143.0515

Table 16 UCS of BCS + 8% untanned leather waste ash after 0 days of curing.

Annexure 1.3.14

Displacement	Load	Strain	Corrected area	Stress
0	0	0	1134.115	0
0.5	0.04	0.006579	1141.626	35.03775
1	0.08	0.013158	1149.237	69.61143
1.5	0.12	0.019737	1156.95	103.721
2	0.14	0.026316	1164.767	120.1957
2.5	0.16	0.032895	1172.69	136.4384
3	0.18	0.039474	1180.722	152.449
3.5	0.19	0.046053	1188.865	159.8162
4	0.19	0.052632	1197.121	158.7141
4.5	0.2	0.059211	1205.493	165.9072
5	0.21	0.065789	1213.982	172.9844
5.5	0.22	0.072368	1222.592	179.9455
6	0.23	0.078947	1231.325	186.7907
6.5	0.24	0.085526	1240.183	193.5198
7	0.24	0.092105	1249.17	192.1276
7.5	0.23	0.098684	1258.288	182.788
8	0.23	0.105263	1267.54	181.4538
8.5	0.21	0.111842	1276.929	164.457

Table 17 UCS of BCS + 8% untanned leather waste ash after 4 days of curing.

Annexure 1.3.15

Displacement	Load	Strain	Corrected area	Stress
0	0	0	1134.115	0
0.5	0.05	0.006579	1141.626	43.79719
1	0.09	0.013158	1149.237	78.31286
1.5	0.13	0.019737	1156.95	112.3645
2	0.15	0.026316	1164.767	128.7811
2.5	0.16	0.032895	1172.69	136.4384
3	0.18	0.039474	1180.722	152.449
3.5	0.19	0.046053	1188.865	159.8162
4	0.19	0.052632	1197.121	158.7141
4.5	0.2	0.059211	1205.493	165.9072
5	0.22	0.065789	1213.982	181.2218
5.5	0.22	0.072368	1222.592	179.9455
6	0.24	0.078947	1231.325	194.912
6.5	0.25	0.085526	1240.183	201.5831
7	0.26	0.092105	1249.17	208.1382
7.5	0.28	0.098684	1258.288	222.5245
8	0.29	0.105263	1267.54	228.7896
8.5	0.29	0.111842	1276.929	227.1073
9	0.3	0.118421	1286.459	233.1983
9.5	0.29	0.125	1296.131	223.7427
10	0.28	0.131579	1305.951	214.4032

Table 18 UCS of BCS + 8% untanned leather waste ash after 7 days of curing.

Annexure 1.3.16

Displacement	Load	Strain	Corrected area	Stress
0	0	0	1134.115	0
0.5	0.05	0.006578947	1141.625695	43.7971922
1	0.1	0.013157895	1149.236533	87.01428914
1.5	0.14	0.019736842	1156.94953	121.0078714
2	0.17	0.026315789	1164.766757	145.9519676
2.5	0.2	0.032894737	1172.69034	170.5480067
3	0.22	0.039473684	1180.722466	186.3265978
3.5	0.23	0.046052632	1188.865379	193.4617695
4	0.24	0.052631579	1197.121389	200.4809222
4.5	0.25	0.059210526	1205.492867	207.3840558
5	0.26	0.065789474	1213.982254	214.1711703
5.5	0.29	0.072368421	1222.592057	237.2009522
6	0.29	0.078947368	1231.324857	235.5186759
6.5	0.3	0.085526316	1240.183309	241.8997238
7	0.31	0.092105263	1249.170145	248.1647526
7.5	0.31	0.098684211	1258.288175	246.3664573
8	0.32	0.105263158	1267.540294	252.4574576
8.5	0.34	0.111842105	1276.929481	266.2637248
9	0.36	0.118421053	1286.458806	279.8379539
9.5	0.34	0.125	1296.131429	262.319077
10	0.32	0.131578947	1305.950606	245.0322382

Table 19 UCS of BCS + 8% untanned leather waste ash after 28 days of curing

Annexure 1.3.17

Displacement	Load	Strain	Corrected area	Stress
0	0	0	1134.115	0
0.5	0.05	0.006579	1141.626	43.79719
1	0.08	0.013158	1149.237	69.61143
1.5	0.1	0.019737	1156.95	86.43419
2	0.11	0.026316	1164.767	94.43951
2.5	0.12	0.032895	1172.69	102.3288
3	0.13	0.039474	1180.722	110.1021
3.5	0.14	0.046053	1188.865	117.7593
4	0.15	0.052632	1197.121	125.3006
4.5	0.16	0.059211	1205.493	132.7258
5	0.18	0.065789	1213.982	148.2723
5.5	0.19	0.072368	1222.592	155.4075
6	0.2	0.078947	1231.325	162.4267
6.5	0.2	0.085526	1240.183	161.2665
7	0.19	0.092105	1249.17	152.101
7.5	0.18	0.098684	1258.288	143.0515

Table 20 UCS of BCS + 10% untanned leather waste ash after 0 days of curing.

Annexure 1.3.18

Displacement	Load	Strain	Corrected area	Stress
0	0	0	1134.115	0
0.5	0.04	0.006579	1141.626	35.03775
1	0.09	0.013158	1149.237	78.31286
1.5	0.12	0.019737	1156.95	103.721
2	0.15	0.026316	1164.767	128.7811
2.5	0.17	0.032895	1172.69	144.9658
3	0.17	0.039474	1180.722	143.9796
3.5	0.19	0.046053	1188.865	159.8162
4	0.21	0.052632	1197.121	175.4208
4.5	0.22	0.059211	1205.493	182.498
5	0.22	0.065789	1213.982	181.2218
5.5	0.23	0.072368	1222.592	188.1249
6	0.24	0.078947	1231.325	194.912
6.5	0.25	0.085526	1240.183	201.5831
7	0.25	0.092105	1249.17	200.1329
7.5	0.24	0.098684	1258.288	190.7353

Table 21 UCS of BCS + 10% untanned leather waste ash after 4 days of curing.

Annexure 1.3.19

Displacement	Load	Strain	Corrected area	Stress
0	0	0	1134.115	0
0.5	0.05	0.006579	1141.626	43.79719
1	0.11	0.013158	1149.237	95.71572
1.5	0.14	0.019737	1156.95	121.0079
2	0.16	0.026316	1164.767	137.3666
2.5	0.18	0.032895	1172.69	153.4932
3	0.19	0.039474	1180.722	160.9184
3.5	0.2	0.046053	1188.865	168.2276
4	0.21	0.052632	1197.121	175.4208
4.5	0.22	0.059211	1205.493	182.498
5	0.23	0.065789	1213.982	189.4591
5.5	0.24	0.072368	1222.592	196.3042
6	0.25	0.078947	1231.325	203.0333
6.5	0.26	0.085526	1240.183	209.6464
7	0.28	0.092105	1249.17	224.1488
7.5	0.29	0.098684	1258.288	230.4718
8	0.3	0.105263	1267.54	236.6789
8.5	0.31	0.111842	1276.929	242.7699
9	0.3	0.118421	1286.459	233.1983
9.5	0.29	0.125	1296.131	223.7427
10	0.27	0.131579	1305.951	206.746

Table 22 UCS of BCS + 10% untanned leather waste ash after 7 days of curing.

Annexure 1.3.20

Displacement	Load	Strain	Corrected area	Stress
0	0	0	1134.115	0
0.5	0.04	0.006578947	1141.625695	35.03775376
1	0.09	0.013157895	1149.236533	78.31286022
1.5	0.14	0.019736842	1156.94953	121.0078714
2	0.18	0.026315789	1164.766757	154.5373775
2.5	0.2	0.032894737	1172.69034	170.5480067
3	0.23	0.039473684	1180.722466	194.7959886
3.5	0.24	0.046052632	1188.865379	201.8731508
4	0.25	0.052631579	1197.121389	208.8342939
4.5	0.27	0.059210526	1205.492867	223.9747802
5	0.28	0.065789474	1213.982254	230.6458757
5.5	0.29	0.072368421	1222.592057	237.2009522
6	0.3	0.078947368	1231.324857	243.6400096
6.5	0.32	0.085526316	1240.183309	258.0263721
7	0.33	0.092105263	1249.170145	264.1753818
7.5	0.33	0.098684211	1258.288175	262.2610675
8	0.34	0.105263158	1267.540294	268.2360487
8.5	0.35	0.111842105	1276.929481	274.0950108
9	0.35	0.118421053	1286.458806	272.0646774
9.5	0.37	0.125	1296.131429	285.4648779
10	0.36	0.131578947	1305.950606	275.661268
10.5	0.35	0.138157895	1315.919695	265.9736771
11	0.34	0.144736842	1326.042154	256.4021053
11.5	0.31	0.151315789	1336.32155	231.9800948

Table 23 UCS of BCS + 10% untanned leather waste ash after 28 days of curing.

Annexure 1.3.21

Waste content (%)	Unconfined Compressive Strength (KN/m^2)
0	117
2	131.7976
4	139.0488
6	146.184
8	154.3053
10	162.4267

Table 24 Variation of UCS of BCS with varied untanned leather waste ash content.

Annexure 1.3.22

Waste content (%)	Unconfined Compressive Strength (KN/m^2)
2	168.1116066
4	178.6693
6	184.1222
8	193.5198
10	201.5831

Table 25 Variation of UCS of BCS with varied Untanned leather waste ash after 4 Days of curing.

Annexure 1.3.23

Waste content (%)	Unconfined Compressive Strength (KN/m^2)
2	205.1796938
4	217.6517
6	227.1073
8	233.1983
10	242.7699

Table 26 Variation of UCS of BCS with varied Untanned leather waste ash after 7 Days of curing.

Annexure 1.3.24

Waste content (%)	Unconfined Compressive Strength (KN/m^2)
2	246.9466938
4	262.3191
6	274.0950108
8	279.8379539
10	285.4648779

Table 27 Variation of UCS of BCS with varied Untanned leather waste ash after 28 Days of curing.

Annexure 1.4.1

Sigma 3	0.5		Sigma3	1		Sigma3	2
Sigma 1	1.136		Sigma1	2.33		Sigma1	3.52
Centre	0.918		Centre	1.665		Centre	2.76
Radius	0.418		Radius	0.665		Radius	0.76

Table 28 Stress value of plain black cotton soil.

Annexure 1.4.2

Sigma 3	0.5		Sigma3	1		Sigma3	1.5
Sigma 1	1.51		Sigma1	2.67		Sigma1	3.34
Centre	1.005		Centre	1.835		Centre	2.42
Radius	0.505		Radius	0.835		Radius	0.92

Table 29 Stress value of black cotton soil + 2% Untanned leather waste ash after 0 days curing.

Annexure 1.4.3

Sigma 3	0.5		Sigma3	1		Sigma3	1.5
Sigma 1	3.03		Sigma1	4.34		Sigma1	5.17
Centre	1.765		Centre	2.67		Centre	3.335
Radius	1.265		Radius	1.67		Radius	1.835

Table 30 Stress value of black cotton soil + 2% Untanned leather waste ash after 4 days curing.

Annexure 1.4.4

Sigma 3	0.5		Sigma3	1		Sigma3	1.5
Sigma 1	5.35		Sigma1	6.72		Sigma1	7.63
Centre	2.925		Centre	3.86		Centre	4.565
Radius	2.425		Radius	2.86		Radius	3.065

Table 31 Stress value of black cotton soil + 2% Untanned leather waste ash after 7 days curing.

Annexure 1.4.5

Sigma 3	0.5		Sigma3	1		Sigma3	2
Sigma 1	2.34		Sigma1	2.903		Sigma1	4.5
Centre	1.42		Centre	1.9515		Centre	3.25
Radius	0.92		Radius	0.9515		Radius	1.25

Table 32 Stress value of black cotton soil + 2% Untanned leather waste ash after 28 days curing.

Annexure 1.4.6

Sigma 3	0.5		Sigma3	1		Sigma3	1.5
Sigma 1	1.73		Sigma1	2.84		Sigma1	3.43
Centre	1.115		Centre	1.92		Centre	2.465
Radius	0.615		Radius	0.92		Radius	0.965

Table 33 Stress value of black cotton soil + 4% Untanned leather waste ash after 0 days curing.

Annexure 1.4.7

Sigma 3	0.5		Sigma3	1		Sigma3	1.5
Sigma 1	3.03		Sigma1	4.34		Sigma1	5.17
Centre	1.765		Centre	2.67		Centre	3.335
Radius	1.265		Radius	1.67		Radius	1.835

Table 34 Stress value of black cotton soil + 4% Untanned leather waste ash after 4 days curing.

Annexure 1.4.8

Sigma 3	0.5		Sigma3	1		Sigma3	1.5
Sigma 1	5.35		Sigma1	6.72		Sigma1	7.63
Centre	2.925		Centre	3.86		Centre	4.565
Radius	2.425		Radius	2.86		Radius	3.065

Table 35 Stress value of black cotton soil + 4% Untanned leather waste ash after 7 days curing.

Annexure 1.4.9

Sigma 3	0.5		Sigma3	1		Sigma3	1.5
Sigma 1	5.97		Sigma1	7.08		Sigma1	8.18
Centre	3.235		Centre	4.04		Centre	4.84
Radius	2.735		Radius	3.04		Radius	3.34

Table 36 Stress value of black cotton soil + 4% Untanned leather waste ash after 28 days curing.

Annexure 1.4.10

Sigma 3	0.5		Sigma3	1		Sigma3	1.5
Sigma 1	1.88		Sigma1	2.92		Sigma1	3.57
Centre	1.19		Centre	1.96		Centre	2.535
Radius	0.69		Radius	0.96		Radius	1.035

Table 37 Stress value of black cotton soil + 6% Untanned leather waste ash after 0 days curing.

Annexure 1.4.11

Sigma 3	0.5		Sigma3	1		Sigma3	1.5
Sigma 1	3.41		Sigma1	4.56		Sigma1	5.51
Centre	1.955		Centre	2.78		Centre	3.505
Radius	1.455		Radius	1.78		Radius	2.005

Table 38 Stress value of black cotton soil + 6% Untanned leather waste ash after 4 days curing.

Annexure 1.4.12

Sigma 3	0.5		Sigma3	1		Sigma3	1.5
Sigma 1	5.11		Sigma1	6.42		Sigma1	7.34
Centre	2.805		Centre	3.71		Centre	4.42
Radius	2.305		Radius	2.71		Radius	2.92

Table 39 Stress value of black cotton soil + 6% Untanned leather waste ash after 7 days curing.

Annexure 1.4.13

Sigma 3	0.5		Sigma3	1		Sigma3	1.5
Sigma 1	6.21		Sigma1	7.36		Sigma1	8.332
Centre	3.355		Centre	4.18		Centre	4.916
Radius	2.855		Radius	3.18		Radius	3.416

Table 40 Stress value of black cotton soil + 6% Untanned leather waste ash after 28 days curing.

Annexure 1.4.14

Sigma 3	0.5		Sigma3	1		Sigma3	1.5
Sigma 1	1.97		Sigma1	2.98		Sigma1	3.63
Centre	1.235		Centre	1.99		Centre	2.565
Radius	0.735		Radius	0.99		Radius	1.065

Table 41 Stress value of black cotton soil +8% Untanned leather waste ash after 0 days curing.

Annexure 1.4.15

Sigma 3	0.5		Sigma3	1		Sigma3	1.5
Sigma 1	3.53		Sigma1	4.65		Sigma1	5.58
Centre	2.015		Centre	2.825		Centre	3.54
Radius	1.515		Radius	1.825		Radius	2.04

Table 42 Stress value of black cotton soil + 8% Untanned leather waste ash after 4 days curing.

Annexure 1.4.16

Sigma 3	0.5		Sigma3	1		Sigma3	1.5
Sigma 1	5.23		Sigma1	6.63		Sigma1	7.48
Centre	2.865		Centre	3.815		Centre	4.49
Radius	2.365		Radius	2.815		Radius	2.99

Table 43 Stress value of black cotton soil + 8% Untanned leather waste ash after 7 days curing.

Annexure 1.4.17

Sigma 3	0.5		Sigma3	1		Sigma3	1.5
Sigma 1	3.14		Sigma1	3.77		Sigma1	4.53
Centre	1.82		Centre	2.385		Centre	3.015
Radius	1.32		Radius	1.385		Radius	1.515

Table 44 Stress value of black cotton soil + 8% Untanned leather waste ash after 28 days curing.

Annexure 1.4.18

Sigma 3	0.5		Sigma3	1		Sigma3	1.5
Sigma 1	2.03		Sigma1	3.04		Sigma1	3.69
Centre	1.265		Centre	2.02		Centre	2.595
Radius	0.765		Radius	1.02		Radius	1.095

Table 45 Stress value of black cotton soil +10% Untanned leather waste ash after 0 days curing.

Annexure 1.4.19

Sigma 3	0.5		Sigma3	1		Sigma3	1.5
Sigma 1	3.54		Sigma1	4.66		Sigma1	5.61
Centre	2.02		Centre	2.83		Centre	3.555
Radius	1.52		Radius	1.83		Radius	2.055

Table 46 Stress value of black cotton soil + 10% Untanned leather waste ash after 4 days curing.

Annexure 1.4.20

Sigma 3	0.5		Sigma3	1		Sigma3	1.5
Sigma 1	5.35		Sigma1	6.72		Sigma1	7.63
Centre	2.925		Centre	3.86		Centre	4.565
Radius	2.425		Radius	2.86		Radius	3.065

Table 47 Stress value of black cotton soil + 10% Untanned leather waste ash after 7 days curing.

Annexure 1.4.21

Sigma 3	0.5		Sigma3	1		Sigma3	2
Sigma 1	2.34		Sigma1	2.903		Sigma1	4.5
Centre	1.42		Centre	1.9515		Centre	3.25
Radius	0.92		Radius	0.9515		Radius	1.25

Table 48 Stress value of black cotton soil +10% Untanned leather waste ash after 28 days curing.

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY, WAKNAGHAT

PLAGIARISM VERIFICATION REPORT

Date: 30/05/2020...........

Type of Document (Tick): PhD Thesis | M.Tech Dissertation/ Report | B.Tech Project Report ✓ | Paper

Name: Sourav Singh & Chahat Garg **Department:** Civil Engineering **Enrolment No** 161608 & 161647

Contact No. 9805088870 & 8146093712 **E-mail.** souravs808@gmail.com & gargchahat76@gmail.com

Name of the Supervisor: Mr. Chandra pal gautam

Title of the Thesis/Dissertation/Project Report/Paper (In Capital letters): Assessment of cured and uncured strength of leather waste stabilised expansive soil.

UNDERTAKING

I undertake that I am aware of the plagiarism related norms/ regulations, if I found guilty of any plagiarism and copyright violations in the above thesis/report even after award of degree, the University reserves the rights to withdraw/revoke my degree/report. Kindly allow me to avail Plagiarism verification report for the document mentioned above.

Complete Thesis/Report Pages Detail:

- Total No. of Pages = 75
- Total No. of Preliminary pages = 12
- Total No. of pages accommodate bibliography/references = 63

Sourav Singh Chahat

(Signature of Student)

FOR DEPARTMENT USE

We have checked the thesis/report as per norms and found **Similarity Index** at ....22..........(%). Therefore, we are forwarding the complete thesis/report for final plagiarism check. The plagiarism verification report may be handed over to the candidate.

15/7/2020

Chandra Pal

(Signature of Guide/Supervisor)

HOD CE DEPT

Signature of HOD

FOR LRC USE

The above document was scanned for plagiarism check. The outcome of the same is reported below:

Copy Received on	Excluded	Similarity Index (%)	Generated Plagiarism Report Details (Title, Abstract & Chapters)	
	• All Preliminary Pages • Bibliography/Images/Quotes • 14 Words String		Word Counts	
Report Generated on			Character Counts	
		Submission ID	Total Pages Scanned	
			File Size	

Checked by

Name & Signature **Librarian**

....

Please send your complete thesis/report in (PDF) with Title Page, Abstract and Chapters in (Word File) through the supervisor at plagcheck.juit@gmail.com