A STUDY OF SOIL STABILIZATION USING WASTE PLASTIC BOTTLE STRIPS

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CERTIFICATE

It is certified that work presented in this thesis entitled **'SOIL STABILIZATION USING WASTE PLASTIC BOTTLE STRIPS'** submitted by **Diwakar Bisht** Roll no 2K16/ENE/07 in partial fulfilment for the award of the degree of Master of Technology in Environmental Engineering, Delhi Technological University, New Delhi is an authentic work. The work is being carried out under my guidance and supervision in the academic year 2016-2018.

The work embodied in this major project has not been submitted for the award of any other degree or diploma to any university or institute.

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ABSTRACT

Soil stabilization is one of the best method for improving physical properties like shear strength, bearing capacity etc. of the soil. For soil stabilization various admixture such as cement, lime, fly ash, gypsum etc. can be used. But these admixture are costly so their use for soil stabilization are limited. In some research it is found that utilization of waste material like plastic, bamboo etc. are quite helpful in stabilization of soil. In present world there is scarcity of good soil which makes construction process difficult. So to enhance the properties of soil so that it can be used for various construction there is need to add the suitable admixture in soil. These admixture should enhance properties of soil and also be economical. In this study plastic bottles are used as an admixture. The waste plastic bottles are cut into small strips and these strips are added in the soil in different percentage of 0%, 0.25%, 0.5% and 0.75% of dry weight of soil. Unconfined compressive strength test is conducted in the soil which gives the strength of soil. Along with plastic bottle strips cement is also added in the ratio of 1% and 1.5% of dry weight of soil. After finding out the unconfined compressive strength of different soil sample mixed with different percentage of plastic strips and cement, graphs and tables are plotted for the comparison of strength of different samples of soil.

CHAPTER 1 - INTRODUCTION

Soil stabilization is a process in which, suitable materials such as cement, lime, fly ash bitumen etc are added which helps in increasing theshear strength and bearing capacity of soil,which leads to the improvement ofthe properties of soil. It controlsthe shrink as well as swell properties, increases shear and bearing strength ofsoil, Plastic is a renewable and non bio-degradable material. Thedisposal of waste plastic bottles causes environnementalpollution. Plastic can be recycledor reused i.e. reprocessing these plastic wastes and make someuseful products. Waste of plastics can be used asadmixture for stabilized soil.Waste plastic materials can be reused because it can be recycled many times thus reducing the wastage . Use of the plastic waste for the enhancement of theproperties of soil,is an effective and economical way of stabilization.Uses of materials made of plastic are increasing day by day, but the disposal of plastic increasing the waste plasticcotent in municipal waste.As technology is improving in the society day by day, , a new technique of soil stabilization is find in which waste quantities such as plastic,bamboo, polythene bags, bottles etc, are effectively utilized for enhancing the soil properties. As these wastematerials are increasing in society day by day whichleads to different natural problems hence the use ofwaste plastic materials as an admixture should be imply whichincreases the strength of the soil , reduces the cost ofadmixtures and leads to economical use of plastic without causing any environmental and ecological hazards. Stabilized soil is more durable having comparatively high strength, good quality of soil, less permeability of soil and useful for constructions of roads by reducing the thickness of pavement and also control the shrink, swell properties of soil,which helps in achieving better soil gradation. It can significantly improves the working platform for various construction operations.

Stabilization enhances the properties of soil, most importantly it increases the load bearing capacity of soil thus, have aremarkable effect on the strength of soil. Additionof suitable admixtures has the key role in soilstabilization. Generally a good soil is needed forconstruction, and the stability of structure also depends on the strength of soil which is related to stabilization. If there is stabilized soil, construction willnot get failed because stabilized soil improves the load bearing capacity of soil.

1.1) METHODS OF SOIL STABILIZATION: There are different materials available from which soil stabilization can be achieved. Depending on the different internal factor which describes the bonding between the soil and the stabilizer used, the methods of soil stabilisation are majorly categorized into two types. They are :

1.1.1) Mechanical stabilization- In this method of soil stabilization friction plays the key role. In this method the friction between soil and admixture helps in increasing the properties of soil.

1.1.2) Chemical stabilization- In this method of soil stabilization ,chemical reactions occurs between the minerals in soil and the different admixtures added to the soil.

Plastics are considered as one of the most significant invention which has assisted notheworthy in various fields of life. The use of plastic has been enormously increasing from past few years. But now, it is becoming the major pollutant of Environment because of the habit of using it and throwing it. The use of plastic has to be restricted otherwise prepare for the dangerous circumstances that human and environment has to face in near future. Various researches are going on for utilizing the waste to the soil and stabilizing it so that it can be used for various purposes. Thus, using plastic as stabilizer will help in two ways,one in helping the problem of disposing the plastic waste without any harsh effect and second, stabilising the comparatively weaker soil for construction and other activities. Present study is condcuted on the soil taken from Rithala located about a distance of 4km from Delhi Technological University and plastic bottles strips are added for its stabilization. For comparison of strength between natural soil and soil having plastic strips, UCS(unconfined compression strength) test is done in this study.

1.2) Objective Of This Study –

1. To study the change in strength (i.e. stability) of soil with addition of different amount plastic bottle strips amount of 0%,0.25%,0.5% and 0.75% w/w and small amount of cement(1% and 1.5%) with curing period of 3 days.
2. Compare the change in strength of soil with varying content of plastic bottle strips with diffrent cement content.
3. To find out the optimum plastic bottle strips content (w/w) for maximum strength of soil for different cement content.
4. Compare the change in strength of soil with varying content of cement for same amount of plastic bottle strips content(w/w).

1.3)PLASTIC- Plastic is material which consists of synthetic or semi-synthetic organic compounds that can be molded into solid materials. Plastics are type of organic polymers of high molecular mass and also contains other substances. They are mostly derivative of petrochemicals. Due to their properties of impermeability to water, low cost, ease of production and versatility, plastics are used in a tonnes of products. They have taken over conventional material like wood. In developed countries, about one third of total plastic is used in packaging and almost the same in piping and plumbing. Other areas include automobiles, furnitures, and toys . India's consumption in packaging is around 40% of total plastic consumption. The success of plastics resuming from the early 20th century leads to environmental concerns due to its very slow decomposition rate. Towards the end of 20th century, one unique way to tackle this problem was taken and that way is recycling.

1.3.1) Properties of Plastic- Plastic have many properties that makes them far superior and usable than any other material.These different properties are categorised mainly into chemical physical and physical and properties.

1.3.2) Physical Properties- Plastic is transparent, flexibile elastic, water resisting, electrical resistance and becomes soft when heated. These are some physical properties of plastic.

1.3.3) Chemical Properties- Chemical and thermal resistivity reactivity, flammability, heat of combustion etc. These are some of the chemical properties of plastic.

1.4) Types of Plastic-

1.4.1) Common Plastic- This category includes both commodity plastics, and engineering plastics. Some examples are-

a-polyamides
b-polycarbonate
c-polyvinyl chloride
d-polyester
e-polyinyliden chloride
f-polyethylene- it includes packingt bags and plastic bottles.

- high density polyethylene
- Low density polyethylene
- polyethylene terephthalate

1.4.2) Special plastic-

- polyepoxide
- phenol formaldehyde
- urea formaldehyde

- polymide

1.4.3) Type of plastic used in this study : In this study strips of plastic bottles are used. Plastic bottles comes under Polyethylene terephthalate group. Some properties of polyethylene terephthalate are :

I. It is hard strong and dimensionally stable material.
II. It absorbs very less water.
III. It can be transparent and colourless but thick sections are opaque and off white.

1.5) Plastic Industry- Plastic production is a major part of the chemical industry and most of the world's biggest chemical companies have been involved from very beginning, like BASF and DOW. These companies came from eighteen countries in with more than two third of the companies has headquarter in the United States. Mostly these plastic manufacturing companies were located in just three countries: United States(12) Japan(8) ,Germany(6). From India export of plastic products stood at US$ 8.85 billion in 2017(source : plastics export promotion council) and it gives employment to about 4 million people .The Indian plastic industry produces and exports a wide range of raw materials, polyester films ,polyvinyl chloride ,soft luggage item, luggage clothes and sheetings ,sanitary fittings ,tarpauline, electrical accessories and others. Among the industry's major strengths the availability of raw materials in the country is its biggest.. According to a report consumption of plastic in India will cross 20 million tonnes by 2020. This indicates that Indian plastic industry growing at a very high rate with plastic consumption rate of 16% per year. Despite having a population of 125 crore plastic companies are reporting of shortage of labour. This shortage of labour has led to investment in modern technology like conveyor belts etc. Along with shortage of labour, India is also facing problem of power deficit of around 15%. In India various fields has share in the plastic consumption. Some of these are electronics industry, packaging industry, transportation industry, agriculture etc.

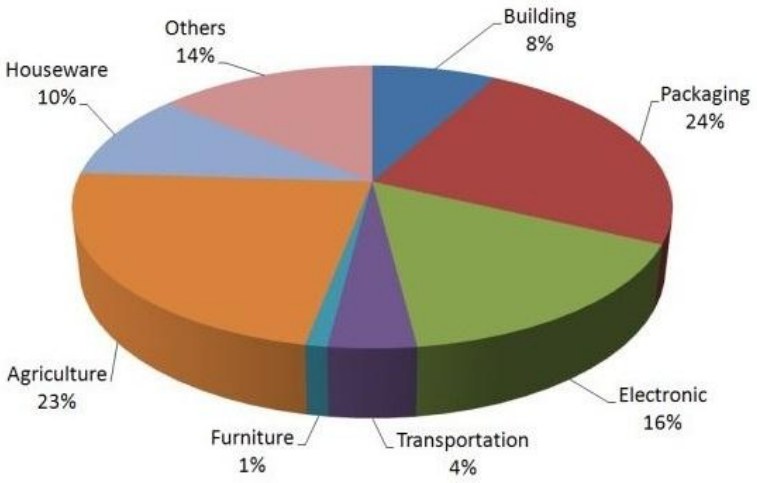

Figure 1.1 plastic consumption in various fields (India)

Source – Central pollution control board(CPCB)

1.6) Plastic waste generation in India- In India around 25,940 tonnes of plastic waste is generated in a day (t/day), according to a report made by the Central Pollution Control Board (CPCB) that studied 60 major cities. These cities together produced 4059 T/day. Delhi takes first position in generating maximum plastic waste followed by Chennai,Mumbai, Banglore and Hyderabad. A graph indicating the major cities producing plastic waste is shown below.

Figure 1.2 Indian cities generating most plastic waste(tonnes/day)

Source – Central pollution control board(CPCB)

1.7) Effects Of Plastic On Environment – As plastic is non decomposable material or has very slow rate of decomposition so it will accumulate in the environment and adversely affects the ecosystem. Plastic which acts as pollutants are divided into two type according to their sizes. These are micro and macro pollutants. As plastic are economical and durable than other materials so their production by humans are quite high. The chemical structutre of plastic makes them resistant to many natural process of decomposition as a result they are almost non decomposable material. These above two factors has created the plastic pollution. Some harmful effects of plastic are noted below.

- When plastic bags left in the soil, it slowly releases toxix compounds which ultimately reaches the ground water table. If any living being drinks this water it will cause severe health issue.

- It leads to the loss of wildlife. Many animals after eating plastic suffer from severe health problems. Any animal whos has eaten plastic suffers from obstruction in intestines which leads to a quite long and painful death. Some animals died after eating plastic because as plastic decomposes very slowly it makes the animal full which ultimately leads to death due to malnutrition.

- Clogging of sewage system by plastic bags mostly in urban areas causes severe harms to the environment. This clogging of sewer causes inconveniences to the people living or working in that area. The excess water rises due to clogging can cause harm to buildings and properties. It will also collects the pollutants from the area and spread them as far as it flow which is an extra problem associated with it.

- It also deteriots the natural beauty. It ruins the aesthetic appearence of every ecosystem.

- Plastic waste disposes into the ocean releases toxic chemical which will sometimes leads to extinction of some aquatic species.

1.7.1) Climate Change- The effect of plastics on global warming is heterogeneous. Plastics are more commonly made from petroleum and its products. If incineration is done, it increases carbon emissions. If it is disposed in a landfill, it becomes a source of carbon sink, . Due to the lighter weight of plastic ,it can reduce energy consumption to some extent. For example, rather than packing beverages in glass or metal if it is packed in PET plastic bottles, it is expected that it can save around 52% of transportation energy.

1.8) Plastic Waste Management- Plastic waste management is becoming a critical issue. About 300 million metric tonnes of plastic is produced in the world every year of which 50% requires disposal treatment. It is bane and also boon at the same time. Although it has many uses but its waste and the pollution resulted from it clogs up our rivers ,oceans, lands and adversely affects the biodiversity. So there is need to plan for the disposal of this plastic waste. There are some method of plastic waste disposal.

- Landfilling- All plastics can be disposed in landfills but it is considered quite wasteful because it needs a vast amount of space or area and also the energy posses by plastic gets wasted. In countries where landfills are not mannaged properly,plastic waste can be carried away by flood water into waterways. In addition to this, when plastic decomposes in landfills , it leaks pollutants like phthalates and bisphenolA into the soil which is very hazardious. So landfills are not the safe way for the disposal of plastic waste.

- Incineration of Plastic- As plastics are derived from petroleum it has a hgh value o stored energy. Incineration process recovers some of this energy It is a process which involves burning of organic substances found in waste material. It is a high-temperature controlled waste treatment system in which temperature reaches above 850 °C for two seconds. It breaks

toxic dioxins and furans from plastic waste and it is also commonly used in municipal waste incineration. These incinerators also generally includes flue gas treatments to reduce further production of pollutants. But it also tends to cause adverse environment and health effects in humans as toxic pollutants may be released into the atmosphere in the process like when pvc is mixed with plastic waste, its incineration releases dioxins and polychlorinated biphenyles which are very harmful for environnment.

- Recycling- Recycling process is applicable to some plastics and the recovered material can be used for different purposes. But because of problems and difficulty in collecting and sorting of plastic waste, this method is not utilised to full extent. Even it is already known that recycling is the most effective method for disposing the plastic waste, its efficiency is highly depends upon awareness of people and implementation of public infrastructure like recycling bins , waste collecting trucks etc Thermoplastics can be reused, but the purity of the materiall degrades with each time it is reused. There are various methods available by which plastics can be broken down to a smaller state. The biggest challenge in recycling of plastics is the difficulty in sorting of waste plastic, making it labor-intensive. Typically, workers sort the plastic by identifying the resin identification code. However, new processes of mechanical sorting are being developed to increase the capacity and efficiency of plastic recycling.. However, developments are taking place in the field of active disassembly, which may result in more product components being reused or recycled. Under a scheme, in a plastic container three triangle are marked and a certain number is written inside these triangle which denotes the type of plastic.

- Biodegradable plastic- These are the type of plastic which can be decompose by microorganisms. This type plastic can solve a number of environmental problems. These types of plastic can be decompose in a safer way thhan other methods but it also has an adverse impact. Some study founds that biodegradable plastics may release metals into the environment which is toxic to the environment.

1.9) Plastic Waste Management In India

Recycle of waste plastic in India is not properly organized. Around 60% of the waste plastic which is collected and sorted gets recycled and ready for the use of people. A national plastic waste management council task force has been setup by collaboration of government of India, Ministry of Environment with the association of department of petroleum and chemical, Ministry of Union affairs and different groups or association of plastic manufacturers. There aim is to properly manage the

recycling or managing of plastic waste. In India municiple solid waste contain around 3% of plastic waste. It is a major source of hazard to the environment. Polythene bags if burnt irresponsibly for disposal releases high amount of toxic gases like carbon monooxide, chlorine, sulphur di oxide and nitrogen dioxide.

1.10) Regulations And Legislations For Plastic Waste In India

- The Ministry of Environment had established a nationwide plastic waste mannagement task force which has encouraged a strategy and action programme for managing plastic waste in India.
- BIS(Bureau of Indian standards) has issued some guidelines on plastic waste recycle which includes code of practice for collectinng the plastic waste, upgradation of technique of sorting the waste plastic etc. Ministry of Environment in association with BIS (bureau of Indian standards) also carried out some practice for the reuse of recycled plastic waste whenever appropriate.
- The prevention of food adulteration department of the government of india has issued directives to food caterers to use only food grade plastic while serving the food. Rules have specified the food grade plastic which has certain requirements and is safe when in contact with the food.
- PET manufacturers has formed a national association of PET which will look on organised collection and recycling of PET bottles.

CHAPTER 2- LITERATURE REVIEWS

A lot of researches has been done by researchers for the stabilization of soil.In present world there is scarcity of good soil which makes construction process difficult.Expansive soil are highly problematic soil because of its property of volume change under different moisture condition. There are different types of method available to stabilize the soil but all methods are not economical, so materials which are cheap should be used most times in soil stabilization. So to enhance the properties of soil so that it can be used for various construction there is need to add the suitable admixture in soil. These admixture should enhance properties of soil and also be economical..Some researches that have been done on soil stabilization by adding some admixture is listed below.

Brooks M . Robert et al. [2009] studied about the soil stabilization using fly ash and rice husk ash. He had conducted tests such as Compaction test, UCS, CBR and free swell index. The test results concluded that, by increasing rice husk ash to the soil results in increase of CBR value, UCS and swell deduction. With increased fly ash content, there was an increase in the stress strain behavior of confined compressive strength. He concluded that optimum fly ash and rice husk ash content was found to be 25% and 12% respectively. He also concluded those soils can be highly recommended for strengthening the sub grade of expansive soil.

Choudhary, Jha And Gill[2010] demonstrated the potential of High density polyethylene(HDPE) to convert as soil reinforcement for improving the engineering properties of sub grade soil. From waste plastic, HDPE strips are obtained and mixed randomly with the soil and by varying percentage of HDPE strips length and proportions, a series of CBR tests were carried out on reinforced soil. Their results of CBR tests proves that inclusion of strips cut from reclaimed HDPE is useful as soil reinforcement in highway application.

Lavanya et al. [2011] studied about utilization of copper slag in geotechnical applications. In this paper, she investigated about the Index properties, free swell index, compaction properties, CBR and UCC. She concluded that the partial replacement of copper slag from 30% to 50% with black cotton soils, considerably showed the increase in properties of the soil. She also concluded that partial replacement of copper slag with black cotton soil resulted in utilization of such soils in sub grade, sub base and embankment of roads and it was also improved the sub grade soil condition.

Otoko Rowland et al. [2011]investigated about the stabilization of Nigerian Deltaic Laterites with saw dust ash. The soil properties were identified by conducting tests of liquid limit, plastic limit, shrinkage limit, free swell index, plasticity index, MDD with OMC, UCC and CBR. He finally concluded that physical properties and engineering characteristics of Nigerian deltaic laterites were

improved with addition of 4% of saw dust ash, and there was also increase in 14% of CBR values. He also concluded that there was reduction in cost of construction because of the use of solid waste.

Patel V Arpita et al. [2011] investigated about the geotechnical properties of black cotton soil which are contaminated by castor oil and stabilized by saw dust. Several Tests were conducted like specific gravity, Atterberg limits, MDD with OMC, CBR (soaked and unsoaked) and UCC. He discussed about the index and engineering properties of contaminated black cotton soil. Then he discussed, that the results were increased with 7.5% partial replacement of saw dust in contaminated black cotton soil. He finally concluded that though soils were contaminated using castor oil, its properties were improved when sawdust was added up to 10% to the soil.

Malhotra Monica et al. [2013] investigated about stabilization of expansive soils by using low cost materials. In this paper fly-ash and lime were added as stabilizing agents with varying percentages. He had conducted various tests like liquid limit, free swell index and standard proctor test. He finally concluded that partial replacement of soil with both lime and fly-ash showed a considerable increase in properties like unequal settlement. He also concluded that shrinkage and swelling characteristics of the soil was reduced.

Gundaliya et al. [2013] studied about the black cotton soil characteristics with partial replacement of cement waste dust and lime. He computed the behaviour of those soils with various tests such as liquid limit, plastic limits and UCC. There results concluded that cement dust acted as a good stabilizing agent for Black cotton soil. He also concluded that compressive strength was improved with partial replacement of cement with soil. He finally concluded that partial replacement with cement dust only shows improved performance compared to lime and cement dust + lime.

Poweth Mercy et al [2013] investigated on safe and productive disposal of quarry dust waste and wasted-plastic by using them in the pavements sub grade. In their paper a series of CBR and SPT test were carried out for finding the optimum percentages of waste plastics, quarry dust in soil sample. The results shows only quarry dust should be mixed with the soil plastic mix, to increase its maximum dry density and is suitable for pavement sub grade. They concluded that Soil plastic mixed with quarry dust maintains the CBR value within the required limit. Soil mixed with quarry dust gives lesser CBR value than soil plastic quarry dust mix but it can be used for pavement sub grade.

Nsaif Hatem et al [2013] concluded by mixing plastic waste pieces with two types of soil (clayey soil and sandy soil) at different mixing ratios (0,2,4,6,8)% by weight respectively that, there is significant improvement in the strength of soils because of increase in internal friction. The percentage of

increase in the angle of internal friction for sandy soil is slightly more than that in clayey soil, but there is no significant increase in cohesion for the two types of soils. Also, it was concluded that due to low specific gravity of plastic pieces there is decreases in MDD and OMC of the soil.

Malhotra Akshat and Ghasemain Hadi [2014] studied the effect of high density polyethylene(HDPE) plastic waste on the Unconfined Compressive Strength of soil. In a proportion of 1.5%, 3%, 4.5% and 6% of the weight of dry soil HDPE plastic waste are added in the soil. They concluded that the Unconfined compressive strength of black cotton soil increases on the addition of plastic waste. When 4.5% plastic waste mixed with the soil, strength obtained was 287.32KN/m^2 which is maximum as the strength of natural soil was 71.35KN/m^2.

Nagle Rajkumar et al [2014] performed CBR for improving engineering performance of sub grade soil. They mixed polyethylene, bottles, food packaging and shopping bags etc as reinforcement with black cotton soil, yellow soil and sandy soil. Their study showed that MDD and CBR value increases with increase in plastic waste. Load bearing capacity and settlement characteristics of reinforced soil were also improved.

Chebet et al [2014] did laboratory investigations to determine the increase in shear strength and bearing capacity of locally available sand due to random mixing of strips of HDPE (high density polyethylene) material from plastic shopping bags. A visual inspection of the plastic material after tests and analysis indicates that the increased strength for the reinforced soil is due to tensile stresses mobilized in the reinforcements. The factors identified to have an influence on the efficiency of reinforcement material were the plastic properties (concentration, length, width of the strips) and the soil properties (gradation, particle size, shape).

Jaypal et al. [2014] discussed about the comparison of different admixtures using weak soil stabilization. In this paper, admixtures such as quarry dust, fly ash and lime were compared. The tests such as liquid limit, plastic limit, modified proctor compaction, sieve analysis, differential free swell and CBR were conducted. He concluded that the addition of quarry dust, lime and fly ash had not prevented the swelling nature. He also concluded that there was increase in the CBR value with the partial replacement of 20% quarry dust which in turn reduced the pavement thickness of road construction.

Baraskar Tushal et al. [2014] had studied about CBR of Black cotton soil. He partially replaced the soil with waste copper slag in various percentages. He conducted various tests such as grain sieve analysis, compaction characteristics and CBR. He concluded that the maximum CBR value is

obtained in black cotton soil with 28% replacement of copper slag. He also concluded that such soils can be effectively used as the sub base layer of road pavement.

Karthik et al. [2014] had studied about the soil stabilization by partially replacing red soil with Fly Ash. He conducted various tests such as CBR, specific gravity, MDD with OMC, UCC, liquid limit and plastic limit. He finally concluded that 9% partial replacement of fly ash in the soil results in improved properties and he also said that those soils showed good bearing capacity.

Mishra Brajesh et al. [2014] had investigated about the engineering behaviour of black cotton soil and its stabilization by use of lime. The tests were conducted for properties like atterberg limit, CBR value, free swell index and compaction factor. He finally concluded that 5% partial replacement of soil with lime is optimum to stabilize the black cotton soil. He concluded that 5% partial replacement of fly-ash resulted in reduced liquid limit (15.27%) and swelling and it also increased the CBR values.

Dhatrak A.I. et al [2015] after reviewing the performance of plastic waste mixed soil as a geotechnical material it was observed that for the construction of flexible pavement, the quality of sub grade soil of pavement gets improved using waste plastic bottles chips is an alternative method . In his paper a series of experiments are done on soil mixed with different percentages of plastic (0.5%, 1%, 1.5%, 2%, 2.5%) to calculate CBR. On the basis of experiment that he conducted using plastic waste strips he concluded that waste plastic strips will improve the soil strength and can be used as sub grade. It is economical and eco-friendly method to dispose waste plastic because there is scarcity of good quality soil for embankments and fills.

Mishra R. S. et al [2015] had studied about the stabilization of black cotton soil by use of Fly ash, Ferric chloride and Stone dust. The soil samples were tested for liquid limit, plastic limit, OMC with maximum dry density and CBR. He concluded that the liquid limit, plastic limit, maximum dry density and CBR values are increased due to the adding of Ferric chloride 2.5%, fly ash 15% and stone dust 25%. The results indicated the improvement in soil properties and reduction in pavement thickness on road construction.

Mohammed et al. [2015] had investigated about the improvement in soil properties of Expansive soil by using copper slag. The soil properties like Grain size analysis, liquid limit, plastic limit, plasticity index, compaction test, direct shear test and CBR were determined. He concluded that copper slag 40% and Black cotton soil 60% was optimum and it showed the increase in value of specific gravity and CBR. He finally concluded that such soil can be effectively used in road embankment sub base and sub grade.

Fauzi Achmad et al [2016] calculated the engineering properties by mixing waste plastic High Density Polyethylene (HDPE) and waste crushed glass as reinforcement for sub grade improvement. The chemical element was investigated by Integrated Electron Microscope and Energy-Dispersive X-Ray Spectroscopy (SEM-EDS). The engineering properties Plasticity index, Cohesion, Optimum moisture content values were decreased and friction angle, Maximum dry density, CBR values were increased when content of waste HDPE and Glass were increased.

Michael Tiza et al [2016] had reviewed about the stabilization of soil using industrial solid wastes. In his paper, he studied about the replacement of different materials such as Red mud, copper slag, brick dust, polyvinyl waste, ceramic dust, sawdust and fly ash. The soil samples were tested by Atterberg limits, CBR and compaction test. He had concluded that almost all the industrial wastes have the ability to enhance the properties of enhancing the properties of expansive soil with less cost.

Ravi et al .[2016] had studied about the characteristics of clay soil by using copper slag stabilization. In this paper, he tested the CBR and Max density, OMD relationship. He observed higher CBR values in 30% replacement of copper slag and this was also served as good conformity for the flexible pavement with simultaneous reduction in the sub base course thickness. He finally concluded that the addition of 30% copper slag with 70% BC soil was the suitable stabilization ratio which increased all characteristics of sub grade requirements.

Summaya et al. [2016] had studied about the soil stabilization using tile waste. In this paper, tests were conducted on UCC, CBR, liquid limit, plastic limit, compaction test and shrinkage limit. She concluded that there was reduction in value of liquid limit, plastic limit and OMC and increase in the value of shrinkage limit, MDD, UCC, CBR on addition of tile waste up to 30%.

Paliwal et al. [2016] had experimentally studied about the stabilization of sub grade soil by using foundry sand waste. In this paper he tested various properties like liquid limit, plastic limit, plasticity index, Standard proctor test, CBR and Direct shear test. He concluded that the CBR value and angle of internal friction of soil was improved with addition of 20% foundry dust. He also concluded that OMC shows a lower value for 10% replacement of foundry waste.

Butt Ali et al. [2016] had investigated about the strength behaviour of clayey soil stabilized with sawdust ash. The soil properties were determined by computing the Liquid limit, plastic limit, plasticity index, specific gravity, UCS and CBR. He observed that the property of soil showed an

acceptable value up to 4% replacement of sawdust ash. He had discovered that sawdust ash acceptably act as a cheap stabilizing material for road pavement.

Michael Tiza et al. [2016] had reviewed about the stabilization using industrial solid wastes. In this paper, he studied about the replacement of different materials such as Red mud, copper slag, brick dust, polyvinyl waste, ceramic dust, sawdust and fly ash. The soil samples were tested by Atterberg limits, CBR and compaction test. He had concluded that almost all the industrial wastes have the ability to improve the expansive soil with less cost compared to conventional soil.

kumar Rajendra et al. [2017] had studied about the Black cotton soil blended with copper slag and fly-ash which are added in different percentages. The soil properties like liquid limit, plastic limit, plasticity index, free swell, compaction test and CBR (unsoaked) were determined. The results indicated that the dry density, CBR values were improved and swelling was reduced due to addition of copper slag 30% and fly ash 10% (% by weight of soil) in the soil.

Babu Ramesh et al. [2017] had investigated about the behaviour of black cotton soil with addition of copper slag and steel slag. The soil samples are tested by compaction test, unconfined compression test and CBR. It is concluded that CBR, optimum moisture content, maximum dry density and shear strength are increased when the soil is added with 20% of copper slag and steel slag.

All the studies that have been done on stabilization of soil suggest that there will be an increase in the shear and bearing strength of soil by the application of suitable admixture like cement, lime ,fly ash ,plastic waste ,bitumen etc. Along with strength, other soil properties like shrink- swell index, liquidity index, permeability etc. also gets better of the soil. But except some admixtures ,most of them are quite expensive. So use of these admixture are not feasible most of the time. New researches on soil stabilization by waste material like plastic, fly ash etc. are economical. So research o soil stabilization should be more focused on adding suitable admixtures which can not only enhance soil properties but can also be economical and feasible most of the time.

CHAPTER 3- MATERIALS AND METHODOLOGY

3.1) Materials used –

3.1.1) Soil- Principal component used for embankment construction and highways subgrade is soil. The performance of pavement specially flexible pavement depends on the type and properties of subgrade soil. In this study soil is taken from Rithala which is about 4km away from Delhi Technological University. The soil is then passed from 425 micron sieve and the soil passed from the sieve is collected and the test is performed in this soil.

3.1.2) Properties of soil used- Different laboratory test are performed in the soil . Properties of soil obtained from the laboratory test are listed below.

Properties	Results
Specific Gravity	2.31
Liquid Limit (LL) %	57.5
Plastic Limit (PL)%	22
Shrinkage Limit	19.2
Plasticity index $(I)_p$	35.5
OMC %	14.7
MDD(kN/m^3)	17.1

Table 1 : Basic properties of soil

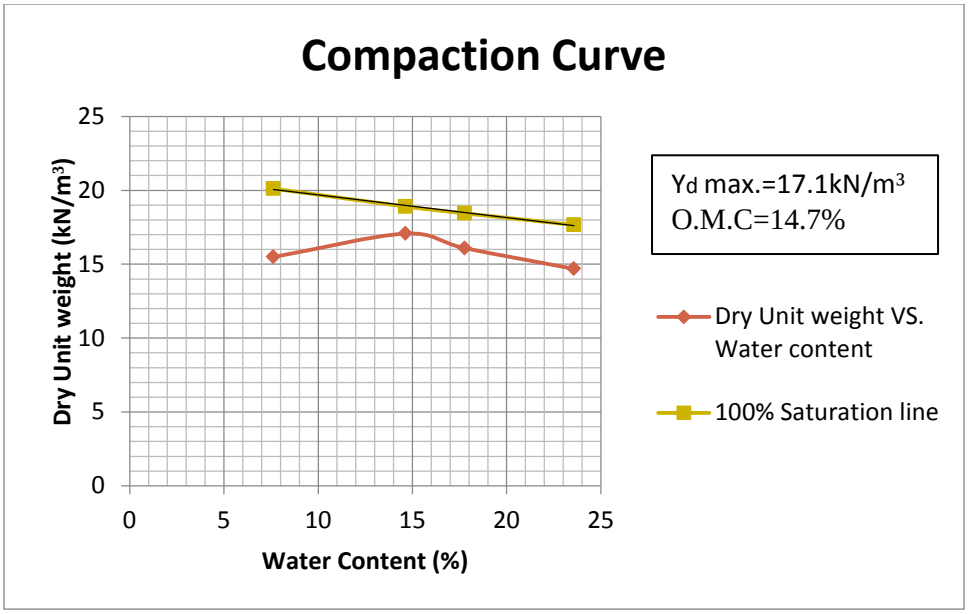

Figure 3.1 compaction curve

3.1.3) Cement- Along with plastic strips some amount of cement is also added as cement is also a admixture which can improve or enhance properties of soil. After adding cement and plastic strips in the soil it is cured for 3 days and then test is performed in the soil.

3.1.4) Waste Plastic Strips- Cold drink bottles are collected and cut into strips of aspect ratio two. The dimensions of waste plastic bottle strips used in this study is 7.5mm × 15mm. These strips are added in the soil- cement mixture in different proportion by weight .In this study strips used are 0%, 0.25%, 0.5% and 0.75% of dry weight of soil. A Picture of strips is shown below.

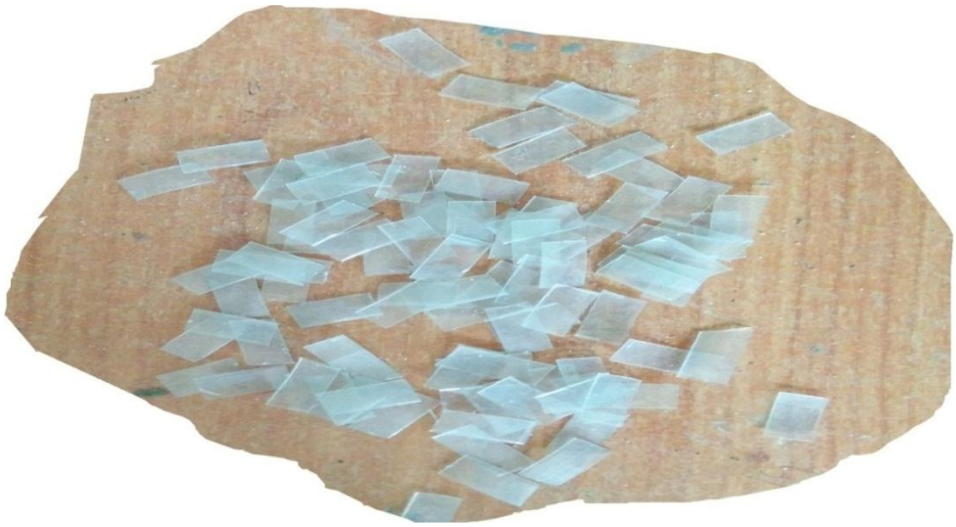

Figure 3.2 plastic bottle strips

3.1.5) Plastic Bottle Cutter- To cut the plastic bottles into strips a plastic bottle cutter is made at home with the help of carpenter. It is made by cutting a wood of length 17.5 cm and width of 3.5cmand base cross section of 3.5cm × 2cm. Two cuts are made in this wood piece ,one along length

upto depth of 4.5cm and one across length which is 1cm deep. A blade is fitted in this cuts which converts plastic bottles into desired strips. A picture of the plastic bottle cutter is shown below.

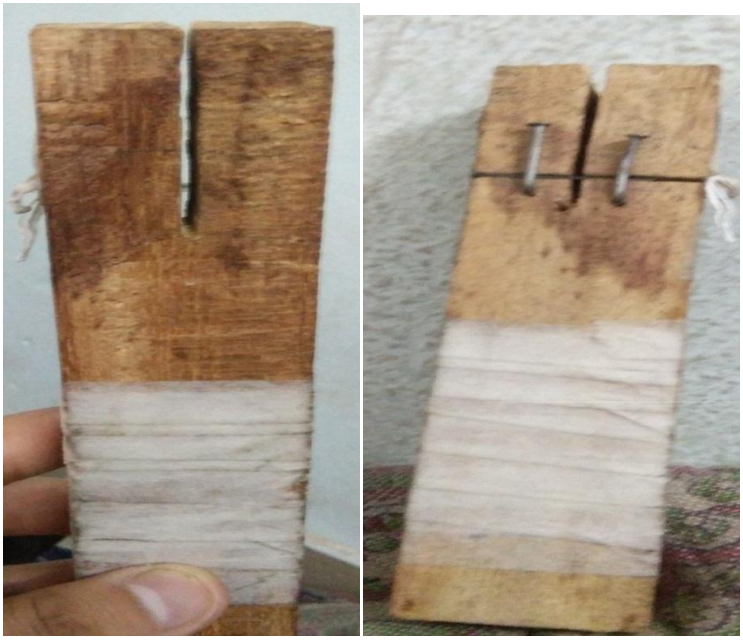

Figure 3.3 plastic bottle cutter

3.1.6) Mould- Mould is used to prepare the cylindrical soil sample in which test is to be performed. Generally mould used in the (UCS)unconfined compression test have depth to diameter ratio of two. The cylindrical mould used in the present study have diameter of 50mm and height of 100mm.

3.1.7) Water- Water is used to prepare the soil sample for test. The amount of water to be added is found out by proctor test. Proctor test gives the value of optimum water content at which soil has maximum dry density. So prior to unconfined compression test ,proctor test is conducted on soil to find the optimum water content.

3.1.8) Triaxial apparatus- In this study unconfined compressive strength of soil is carried out in triaxial apparatus however triaxial apparatus is used to carried out different types of test like unconsolidated undrained test,consolidated undrained test, consolidated drained test etc. Unconfined compressive strength test is a special type of triaxial shear test in which confining pressure is zero i.e σ_3=0. Triaxial shear test is conducted in 2 stages in which drainage valves may be closed or open(drained or undrained). A cylindrical soil specimen is prepared from a saturated soil mass which is enclosed inside the impermeable rubber membrane. The length of sample is usually two times of its diameter. In triaxial shear test there is complete control over drainage condition and there is mechanism to measure pore pressure. The two stages in triaxial shear test are-

Stage 1- confining presssure stage- in this stage all around confining presure(σ_3 or σ_c) is applied using external water pressure. If test is unconsolidated then dxrainage valve will be closed but if test is consolidated ,then drainage valves are open and expulsion of pore water is permitted. When expulsion of pore water stops, first stage is completed.

Stage 2 – Deviator pressure stage- in this stage confininng pressure is kept constant and additional axial stress is applied, this axial stress is called deviator stress(σ_d). deviator stress is increased gradually until the soil fails in shear. If test is undrained then drainage valves will be closed and if test is drained then drainage valves will be open.

3.2)Unconfined Compression Test

Unconfined compression test is a special type of triaxial test in which confining pressure is zero i.e (σ_3=0). It means that there is no first stage(confining pressure stage) because confining pressure is zero,therefore no rubber membrane is required in this test. Without rubber membrane dry soil and sand cannot be held in position hence this test can be conducted in saturated silt and clay but it is more suitable for clay. The saturated sample is subjected to axial loading, then deviator stress at failure($\sigma_{d)f}$ is termed as unconfined compressive strength(q_u). So $q_u = (\sigma_d)_f$.

3.3 METHODOLOGY

3.3.1) PROCEDURE

1. A dry soil sample passing through 425µ sieve is taken and some laboratory tests are done prior to UCS in order to obtain various soil properties.
2. After finding out the various soil properties in laboratory, soil sample is prepared for UCS test.
3. In first attempt approximate 500gm of soil is taken and water of optimum moisture content is added in the soil. Then this moist soil sample is filled and compacted in the mould of height 100mm and diameter 50mm but the soil taken is little less than the volume of mould so some more soil with respective optimum moisture amount is added until the mould is fully filled . Note the total amount of soil added.
4. After fully compacting the soil in the mould it is taken out of the mould for testing.
5. Testing of the soil is done in triaxial apparatus. A picture of triaxial apparatus is shown below.
6. The prepared soil sample is placed in this triaxial apparatus and load is applied at a uniform rate of displacement of 1.25 mm/min. Load is applied until sample breaks into two. All the values are automatically saved in the the triaxial apparatus.

Figure 3.4 triaxial apparatus

7. For soil sample in which cement is to be added, exact amount of soil which is taken in first sample preparation is taken and cement is added in the soil in amount of 1% weight of dry soil. This cement and soil mixture is thoroughly mixed and then the optimum water amount is added to this sample. After this, the sample is filled in the mould and compacted with hand rammer. Sample is taken out from the mould after 30 minutes and is placed for curing for 3 days. After 3 days this sample is placed in the triaxial apparatus for testing. Loading is applied in the sample at a uniform rate of displacement of 1.25mm/min until the soil breaks in two. Same steps are followed for sample containing cement content of 1.5% weight of dry soil.

Figure 3.5 soil sample

8. A new sample is prepared with adding 0.25% of weight of dry soil of plastic strips along with 1% cement. After thoroughly mixing the all three ingredients optimum water content is added

to the mixture and soil sample is filled in the mould and compacted. After 30 minutes it is taken out from the mould and is placed for curing for 3 days. After 3 days it is placed in triaxial apparatus and loading is applied on the sample at a uniform rate of displacement of 1.25 mm/min until the sample breaks in two. Readings are saved in the apparatus automatically. Same steps are followed for plastic strips amount of 0.5%, 0.75% and 1% of weight of dry soil.

9. Same above steps are followed for cement content of 1.5% of weight of dry soil.
10. With the help of all the values of strength obtained from the test, comparison is done between different samples with different amount of cement and plastic bottle strips and graphs are plotted for the same.

Table of different soil samples is drawn below

Soil sample no.	**Cement content (%)**	**Plastic strips (%)**
1	0	0
2	1	0
3	1.5	0
4	1	0.25
5	1.5	0.25
6	1	0.5
7	1.5	0.5
8	1	0.75
9	1.5	0.75

Table 2 : different soil samples used in the study

CHAPTER 4- RESULTS AND DISCUSSION

In this project unconfined compression test is performed which gives the strength of soil. Prior to this proctor test is done to find the optimum moisture content of the soil which is found to be 15%. The soil in which test is conducted is collected from Rithala which is located at around 4 km away from Delhi Technological University campus. The unconfined test is conducted on triaxial apparatus. Results obtained from the test are drawn into graphs and comparison is done between soil sample mixed with different proportion of cement and plastic strips. Graphs are drawn between stress and percentage strain values. Stress- strain curve of normal soil without any admixture is shown below.

Sample 1- In this sample no cement and plastic strips are added. UCS test is being carried out and stress vs strain curve are plotted.

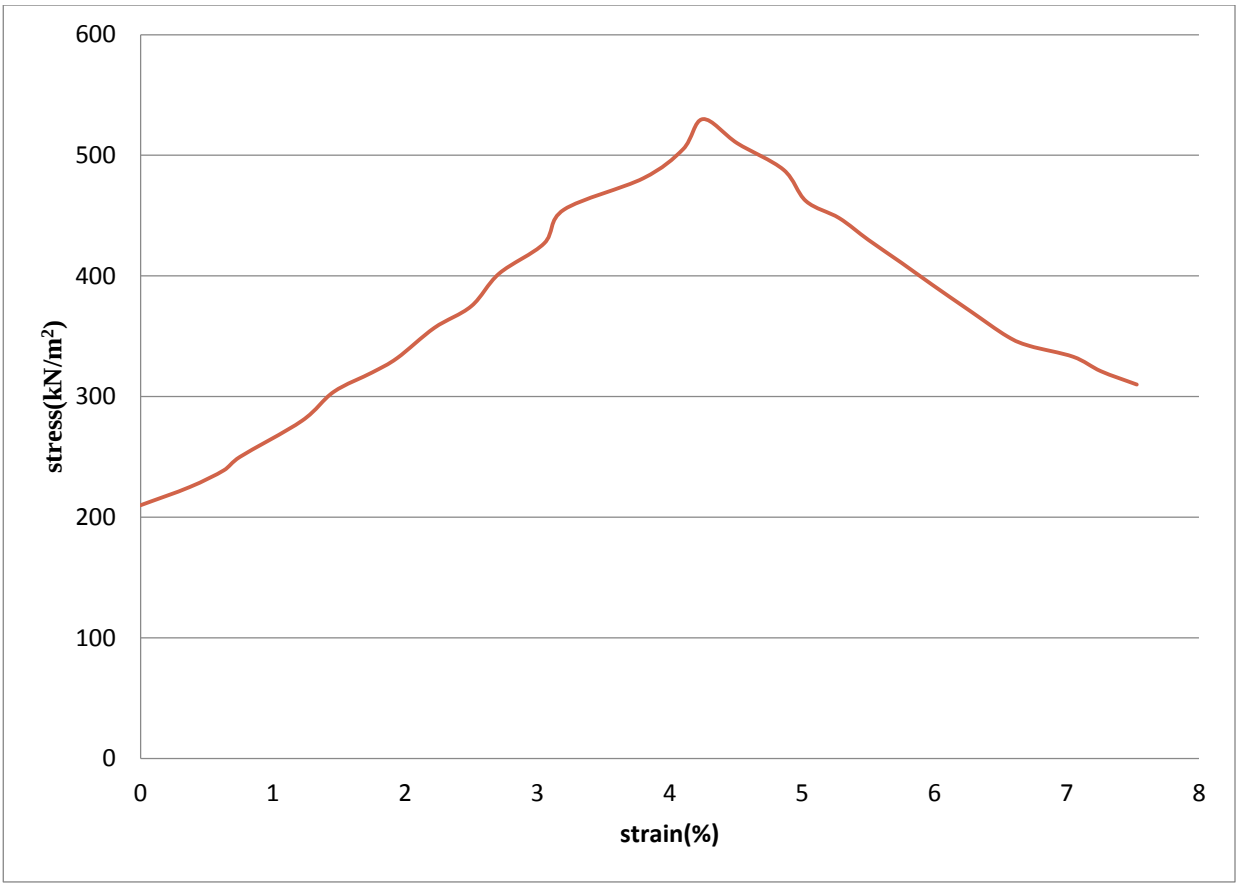

Figure 4.1 stress vs strain curve of normal soil

From the stress vs strain curve it is clear that the strength of this soil sample having no admixture is 530KN/m^2.

4.1- Sample 2 - In this soil sample, cement is added in the soil in the amount of 1% of dry weight of soil. No plastic bottles strips are added in this sample.

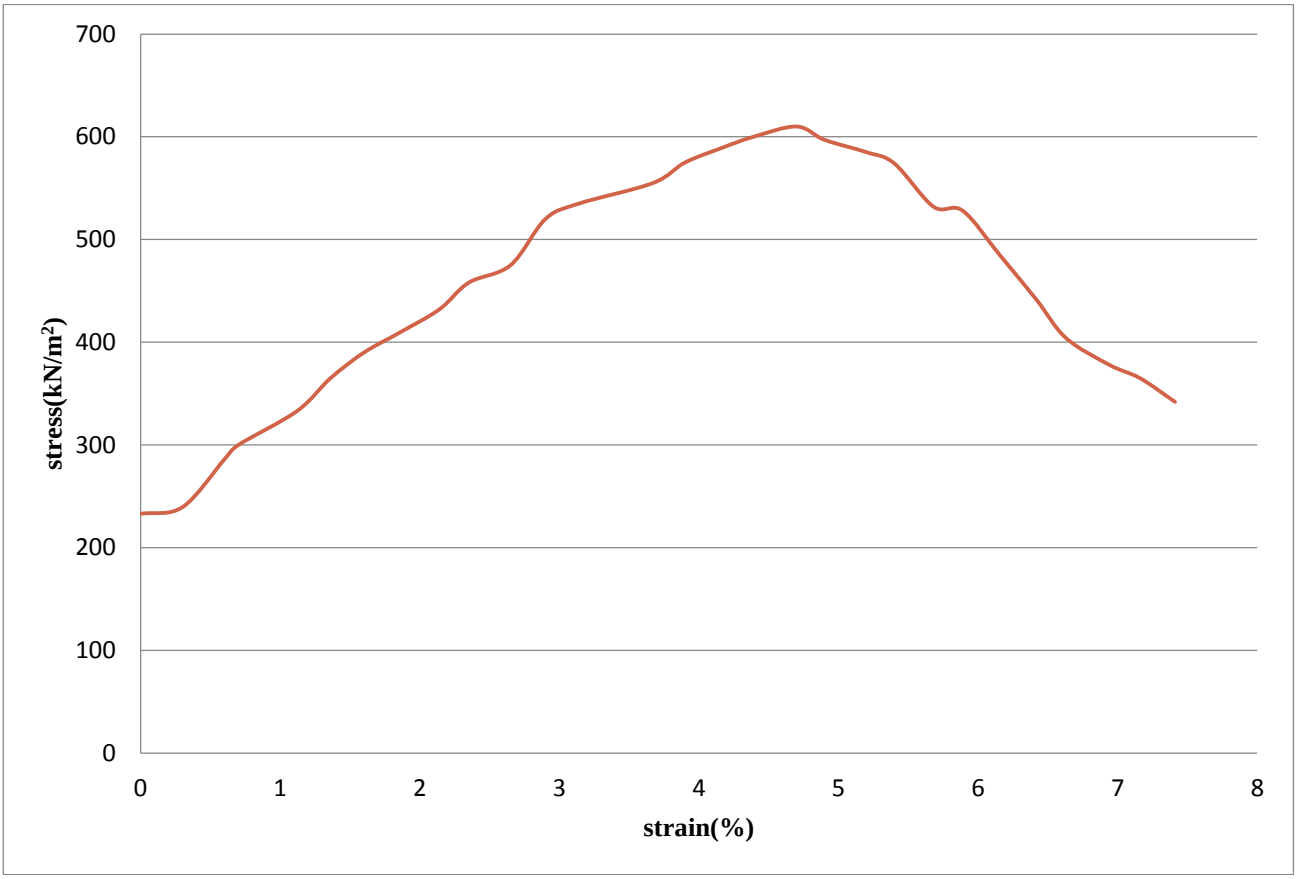

Figure 4.2 stress vs strain curve of soil containing 1% cement

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After conducting test on this sample stress vs strain curve is drawn. From the stress vs strain curve it is clear that the value of strength obtained of this sample containing 1% cement and 0% plastic is 610KN/m^2. While the normal soil sample without any admixture has strength of 530KN/m^2, this soil sample having 1% cement has a strength value of 610KN/m^2. So it can be said that the amount of cement added has significant impact on the strength of soil**.**

4.2- Sample 3 – In this sample, soil is mixed with 1.5% cement. No amount of plastic strips are added in this sample. Stress vs strain curve is drawn for this soil sample and strength is obtained.

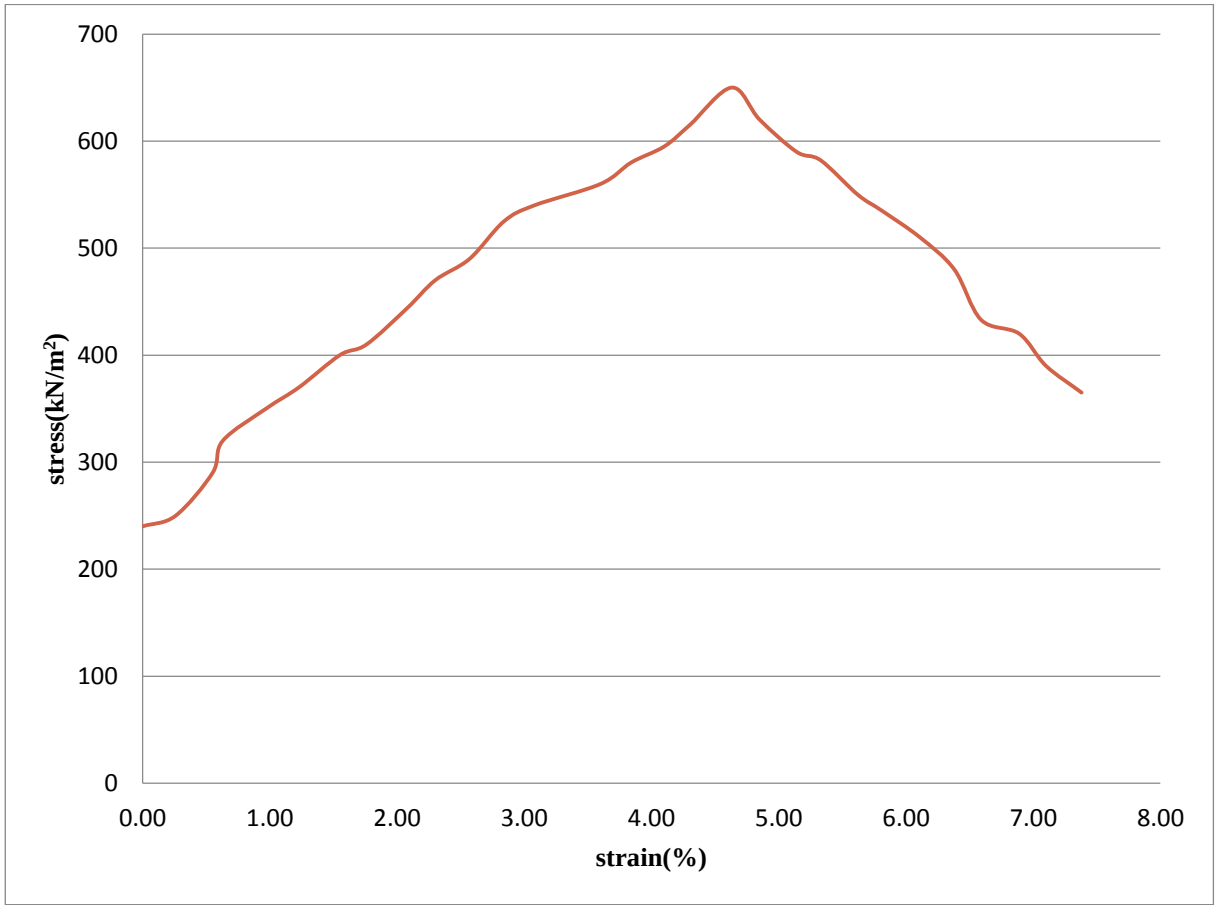

Figure 4.3 stress vs strain curve of soil containing 1.5% cement

Test is conducted on this soil sample and from the value stress vs strain curve is plotted. From the stress vs strain curve, strength of the sample is obtained which is found to be 650KN/m^2. It is clear from observing the graph that increasing the amount of cement in soil increases its strength.

4.3- Sample 4 – In this sample, soil is mixed with 1% cement and 0.25% of plastic bottle strips. Test is conducted on this soil sample and results are obtained. Stress vs strain curve is plotted with the help of readings. The result of this sample indicates the effect of adding plastic strips in soil.

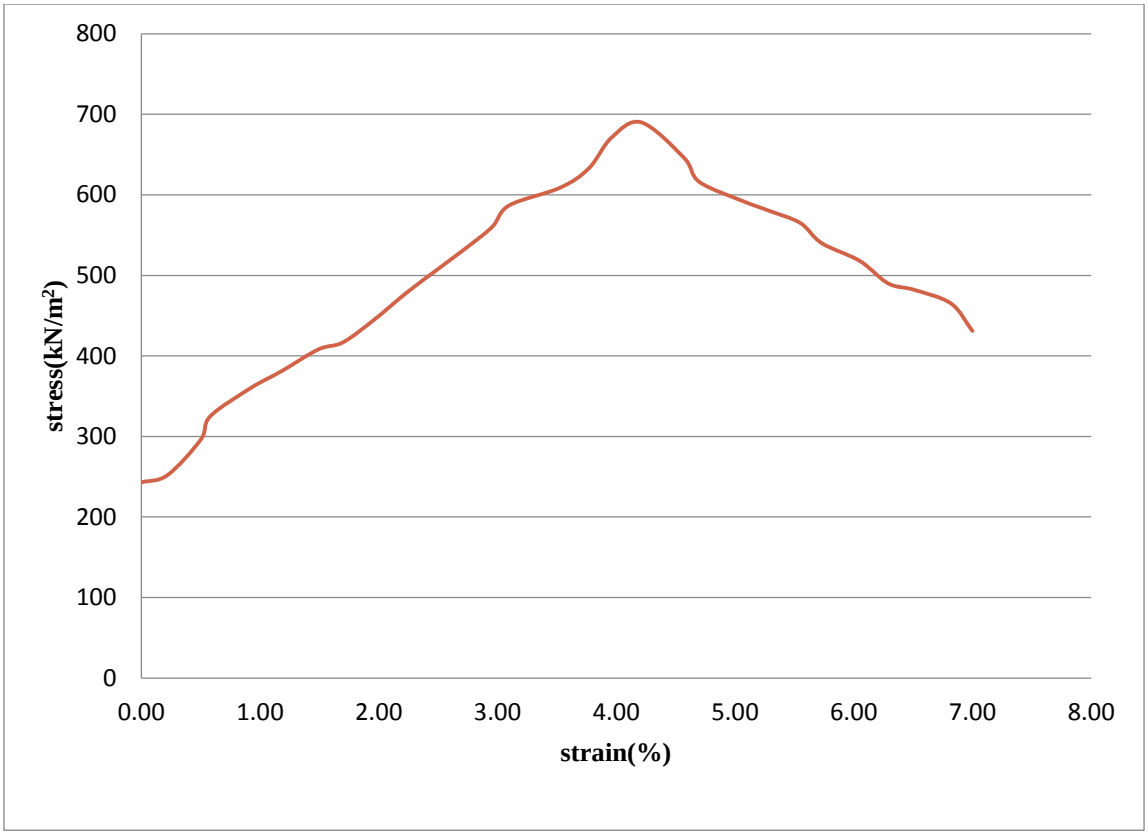

Figure 4.4 stress vs strain curve of soil sample having 1% cement and 0.25% plastic

The readings obtained from the test are plotted into a stress vs strain curve and strength of the sample is noted. Test conducted on this sample gives the strength value of 690KN/m^2 which is more than the sample containing 0% plastic strips. So from the result of this sample we can say that even a little amount of plastic strips have effect on the strength of soil.

4.4- Sample 5 – In this sample soil is mixed with 1.5% cement and 0.25% plastic bottle strips. Test is conducted on this sample and results are observed.

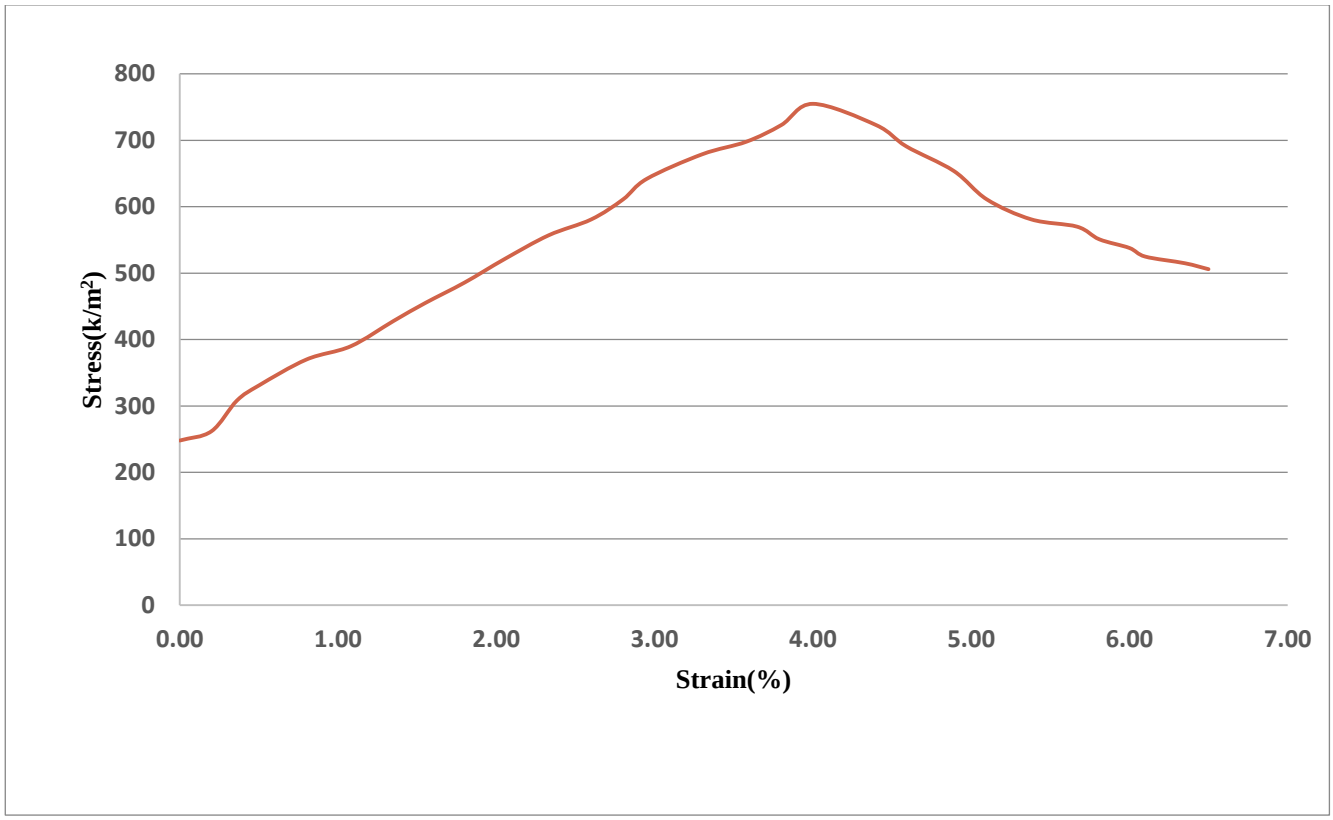

Figure 4.5 stress vs strain curve of soil sample containing 1.5% cement and 0.25 % plastic strips.

Test is conducted on this sample and stress vs strain curve is plotted from the readings. From the stress vs strain curve the strength of this soil sample is found to be 755KN/m^2 which is greater than the soil containing 1% cement and 0.25% plastic. This results indicate that that the increasing cement value increases the strength of soil.

4.5- Sample 6 – In this sample, soil is mixed with 1% cement and 0.5% plastic bottle strips. Test is conducted on this sample and results are observed.

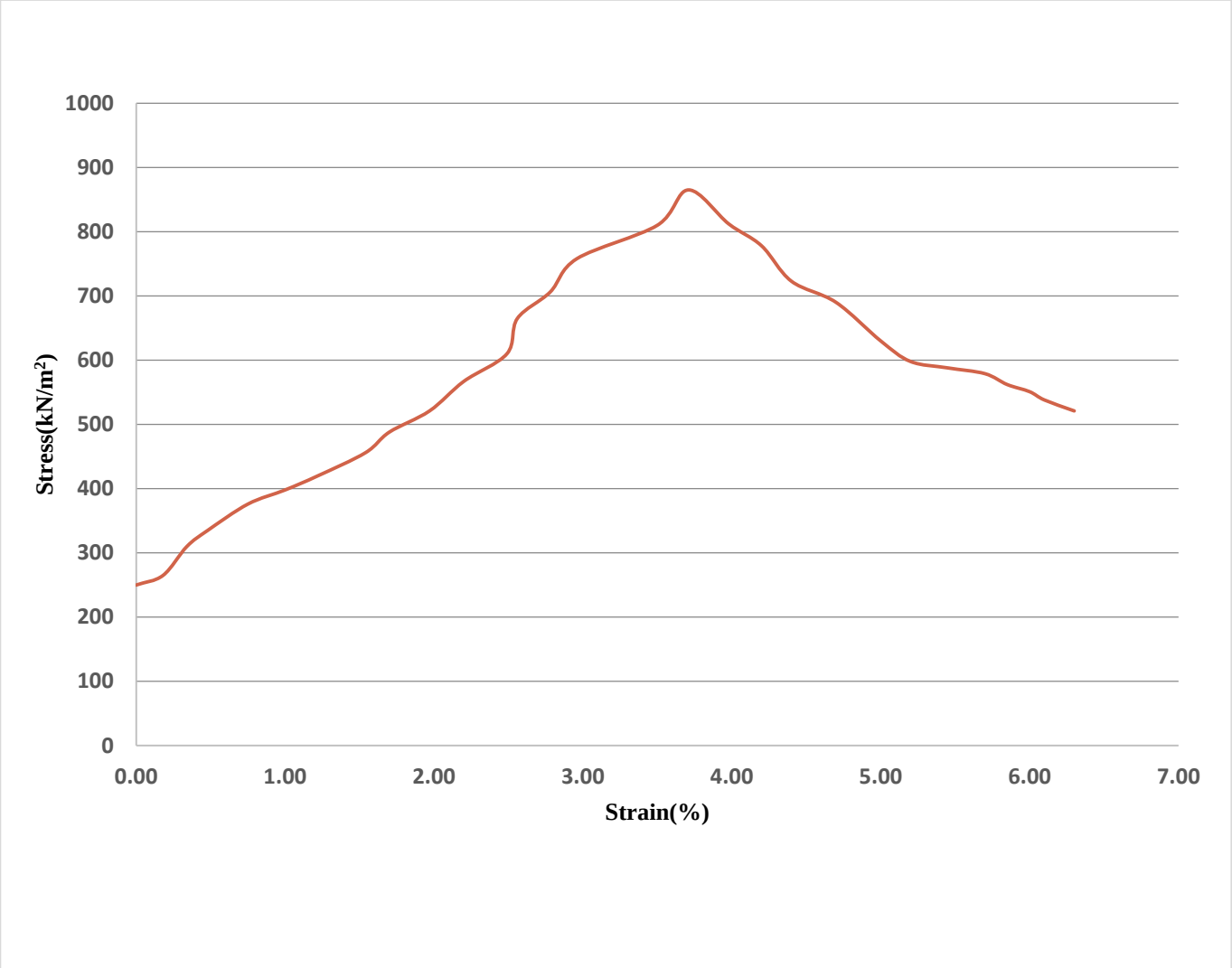

Figure 4.6 stress vs strain curve of soil sample containing 1% cement and 0.5% plastic strips

Test is conducted on this sample and stress vs strain curve is plotted. From stress vs strain curve strength of this soil sample is found to be 865KN/m^2 which is very much greater than the soil sample containing 0.25% of plastic strips. Thus test results of this sample indicates the effect of plastic strips in strength of soil.

4.6- Sample 7 – In this sample ,soil is mixed with 1.5% cement and 0.5% plastic bottle strips. Unconfined compression test is performed on this sample and results are observed.

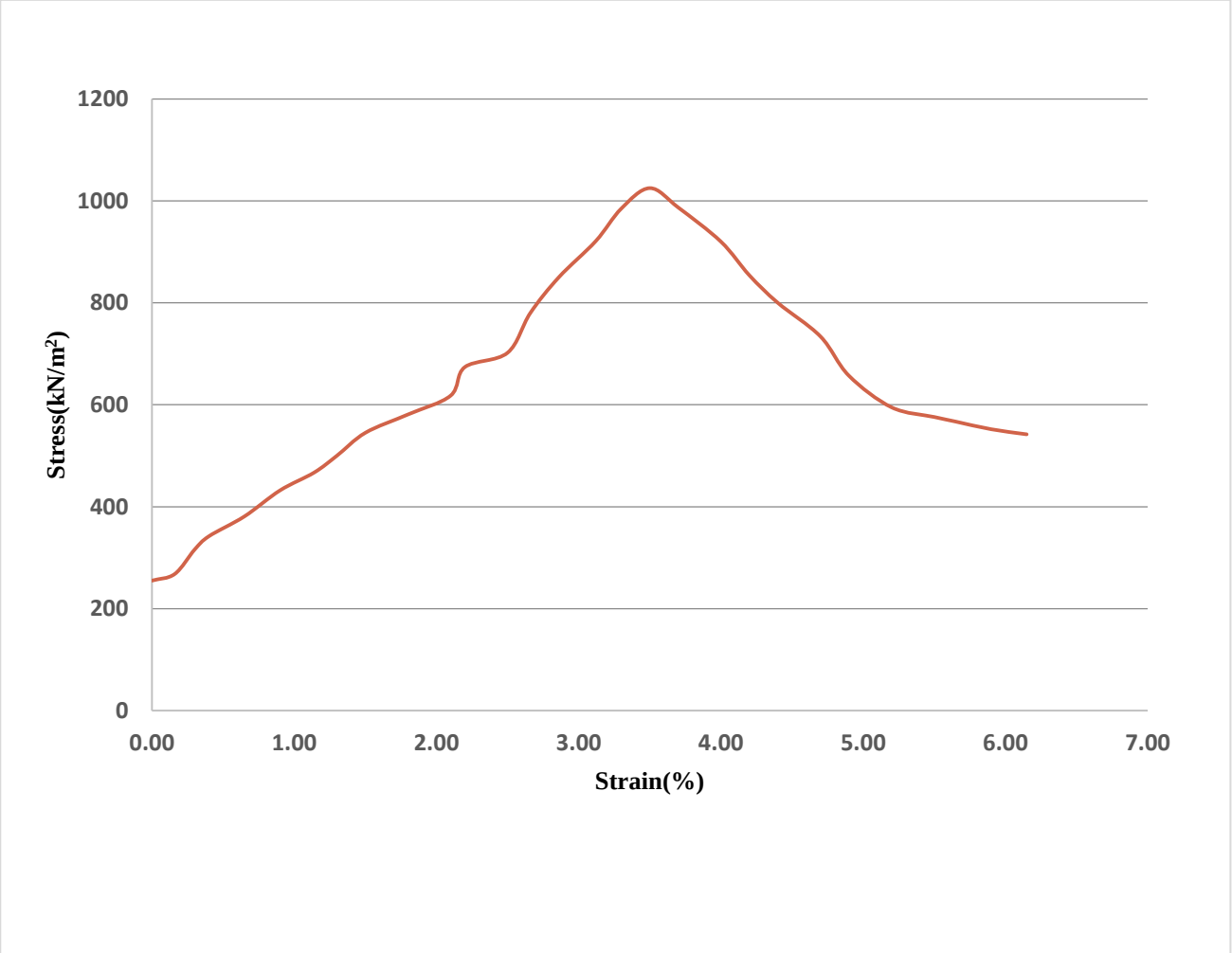

Figure 4.7 stress vs strain curve of soil containing 1.5% cement and 0.5% plastic bottle strips

Unconfined compression test conducted on this sample and readings obtained from the test are plotted into stress vs strain curve. Strength obtained from this sample is 1025 KN/m^2 which is very greater than the strength of the sample containing 1% cement and 0.5% of waste plastic bottle strips. This shows that along with strips increase in the amount of cement also increases the strength of soil.

4.7- Sample 8 - In this sample soil is mixed with 1% cement and 0.75% of plastic bottle strips. Unconfined compression test is conducted on this soil sample and results are collected and observed.

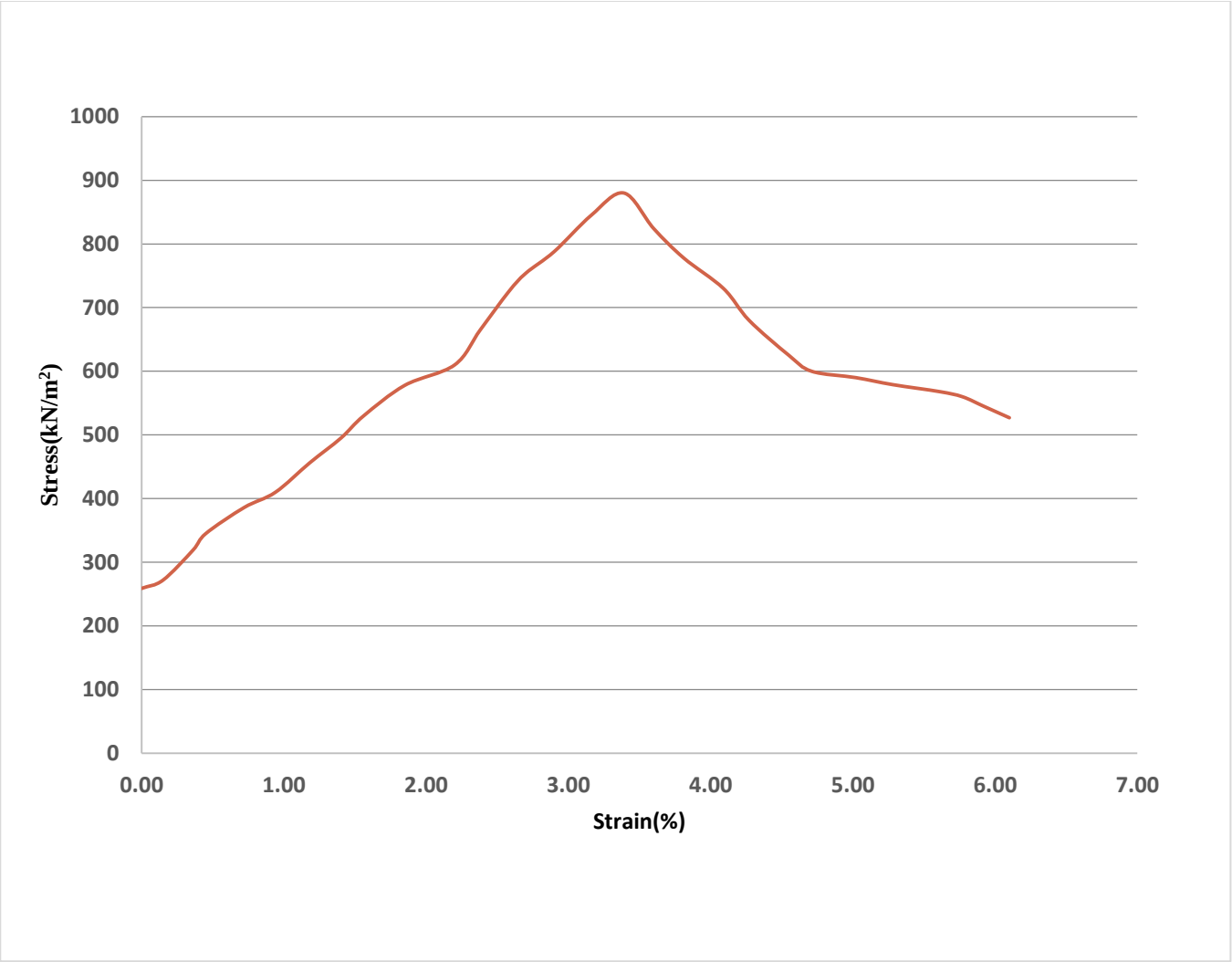

figure 4.8 stress vs strain curve of soil sample containing 1% cement and 0.75% plastic strips.

Test is conducted on this soil sample and from the readings stress vs strain curve is plotted. From stress vs strain curve strength of the sample is found out to be 880KN/m^2 which is less than the sample having 0.5% of waste plastic bottle strips. So this result indicates that after increasing the value of plastic bottle strips beyond 0.5%, strength of the soil starts to decrease.

4.8- Sample 9 – In this sample, soil is mixed with 1.5% cement and 0.75% plastic strips. Test is conducted on this soil sample and results are collected and observed.

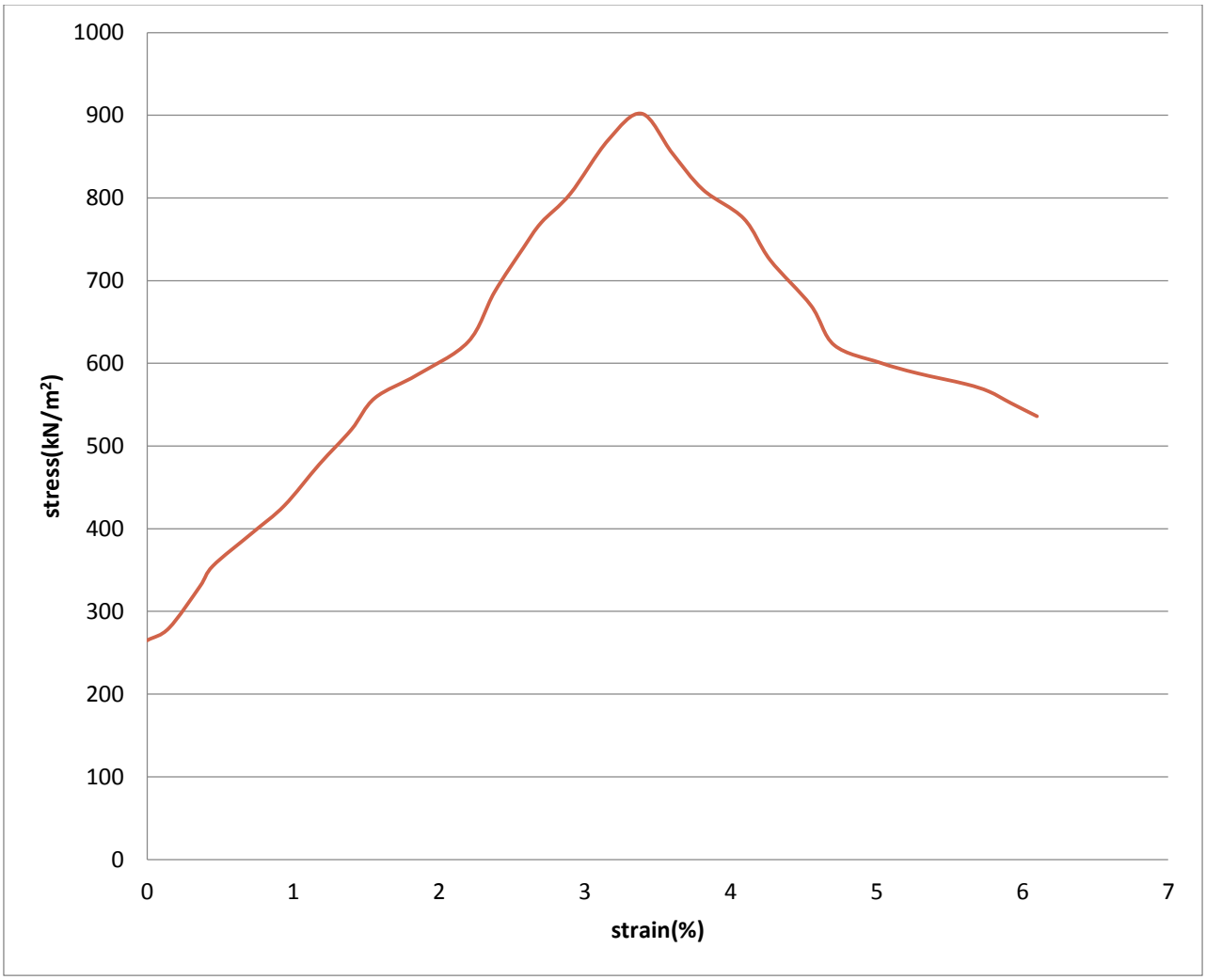

figure 4.9 stress vs strain curve of soil sample containing 1.5% cement and 0.75% plastic bottle strips

Test is conducted on this soil sample and with the help of readings stress vs strain curve is plotted . from stress vs strain curve strength of the soil is found to be 904 KN/m^2 which is lesser than soil having 0.5% plastic strips. But its strength is greater than the soil sample having 1% cement and 0.75% plastic strips. So result of this soil sample indicates the after a amount of 0.5% plastic strip, strength of the soil starts to decrease. So the optimum content of plastic strip in soil is 0.5%. we also observed that at 0.75% plastic strip content ,there is a increase in strength of soil when cement content is increased from 1% to 1.5%.

4.10- Comparison Of Strength Between Different Samples

1- In this stress vs strain curve, plastic bottle strip content is kept constant at 0% and curve is plotted for cement value of 1% and 1.5% and observation is being made.

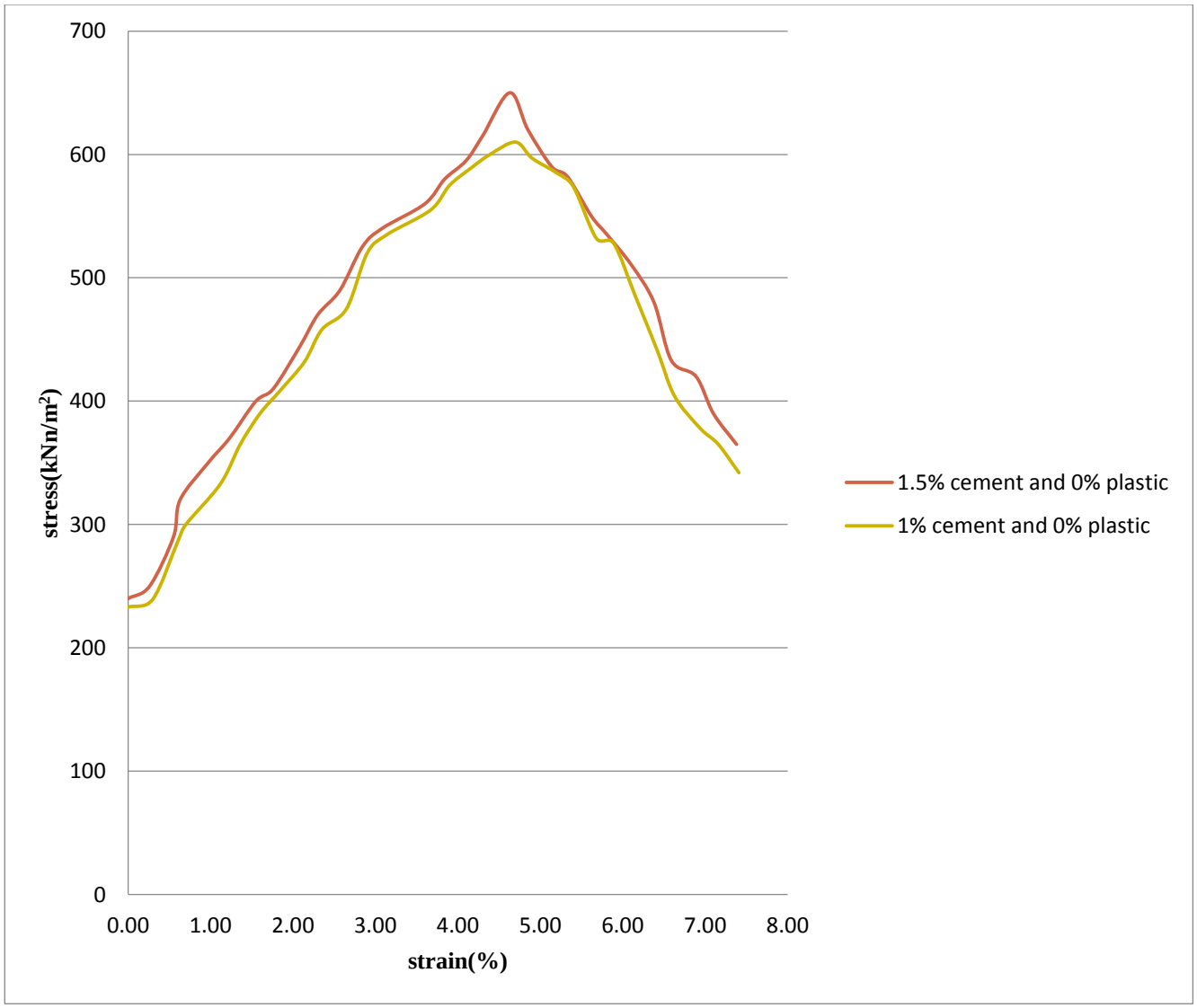

Figure 4.10 comparison of stress vs strain curve of soil sample containing 1% and 1.5% cement and 0% plastic.

After observing the above stress vs strain curve of soil sample having 0% plastic strip content and cement content of 1% and 1.5% respectively, we can say that the strength of soil sample containing 1.5% cement have slightly greater strength than sample containing 1% cement content.

2- In this comparison of stress vs strain, soil samples containing 0.25% plastic strip content and cement content of 1% and 1.5% are taken **.**

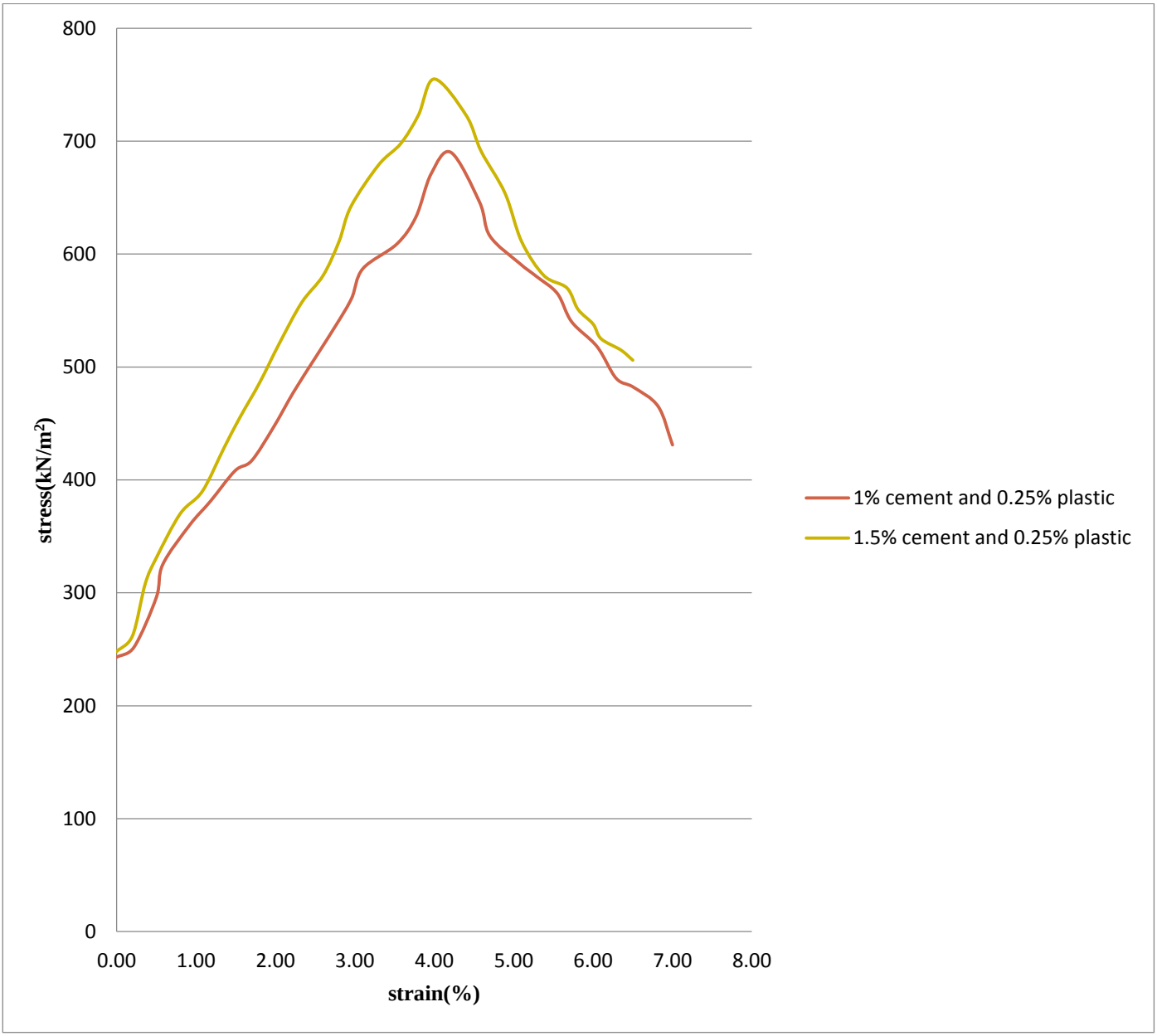

figure 4.11 comparison of stress vs strain curve of soil containing 1% and 1.5% cement and 0.25% plastic strips.

From the stress vs strain curve of both the soil samples , it is clear that soil having greater amount of cement has greater strength. Thus it can be said that the increase in the cement content increases the strength of soil.

3- In this comparison of stress vs strain, soil samples containing 0.5% plastic strip content and cement content of 1% and 1.5% are taken **.**

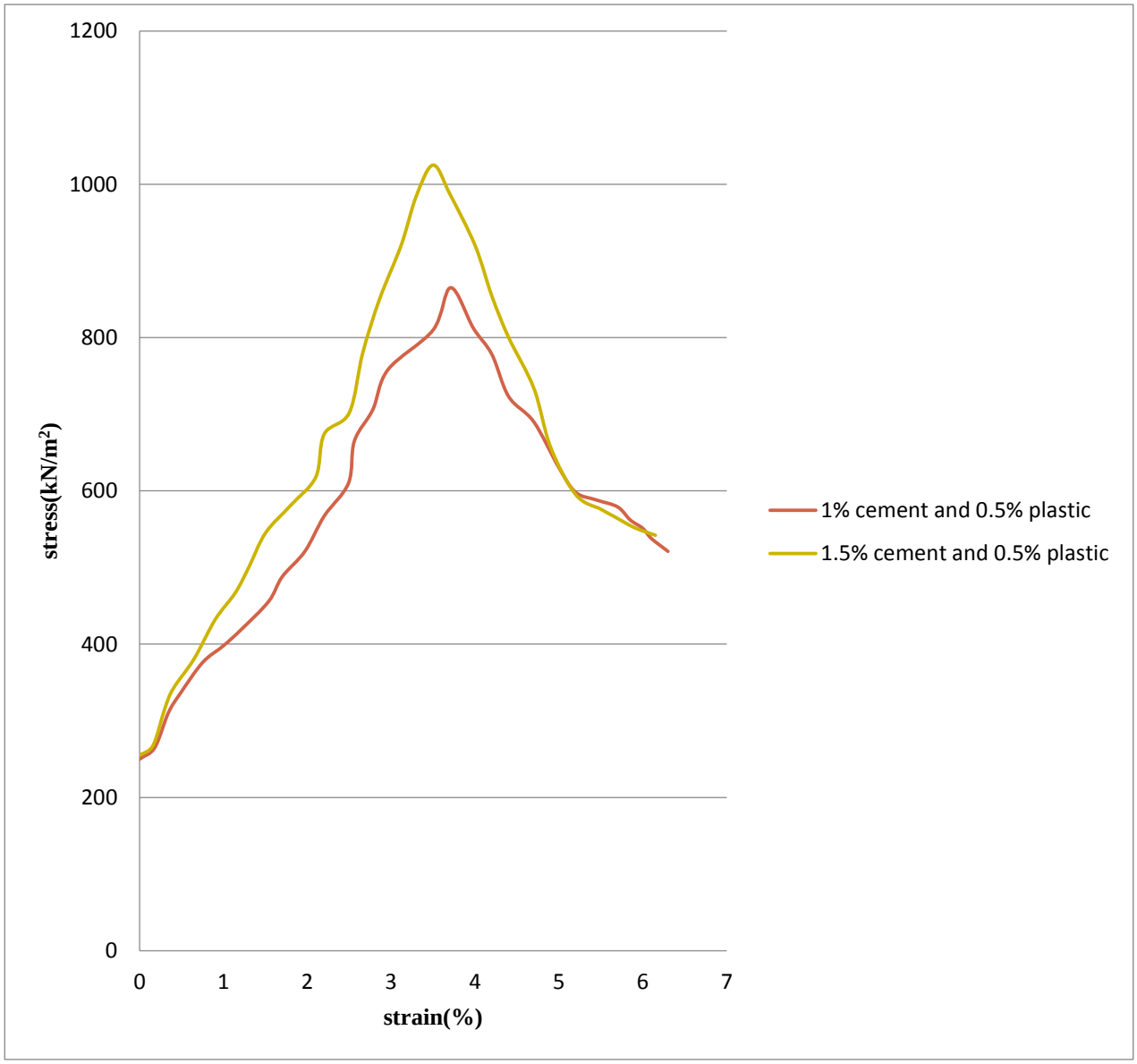

Figure 4.12 comparison of stress vs strain curve of soil sample containing 1% and 1.5% cement and 0.5% plastic strips.

From the stress vs strain curve of both the soil samples , it is clear that soil having greater amount of cement has greater strength. Thus it can be said that the increase in the cement content increases the strength of soil. The soil having plastic strips content of 0.5% and cement content of 1% has strength of 865KN/m^2 while soil sample having 0.5% plastic strips content and 1.5% cement content has strength of 1025KN/m^2.

4- In this comparison of stress vs strain, soil samples containing 0.75% plastic strip content and cement content of 1% and 1.5% are taken.

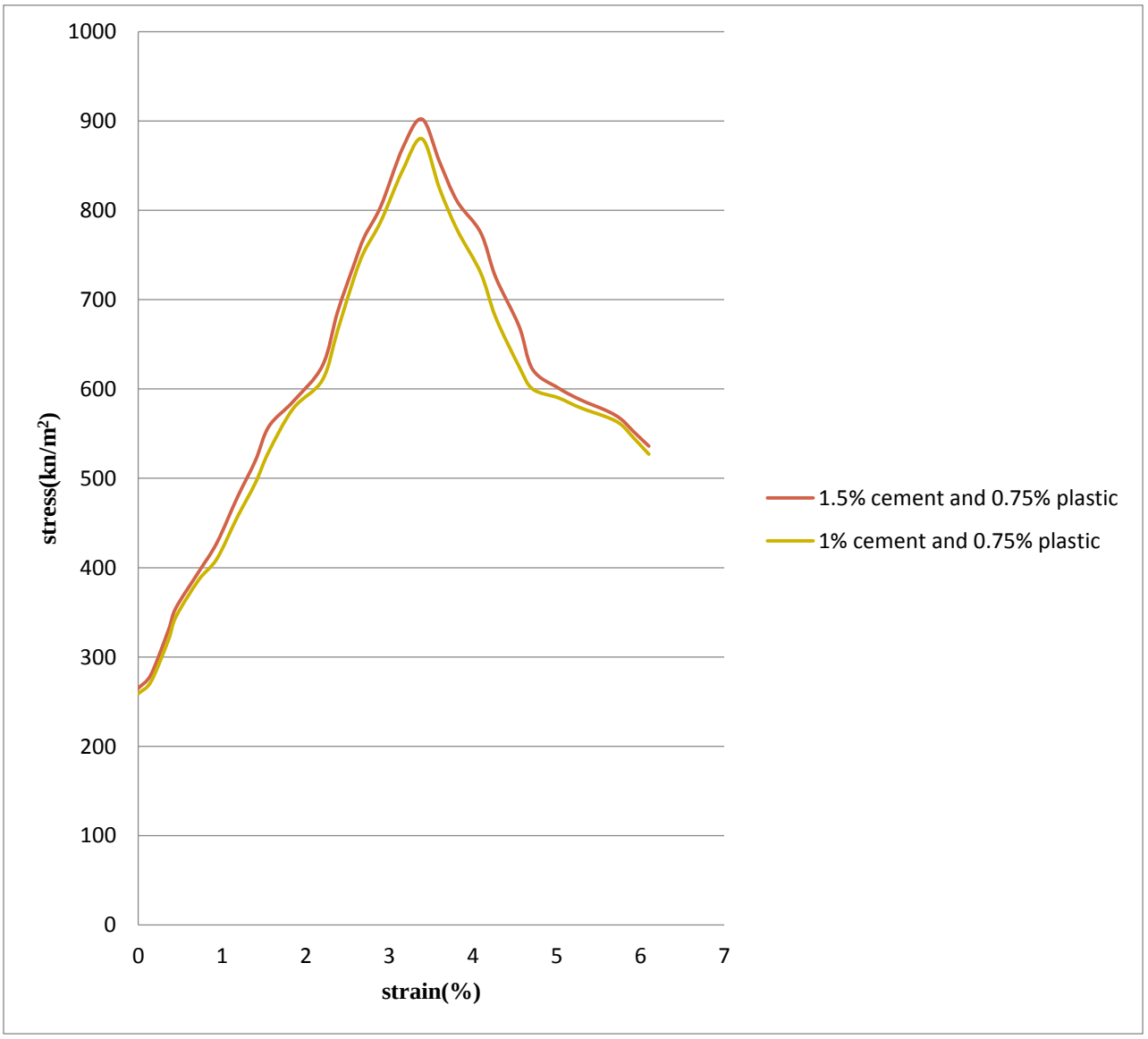

Figure 4.13 comparison of stress vs strain curve of soil samples containing 1% and 1.5% cement and 0.75% plastic strip.

From the above stress vs strain curve it can be easily seen that the extra amount of cement added to the soil has enhances the strength of soil. It can be also observed that after increasing the plastic strip amount beyond 0.5% ,the strength of soil starts to decrease. So optimum amount of plastic strip content is 0.5%.

5- In this comparison, stress vs strain curve of four samples are compared. samples containing 1% cement and plastic strips content of 0%,0.25%,0.5%,0.75% are compared by plotting stress vs strain curve.

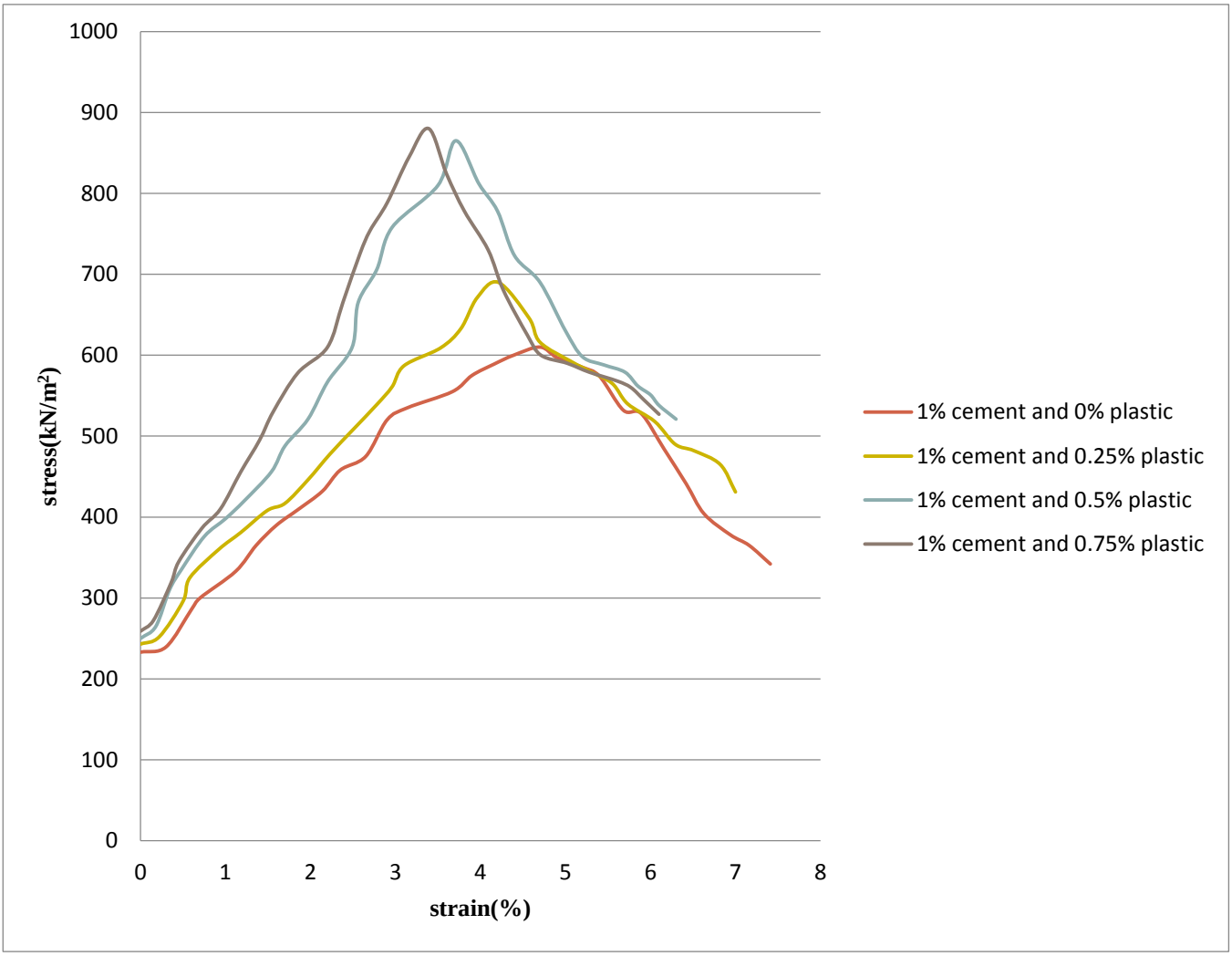

Figure 4.14 comparison of stress vs strain curve between soil samples containing 1% cement and plastic strips of 0%,0.25%0.5%,0.75%.

From the stress vs strain curve of soil samples having fixed quantity of cement of 1% and varying plastic content of 0%,0.25%,0.5% and 0.75% it is clear that the strength of soil having fix cement quantity of 1%, increases by increasing plastic strips content upto 0.5% . increasing the plastic strips content beyond shows decrease in the strength of soil. So it can be said that the optimum plastic content of the soil is 0.5%.

6- In this comparison four soil sample are taken and their stress vs strain curve are plotted in the same curve. From the curve comparison between different samples of fixed cement quantity of 1.5% and different plastic strip content of 0%,0.25%,0.5% and 0.75% is done.

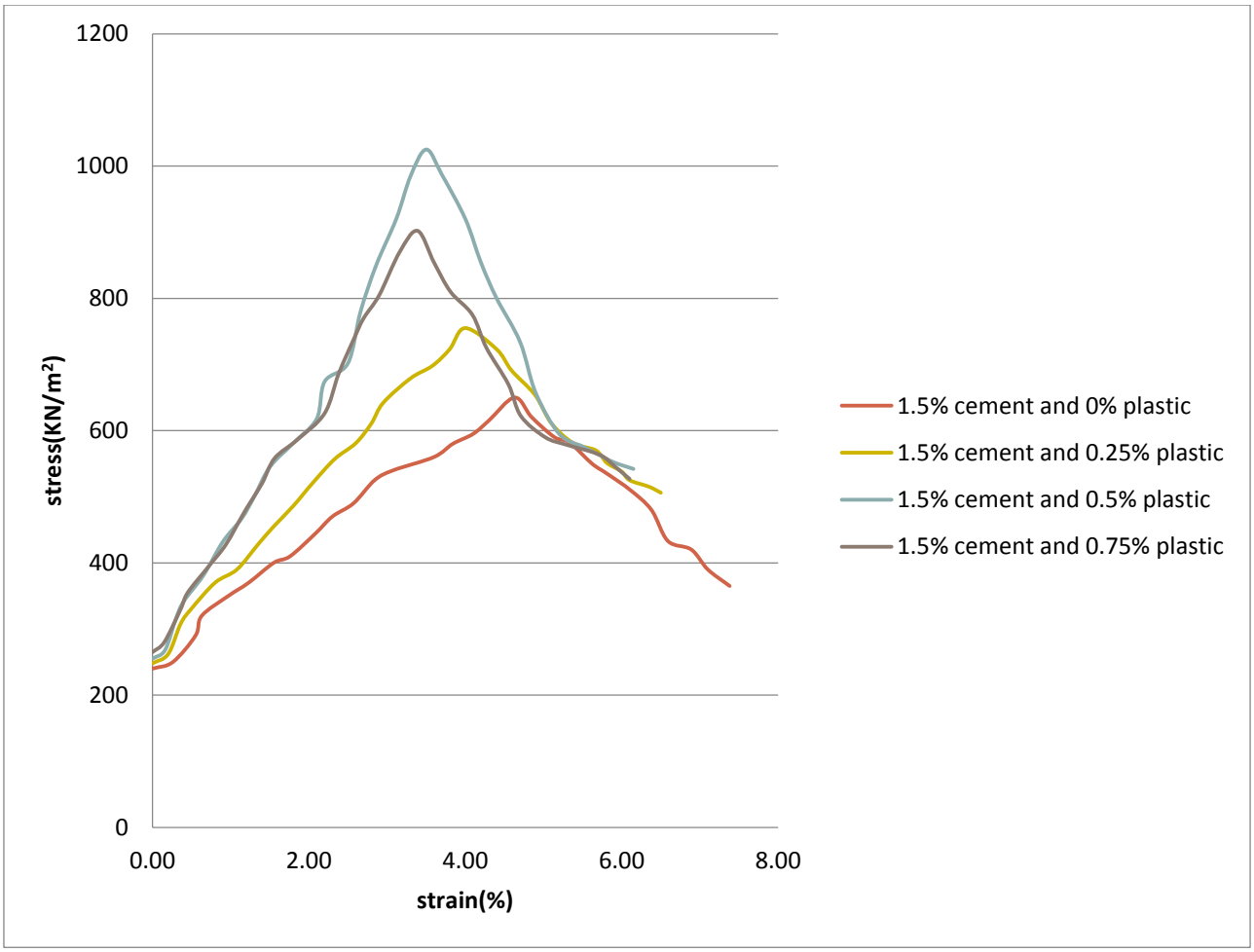

Figure 4.15 comparison of strength between soil samples containing 1.5% cement and plastic strips of 0%,0.25%,0.5% and 0.75% respectively.

From the stress vs strain curve of soil samples having fixed quantity of cement of 1.5% and varying plastic content of 0%,0.25%,0.5% and 0.75% it is clear that the strength of soil having fix cement quantity of 1.5%, increases by increasing plastic strips content up to 0.5% . Increasing the plastic strips content beyond shows decrease in the strength of soil. So it can be said that the optimum plastic content of the soil is 0.5%.

After conducting test on all the samples a table is prepared representing unconfined compressive strength of all soil samples.

Soil sampleno.	**Cement Content (%)by dry weight**	**Plastic strip (%)by dry weight**	**Unconfinedcompressivestrength(KN/m^2)**
1	0	0	530
2	1%	0	610
3	1.5%	0	650
4	1%	0.25%	690
5	1.5%	0.25%	755
6	1%	0.5%	865
7	**1.5%**	**0.5%**	**1025**
8	1%	0.75%	880
9	1.5%	0.75%	904

Table 3 : UCS value of diffrent soil samples

Observing the above table, it is clear that increase in cement quantity from 1% to 1.5% results in increase in the strength of soil and increase in the plastic strip content upto 0.5% will increase the strength of soil. But increasing the plastic strip content beyond 0.5% results in decrease in the strength of soil.

CHAPTER 5- CONCLUSION

After conducting test and observing the results obtained, following conclusions can be made-

1. There is an increase in strength of soil with increase in the amount of cement added to the soil.
2. The soil having 1% cement and 0% plastic bottle strips content has an strength of 610KN/m^2 while soil sample having 1.5% cement and 0% plastic bottle strips has an strength of 650KN/m^2.
3. There is also increase in the strength of soil by increasing the amount of plastic bottle strips added to the soil.
4. The strength of soil without any admixture is 530KN/m^2, which increases upto 1025 KN/m^2 at a cement content of 1.5% and plastic bottle strips content of 0.5%.
5. But increasing the amount of plastic bottle strips beyond 0.5% of weight of dry soil will decrease the strength of soil.
6. After increasing the plastic bottle strips beyond 0.5% to 0.75% ,there is decrease in the strength of soil. The strength of soil at 1.5% cement content and 0.5% plastic bottle strips is 1025 KN/m^2 which decreases to 904KN/m^2 at a cement content of 1.5% and plastic bottle strip content of 0.75%.
7. So the optimum amount of plastic bottle strips to be added to enhance the strength of soil is 0.5% at a cement content of 1.5%.

REFERENCES

[1] Ashraf Anas, Arya Sunil, Mariamma Joseph" Soil stabilization using raw plastic bottles", Journal of Engineering and Development, Vol. 17, Issue No.4, October 2013, pp- 489-492.

[2] Baraskar Tushal, Ahirwar S.K, "Study on California bearing ratio of black cotton soil use waste copper slag', International Journal of structural and civil engineering research", Vol.3, Issue No.4, November 2014, pp- 44-56.

[3] Bhattarai Pragyan, Kumar Bharat, "Engineering behavior of soil reinforced with plastic strips", International Journal of Civil, Structural, Environmental and Infrastructure Engineering Research and Development (IJCSEIERD) Vol. 3, Issue No. 2, Jun 2013, pp- 83-88.

[4] Brooks R M., "Soil Stabilization with Fly Ash and Rice Husk Ash", International Journal of Research and Reviews in Applied Science, Vol. 01, Issue No. 3, December 2009, pp- 209-217.

[5] Butt Wajid, Gupta Karan, Jha J.N, "Strength behaviour of Clayey soil Stabilized with Saw Dust Ash", International Journal of Geo-Engineering, Issue No. 21, October 2016, pp- 7-18.

[6] Celestine O. Okagbue,"Stabilization of clay using wood ash" Journal of Materials in Civil Engineering, ASCE, Vol. 19, Issue No.1, January 2007, pp- 14-18.

[7] Chand.A Mohan, Babu V Ramesh, Babu B. Ramesh,. Niveditha K, "Behaviour of Black Cotton Soil with Addition of Copper Slag and Steel Slag", International Research Journal of Engineering and Technology,Vol .4, Issue No. 01, Jan-2017, pp- 752-758.

[8] Consoli, N. C., Montardo, J. P., Prietto and Pasa, G. S.," Engineering behavior of sand reinforced with plastic waste", Journal of Geo technical and Geo environmental Engineering. Vol.128, Issue No. 6, 2002, pp- 462-472.

[9] E. Ravi, R. Udhayasakthi, T. Senthil Vadivel, "Enhancing the Clay Soil Characteristics using Copper slag Stabilization",Journal of Advances in Chemistry, Vol.12, Issue No. 26, December 2016, pp- 1212-1215.

[10] George Rowland Otoko, Braide K. Honest, “Stabilization of Nigerian deltaic laterites with saw dust ash”, International Journal of scientific research and management, Vol 2, Issue No.8, August 2014, pp- 69-75.

[11] Ghiassian H., Poorebrahim G., and Gray D. H., “Soil reinforcement with recycled carpet wastes”. Waste Management Research, Vol. 22 Issue No. 2, 2004, pp- 108-114.

[12] Jayapal, S.Boobathiraja, M.Samuel Thanaraj, K.Priyadharshini, “Weak soil stabilization using different admixtures A comparative study”, International Journal of engineering research and technology, Vol 3, Issue No.10, October 2014, pp- 57-63.

[13] Kaniraj, S. R. and Havanagi, V. G., “Behaviour of cement-stabilized fiber reinforced fly ash–soil mixtures” Journal of Geotechnical and Geo environmental Engineering, Vol. 12., Issue No.7, 2001, pp- 18-26.

[14] Karthik.S, Kumar Ashok. E Gawtham, P Elango, G, Gokul, D Thangaraj, “Soil Stabilization by Using Fly Ash”, IOSR Journal of Mechanical and Civil Engineering, Vol. 10, Issue No.6, Jan 2014, pp- 20-26.

[15] Kumar P. Rajendra, Kumar Praveen,. Maheswari G, “Laboratory Study of Black Cotton Soil Blended with Copper Slag and Fly Ash”, International Journal of Innovative Research in Science, Vol. 6, Issue No.2, February 2017, pp- 1960-1967.

[16] Kumar Prashant,. Paliwal M.C, Jain A.K.,“Stabilization of Sub Grade Soil by using Foundry Sand Waste”, International Journal of Engineering Science and Research Technology, Vol. 5 , Issue No .9, September 2016, pp- 300-308.

[17] Maheshwari K.,”Behaviour of Fibre Reinforced Soil”,Australian Geomechanics Journal, Vol. 44, Issue No. 4, December 2009, pp- 65-74.

[18] Malhotra Monica, Naval Sanjeev, “Stabilization of Expansive Soils Using Low Cost Materials” International Journal of Engineering and Innovative Technology , Vol. 02, Issue No. 11, May 2013, pp- 181-184.

[19] Madurwar K.V, Dahale P.P., "Comparative Study of Black Cotton Soil Stabilization with RBI Grade 81 and Sodium Silicate", International Journal of Innovative Research in Science, Engineering and Technology Vol. 2, Issue No. 2, February 2013, pp- 213-217.

[20] Mishra Brajesh, Mishra Ravi Shankar "A Study on Stabilization of Black Cotton Soil Use of Fly Ash, ferric Chloride and Stone Dust", International Journal of Engineering and Science, Vol.5, Issue No. 10, October 2015, pp- 20-25.

[21] Muntohar Agus Setyo, Widiantin Anita, Wilis Diana,"Engineering properties of silty soil stabilized with lime and rice husk ash and reinforced with waste plastic fiber" Journal of Materials in Civil Engineering, ASCE ,Vol 25, Issue No. 9, September 2013, pp- 1-9.

[22] Nsaif Hatem, "Behaviour of Soils Strengthened By Plastic Waste Materials", Journal of Engineering and Development Vol. 17 , Issue No 4, October 2013, pp- 1874-1877.

[23] Qureshi Mohammed, Mistry Hevin, Patel Vikas, "Improvement in Soil Properties of Expansive Soil by Using Copper Slag", International journal of Advance Research in Engineering in Science and Technology, Vol.2, Issue No.07, July 2015, pp- 125-130.

[24] Shekhar Jink Chandra, Chokshi Timir A, "A Review on Utilization of Waste Material Copper Slag in Geotechnical Applications", International Journal for Innovative Research in Science and Technology, Vol. 1, Issue No.12, May 2015, pp- 187-199.

[25] Summaya K.P, Refeequedheen Mohammed, K Sameer, Firoz V.T, K Jithin, "Stabilization of expansive soil treated with Tile Waste", International Journal of Civil Engineering, Vol. 3, Issue No. 03, March 2016, pp- 60-68.

[26] Tang, C., Shi S, Gao B., Chen W,"Strength and mechanical behavior of short polypropylene fiber reinforced and cement stabilized clayey soil". Geo textiles and Geo membranes, Vol. 25,Issue No 6 2007, pp- 194-202.

[27] Thyagraj T., Rao Sudhakar, Sailani U, "Stabilization of expansive soil by lime precipitation technique", Journal of Materials in Civil Engineering, Vol. 24, Issue No. 8, August 2012, pp- 1067-1075.