SOIL STABILIZATION USING FLY ASH AND LIME
A
MAJOR PROJECT REPORT

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

BACHELOR OF TECHNOLOGY
IN
CIVIL ENGINEERING

Under the supervision of

Dr. Rishi Rana
Assistant Professor (Senior Grade)

By

ISHAN SINGA [191611]

Department of Civil Engineering
JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY
WAKNAGHAT SOLAN – 173234, HIMACHAL PRADESH, INDIA

May 2023

STUDENT'S DECLARATION

I hereby declare that the work presented in the Project report entitled **"SOIL STABILIZATION USING FLY ASH AND LIME"** submitted for partial fulfillment of the requirements for the degree of Bachelor of Technology in Civil Engineering at **Jaypee University of Information Technology, Waknaghat** is an authentic record of my work carried out under the supervision of **Dr. Rishi Rana**. This work has not been submitted elsewhere for the reward of any other degree. I am fully responsible for the contents of my project report.

Signature of Student

Ishan Singa (191611)

Department of Civil Engineering

JUIT, Waknaghat

Date:

CERTIFICATE

This is to certify that the work presented in the project report titled "**SOIL STABILIZATION USING FLY ASH AND LIME**" submitted to the Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology in Civil Engineering is an authentic record of work carried out by Ishan Singa under the supervision of **Dr. Rishi Rana.** To the best of my knowledge, the preceding statement is correct.

Date:

Signature of Supervisor

Dr. Rishi Rana

Assistant Professor (SG)

Department of Civil Engineering

JUIT, Waknaghat

ACKNOWLEDGEMENT

The success and final end of this project necessitated a great deal of direction and assistance from many people, and I am extremely fortunate to have received it all as part of the project's completion. I owe everything I have accomplished to their oversight and help, and I would like to express my gratitude.

I would like to express my sincere gratitude to Dr. Rishi Rana (Assistant Professor SG) for their valuable guidance and kind supervision throughout the project.

ABSTRACT

Soil stabilisation has emerged as a critical topic in building engineering. The number of studies on the effectiveness of utilising chemical wastes is steadily growing. Soil stabilisation is the process of improving the bodily qualities of soil in order to increase its toughness and durability, and so on by combining or combining with chemicals. Soil stabilisation methods include: soil stabilisation using coconut coir fibres, soil stabilisation with jute fibre, and soil stabilisation with fly ash and lime. When the soil stabilisation method is used in construction, the overall cost is lowered when compared to the conventional method of construction.

The primary goal of this study is to investigate the usage of chemicals that act as stabilisers such as fly ash and lime in geotechnical applications and to analyse the consequences of these chemical elements on the load capacity of unsaturated soil using California soil testing. Bearing ratio studies on soil samples with two distinct chemical stabilisers. The results for these two stabilisers are compared, and conclusions are reached about the usage and efficiency of fly ash and lime as a cost-effective foundation replacement. With this in mind, an experimental investigation on soil samples combined with varied percentages is carried out using fly ash and lime.Soil samples are produced at their maximum dry density, matching to their optimum moisture content, for California Bearing ratio (CBR) and standard proctor test (SPT). The percentages of fly ash and lime by dry weight of soil are 5%, 10%, 15%, and 20%, and CBR and SPT tests are performed in the laboratory for each stabiliser concentration.

The addition of fly ash and lime reduces building costs, resulting in the economy of foundation and roadway construction. In this section of my study, I will explore how chemical stabilisers such as fly ash and lime can boost soil carrying capacity to make it acceptable for any structure at a low cost of stabilisation.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER – 1

INTRODUCTION

1.1GENERAL

Soil is described as the aggregation containing flaky substance formed through rock disintegration (physical or chemical), as well as air, water, biological materials, and other substances that may be present. Uneven, porous material known as soil earthy engineering-behaving materials are impacted by moisture content and density fluctuations. The dirt on-site is not always suitable for construction. It may be weak or compress excessively under the effect of a load. In such cases, it is preferable to transfer the facility or change the soil structure, therefore stabilising the soil. The technique of stabilising soil enhancing the technical qualities of weak dirt by applying various stabilising agents. Stabilisation is described as a modification or conservation of one or more dirt qualities in order to better a dirt's engineering features and performance.

1.2SOIL STABILIZATION AND ITS NEED

The role of soil is crucial part in the design and construction of a building, a bridge, or a road, a runway, or a railway track. This is due to the fact that it functions as a medium for the successful burden transfer into the dirt. This implies that a poor dirt foundation will ultimately compel the structure to collapse resulting in failure. The practise of improving the technical properties of the dirt prior to construction is known as stabilisation. It is a procedure that transforms a dirt's physical properties to offer long-term irreversible strength benefits. Stabilisation is done to improve dirt capacity and shrink swelling potential are increased, hence improving the load-bearing ability and overall safety of dirt. Dirt stabilisation is a process for refining and improving dirt technical features. These properties include mechanical strength, permeability etc.

Stabilised dirt provide a stable working platform that serves as the basis for all other project components. Weak dirt can be improved after stabilisation measures by the establishment of permanent pozzolanic reactions. That is, soils are not prone to leaching and have significantly reduced permeability, resulting in less shrink and higher freeze-thaw resilience. Furthermore, dirts that have been stabilised have undergone some alteration. In other words, the soil has altered physically, making compaction simpler and decreasing flexibility. Easier compaction facilitates reaching maximal dry density. The plasticity index is a fundamental geotechnical statistic that takes into account the critical water content of dirts. When their sturdiness is reduced they become more soft and practical. The following are the reasons for soil stabilisation:

- In the case of low-cost highways, to strengthen sub-bases, bases, and sometimes surface courses.
- To reduce the cost of road and building construction.
- Using lesser grade locally available soils/materials. (Whenever if the required or mandated power cannot be found in the local material dirt stabilisation treatments can be utilised)
- To ameliorate unfavourable dirt qualities such such as excessive swell or shrinkage, high plasticity, compaction issues, and so forth.
- Increased carrying capability and settling.
- Reduce settlement and, hence, compressibility.

1.3METHODS OF SOIL STABILISATION

Soil stabilisation comes in numerous forms, but the two most common are as follows:

1. Mechanical Soil Stabilization

2. Chemical Soil Stabilization

All of the soil stabilisation methods are detailed in full below.

1.3.1 MECHANICAL SOIL STABILISATION

It is the technique of modifying the fleck area spreading and flexibility of soil by adding or withdrawing different soil components to alter its bodily properties. Mechanical stabilisation is the modification of dirt porosity and interparticle friction or interlock. The two processes work together to stabilise the dirt. Physical and mechanical dirt stabilisation processes include settling,oil-infused, dewatering cycles, reinforcing, and solid waste. Compaction is a typical dirt stabilisation technique that uses mechanical procedures to expel air cavities within the dirt mass, allowing the dirt to absorb load without further immediate compression. Oil infused is a primitive practise that was once employed to reduce dirt swelling by soaking the dirt and creating a moisture-rich environment, which causes the soil to absorb water and swelling, causing construction heave. Fundamentally, saturation causes the soil to swell such that subsequent wetting does not result in detrimental heave since the soil maintains a consistent volume at extremely high moisture content. The following are some points on physical and mechanical soil stabilisation:

- The constituent materials' mechanical strength and purity
- The amount of supplies in the overall mixture and their class
- The amount to which dirt adsorption takes place
- The combining, moving, and compact treatments utilised in the field
- Weather and surroundings.

Figure 1.1 Mechanical Soil Stabilization

1.3.2 CHEMICAL SOIL STABILIZATION

Chemical solutions are another common type of dirt stabilisation. All of these methods rely on adding new material to the dirt, which will chemically and physically react to it, altering its properties. Because of the challenges in distributing anhydrous stabiliser among cohesive clays and because bigger granular particles can be trapped and coated by the cement paste, cement stabilisation is most successful on low cohesion soils.

Many particles in dirts that are cohesive, on the other hand, are smaller than dried cement flakes and hence more difficult to cover. Several methods of dirt stabilisation rely on chemical additives of some kind you'll frequently come across compounds that use cement, lime, fly ash, rice husk ash, or brick dust. Depending on the type of dirt present at the area under research, the bulk of the reactions sought are either cementitious or pozzolanic in nature. Calcium and magnesium oxides and hydroxides, for example, are found in lime, with commercial manufacturing options including calcination of carbonate rock minerals for high calcium limes or as dolomitic limestone. Calcium and magnesium oxides are formed during pressure hydration.

Figure 1.2 Chemical soil stabilization

1.4 FLY ASH

Fly ash is a tiny grey dust made up mostly of oval, shiny parts generated by coal-fired power stations. Because fly ash has pozzolanic properties, it reacts with lime to produce cementitious compounds. Fly ash is a burn byproduct made up of fine particles that rise with the flue gases. Bottom ash is ash that does not rise to the surface.

Composition of fly ash is given in the table mentioned below.

Table 1.1: Composition of fly ash

CHEMICAL COMPOSITION	FLY ASH (%)	LIME (%)
carbon	23.29	0
calcium oxide	3.10	91.99
silicon dioxide	36.10	3.75
aliminum oxide	25.03	2.09
ferrous oxide	8.66	0.50
magnesium oxide	1.24	1.19
sodium oxide	0	0.43
sulfur trioxide	0.59	0.05
titanium dioxide	0.91	0
potassium oxide	1.08	0
TOTAL	100.00	100

Several studies have revealed that fly ash reduces the flexibility index of organic dirt while increasing the liquid and plastic limits. As a result of adding fly ash, the dry density of the fly ash dirt mixture increases dramatically, while the water demand decreases.

Figure 1.3 Fly Ash

1.5LIME

It comes in the form of a white powder made largely of oxides and hydroxide which has been satisfied with water. Lime is widely utilised in construction and engineering products. It is obtained from rocks and minerals, most notably limestone or chalk.

Lime, often known as consumable lime or quicklime, is a white, burning, crystalline powerful substance that comprises calcium oxide (CaO).

Figure 1.4 Lime

CHAPTER – 2

LITERATURE REVIEW

Needhidasan et al. (2019) Soils are challenging because of the performance of clay constituents, which have the ability to demonstrate unfavourable technical traits as in poor bearing capacity, The different characteristic of the dirt makes it unsuitable for technical use in its native state, therefore dirt stabilisation can be done physically or chemically to improve its engineering quality and make it more usable. For a long time, dirt stabilisation has been accomplished by applying mixes. An experiment was carried out to investigate the both individually and collectively impacts of admixtures, admixture one and admixture two on the geotechnical features of problematic dirts First, problematic dirt is combined with four percent and eight percent admixture one, followed by ten percent admixture two plus four percent admixture one and ten percent admixture two plus eight percent admixture one. Results show that putting admixture one instead of admixture two in various percentages to problematic soils reduced the liquid limit, plastic limit, while growing the maximum dry unit weight and dirt's admixture strength. The plasticity features, ideal moisture content, and differential free swell index with admixture-filled voids are reduced, whereas the maximum dry unit weight and therefore strength of dirt admixtures grows when compared to ideal dirt.

Pagadala et al. (2019) Water characteristics in dirt is a typical challenge in dirt stabilisation today. Dirt is difficult to design or manufacture because of its less bearing capability, more shrinkage properties, . Stabilisation of the dirt is a common practise for increasing its strength. The physical properties of the dirt were determined using IS standards. It is a finely divided accumulation created by the combustion of the earth or crushed coal in power plants. It has a high water-holding capacity. Admixture one is readily available in a short distance for the inquiry. Dirt was tested without changes to find the right liquid and plastic limits,. Various amounts of admixtures were applied.

Songyu et al (2019) Treatments with admixtutre one and admixture two, admixture one minimise problematic soil from swell. The free swell, decreased as the admixture one and admixture two content increased. As curing time grew, the swelling pressure of admixture one and admixture two treated dirt decreased. As the admixture one and admixture two content increased, along with the correct water content and top dry unit . There are low changes in compressive strength as the admixture one gets higher without curing. The use of admixture two greatly improved its strength. The best admixture one percentage for treated dirts with a seven day curing time is found to be nine to twelve percent.

Patil et al. (2020) I conclude in this research that the application of admixture one and admixture two in dirt result shows significant change in index characteristics. It also contributes to dirt stabilisation. With the help of this dirt stabilisation, the swell behaviour of problematic dirt is reduced. Admixture two and admixture one are combined with problematic dirt mixing admixture two raises the plastic limit whereas mixing admixture two lowers the liquid limit. It is determined that admixture one can be employed in building of civil engineering that when mixed with five percent it becomes more effective.

Kumar et al. (2020) An attempt was made in this work to improve the properties of clay rich dirt by mixing easily available admixture one and admixture two, it could be used as a sub-dirt. The addition of three percent admixture two and thirty percent admixture one by weight of dirt improved the california bearing ratio values greatly. The wet california bearing value of clayey dirt (after four days of curing) was discovered to be two percent. After eight days of wet curing in air with a further four-day submerging (total 12 days curing), soil treated with thirty percent admixture one and three percent admixture two by weight increased the submerged california ratio to fifty five point eight percent.

Hussein et al. (2020) According to this research report subsoil dirt is so important in road construction, insufficient subsoil may result in not enough support for the road and could shorten its life. To improve the qualities of the road, the subsoil with poor qualities should be replaced with a strong soil, which is pricy. Given this, it may be important to improve the poor subsoil properties on-site by combining it with various addition materials and stabilising it. The purpose of this study was to improve the features of a sample subsoil by stabilising it with three separate addition materials of different quality and volumes. This was achieved by using three percent portland cement and six percent lime and ten percent fly ash . The results of different test like Unconfined Compression Strength and California Bearing Ratio showed that stabilising the subsoil with different ratios of those agents improved the subsoil's mechanical capabilities.

Khatun et al. (2020) Admixture one and admixture two dirt treatment results in terms of pores and void percentage response.The tests in the lab were carried out on clay with low plasticity and sand with poor grade. Three different admixture two content one percent, three percent and five percent were investigated for treatment purposes. After mixing the dirt with the additions, a reaction period of between three and fourteen days was allowed for both admixture to link with dirt particles. The combination of both admixture reduces the plasticity index of problematic soil, according to the results of the tests.The permeability of the admixture treated problematic dirt decreases to fifety eight to ninety two percent and sixety eight to ninety five percent respectively, after a 14-day reaction period. This reduction is thirty to eighty four percent for problematic dirt and fifety five to ninety five percent for both admixture treated dirt under similar testing conditions. The difference in ratio of void pattern with additions shows that problematic dirt forms better with admixture . admixture one has been shown to be better than admixture two in lower problematic dirt pores in dirt between five to thirty percent . The results indicate that the selected additives are successful in stabilising both low problematic dirt and poorly graded problematic dirt, allowing these types of dirt to be used as protection materials for water bodies.

Ansary et al. (2020) The use of admixture one has been studied in order to determine the toughness capabilities of stabilised dirt borrowed from two locations . The current study analysed compressive strength properties, and flexion factors. A compaction gadget was used to determine the toughness of the stabilised dirt. After 28 days of cure, the specimens were tested for strength. The admixture under considered was fly ash with lime; the admixture two content was set at three percent, with the admixture one content set at zero ,six , twelve, and eighteen percent. The results of the study show that adding more admixture one improves the capacity of admixture one admixture two stabilised dirt. The combo of admixture one and admixture two offered greater power and may have been cheaper to use. For both marine soils, the compressive strength of admixture one and admixture two treated samples grew dramatically as compared to untreated samples, depending on additive dose and curing age. Depending on the additive amount, toughness and a material's grew dramatically when compared to untreated samples. When flexural strength and flexural modulus of admixture one treated samples were compared to untreated samples for both dirt, they grew by roughly four point six and four point seven times and three and four point times, respectively. It was feasible to identify that the seaside dirt studied would benefit from admixture one stabilisation for road construction.

Yong et al. (2020) Admixture one and admixture two have frequently been employed to reduce the thickness of problematic dirt . Using lab experiments, scanning electron microscopy , and x ray diffraction , this study studied the stabilising effect of admixture one and admixture two on problematic dirt. Before and after stabilisation, the parameter mechanical features, mineral content of problematic dirt got compared. The experiment reveal that adding five percent admixture two based on admixture two reduces the problematic dirt's normal weight by sixety four point nine percent the increase in volume ratio to almost ten percent, and the unloaded increase in volume ratio to nearly four percent, and the stabilised dirt no longer exhibits the problematic feature.The compressive and tensile strengths of the stabilised dirt increase first, then decline as the admixture one content increases. The unconfined compressive and tensile strengths both increase significantly after the addition of five percent admixture two. The best modifier combination ratio is ten percent admixture one plus five percent admixture two. Images show that the ferrite of the stabilised problematic soil range from irregular flake structures to blocky structures, and the compactness of the dirt sample is improved. According to the x ray diffraction data, quartz is the major component of the stabilised dirt. These are the root causes of the increase in strength. The study's findings can be used for engineering design and construction of problematic dirt.

Mohajerani et al. (2021) A five-part experimental design was used in the investigation. First, studies were conducted to determine the appropriate quantities of admixture one and microbes based on their impact on dirt's capacity for growth. Part 2 studied the time-related capacity of stabilised dirt using samples prepared over a twenty eight day curing period. Part 3 looked at the effects of admixture assimilation in biological admixture one . Part 4 of the study includes organic and tiny imaging studies on the samples to better grasp the stabilisation process of the admixture one based dirt stabilisation along with secondary data. Part 5 studies the use and benefits of the combination studied in the study. Low metabolism levels (1:500 1%) are suitable to reduce the activation energy needed to fast start the pozzolanic reaction and gain maximum power in four days, compared to twenty eight days in dirts stabilised with fifteen percent admixture one .

Cokca et al. (2021)) For this investigation, highly plastic dirt samples were taken. As chemical stabilisers, hydrated admixture two or admixture one were used. The dry weight of the problematic soil samples was taken into account while mixing them with a stabilising agent admixture one with one percent, three percent , five percent , seven percent and nine percent admixture two with content five percent, ten percent, fifteen percent, twenty percent, and twenty five percent. Laboratory tests were conducted to determine the technical qualities of the improved dirt samples. This work examined the changes in engineering qualities, particularly the increase in volume and toughness strength. Normal weight, change in height, and submerging the sample were discovered to have correlations. The successful admixture one concentration ranged from four to five percent for lowering the liquid limit and normal weight, whereas a permissible increase in volume required approximately eight percent admixture two. In moderate proportions twenty to twenty five percent, admixture one did not improve the swelling properties of plastic clay.

Chen et al (2021) In this study, I show how, when admixture two and admixture one concentration increased, alkaline saltwater dirt stress-strain graph shifted strain softer to strain hardness. Simultaneously, a strain corresponding to a dirt's peak deviatoric stress was changed. The outcomes of the testing shown that the modest amount of admixture one may improve the pH of saltwater dirt's highest variance and the friction angle, admixture two inclusion Carbonate saline dirt's highest deviatoric stress, unity and inner friction angle have been dramatically enhanced. Admixture two played an important role that enhance the shear strength of alkaline saltwater dirt when admixture two and admixture one were applied.

OBJECTIVES

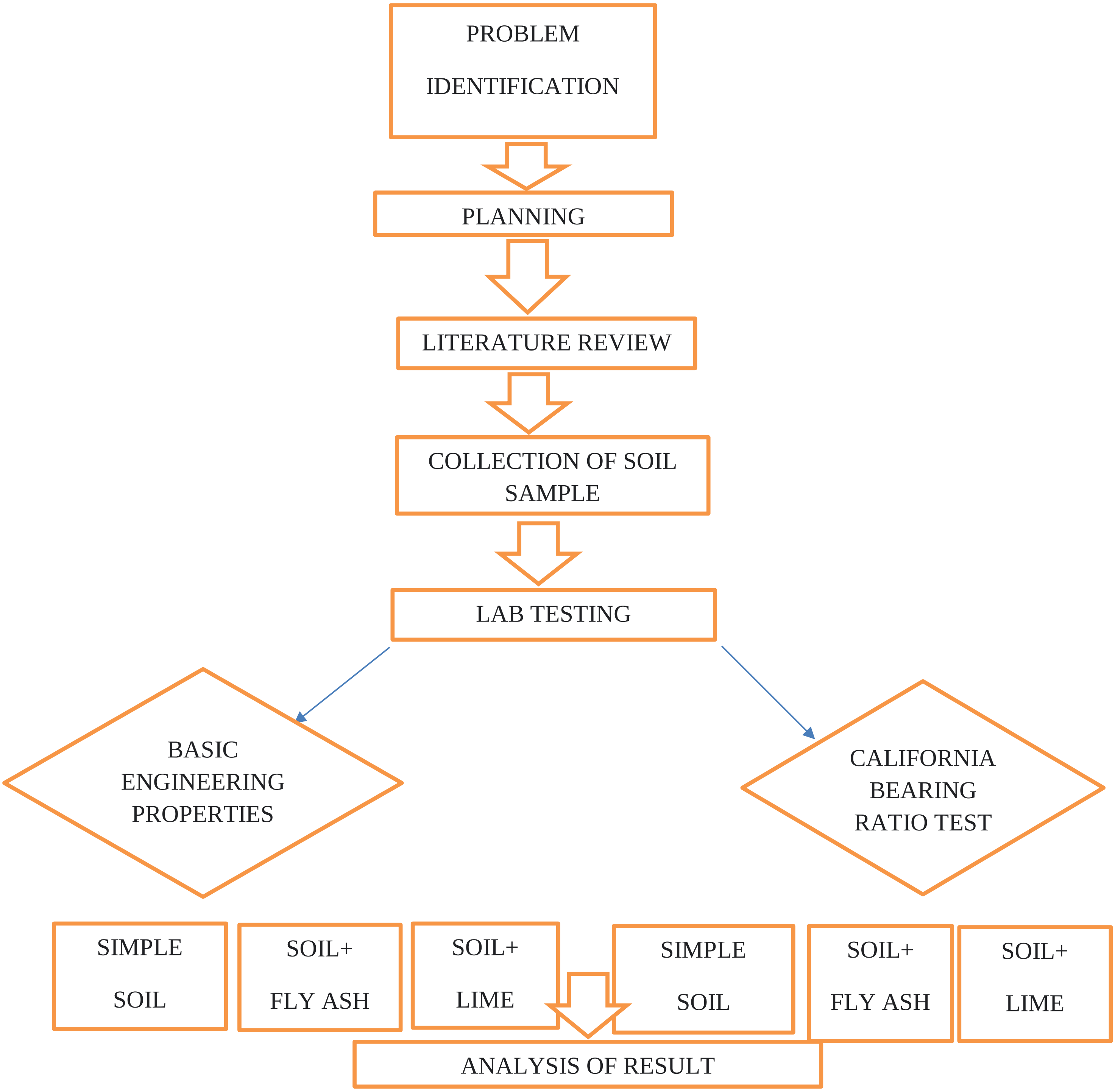
- Identifying soil technical features
- To examine the role of fly ash on soil technical behaviours.
- Comparison of fly ash and lime as soil stabiliser.

CHAPTER – 3

METHODOLOGY

3.1 GENERAL: In this chapter, I divided my project into distinct phases based on the literature studies I conducted and ran various lab tests to validate my study, and the findings of the lab tests were also analysed at the conclusion.

3.2 FLOW CHART REPRESENTING ADOPTED METHODOLOGY



3.3 COLLECTION OF SAMPLE

A soil sample was collected from Domehar Vvillage in Waknaghat, where the soil is in poor condition. The soil was crushed down to remove lumps, and all unnecessary waste was carefully picked out and cleaned.

3.4 APPLICATION OF FLY ASH AND LIME

3.4.1 Fly Ash

Fly ash is a molten mineral residue that is recovered through electric precipitation following the combustion of coal in a thermal power plant. It comprises alumina (Al2O3), silica (SiO2), and calcium oxide (CaO) and has cementitious qualities as well as acting as a binder. I used several percentages of fly ash in the soil, such as 5%, 10%, 15%, 20%, and 25%, and ran various tests on it, including specific gravity tests, plastic limit tests, liquid limit tests, standard proctor tests, and California Bearing Ratio tests.

3.4.2 Lime

Lime is an inorganic calcium-containing substance made mostly of oxides and hydroxide, most commonly calcium oxide and calcium hydroxide.It is also the name given to calcium oxide, which is found in coal seam fibres and altered limestone xeonliths in volcanic ejecta. I added lime to the soil in various percentages, such as 5%, 10%, 15%, 20%, and 25%, and then tested it for specific gravity, plastic limit, liquid limit, standard proctor, and California Bearing Ratio.

3.5LIST OF TESTS PERFORMED

1. Sieve analysis
2. Specific gravity test
3. Liquid limit test
4. Plastic limit test
5. Standard proctor test
6. California bearing ratio test.

3.5.1 SIEVE ANALYSIS:

Objective: To locate the particle measurement pattern in soil by sieving.

Theory: The particle research test measures the percentage of each particle proportions in a soil sample, and its outcomes can be utilised for establishing the distribution curve . The data is used to arrange the dirt and predict the way it acts. The range of grain dimension of soils with dimension bigger than zero point zero seven five mm is identified through using a sieve. It is often used to figure out the grain dimension distribution of sand and gravel, but it cannot be used to evaluate the grain dimension distribution of lighter stuff. The technique makes use of sieves made of twisted cables with square openings. We use various types of sieves in relation to the IS code and then run the samples through them to gather different size parts left over from different filters.

Apparatus used: i. Sieves - The following IS sieve size used for the test: 20mm, 16mm, 12.5mm, 10 mm, 4.75 mm, 3.35mm, 2.36 mm, 1.18 mm, 600micron, 300micron, 150micron, 75microns, PAN. **ii.** Balance understandable and clear up to zero pont one percent of weight of test sample.

Figure 3.1 Sieve analysis

Procedure:

1. The sample is dried at room temperature by heating to 100° to 110°C.
2. Before usage, the sieves are cleaned.
3. Arrange the sieves in the following order: smaller opening sieve last, pan, and larger opening sieve on top.
4. The ventilate specimen is measured and sieved with the correct sieves, starting with the biggest.
5. Rotate all of them separately into a fresh surface for not more than two minutes, so that nothing more than a small amount goes through it.
6. The shaking is done manually or with a sieve shaker in a varying motion, backwards and forwards, left to right.
7. Hand pressure is not being used to drive material through the sieve.
8. Lumps of fine material were shattered with moderate finger pressure.
9. During sieving the stuff left on all of the sieve as well as anything that's visible through the net is separately evaluated.

Calculation:

The outcome is calculated as follows:

1. The average percentage by the mass of each specimen going through each sieve, to the near whole integer.
2. The proportion by the mass of the entire material entering each sieve and remaining for a further less sieve, to the closest zero point one percent.

3.5.2 SPECIFIC GRAVITY TEST :

Objective: To find the specific gravity of dirt.

Theory: The soil specific gravity test can be utilised to figure out a material's toughness or grade. At normal temperature the specific gravity of an amount of soil equals the mass or a single litre of filtered water at that exact degree. It also helps with soil categorization and determining other weight-volume metrics including void ratio, porosity, and unit weight.

Apparatus used:

- **i.** Pycnometer of about 1L capacity
- **ii.** Weighing balance
- **iii.** Oven
- **iv.** Glass rod

Figure 3.2 Pycnometer

Procedure:

1. The weight of an empty and dry Pycnometer was recorded as W1.
2. Using a pycnometer and 300g of oven dried dirt, the weight was reported as W2.
3. Fill the pycnometer halfway with water or carefully stir the stuff.
4. Added further fluid to the pycnometer till the toe of the meniscus was nearly at volume mark, and then measured the pycnometer as W3.
5. Emptied and cleansed the pycnometer, then filled it with water to the mark and weighed it as W4.
6. Repeated the above technique 3-4 times.

Figure 3.3 Pycnometer with soil + distilled water

Source: JUIT, Geotechnical Lab

Calculation:

$$Sp.Gravity(Gs) = \frac{(W_2 - W_1)}{((W_2 - W_1) - (W_3 - W_4))}$$

W1= The pycnometer's vacant mass.

W2= The mass of a pycnometer including oven dried dirt.

W3= Mass for a pycnometer plus dry in the oven dirt plus liquid.

W4= Mass of pycnometer plus full liquid .

3.5.3 LIQUID LIMIT TEST

Objective: To identify the dirt's liquid limit.

Theory: The liquid limit is the concentration of water which occurs when the dirt shifts from a plastic to a liquid state. Or it is the level of water where a common tool groove created into ordinary cups of dirt closes at ten mm after twenty five usual blows. At this point, the shear strength of a dirt is restricted. The liquid limit is important for knowing the stress past and basic soil qualities noticed during work. The liquid limit results can be used to estimate the compression index.

Apparatus Used:

i. Casagrande's Liquid limit device

ii. Grooving tool

iii. Balance

iv. Mixing dishes

v. Spatula

vi. Oven

Procedure:

1. Approximately two fifety gm of freeze dry dirt is poured into a cooling dish after being passed through a four twenty five mm screen, and filtered water is added and properly blended into the dirt to produce a smooth mix. The mixture is so thick that thirty to thirty five drops of cup would be needed to close a normal groove of suitable length.
2. Small portion of dirt substance is placed in the vessel and spread with a knife.
3. Trimmed to an area of one cm from the thickest mark, with excess dirt returned in the bowl.
4. With the help of the cutting tool, cut a groove across the middle point of the dirt inside the vessel, resulting in a clear crisp channel of appropriate dimensions eleven mm wide at the top two mm.
5. The cup was lifted and dropped by spinning a handle at two rotations every sec while both sides of the dirt layer met in contact with one another for a measurement of roughly thirteen mm by flowing number of blows n was recorded.
6. To figure out moisture content a typical amount of dirt was eliminated from the vessel.
7. Repeated the procedure further four times for blows that varied from ten to forty with different levels of liquid content.

Figure 3.4 Forming soil paste
Source: JUIT, Geotechnical Engineering Lab

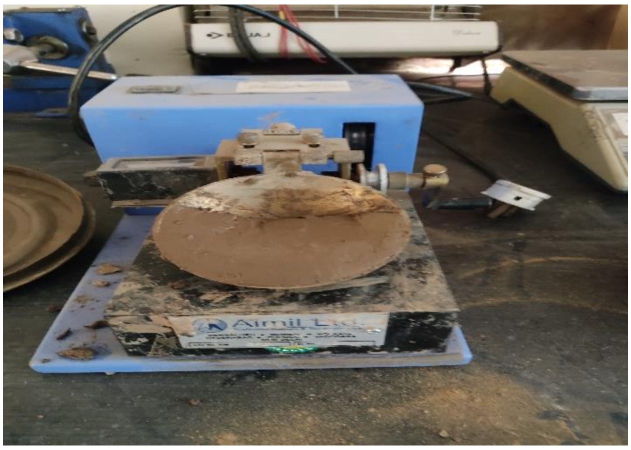


Figure 3.5 Liquid Limit Device
Source: JUIT,Geotechnical Lab

Calculation:

The semi log curve shows the relationship between liquid amount that is on y axis and the number of strokes on the x axis. A resulting curve is referred to as a flow curve. The liquid content of twenty five stokes calculated by the indicates liquid limit typically is rounded to the closest whole value.

WL = (At 25 blows, from a semilog graph of water content vs. number of blows)

W Two minus W one/ log(N one divided by N two) = slope of the flow curve.

3.5.4 PLASTIC LIMIT TEST

Objective: To discover the dirt's plastic limit.

Theory: When rolled into a thread three mm in diameter on a flat piece of mirror or other equivalent area the plastic limit is the moist stage at which a dirt begins to dissolve.

Apparatus Used:

i. 425micron IS sieve

ii. Weighing balance

iii. Glass plate

iv. Air tight container

v. Spatula

Procedure:

1. 1. Pour 20g of air dried soil over a drying dish and pass it through a 425mm mesh Furthermore, purified liquid is carefully blended by the dirt to create an uniform slurry .
2. Squeezing the dirt between fingers yielded several ellipsoidal-shaped soil masses.

3. Roll one of the dirt mounds across the glass plate with your fingertips. The rolling pressure is sufficient to generate an opening with a consistent pitch along the entire distance.
4. We continued rolling until we had a thread with a diameter of 3mm.
5. If the soil did not crumble at 3mm diameter, it was kneed together to make a homogenous mass before being re-rolled.
6. Continued the technique until the thread crumbled at 3mm in diameter.
7. Gathered the disintegrated thread bits for moisture content analysis.

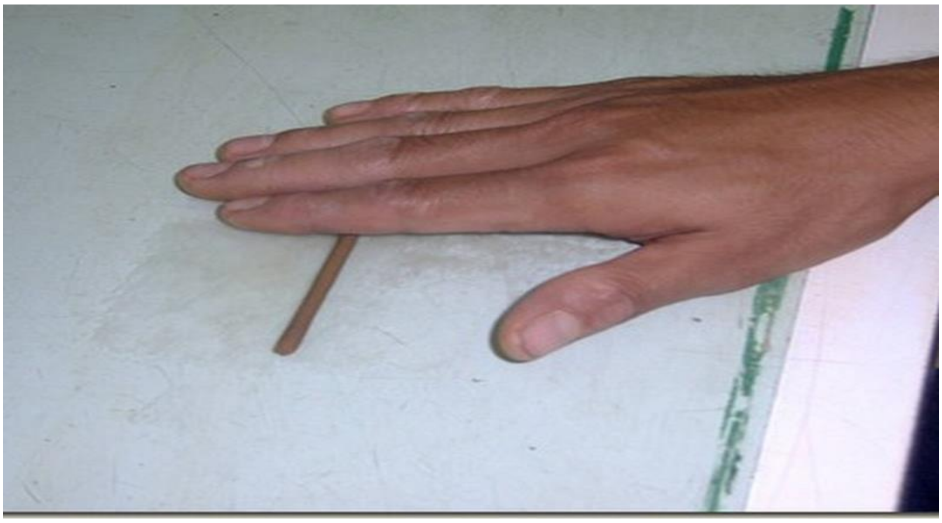


Figure 3.6 Soil mass of 3mm diameter

Calculation:

W one minus W two divide by logten (N two divide by N one) is the flow index, then

W1 = The amount of moisture in percentage comparable to N one drops

W2 = The quantity of moisture expressed as an amount comparable to N two drops

3.5.5 STANDARD PROCTOR TEST

Objective: To discover the best moist level and the highest dry weight of the dirt**.**

Theory: As a tension is put on on the dirt, it causes densification by shifting gas through the spaces across dirt seed. The Proct or's compact investigation is a testing technique to calculate the best level of moisture at which a particular kind of dirt will become biggest and have a highest dry mass or This technique is performed to assess the connection among the level of moisture of the dirt and the dry volume for a particular compactive attempt. Results of this test will be useful in strengthening foundation bearing capacity, and other applications.

Apparatus Used:

- **i.** A 944 cc Proctor mould which has a 10.2 cm inside dia and an 11.6 cm top. The tool has a detachable collar unit and a movable the bottom plate.
- **ii.** Rammer: 2.5 kilogramme mechanically powered metallic rammer with a face diameter of five point zero eight cm. The rammer must be equipped with an appropriate device that keeps the drop elevation to thirty cm free fall.
- **iii.** 15 kg capacity mass with a straight edge, graduated cylinder, and moisture tins.
- **iv.** A sample extruder and mix equipment such as a mixing pan, spoon, towel, and spatula.

Procedure:

1. In the provided pan, collect a typical oven dried specimen weighing around five kilograms. Combine the specimen thoroughly with enough liquid to a moisture level of four to six percent.
2. Weighed the proctor cast before and after removing the base frame and collar. Change the collar and base plate.
3. Placed the dirt in the Proctor casting and crushed it in three layers, using a 2.5kg rammer to strike each layer 25 times. The blows are distributed evenly throughout the surface of each layer.
4. Removed the collar and weighted down a straight edge to cut the settled dirt evenly along the upper side of the mould.
5. Determine bulk density by dividing the compacted sample's mass by nine hundred fourty four cc.

6. Removed a sample from its mould and sliced vertically through to obtain a sample of water content.
7. completely breaking the remaining material until it passes through a no.5 sieve, adding enough water to raise the water content of the dirt specimen by 2-3 percentage and repeating the mentioned operation.
8. Recalculated the moist unit weight of the compacted soil until it dropped or remained constant.

Figure 3.7 Proctor mould with compacted soil

Source: JUIT, Geotechnical Engineering Lab

Calculation:

A graph is drawn to show the relationship between dry density and moisture content.

3.5.6 CALIFORNIA BEARING RATIO TEST

Objective: To locate the dirt's California Bearing ratio.

Theory: CBR for dirt is the ratio of force needed for every region of entering the mass of dirt at a rate of one point two five mm per minute with a usual round plunger of fifty millimetres dia relative to the necessary for equal penetration in a common stuff. This ratio is usually calculated for penetrations of two point five mm and five mm. As the value at five mm is always higher than the proportion at two point five mm it is used. The motive of the exercise is to figure out the subgrade power of roads. To figure out the depth of road and its separate layers the findings of these tests are paired with empirical curves..

Apparatus Used:

- **i.** A circular mould with a middle dia of one fifty mm and an elevation of one seventy five mm, of detachable collar with an elevation of fifty mm or a removable base plate with a thickness of ten mm.
- **ii.** A handle and spacer disc with a measurement of one forty eight mm and an elevation of forty sevent point seven mm.
- **iii.** Metal rammer with a fall of three hundred ten mm and a mass of two point six kilogram.
- **iv.** One ringed metal with the mass two point five kilogram and size one forty seven mm in dia with a fifty three mm dia middle hole.
- **v.** Loading device. With a load of 5000 kilogram and movable top or bottom that moves at a constant rate of 1.25 mm/min.
- **vi.** A metallic penetration pump with at least a dia of fifty mm and a length of hundred mm.
- **vii.** Sieves of four point seven five mm and twenty mm.
- **viii.** Mixing trowels, a drying oven, and filter paper round off the list.

Procedure:

1. First, I took around 6kg of dirt and properly mixed it with the necessary water (optimal moisture content).

2. Connect the extra collar and bottom support to the mould, and then insert the spacer disc on base.
3. The mix dirt was then crushed in the mould in three separate parts using light compaction, with every surface receiving 55 hits from two point six kilogram rammer.

Figure 3.8 Compaction of soil in mould
Source: JUIT, Transportation Engineering Lab

4. Removed the collar and clipped away any excess soil.
5. Flip the mould over and remove the bottom surface and displacer disc.
6. Weighed a mould of compressed dirt to estimate the dry density.
7. Placed the paper filter on the above compacted dirt or clamped the perforate frame to it.
8. Attached the tool equipment and extra weights to the penetration testing device.
9. Placing the penetration pump in sample's centre with as little or no load as possible.
10. Zero out the tension and strain dial gauges. The piston was loaded at a rate of approximately 1.25 mm/min.

11. Load values are measured at penetrations of zero point five, one point zero, one point five, two point zero, two point five, three point zero, four point zero, five point zero, seven point five and ten mm.

Figure 3.9 CBR Testing machine setup

Source: JUIT, Transportation Engineering Lab

Calculation:

A graph is created between penetration load and penetration.

CBR value is calculated as;

$$\text{CBR, \%} = \frac{\left[\begin{array}{l}\text{Load (or pressure) sustained by the} \\ \text{specimen at 2.5 or 5.0 mm penetration}\end{array}\right]}{\left[\begin{array}{l}\text{Load (or pressure) sustained by standard aggregates} \\ \text{at the corresponding penetration level}\end{array}\right]} \times 100$$

The standard load at 2.5mm penetration is taken to be = 1370 kg

and standard load at 5mm penetration is assumed to be = 2055 kg.

CHAPTER – 4

RESULT AND DISCUSSION

4.1 EXPERIMENT RESULT

4.1.1 SIMPLE SOIL TEST RESULTS: Soil was taken from Domehar village, Waknaghat Himachal Pradesh. As soil contains silt, clay and sand.

Other experiments on soil were performed to determine qualities such as bearing capacity, liquid limit, plastic limit, maximum dry density, and specific gravity. The dirt was then subjected to the same experiments with two stabilisers, fly ash and lime, individually. The table shows the results of all of these tests, which were conducted on soil without a stabiliser.

Table 4.1 Values of Different Properties of Soil

S.no	Test performed	Values
1	Liquid limit(%)	33.64
2	Plastic limit(%)	23.06
3	Specific gravity	2.32
4	OMC(%)	14
5	MDD(g/cm3)	2.01
6	CBR @ 2.5mm	0.89

4.1.2 Variation of Specific gravity of soil with different percentages of fly ash and lime

The specific gravity of soil is also determined using different percentages of fly ash and lime, and it is discovered that the specific gravity of soil drops up to 15% and then increases at 20% in both situations. The table and graph below demonstrate how the findings changed at different percentages.

Table 4.2 Impact of fly ash on specific gravity of dirt

S.no	Percentage of Fly Ash (%)	Specific gravity
1.	0	2.32
2.	5	2.05
3.	10	2.13
4.	15	2.22
5.	20	2.30

Table 4.3 Affect of lime on specific gravity of dirt

S.no	Percentage of Lime(%)	Specific gravity
1.	0	2.32
2.	5	2.08
3.	10	2.15
4.	15	2.49
5.	20	2.89

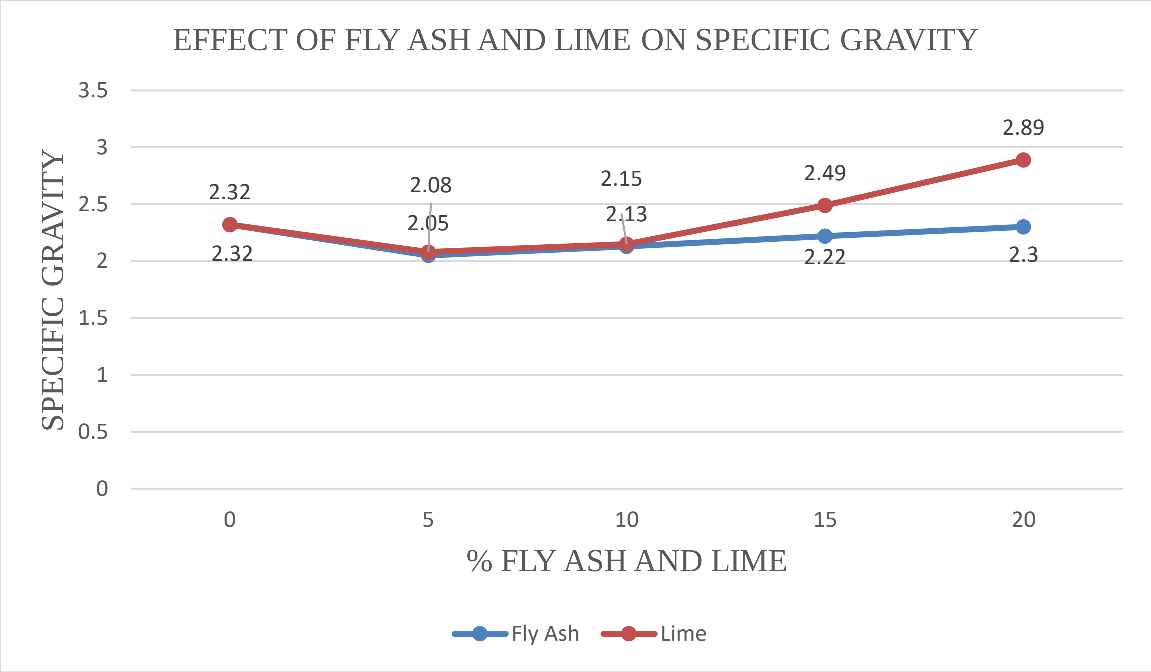


Figure 4.1 Efect of fly ash and lime on specific gravity of soil

4.1.3 Variation of Liquid limit of soil with different percentages of fly ash and lime.

The percentages of fly ash and lime added to the soil were 5%, 10%, 15%, and 20%, and the liquid limit was established at each percentage. It was discovered that the liquid limit first drops with the addition of fly ash and lime, and then begins to increase after 10% addition. The liquid limit findings at various percentages are presented below.

Table 4.4 Impact of fly ash on liquid limit of soil

S.no	Percentage of Fly Ash (%)	Liquid Limit (%)
1.	0	33.64
2.	5	27.45
3.	10	30.78
4.	15	36.64
5.	20	40.81

Table 4.5 Affect of lime on Liquid limit of soil

S.no	Percentage of Lime (%)	Liquid Limit (%)
1.	0	33.64
2.	5	29.87
3.	10	32.43
4.	15	35.51
5.	20	42.75

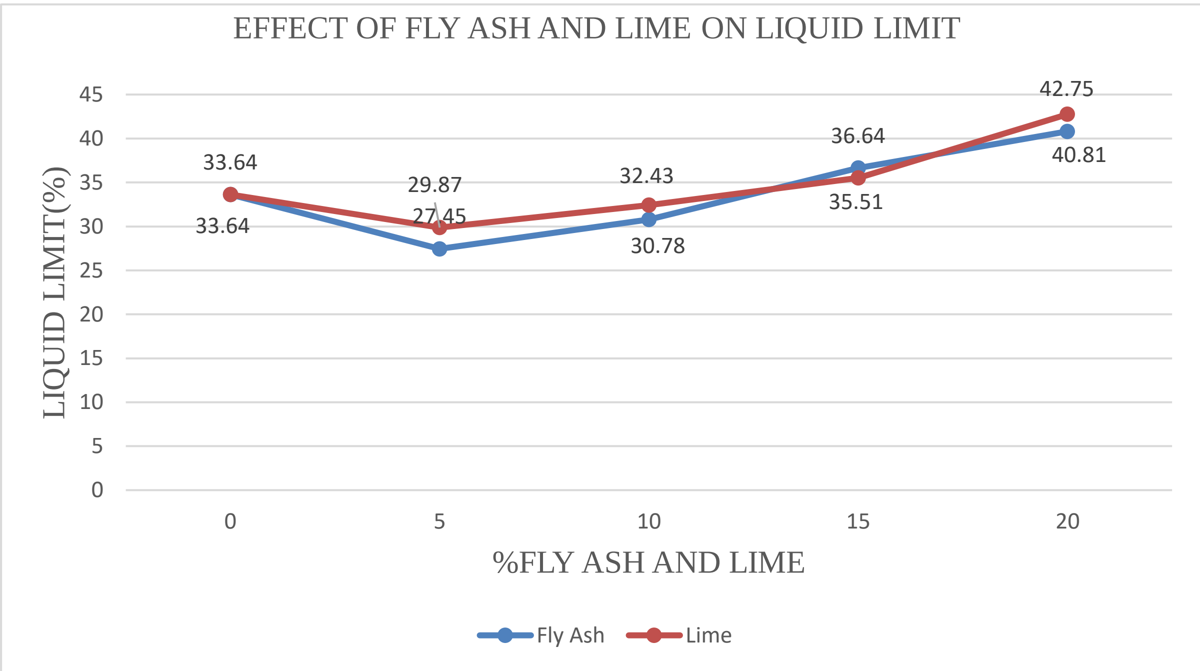


Figure 4.2 Efect of fly ash and lime on Liquid limt of soil

4.1.4 Variation of Plastic limit of soil with different percentages of fly ash and lime

Fly ash and lime were applied to soil in various percentages, and the plastic limit of the soil was established, first at various percentages of fly ash and then at various percentages of lime; in both cases, the plastic limit fell up to 15% and increased at 20%. The general variation was a decrease in plastic limit values compared to the original value of soil plastic limit. The table and graph below demonstrate how the results vary at various percentages.

Table 4.6 Impact of fly ash on plastic limit of soil

S.no	Percentage of Fly Ash (%)	Plastic Limit (%)
1.	0	23.06
2.	5	19.23
3.	10	17.86
4.	15	18.97
5.	20	21.42

Table 4.7 Affect of lime on plastic limit of soil

S.no	Percentage of Lime (%)	Plastic Limit (%)
1.	0	23.06
2.	5	21.65
3.	10	19.43
4.	15	20.05
5.	20	20.42

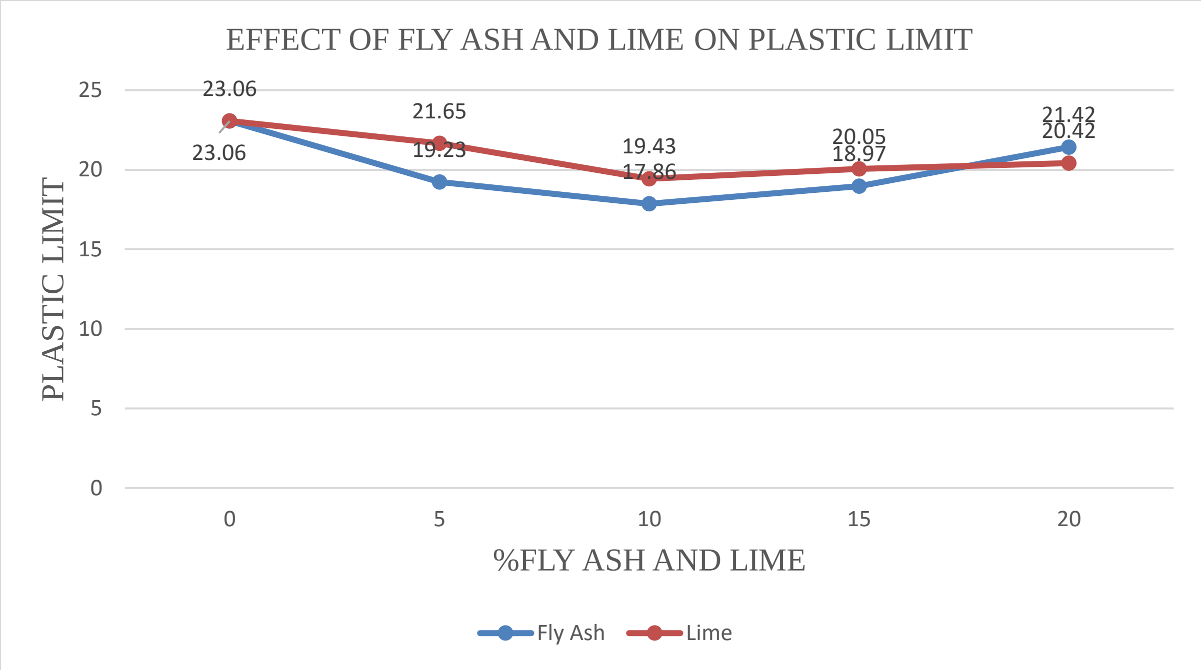


Figure 4.3 Effect of fly ash and lime on Plastic limit of soil

4.1.5 Variation of Optimum Moisture Content (OMC) of soil on addition of different percentages of fly ash and lime

The OMC of soil reduced initially with the addition of fly ash but stayed constant after 10%, 15%, and 20% additions, and it decreased with the addition of lime although the change in decline was minute with respect to the amount of stabiliser supplied. The table and graph below demonstrate how the outcomes differed by % for both scenarios.

Table 4.8 Impact of fly ash on OMC of soil

S.no	Percentage of Fly Ash (%)	OMC(%)
1.	0	14
2.	5	13
3.	10	12
4.	15	12
5.	20	12

Table 4.9 Affect of lime on OMC of soil

S.no	Percentage of Lime (%)	OMC(%)
1.	0	14
2.	5	14
3.	10	12
4.	15	11
5.	20	11

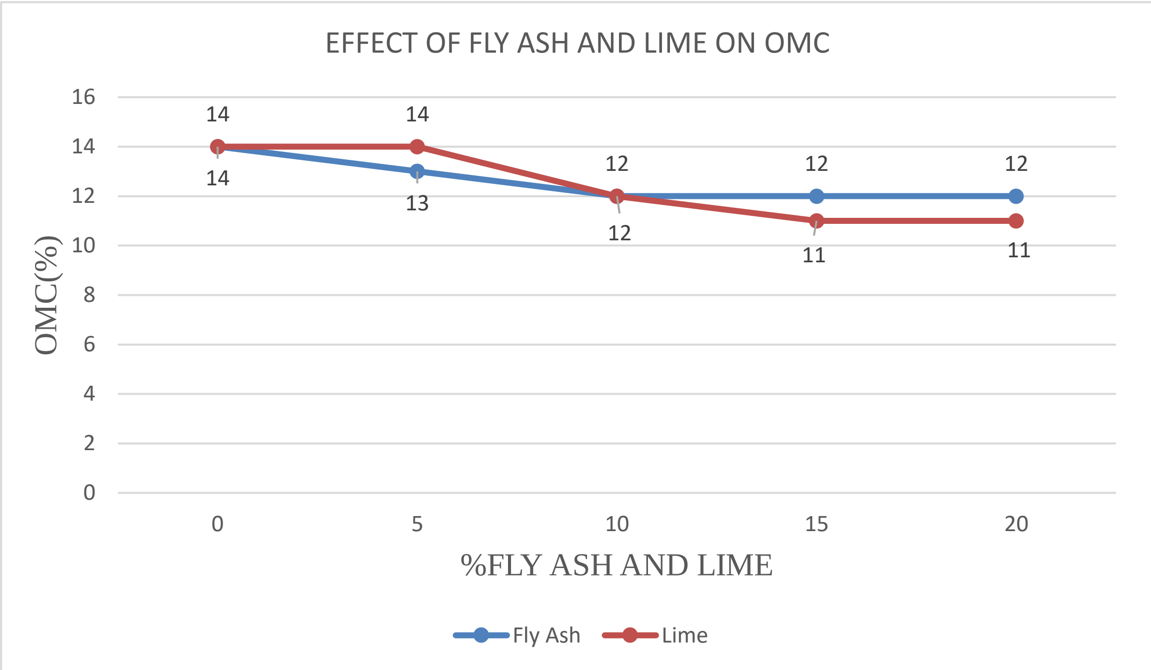


Figure 4.4 Effect of fly ash and lime on OMC of soil

4.1.6 Variation of MDD of soil with different percentages of fly ash and lime.

According to the Standard Proctor test, adding fly ash or lime to soil in various percentages causes maximum dry density to decline up to 15% and then increase, implying that an optimum amount of fly ash and lime should be between 15-20% for best results.

Table 4.10 Impact of fly ash on MDD of soil

S.no	Percentage of Fly Ash (%)	MDD(g/cm3)
1.	0	2.01
2.	5	1.99
3.	10	1.94
4.	15	1.95
5.	20	1.97

Table 4.11 Affect of lime on MDD of soil

S.no	Percentage of Lime (%)	MDD(g/cm3)
1.	0	2.01
2.	5	1.96
3.	10	1.92
4.	15	1.94
5.	20	1.95

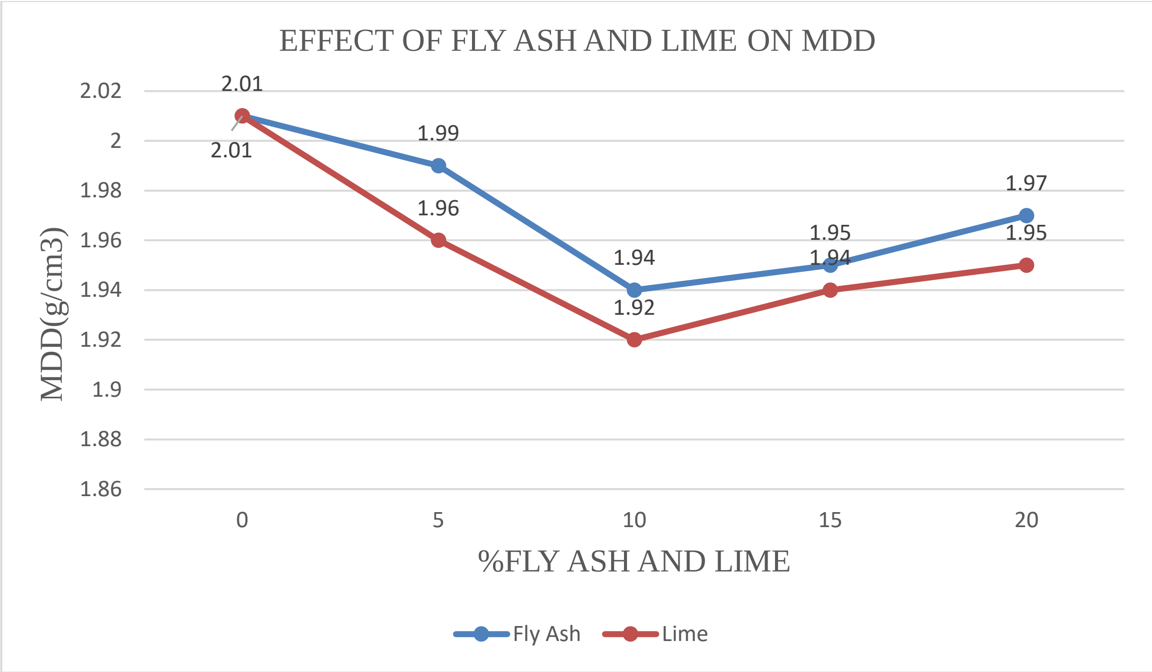


Figure 4.5 Effect of fly ash and lime on MDD of soil

4.1.7 Variation of CBR (@ 2.5mm) of Soil with different percentages of Fly ash and Lime - The purpose was to determine how CBR value fluctuates, and the results revealed an increase in CBR value @2.5mm penetration up to 15% and then drops with additional addition of fly ash and lime, soil demonstrated almost the same trend with the only difference being a higher jump in value at 15%. It occurred as a result of cation exchange in the soil-fly ash mix, in which sodium ions in the soil are replaced by calcium ions in the fly ash, reducing settling and increasing CBR value**.**

Table 4.12 Impact of fly ash on CBR of soil

S.no	Percentage of Fly Ash (%)	CBR @(2.5mm)
1.	0	0.89
2.	5	3.87
3.	10	4.16
4.	15	10.71
5.	20	4.39

Table 4.13 Affect of lime on CBR of soil

S.no	Percentage of Lime (%)	CBR @(2.5mm)
1.	0	0.89
2.	5	2.46
3.	10	3.91
4.	15	12.57
5.	20	3.98

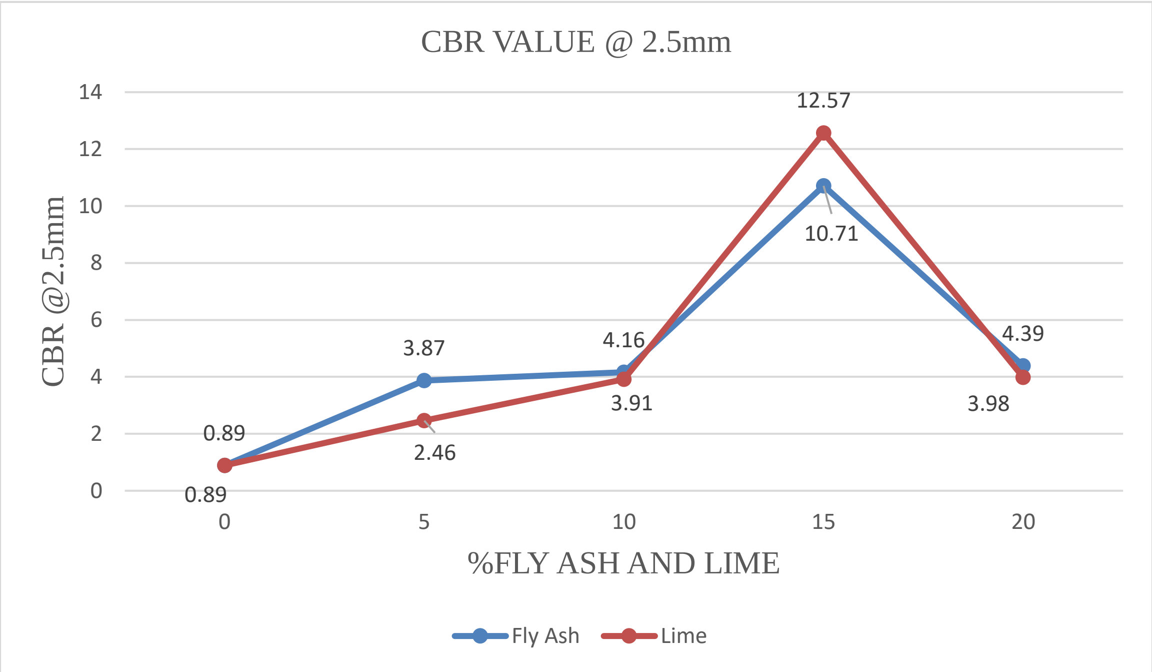


Figure 4.6 Effect of fly ash and lime on CBR of soil

CHAPTER – 5

CONCLUSIONS

5.1 CONCLUSION

The following conclusions can be drawn from the experimental work on soil stabilisation with fly ash and lime:

Specific gravity was shown to drop up to 15% as the proportion of fly ash in soil increased, but it slightly increased after that. A similar pattern was observed with lime addition.

The effect of fly ash on soil liquid limit was unusual, with addition up to 5% resulting in a fall in liquid limit and a progressive increase on additional addition up to 20%, which was even bigger than the original liquid limit of the soil utilised. The same was true with lime.

The soil plastic limit was 25%, and it gradually decreased with the addition of fly ash and lime up to 10%, after which it marginally increased.

OMC decreased by 2% with the addition of fly ash and by 3% with the addition of lime.

Soil MDD was 2.01g/cm3, which dropped to 1.92g/cm3 after 10% fly ash addition and increased slightly to 1.95g/cm3 with additional addition. In the case of lime, the MDD decreased but not as much as in the case of fly ash, with a minimal decrease of 1.94g/cm3 followed by a tiny increase to 1.97g/cm3.

CBR @ 2.5mm for soil was 0.49, increasing to 4.16 with 10% fly ash addition, then a massive rise to 10.71 with 15% addition, although it dropped with additional addition. In the case of lime, there was a linear increase up to 10%, but at 15%, the value increased even more than in the case of fly ash, to 12.57.

As a result, soil with an optimal amount of fly ash and lime (15-20%) is most suited and cost-effective for highway construction.

5.2 FUTURE SCOPE OF WORK

Lime and Fly Ash are both agricultural and industrial waste. Both of them contain a significant proportion of siliceous substance. The lime manufacturing method is based on a chemical reaction caused by heating calcium carbonate ($CaCO_3$), which produces quicklime (CaO). This process will inevitably produce CO_2. These CO_2 emissions, which are inherent in the lime production process, are referred to as process emissions. These process emissions alone account for 70% of overall CO_2 emissions from the lime production process and are unavoidable. Coal-fired power facilities in India generate around 196 million tonnes of fly ash each year. The management of fly ash has thus been a source of worry, given the vast amount of land required for disposal and the potential for pollution of air and water. Although the cement business is heavily utilising, it has hit its utilisation level. As a result, a new region for its disposal is urgently required. One of the finest options for soil stabilisation is to use fly ash. The use of fly ash in bulk in building and soil stabilisation has a lot of potential. NHAI is now utilising 100 lakh Tone fly ash in construction on various NH projects across India, with plans to double it in the future. The application of fly ash in road building includes the following:

- Embankment stabilisation and roadway backfill
- Pavement subgrade stabilisation
- Railway embankment stabilisation.

REFERENCES

[1] Saleh, S. A., & Hussein, S. K. (2020). Effect of Soil Stabilization on Subgrade Soil Using Cement, Lime and Fly. *Eurasian Journal of Science & Engineering*, 39-52.

[2] Andavan, S., & Pagadala, V. K. (2019). Experimental study on addition of lime and fly ash for the soil stabilization. *Materials Today: Proceedings* , 1-5.

[3] Chen, K., Huang, S., & Ding, L. (2022). Improving Carbonate Saline Soil in a Seasonally Frozen Region Using Lime and Fly Ash. *Hindawi Geofluid*, 1-12.

[4] Indiramma, P., Sudharani, C., & Needhidasan, S. (2019). Utilization of fly ash and lime to stabilize the expansive soil. *Materials Today: Proceedings*, 1-7.

[5] Islam, M. S., Islam, T., & Khatun, N. (2020). Permeability Alteration of Low Plastic Clay and Poorly Graded Sand Using Lime and Fly Ash. *Springer Nature*, 1-12.

[6] KALYANE, A., & PATIL, R. (2020). Experimental investigation of Black Cotton Soil by Lime and Fly Ash Stabilization. *Bulletin of Engineering*, 1-6.

[7] Lav, M. A., & Cokca, E. (2021). Improvement of an Extremely Highly Plastic Expansive. *Springer Nature Switzerland*, 1-16.

[8] Renjith, R., Robert, D., Setunge, S., & Mohajerani, A. (2021). Optimization of fly ash based soil stabilization using secondary. *Journal of Cleaner Production*, 1-14.

[9] Phanikumar BR, Sreedharan R, Aniruddh C (2015) Swell compressibility characteristics of lime-blended and cement-blended expansive clays - A comparative study. Geomech Geoeng Int J 10(2):153–162

[10] George S, Ponniah D, Little J (1992) Effect of temperature on lime-soil stabilization. Constr Build Mater 6(4):247–252

[11] Kang X, Kang GC, Chang KT, Ge L (2015) Chemically stabilized soft clays for road-base construction. J Materials Civ Eng. 27(7):04014199

[12] Geiman, C.M. (2005). Stabilization of Soft Clay Subgrades in Virginia Phase-I Laboratory Study, M.S. Thesis, Virginia Polytechnic Institute and State University

[13] Seed HB, Woodward RJ Jr, Lundgren R (1962) Prediction of Swelling Potential for Compacted Clays. J Soil Mech Found Div 88(3):53–87

[14] Kolay PK, Ramesh KC (2016) Reduction of expansive index, swelling and compression behavior of kaolinite and bentonite clay with sand and class C fly ash. Geotech Geol Eng 34:87–101

[15] Skempton, A.W. (1953). The colloidal activity of clays. Proc., 3rd Int. Conf. Soil Mech. Found. Eng., Vol.1, Switzerland, 57–61

[16] Mitchell JK, Raad L (1973) Control of volume changes in expansive earth materials. In: Lamb DR, Hanna SJ (eds) Proc Workshop Expansive Clays and Shales in Highway Design and Construction, vol 2. Federal Highway Administration. Denver, CO, pp 200–219

[17] Wilson SD (1950) Small soil compaction apparatus duplicates field results closely. Eng News Record 135(19):34–36

[18] Su¨t U¨ nver I˙ (2018) Static and Cyclic Properties of Expansive Clays Treated with Lime and Fly Ash with Special Reference to Swelling and Resilient Moduli. Ph.D. Thesis, Istanbul Technical University, Turkey

[19] Mitchell JK, Soga K (2005) Fundamentals of soil behavior, 3rd edn. Wiley, USA

[20] Nelson JD, Miller DJ (1992) Expansive soils: problems and practice in foundation and pavement engineering. Wiley, USA

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY, WAKNAGHAT

PLAGIARISM VERIFICATION REPORT

Date: ....

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

Name: ___________________________ __Department: _________________ Enrolment No _________

Contact No. ______________________________E-mail. ______________________________________

Name of the Supervisor: ____

Title of the Thesis/Dissertation/Project Report/Paper (In Capital letters): ________________________

____

____

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 =
- Total No. of Preliminary pages =
- Total No. of pages accommodate bibliography/references =

(Signature of Student)

FOR DEPARTMENT USE

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

(Signature of Guide/Supervisor) **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

ishan

ORIGINALITY REPORT

15%	8%	8%	6%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to PSB Academy (ACP eSolutions) Student Paper	1%
2	R. K. Goswami, B. Singh. "Influence of fly ash and lime on plasticity characteristics of residual lateritic soil", Proceedings of the Institution of Civil Engineers - Ground Improvement, 2005 Publication	1%
3	Submitted to Universiti Malaysia Perlis Student Paper	1%
4	acikbilim.yok.gov.tr Internet Source	1%
5	"Problematic Soils and Geoenvironmental Concerns", Springer Science and Business Media LLC, 2021 Publication	1%
6	Submitted to University of Teesside Student Paper	1%
7	"Proceedings of the Indian Geotechnical Conference 2019", Springer Science and	<1%

Business Media LLC, 2021
Publication

8	Submitted to University of Wolverhampton Student Paper	<1%
9	"Sustainable Environment and Infrastructure", Springer Science and Business Media LLC, 2021 Publication	<1%
10	www.corrosionpedia.com Internet Source	<1%
11	M. A. Ansary. "Effect of Fly Ash Stabilization on Geotechnical Properties of Chittagong Coastal Soil", Solid Mechanics and Its Applications, 2007 Publication	<1%
12	www.ijeast.com Internet Source	<1%
13	Submitted to Visvesvaraya Technological University Student Paper	<1%
14	B. Sahak, M. Singh, A. Adhikari, S. Hussain. "Sustainable soil stabilization using combination of geotextile, fly-ash and saw dust for pavement subgrade", Archives of Materials Science and Engineering, 2021 Publication	<1%

coek.info

15	Internet Source		<1 %
16	Submitted to Amman Academy Student Paper		<1 %
17	Submitted to Birzeit University Main Library Student Paper		<1 %
18	Rintu Renjith, Dilan Robert, Sujeeva Setunge, Susanga Costa, Abbas Mohajerani. "Optimization of fly ash based soil stabilization using secondary admixtures for sustainable road construction", Journal of Cleaner Production, 2021 Publication		<1 %
19	acta.fih.upt.ro Internet Source		<1 %
20	doaj.org Internet Source		<1 %
21	esolution2010.blogspot.com Internet Source		<1 %
22	openjicareport.jica.go.jp Internet Source		<1 %
23	Goswami, R.K.. "Leaching characteristics of residual lateritic soils stabilised with fly ash and lime for geotechnical applications", Waste Management, 2007 Publication		<1 %

24	Submitted to Wesleyan University Student Paper	<1 %
25	earthsciencesmalaysia.com Internet Source	<1 %
26	Fusheng Zha. "Behavior of expansive soils stabilized with fly ash", Natural Hazards, 12/2008 Publication	<1 %
27	www.mdpi.com Internet Source	<1 %
28	Submitted to Coventry University Student Paper	<1 %
29	mdpi-res.com Internet Source	<1 %
30	Submitted to Universiti Teknologi MARA Student Paper	<1 %
31	www.researchgate.net Internet Source	<1 %
32	Submitted to Jawaharlal Nehru Technological University Student Paper	<1 %
33	Submitted to Liverpool John Moores University Student Paper	<1 %
34	Submitted to Shinas College of Technology	

	Student Paper	<1 %
35	Yuli Shan, Zhu Liu, Dabo Guan. "CO2 emissions from China’s lime industry", Applied Energy, 2016 Publication	<1 %
36	utpedia.utp.edu.my Internet Source	<1 %
37	civilmint.com Internet Source	<1 %
38	globalroadtechnology.com Internet Source	<1 %
39	hdl.handle.net Internet Source	<1 %
40	polen.itu.edu.tr Internet Source	<1 %
41	Nalbantoglu, Z.. "Effectiveness of Class C fly ash as an expansive soil stabilizer", Construction and Building Materials, 200407 Publication	<1 %
42	Qin-yong Ma, Zi-ming Cao, Pu Yuan. "Experimental Research on Microstructure and Physical-Mechanical Properties of Expansive Soil Stabilized with Fly Ash, Sand, and Basalt Fiber", Advances in Materials Science and Engineering, 2018	<1 %

Publication

43	"Geotechnics for Transportation Infrastructure", Springer Science and Business Media LLC, 2019 Publication	<1 %
44	adventuresprocessingcompany.com Internet Source	<1 %
45	ijeit.com Internet Source	<1 %
46	ir.cut.ac.za Internet Source	<1 %
47	link.springer.com Internet Source	<1 %
48	www.fesss.org Internet Source	<1 %
49	www.jstage.jst.go.jp Internet Source	<1 %
50	1library.net Internet Source	<1 %
51	Submitted to Central Queensland University Student Paper	<1 %
52	Submitted to College of Engineering & Technology Bhubaneswar Student Paper	<1 %

53	Pati, S.S.. "CO"2 evolution and enzyme activities (dehydrogenase, protease and amylase) of fly ash amended soil in the presence and absence of earthworms (Drawida willsi Michaelsen) under laboratory conditions", Geoderma, 200402 Publication	<1%
54	Sagar D. Turkane, Sandeep K. Chouksey. "Mechanical performance and stability analysis of moorum embankment partially replaced with fly ash", Journal of Building Pathology and Rehabilitation, 2022 Publication	<1%
55	Z. Zimar, D. Robert, A. Sidiq, A. Zhou, F. Giustozzi, S. Setunge, J. Kodikara. "Waste-to-energy ash for treating highly expansive clays in road pavements", Journal of Cleaner Production, 2022 Publication	<1%
56	base.dnsgb.com.ua Internet Source	<1%
57	core.ac.uk Internet Source	<1%
58	etd.lib.metu.edu.tr Internet Source	<1%
59	media.neliti.com Internet Source	<1%

60	ore.exeter.ac.uk Internet Source	<1 %
61	rmrc.wisc.edu Internet Source	<1 %
62	rosap.ntl.bts.gov Internet Source	<1 %
63	Submitted to ustp Student Paper	<1 %
64	"Foundation Engineering Handbook", Springer Science and Business Media LLC, 1991 Publication	<1 %
65	Z. Zimar, D. Robert, A. Zhou, F. Giustozzi, S. Setunge, J. Kodikara. "Application of coal fly ash in pavement subgrade stabilisation: A review", Journal of Environmental Management, 2022 Publication	<1 %

Exclude quotes	Off	Exclude matches	Off
Exclude bibliography	On		