GROUND IMPROVEMENT USING INDUSTRIAL WASTE

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ABSTRACT

As the population of the country is increasing more and more people are shifting towards the cities and demand for infrastructure is at an all-time high. Due to shortage of adequate subgrade soil, the Engineers are obliged to construct structures on unstable soil. Due to the soil's poor strength and high compressibility, a variety of issues, including slope instability, load-bearing failure, excessive settlement, and total building collapse, may arise. To improve several engineering properties of soil such as bearing capacity, additional materials and different methods are used. These methods include addition of different chemical or pozzolanic filler in different proportions to get optimum engineering properties required for that construction project. Soil stabilization can be achieved through controlled compaction or by using appropriate admixtures, such as fly ash, lime, cement, and rice husk ash. Enhancing the soil's qualities at the construction site is the main objective of this research, so that it can resist the load of the building structure without breaking under its weight. The use of excessive amounts of cement in this procedure is to be reduced, and other materials that can produce the same results are to be explored. Fly ash is one such resource and in many areas it is a more affordable alternative to Portland cement. Thus , some tests are done to identify the maximum dry density, Atterberg limits, maximum shear strength and optimum moisture content of the soil with no additives, one more is to identify the maximum dry density as well as optimum moisture content of the soil with 6%, 8%, 10% fly ash as additive, the results with fly ash and without fly ash are compared to determine the change in the geotechnical properties of soil sample.

KEYWORD : Soil Stabilization, Proctor Test , Maximum dry density , Optimum moisture content , Fly Ash, Sandy Soil

INTRODUCTION

In the current industrial period, factories and industries perform the majority of the manufacturing job. Whether it be clothing or building supplies, industries make everything. India generates a sizable amount of various waste products as a result of many industries, including industrial, agricultural, etc. Pollution and the generation of solid waste were two significant issues that emerged as a result of industrialization. Soil stabilization is any process that improves the physical properties of soil, such as increasing its shear strength or load carrying capacity. This can be achieved through controlled compaction, the addition of suitable admixtures like cement, lime, and waste products like fly ash and rice husk ash, or both. By producing valuable material from non-useful waste materials, this novel strategy of soil stabilization might be used to tackle societal difficulties and reduce waste production. This practice is being used from ancient time, for example Romans used lime as a binding material and used volcanic ash to create a strong and durable building material. The enhanced soil can be used in construction of roads, buildings, airports, etc. As the

rapid industrialization is happening waste products released from industries causes severe air, water and soil pollution which causes harm in the atmosphere and causes imbalance in earth's climate. Disposal of these waste needs a real solution and hence using it in soil stabilization in construction industry is beneficial for both environment and economy of the project. Therefore
many of these waste material can be used for enhancing the geotechnical properties of soil.

Many industrial wastes, such as fly ash (FA), ground granulated blast furnace slag (GGBS), marble powder (MP), cement kiln dust, quarry dust, etc., are used in the current day due to significant demand and financial restrictions of the project. The RHA (Rice husk ash), bagasse ash and chicken-eggshells are just a few examples of agricultural and farming waste. The geotechnical qualities of the soil can also be improved by using some fiber materials as , coir fiber, and polypropylene fiber. When coal is burned in the industries Fly ash is formed as a byproduct, beneficial elements including calcium, magnesium, and potassium are present in fly ash and can assist increase soil fertility. Additionally, it has a high pH value, which can aid in balancing acidic soils. Fly ash can also enhance soil texture and water retention due to its tiny particle size. Burning of rice husk, a waste product obtained from processing of paddy in rice mills produces rice husk ash (RHA). Lime is used to increase load bearing capacity of the soil on construction sites, quicklime is used to dry moist soil which reduces downtime and improve the working surface.
In this study Fly Ash is being used for soil improvement and several tests like Atterberg's limit, Particle size analysis, Standard proctor test has been done to study the change in characteristics of soil sample
for different proportions of Fly ash added has been studies and reviewed.

LITERATURE REVIEW

In recent years, a number of studies have been done on the stabilization of soil using industrial waste. The purpose of this study is to utilise waste products from diverse sectors to discover a cost-effective and sustainable solution for soil stabilization.
One such study which examined the use of fly ash, a waste product from coal-fired power stations, for soil stabilization was published in the Journal of Hazardous Materials in 2018. The scientists discovered that fly ash could strengthen the soil in an efficient manner, cause reduction in its plasticity and thus it stabilizes soil. Additionally, they discovered that fly ash might be utilised as a sustainable substitute for conventional stabilization techniques by combining it with various types of soil.
A different study which involved the use of steel slag, a byproduct of steel industry could also be used for soil stabilization was published in the Journal of Materials in Civil Engineering in 2019. The scientists discovered that soil's mechanical properties, such as its strength, stiffness, and deformation characteristics, could be significantly improved by steel slag.
A research into the use of waste marble dust for soil stabilization was published in the Journal of Cleaner Production in 2020. Leftover Marble dust of the marble industry may be utilized as a sustainable substitute for conventional stabilization techniques and could effectively increase the strength and stability of soil.
Overall, studies on the effectiveness and sustainability of soil stabilization utilization industrial waste have produced favourable results. This strategy can minimize waste, enhance soil quality, and provide a cost-effective method for stabilizing soil by utilization waste products from diverse sectors.

Moreover, the review of old techniques used in previous research has been listed below:

Ashiq et al (2022)

In this project, clays from the Upper Siwalik Formation, which are found in a subtropical region with an average annual rainfall of 297 mm, will have their engineering qualities improved. Utilizing industrial waste glass powder (IWGP) is part of the strategy. The experimental results showed that the UCS (110%), un-soaked (67%), and soaked (300%) CBR values all improved most when 20% IWGP was added.

Lakshmi et al(2021)

Industrial wastes including ground granulated blast furnace slag (GGBFS) and rice husk (RH) ash were used to strengthen the locally accessible clayey subgrade soil in the Vembakkam region of Thiruvannamalai district, Tamil Nadu. The most appropriate percentages of GGBFS and RH ash were found to be 30% and 20%, respectively, using the unconfined compressive strength (UCCS) test and soaked CBR test.

Ram et al (2018)

Examining the use of leftover marble dust in geotechnical applications and determining how marble dust affects unsaturated soil's OMC, MDD, and CBR values using the Standard Proctor Test and CBR test on various soil samples are the main goals of this study. At a 15% addition of marble dust, the OMC increased by 22.39%. The optimal proportion of marble dust was discovered to be 15%, which caused the CBR value to grow from 2.36% to 14.86%. As the percentage of marble dust in the soil raised so did its CBR values.

Seth et al (2019)

In this research experiments were performed with 5%, 10%, 15% RHA and 6% cement as an additive to an soil sample . CBR values of soil specimen shows that the bearing capacity of soil specimen was improved from less than 3% (0.92%) to 3.1%. The outcomes also showed that the soil's shear strength had increased to 1.01kg/cm2 from initial 0.75kg/cm2.

Sharma and Hymavathi (2016)

The use of C&D (construction and demolition) debris in the soil stabilization is the primary topic of this study. To analyze the effect of adding FA, C&D waste, and lime, numerous tests were carried out, including pH, differential free swell, compaction, UCS as well as CBR. The findings indicated that Fly Ash has a higher UCS at 28 days than lime or C&D waste.

Singh et al (2014)

In this study, an effort has been made to enhance the inadequate geotechnical properties by mixing admixtures, such as sand, fly ash (FA), and tile waste in the proper quantities. The results of the experimental research show that the finest ideal mixtures are :
soil:sand::70:30,
soil:sand:FlyAsh::63:27:10and
soil:sand:FlyAsh:Tilewaste::63:27:10:9

- **Ray et al (2019)**

This study states that the places which have extensive deposits of clayey soil, need to be pre-treated before any construction project. Fly Ash and lime were considered as additives to improve the locally availiable clayey soil and sandy soil. It was observed that, addition of Fly Ash within 40-60% range for clayey soil and 20-40% for sandy soil can be used for the replacement process .

Devi et al (2020)

In this study, it is revealed that incorporating waste products which includes fiber, cement, lime, and plastic waste, etc., improved the compaction as well as strength of stabilized soil. It was discovered that plastic waste increased load carrying capacity, whereas RHA addition increased OMC and decreased MDD. Fiber was also found to increase the tensile strength of the soil. By increasing the cementitious materials in the soil, it has been found that using cement and C&D waste improves its strength qualities.

METHODOLOGY AND MATERIAL

To study the effect of Fly Ash on a sandy soil as a soil stabilizer it is mixed with different proportions of soil. The mixers are further tested to find different properties of soils. The fly ash is mixed in soil with different proportions such as 6%, 8%, 10%. The different type of test conducted on soil are as follows: -

- Plastic Limit Test
- Particle size analysis
- Liquid Limit Test (Casagrande Test)
- Standard Proctor Compaction Test

PLASTIC LIMIT

Finding the moisture content when the soil changes from a plastic state to a semisolid state is the primary goal of the Plastic Limit test. It is determined by breaking down a thread of soil mixture that has been rolled out on a flat surface. The disintegration of the soil begins as the moisture content decreases as a result of the soil rolling out into a fine thread-like structure. Understanding the strength and deformation properties of soils depends on this crucial test.

In the experiment of Plastic Limit, materials used are spatula, a grooving tool, a flat glass plate, and a metal dish. It is a common test procedure that is employed extensively in soil mechanics and geotechnical engineering.

LIQUID LIMIT

The liquid limit test is an essential soil test that is used to determine the moisture content at which soil transitions from a plastic state to a liquid state. This test involves taking a soil sample and placing it into a standard cup, which is then raised and allowed to drop a certain distance using a device called Liquid limit apparatus. After each drop a cut is made through the soil by a Spatula. The no. of drops to close a distance of 12.7mm along the groove is noted. The moisture content at which soil it closes the specified distance after number of 25 blows is called liquid limit.

STANDARD PROCTOR TEST

The Standard Proctor Compaction test is a method used to determine the maximum dry density and optimum moisture content of a soil under a specific compactive effort. It is a tribute to Ralph Roscoe Proctor who, in 1993, proved that the dry density of soil, under a specific compactive effort, is influenced by the water content during compaction. The compactive effort is administered by dropping a hammer with a designated weight from a specific height onto the soil in a Mould. In the standard test, the number of drops, weight, and height of the hammer are specified. The soil is weighed to assess its dry density at the appropriate moisture content after each compaction round. This procedure is repeated for various moisture contents until the optimal moisture content (the point at which the highest dry density is attained) is reached. These data provide important insight into the features of the soil, including its shear strength and compaction characteristics. The Standard Proctor Compaction Test is a laboratory test that adheres to standards set by various national and international organizations, such as AASTM, AASHTO, and BS.

PARTICLE SIZE ANALYSIS

It is a method which involves the soil sample passing through mechanical sieves of different standard sizes.

Sieves of different sizes are arranged on a mechanical shaker and the soilsample is deposited on the topmost IS sieve. Then the sieves are well shaked for 15 min

Weight of the soil sample retained after each sieve passing is analyzed. This data is used to plot a particle size distribution curve between percentage finer soil and log scale of sieve size. This curve is then studied to check whether the soil sample is well graded , gap graded or poorly graded .

FLY ASH

Fly Ash is an industrial waste and it can be used effectively for soil stabilization. This material is mainly obtained from thermal power plants after coal burning for electricity generations. Fly ash contains mainly silicon dioxide (Si02) approx. 60% ,aluminium oxide(Al203) approx 35%, and other materials like calcium oxide(CaO) , ferric oxide(Fe2O3).

Fly ash can be classified into two types

- class F fly ash
- class C fly ash

There major difference is if calcium oxide(CaO) is less than 7% then it is consider to be class F and if the calcium oxide(CaO) is more than 20% then fly ash is consider to be in class C type.

For class F we should need additional activator such as sodium silicate (Na2SiO3) while class C hasself cementing property , there is no need of chemical activator.

SOIL SAMPLE

Soil is taken from CENTRAL PARK SECTOR XU-1 Greater Noida, Uttar Pradesh, India . The collected soil sample is found to be sandy soil. The sample was collected by digging a pit of 1m. The Soil specimen collectedwas disturbed. Soil sample particles are large between 0.06-2mm and sample is weak in structure and having high proportion of sand and clay silt. Upon analysis if the soil it was found to be gap graded. Due to spaces between the particles the sample was considerd to have high porosity that allows water to flow freely between the sand particles. As the soil sample had low nutrients it was in brownish colour and had gritty texture.

RESULTS AND DISCUSSION

Particle size analysis:

Particle size distribution curve shown in figure 1 represents that the soil sample is gap graded. A considerable decrease in the particle size frequency can be used to identify gaps. These cracks may have an impact on the permeability, porosity, and shear strength of the soil or sediment.

Liquid Limit test:

Casagrande test for finding the liquid limit of the given sample of the soil was done with adding fly ash with three different proportions i.e. 6%, 8%, 10%, the liquid limit decreases from 37.08 % to 18.35% when 6% flyash is mixed with the sample. On mixing 8% fly ash the liquid limit was found to be 8.34% and for 10% fly ash it was found to be 9.4% Figure 2 shows the change in liquid limit for different proportions of FA.

Standard proctor test:

For water content of 4%, 6%, 8%, 10%, Standard proctor test was performed with 6%, 8%, 10% FA. On adding 6% of FA the dry density of the soil sample was decreased from 1.59 kg/m^3 to 1.55 kg/m^3, with 8 % of FA the dry density was found to be 1.64 kg/m^3. Upon adding 10% fly ash the dry density was further decreased 1.425 kg/m^3. Therefore the ideal maximum dry density was found to be at 8% of FA. Moisture content was also calculated and studied from this test, when 6% FA was added the optimal moisture content reduced from 21.79% to 16. 45%. On adding 8% FA the moisture content was obtained to be 17.85%. Upon finally adding 10% FA to the sample of soil the optimum moisture content further increased to 20.11%. Figure 3 shows the change in dry density of soil sample for different proportions of FA.

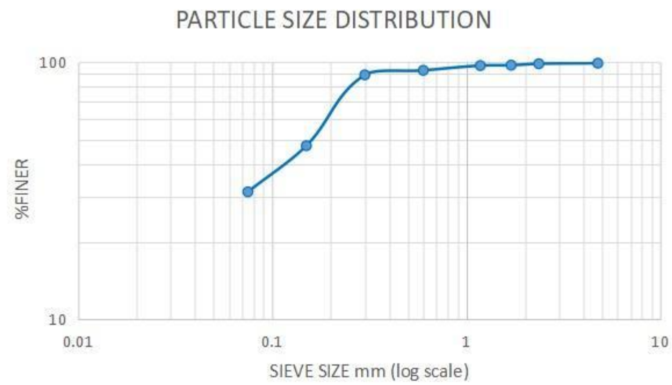

Figure 1: Particle size Analysis curve.
Sieve Size in mm (log scale) vs %Finer

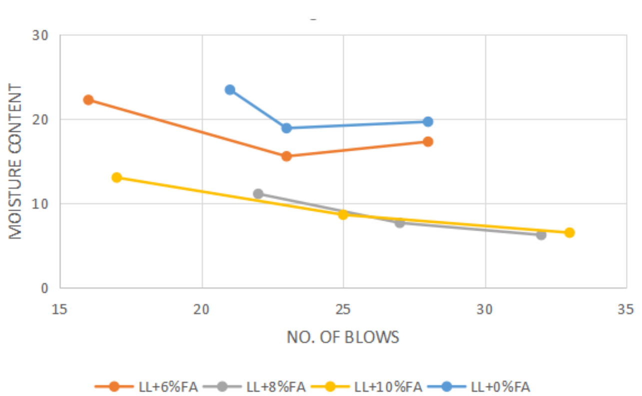

Figure 2: Liquid Limit Graph :
Number of blows vs Moisture content.

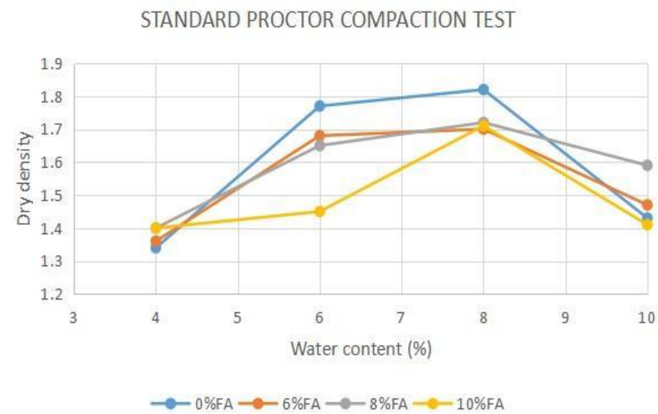

Figure 3: Standard Proctor Test Graph
Water content (%) vs Dry Density

CONCLUSION

- Particle size analysis was done for the soil sample using several different sizes of the IS sieve. Upon analyzing the particle distribution curve the soil sample was found to be gap graded.
- The liquid limit test was done by Casagrande apparatus, upon adding 6% FA the liquid the liquid was decreased from 37.08% to 18.35%, which is optimal for shear strength of the soil for construction on that subgrade soil.

Standard proctor compaction test was done for different water content and different proportions of FA. On 8% FA the the maximum dry density of soil was increased from 1.59kg/m^3 to 1.64kg/m^3.

- The optimum moisture content at 8% FA was found to be 20.11%, which is within allowed limit for construction.

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