A Research Study on Soil Stabilization by Powdered Glass and Rice Husk Ash

Rohit Sahu, Gangte Tagar, Taba Issac, Taring Sanjay, Hillang Reema

***Abstract:** The safe disposal of both hazardous and non-hazardous waste and degradable and non-degradable wastes has become a problematic for the civil engineers as well as to many citizens. This is because only few states are able to dump these wastes emanating from industries safely. This paper presents a research on soil stabilization by means of industrial waste and agricultural waste such as Glass Powder and Rice Husk Ash (RHA). So, efforts have been made using glass powder and rice husk ash (RHA) in this research to revamp, intervene the quality of the soil. The main objective of the soil stabilization is to increase the shear strength and decreasing the compressibility of the soil. Soil Stabilization is the process which improves the physical properties of soil, such as increasing shear strength, bearing capacity, etc. which can be done by use of controlled compaction or addition of suitable admixtures like cement, lime and waste materials like flyash, glass bottle, etc. During the course of the project it is planned to conduct various experiment like Specific gravity, Atterberg limits tests, Sieve analysis, Proctor compaction test, and CBR test to increase the strength and behavior of the soil properties. Then the results and graphs of various mixes are compared to see their effects in the soil stabilization. The stabilization technique has an additional benefit of providing an environment friendly way to deal with industrial waste and household wastes. The paper shows that there is a great possibility of the replacement of Industrial and Agriculture waste.*

***Keywords:** Atterberg Limits, Sieve Analysis, Soil Stabilization, Compaction, California Bearing Ratio.*

I. INTRODUCTION

Soil stabilization is the method of improvement of stability or bearing power of the soil by using controlled compaction, proportioning and/or the addition of suitable admixture or stabilizers. The need to improve quality of soil using soil stabilization is becoming more important as good soil becoming scarcer and their location more difficult and costlier. Soil stabilization using raw agriculture waste, industrial waste and powdered glass waste is an alternative method for the improvement of sub grade soil of pavement. This significantly enhances the soil properties used in the construction of road infrastructure.

The basic principles of soil stabilization are:

i. Evaluating the properties of given soil.
ii. Deciding the lacking property of soil and choose effective and economical method of soil stabilization.
iii. Designing the stabilized soil mix for intended stability and durability values.

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Earlier traditional soil stabilization using lime or cement is well established and has been successful in the past; other alternative technologies which are eco-friendlier and more economical are to be well studied. Lime and cement being an expansive material and is difficult to work with, as the CO2 emitted from the manufacturing of cement and lime is the major influence on climate change (enhanced greenhouse effect). These days the use of lime or cement is replaced by the industrial and/or agricultural waste by-product has proved to be sustainable and provides cost effective methods to improve the engineering properties of low load bearing soils. Mohamad Nidzam Rahmat, et al, soils stabilized with industrial waste materials have been extensively tested and do not have any adverse environmental impact and consequences. The shear strength of a soil and shrink-swell properties of a soil can be improved by the stabilization of soil, thus the load bearing capacity of a soil to support foundations of substructure and super-structures being improved. A wide range of sub-grade materials from expansive clays to granular materials can be used to treat by stabilization.

In wet weather, stabilization may also be used to provide a working platform for construction operations. Benefits of soil stabilization are higher resistance values, reduction in plasticity, lower permeability, reduction of pavement thickness, elimination of excavation, material hauling and handling, and base importation, aids compaction, provides all-weather access onto and within projects sites. In other terms soil stabilization or soil quality improvement are referred to as soil modification.

II. MATERIAL USED

2.1. Collection, Processing and Composition of Materials:

2.1.1. Powdered glass

Glass is an amorphous non-crystalline material, which is typically brittle and optically transparent. The glass bottles were collected or obtained from the Dr. K.N. Modi University Campus and as well as from the nearby garbage area of any shops or houses in Newai. The bottles were cleaned and air dried before crushing them. The broken glass was then placed in a sieve set and sieved it in a sieve shaker thoroughly for 10 min at each round of sieving. That glass powder passing IS sieve 425 Micron were considered for the use.

Glass is totally inert and therefore non-biodegradable. It degrades in a manner similar to natural rock; it can increase the strength of various road building elements. It has also been experimented on as a substitute aggregate in asphalt concrete also as an aggregate for sub-base.

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The other different types of waste glass materials include drinking vessels, windows, etc. most of the readily available waste glass material is soda-lime glass composed of about 75% silica (Si02), Na_2O, CaO and several additives.

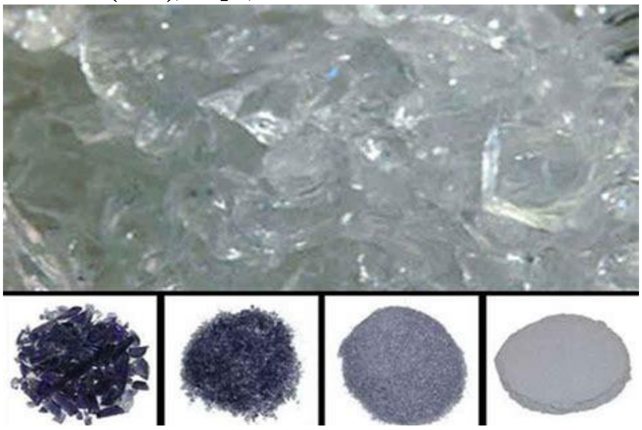

Fig.2.1: Powdered Glass

2.1.2. Rice Husk Ash

Rice is an agricultural crop that continues to be an important source offood and nutrition in many parts/regions of India. The Rice husk is an agriculturalby product from rice milling. During the paddy milling, about 78 percent of weight is received as rice,broken rice and bran while the other 22 percent of the weight of paddy is received as husk. The RiceHusk Ash (RHA), which is developed from the burning of the rice husk at a certain temperature, hasbeen used for cementing material and has good adsorptive properties.

The Rice Husk Ash has been obtained from (through means of online shopping using the India Mart e-Shopping)

Fig.2.2: Rice Husk

III. LITERATURE REVIEW

3.1. Soil Stabilisation using Fly Ash

(By S. Bhuvaneshwari, R. G. Robinson, S. R. Gandhi)

According to writers, they focused on the soil stabilization by using fly ash. The result has been carried out by various aspect of test conducted by them. The tests carried out with different proportion of Fly Ash indicated that the workability is maximum with 25% Fly Ash. And the maximum dry density has been found to be by using 25% of Fly Ash. The natural soil used for construction shall be dried with moisture content below 7%. If soil has more moisture it is difficult to mix with Fly Ash. Such soil shall be spread on surface and allowed to dry before construction. In the presence of dry clay lumps in the borrow soil increases the number of passes of disc harrow for mixing. It is therefore necessary to eliminate such soil lumps in the construction. It is observed that placing two different materials (local soil and FA) in three layers with Fly Ash layer sandwiched between soil layers and mixing them with disc harrow is workable. It is preferable to cover the compacted soil-Fly Ash bond with a suitable soil cover of minimum 500mm thickness. For this purpose, suitable borrow soil of CI type (in limited quantity) shall be used. Strict quality control shall be exercise regarding quality of borrow soil, its natural moisture content, number of disc harrow passes, density and moisture content after compaction, etc. The hydraulic conductivity of expansive soils mixed with flyash decreases with an increase in flyash content, due to the increase in maximum dry unit weight with an increase in flyash content. When the flyash content increases there is a decrease in the optimum moisture content and the maximum dry unit weight increases. The effect of fly ash is akin to the increased compactive effort. Hence the expansive soil is rendered more stable. The undrained shear strength of the expansive soil blended with flyash increases with the increase in the ash content.

3.2. Soil Stabilisation Using Raw Plastic Bottles

(By Anas Ashraf, Arya Sunil, J Dhanya, Mariamma Joseph, Meera Varghese, M. Veena,Proceedings of Indian Geotechnical Conference December 15-17,2011, Kochi (Paper No. H-304))

The test carried out soil stabilization by applying raw plastic bottles it has been obtained that the maximum dry density and optimum moisture content were obtained as 18.95kN/m3 and 11.22 % respectively. This is used for finding the bulk density of the soil filled in the tank for plate load test. The California Bearing Ratio test was also carried out by mixing the soil with optimum moisture content. The California Bearing Ratio test was conducted to determine the optimum number of plastic strips in soil. This is done by mixing soil with varying percentages (0.0%, 0.2%, 0.4% etc.) of plastic strips in soil and the 4-day soaked CBR Value is obtained It is observed from the test results that for soil mixed with waste plastic strips, soaked CBR values increased from1.967 to 2.479 with 0.6% of plastic and there after decreased. Hence the optimum percentage of plastic strip in soil is found to be 0.6%. It was also observed that there was a reduction in the CBR value from 1.967 for plain soil to1.687 on adding 0.2% plastic this is because the addition of small amount of plastic into soil lead to a dispersed and disturbed structure to soil than that it was in its compact form. Also, the optimum moisture content was maintained the same, so it also affected the decrease in the value. it can be inferred that the load carried corresponding to 4mm settlement is much more for soil stabilized with plastic than that of plain soil and thus the there is considerable increase in bearing capacity of the soil. The plastic bottles and bottle cut to halves gave more strength when kept at D/B=1 than that at D/B=0.67. At D/B=0.67, only a portion of the plastic bottles become effective in carrying the load,

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while at D/B=1, the whole layer contributes in taking the load. This may be the reason for the above phenomenon noted. Also, it is found that the improvement in strength is much more for plastic bottles cut to halves than for plastic bottles filled with sand. Arch action may be stated as the reason for this increase in strength. it is evident that the final settlement for all cases of soil stabilized with plastic is much less than that of plain soil. Decrease in settlement points to the increase in the bearing capacity of the soil. The factors contributing to this increase are the position of bottles, arch action etc. While comparing the percentage variations, it is clear that the maximum percentage decrease in settlement is that for the soil mixed with optimum number of plastic strips. In the case of soil stabilized with plastic bottles minimum settlement is noted for the plastic bottles cut to halves at D/B=1; this may be due to arch action. It can also be noted that there is not much difference in final settlements for the soil stabilized with sand filled bottles at D/B=0.67 and D/B=1, whereas there is considerable difference comparing the final settlements of the soil stabilized with bottles cut to halves kept at the respective position. The ultimate load and corresponding settlement of the plate is determined from the load-settlement graph plotted for various test arrangements. It is obtained from the load and settlement corresponding to the intersection of the tangents drawn to the initial and final straight portions of the curve obtained.

3.3. Soil Stabilisation by Utilisation of Agriculture Waste

(By Mohamad Nidzam Rahmat, Muhammad Redzwan Raffe, Norsalisma Ismail, Faculty of Architecture, Planning and Surveying, University Teknologi MARA, 40450 Shah Alam.Selangor, Malaysia)

The agricultural wastes are being the most prominent materials that is being used for various purposes. Here, the activity carried out for stabilization of soil using agricultural waste like Palm Oil Fly (POFA) ash and Rice Husk Ash (RHA).The strength development when landfill soil on its own were stabilized with agricultural waste POFA and RHA combined with either lime or PC at 50:50 ratio, 10% and 20% dosage (POFA: PC/POFA: lime) and RHA: PC/RHA: lime).At 10% stabilizer content was not enough to boost the strength development for both POFA-lime and POFA-PC, which recorded lower strength development compared to when 20% stabilizer was used. The combination of PC to POFA or RHA as stabilizer gives higher strength in this system to compare with when lime was used to combine with POFA or RHA. The highest strength value was recorded when landfill soil was stabilized with 20% dosage of RHA: PC at 60 days of curing which is 560 kN/m^2. Whereas when landfill soil was stabilized with 20% dosage of POFA: PC the strength was only 270 kN/m^2. The combination of RHA: PC marked the highest strength values which is 1105 kN/m2 compared with POFA: PC which is 574 kN/m^2 were recorded at 60 days of curing period. Lime did not perform well in terms of strength development when combined with either POFA or RHA. This test was to determine the percentage of water absorb by the stabilized specimens by total immersion of the samples into the water after being cured for 28 days. Readings were taken for 8 days consecutively. From the observation, generally in all systems the percentage of water absorption increases rapidly within the first 3 days of immersion. The rate of absorption became slow and levelled off on day 4 and onwards which is between 8-10% absorption. Landfill soil on its own when stabilized with combination of lime to POFA or RHA attained lower percentage of water absorption compared to when PC were used to incorporate with the agriculture wastes. When landfill soils were combined with siliceous material clay, the absorption rate is comparable with the previous system. This system recorded that stabilized POFA-Lime at 20% absorb the highest amount of water (about 10%) compared to another stabilized specimen. The composition of POFA: PC (50:50) and RHA: PC (50:50) at 20% dosage recorded the highest compressive strength of stabilized soil when clay was incorporated with landfill soil at 50:50 ratios. However, when landfill soil on its own was stabilized with all blended stabilizer, the strength recorded were half of the strength achieved when clay was in corporate in the system. The result shows that POFA and RHA are capable to replace certain amount of cement and lime in soil stabilization but not in a large scale. RHA are more favorable stabilizer in terms of strength development when combined with PC. The ratio of lime and PC must always be the dominant ingredient for stabilization. Incorporation of agricultural wastes POFA and RHA as stabilizer, tend to absorb high percentage of water compared to control specimen. This shows that although the addition of POFA or RHA assist to increase the compressive strength of stabilized soil, but it has a lower durability compared to lime or PC stabilized soil.

3.4. Soil Stabilisation Using Powdered Glass

(J. Olufowobi, A. Ogundoju, B. Michael, O. Aderinlewo, Department of Civil Engineering, Federal University of Technology Akure, P.M.B. 704, Akure, Nigeria)

The suggested soil stabilization using powdered glass that the broken glass waste is collected and crushed into powder form, made suitable for addition to the clay soil in varying proportions of 1%, 2%, 5%, 10% and 15% along with 15% cement (base) by weight of the soil sample. Compaction, California bearing ratio (CBR) and direct shear tests on the soil with and without the addition of the powdered glass, showed improvement results in the maximum dry density values on addition of the powdered glass and with corresponding gradual increase up to 5% glass powder content. And at 10% and 15% powdered glass content following test results decreased. At 5% glass powder content the highest CBR values of 14.90% and 112.91% were obtained for both the unsoaked and soaked treated samples, 5mm penetration is obtained respectively. The maximum cohesion and angle of internal friction values of 17.0 and 15.0 respectively were obtained at 10% glass powder content. 5mm penetration for both the unsoaked and soaked treated samples respectively. The maximum cohesion and angle of internal friction values of 17.0 and 15.0 respectively were obtained at 10% glass powder content. improvements in the properties of the clay soil obtained herein are more significant with the addition of the powdered glass.

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It seems that the percentage quantity of the powdered glass required achieving the best results in terms of the clay soil properties lies between 5% and 10% by mass of the soil. This is because the corresponding maximum values from both the compaction and CBR tests were obtained at 5% glass powder content while the maximum values from the shear strength test were obtained at 10% glass powder content. The powdered glass can be effectively used as a soil stabilizer since it was able to produce considerable improvements in the properties. Such improvements included an increase in the MDD value from 25.37 kN/m^3 for the control sample up to 25.90kN/m^3 for the sample containing 5% powdered glass by mass of the soil, achievement of the highest CBR values of 14.90% and 112.91% obtained at 5% powdered glass content for both the unsoaked and soaked treated samples respectively as well as achievement of the maximum values of cohesion and angle of internal friction of 15.0and 17.0 respectively obtained at 10% powdered glass content.

3.5. Soil Stabilizsation Using Industrial Waste And Lime

(By M. Adams Joe, A. Maria Rajesh Associate Professor, Department of Civil Engineering, Middle East Engineering College, Oman Assistant Professor, Department of Civil Engineering, ACEW, Tamil Nadu, India)

According to the writers regarding the soil stabilization using industrial waste sand and lime are used as raw materials. The ingredients used are copper slag, cement and lime. The test had been conducted in 4 different location (1,2,3,4). The results of the tests obtained are as follows as per the respective location. Proctor compaction test at optimum moisture content of 9.3%, 11%, 7.9%, 10.6%, and 7.25% obtained dry density (g/cc) of 1.837, 1.730, 1.905, 1.806 and 1.890 respectively. Unconfined compressive strength (kN/m^3) of 66, 180, 197, 152, 167 respectively. CBR test: bearing ratio of 25%, 33%, 17%, 14%, 25% respectively. it is observed that there is an appreciable improvement in the optimum moisture content and maximum dry density for the soil treated with industrial waste. In terms of material cost, the use of less costly Admixtures can reduce the required amount of industrial waste. Soils had the greatest improvement with all soils becoming non-plastic with the addition of enough amounts of industrial waste. The study after conducting several experiments revealed the following significances in using lime and industrial waste as a stabilizing agent. The addition of lime and industrial waste mixes to sub base increases the unconfined compressive strength value more than that by ordinary methods. The sub base stabilisation with lime and industrial waste mixes improves the strength behavior of sub base. It can potentially reduce ground improvement costs by adopting this method of stabilisation.

IV. METHODOLOGY

4.1 Laboratory tests and analysis:

Various tests and analysis were carried out to study the effects of the glass powder and Rice Husk Ash (RHA) on the sandy soil namely particle size distribution analysis, specific gravity test, Atterberg limits test, compaction test, California Bearing Ratio test were carried to the investigate the effect of glass powder and rice husk ash (RHA). Based on these tests, the required quantity of glass powder and rice husk ash for effective stabilisation of the clay soil was determined.

3.5.1. Particle Size Distribution Analysis:

The particle size distribution expresses the size of particles in terms of percentage by weight of the soil passing each sieve. The procedure involves oven drying the sand soil sample for 24 hours allowing it to cool. The sieve 2mm-75μm was then used to sieve the soil which wasoven dried. The sieves were arranged according to the aperture size and shaken vigorously for 10minutes. The sieve was left for a while for the sample to settle, the sand retained on each sieve was weighed and recorded and the corresponding percentage retained and passing were calculated. A graph of the percentage passing was plotted against the sieve sizes.

3.5.2. Natural moisture content:

In this test the amount of moisture content present in the soil as a percentage of its dry masswas determined. The empty container was weighed to the nearest 0.1 g (as W_1) after which a considerable amount of wet sample was placed therein and weighed (as W_2). Thereafter, it was placed into the oven to dry for 24 hours, removed and weighed (as W_3). The moisture content (MC) was calculated as a percentage of dry soil mass by using Eq. (1).

$$\text{Moisture Content}=\left(\frac{W_2-W_3}{W_3-W_1}\right)100 \text{ in } \%. \quad (1)$$

3.5.3. Specific gravity test:

The specific gravity of a soil sample can be defined as the ratio of the density of a substance to the density of a reference substance.

During the course of the test we used pycnometer for determination of the specific gravity of the soil sample. The procedure for its determination involved emptying, drying and weighing the pycnometer (as W1) andplaced 200 g of the soil sampleand weighed (as W2). Water was then added to the sample in the pycnometer to 1/3of its real height and stirred vigorously till the sample particles were in suspension. This was allowed to stand for 30 minutes and againup to 2/3 of the pycnometer and kept for 24 hours after which it was filled to the pycnometer brim and weighed (as W3). Thereafter, the bottle content was poured out and cleaned. And then the pycnometer was filled with water to the brim and its resulting weight was determined (as W4). The specific gravity (*Gs*) was calculated by using Eq. (2).

$$Gs=\left[\frac{w_2-w_1}{(w_2-w_1)-(w_3-w_4)}\right] \quad (2)$$

3.5.4. Atterberg limits tests:

J. Olufowobi, **et al** The Atterberg limits are basic measures of the critical water contents of a fine-grained soil, depending on the water content, a soil may appear in four states: solid, semi-solid, plastic and liquid. In each state, the Consistency, Behavior and Engineering properties of a soil is different.

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Following are the different Atterberg limits test

i. **Liquid limit**: The liquid limit is the limiting moisture content at which the cohesive soil passes from liquid state to plastic state or in general the soil sample at Casagrande's grooving device closes for 10mm on being given 25 blows.

The procedure for determining the liquid limit (LL) was performed in a Casagrande's device, involved measuring of soil sample passing the 420μm IS test sieve, placed it on the metallic trays, adding a little quantity of water to it and mixed thoroughly to obtain a paste that was not too thick nor too watery. It was then placed in the Casagrande's device, levelled and divided with the grooving tool. The number of blows at which the divided part attached closed was recorded.

ii. **Shrinkage limit**: It may be defined as the water content of the soil when the water is just sufficient to fill all the pores of the soil and the soil is just saturated. The volume of the soil does not reduce when the water content is decreased below the shrinkage limit.

iii. **Plastic limit test**: The plastic limit of a soil is the moisture content at which soil begins to behave as a plastic material at which the soil crumble when rolled into threads of 3mm in diameter.

The plastic limit was indicated by the moisture content corresponding to the point at which the soil rolled first crumbled. Consequently, the plasticity index (PI) was calculated by using Eq. (3).

$$\mathbf{PI = LL - PL} \quad (3)$$

3.5.5. Compaction test:

The maximum dry density (γ-max as MDD) and optimum moisture content (OMC opt) of the soil with and without additives is determined in this test. The acquired OMC is further used in preparation of sample for the California Bearing Ratio (CBR) test.

For the test we have used glass powder with addition of rice husk ash as a base and glass powder in a varying proportion of 1%, 2%, 5%, 10% and 15% respectively. The mouldsis compacted with a maximum blow of upto 25 blow per layer with a rammer weighing 2.5 Kg free falling from a 30cm height. A graph of moisture content vs dry density was plotted and the maximum dry density (MDD) and optimum moisture content (OMC) corresponding to standard doctor compaction test were determined. The following Eq. (4) and (5) was used for calculations under the compaction test.

Bulk Density, $\gamma_b = \frac{w}{v}$ (g/cm^3) (4)

Dry Density, $\gamma_d = \frac{\gamma_b}{1+w}$(5)

The necessity of performing of the Compaction tests is as it provides necessary information about the soil quality of a site for determining the most favorable building sites, the maximum load the soil can withstand and the requirement of the site for building.

3.5.6. California bearing ratio test:

J. Olufowobi, **et al**, The CBR is a measure of resistance of a material to penetration of standard plungerunder controlled density and moisture conditions. The test is performed on a disturbed soil or undisturbed soil of soaked and unsoaked soil. It is measured by the pressure required to penetrate a soil sample with a plunger of standard area which is then divided by the pressure required to achieve an equal amount of penetration on a standard crushed rock material.

For the test, mix proportions used for the compaction test were used again, dry soil was mixed thoroughly with calculated quantity of water to obtain moist soil as per the required moisture percentage obtained from the compaction test. The soil was compacted in a CBR moulds, each in 3 layers and of 56 blows at each layer using the standard rammer (4.5 kg and falling through 30 cm). The top surface was scraped and levelled after compacting the third layer.

The loading was applied at the rate of 1.25 mm/min. 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 4.0, 5.0, 7.5, 10.0 and 12.5.

A graph is plotted for load intensity against the penetration.The values of the load at penetration of 2.5 mm and 5.0 mm were expressed as percentages of standard loads. The CBR values were calculated by using Eqs. (6) and (7).

CBR at 2.5mm penetration

$$= \frac{\text{Actual load taken by soil (Kg/cm)}}{\text{Standard load at 2.5 mm penetration (Kg/cm)}} \quad 6$$

CBR at 5.0 mm penetration

$$= \frac{\text{Actual load taken by soil (Kg/cm)}}{\text{Standard load at 5.0 mm penetration (Kg/cm)}} \quad 7$$

The higher value out of 2.5mm and 5.0mm value was considered as the CBR. In most cases, CBR decreases as the penetration increases.

V. RESULTS AND DISCUSSION

During the test specimen the particle size distribution, the natural moisture content, the specific gravity and Atterberg limit tests was perform to determine the sandy soil for the process of compaction, California bearing ratio and also the Los Angeles laboratory work were carried out to crush the glass powder and the Rice Husk Ash (RHA) was obtained from (through India Mart e-shopping)

5.1 Moisture content test result:

The nature moisture content obtained for the sandy soil was 4.4833% as shown in the table

Table 5.1: Moisture Content

Test sample	Mass of empty+ bowl (g) (w_1)	Mass of bowl + wet (g) (w_2)	Mass of bowl + dry (g) (w_3)	Moisture Content	Avg. Moisture Content (%)
1	13	34	33	5.00	
2	12	38	37	4.00	
3	13	35	34	4.45	4.48%

5.2 Specific Gravity

The specific gravity test of the sandy soil sample was determined as 2.55% as shown in table

Table 5.2: Specific Gravity

Sample	1	2	3
Wt. of Dry Soil g	200	200	200
Wt. of Empty Pycnometer (W_1) g	634	634	634
Wt. of Pycnometer + Dry Soil (W_2) g	834	884	934
Wt. of Pycnometer + Soil + Water (W_3) g	1573	1602	1644
Wt. of Pycnometer + Water (W_4) g	1454	1454	1454
Specific Gravity (Gs)= $\{\frac{(w_2-w_1)}{(w_2-w_1)-(w_3-w_4)}\}$	2.47	2.45	2.73

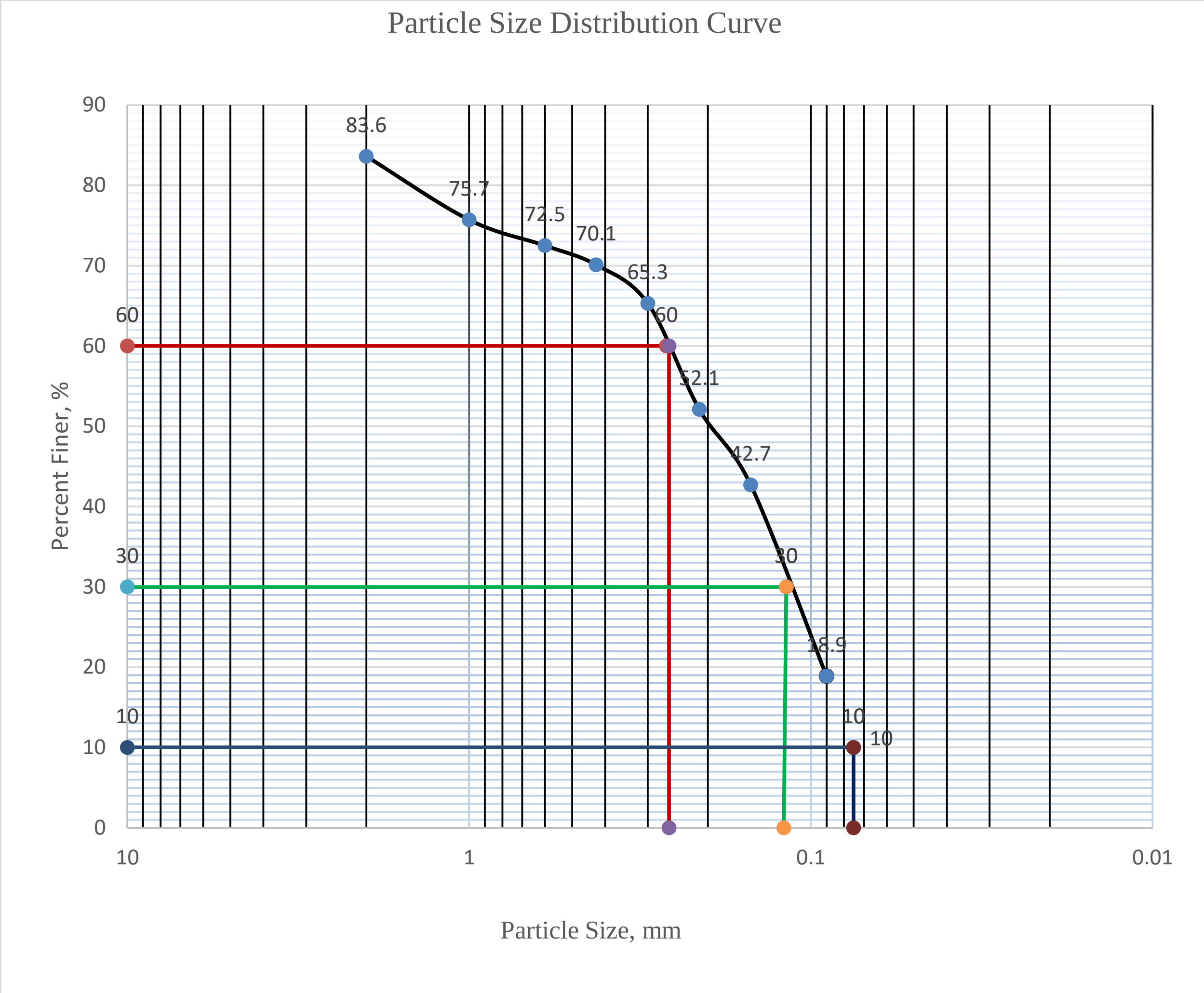
Average Specific Gravity (Gs) = 2.55 g/cm^3

5.3 Particle size distribution:

Particle size distribution shows a breakdown of the particle size distribution analysis with the corresponding percentages retained on and passing through each of the sieves. Such as 0.75mm,90mm,150mm,300mm,4.75mm etc. This analysis shows that the nature of soil sample comprised of 10% coarse soil fraction and 60% fine soil fraction as plotted in the graph.

Table 5.3: Grain Size Analysis

Sieve Size (mm)	Mass of each Sieve (m_1) in g	Mass of each Sieve + Retained Soil (m_2)in g	Mass of Soil (m_2-m_1) in g	% Retained on each sieve	Cumulative % Retained	Percent finer
2.000	320	493	173	16.4	16.4	83.6
1.000	338	421	83	7.9	24.3	75.7
0.600	282	315	33	3.2	27.5	72.5
0.425	277	302	25	2.4	29.9	70.1
0.300	308	358	50	4.8	34.7	65.3
0.212	259	398	139	13.2	47.9	52.1
0.150	283	382	99	9.4	57.3	42.7
0.090	294	545	251	23.8	81.1	18.9
0.075	283	377	94	8.9	90	10.0



Graph 5.3

5.4 Atterberg Limit Test

The Atterberg limit test has moisture content values under the Atterberg limit test (consist of plastic limit and liquid limit) as in the evaluated in table and the graph shown. The liquid limit, plastic limit and plasticity index of the natural soil sample obtained as 38.1015%, 28.333% and 20.7682% respectively.

5.4.1 Liquid Limit:

Table 5.4.1: Liquid Limit

No. Container	1	2	3
No. of Impact	35	28	17
Wt. of Container (W_0) g	12	13	12
Wt. of Container + Wet Soil (W_1) g	35	31	24
Wt. of Container + Dry Soil (W_2) g	31	26	20
Wt. of Water (W_1-W_2) g	4.0	5.0	4.0
Wt. of Oven Dry Soil (W_2-W_0) g	19	13	8.0
Water Content=$\left(\frac{W_2-W_1}{W_3-W_1}\right)$ 100 in %	21.05	38.46	50.0

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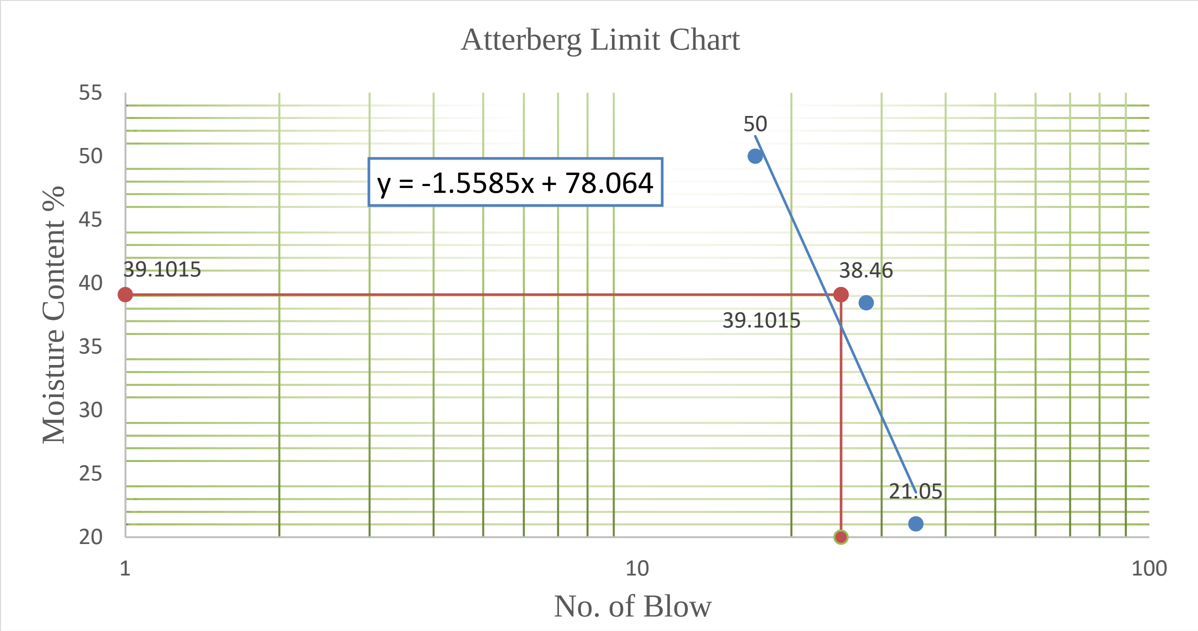

Graph 5.4

Liquid Limit = 39.1015%

5.4.2 Plastic limit test:

Table 5.4.2: Plastic Limit

Container	1	2	3
Wt. of Container (W_0) g	13	12	13
Wt. of Container + Wet Soil (W_1) g	20	22	21
Wt. of Container + Oven Dry (W_2) g	19	20	20
Wt. of Water (W_1-W_2) g	1.0	2.0	1.0
Wt. of Oven Dry (W_2-W_0) g	6.0	8.0	7.0
MC $=\left(\frac{w_1-w_2}{w_2-w_0}\right) 100$	16	25	14

Average Plastic Limit=18.3333%

5.4.3 Plasticity index (PI):

It is the difference between the liquid limit and the plastic limit. So, Plasticity index for the sandy soil is

PI = liquid limit-plastic limit

PI = 39.1015% -18.3333%

PI = 20.7682%

Therefore, the plasticity limit of nature soil has under the ranged (20 to 24) govern as the safe zone.

The sandy soil stabilization by additive of 15% of Rice husk fly ash (R.H.A) and powder glass at different proportion. Here different method was used to check the soil stabilization such as compaction test, California bearing test, etc.

5.5 Compaction test:

The compaction test as articulated in table and graph shows the result of natural sandy soil and the additive of 15% Rice Husk Fly Ash andGlass Powder of varying percentage. When compared with natural sandy soil compaction gives 1.79 kN and admixture sandy soil compaction gives 2.7 kN, the admixture compaction gives higher values than the natural compaction. Which leads to the good amount of bearing capacity of sandy soil.

1. **Normal Soil:**

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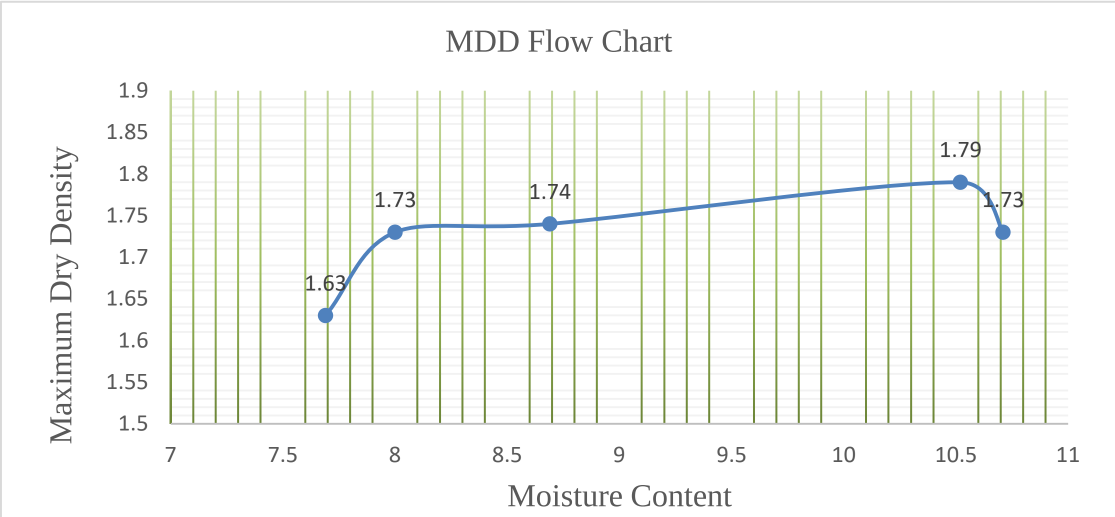
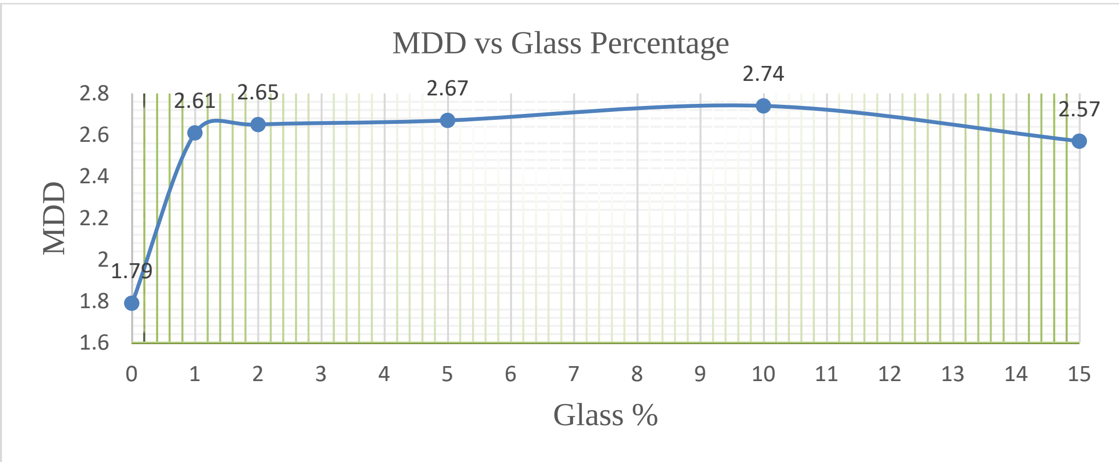
Table 5.5: Compaction Test of Natural Soil

Sample	1	2	3	4	5
Volume of Water, V (cm^3)	1000	1000	1000	1000	1000
Wt. of Mould, W_1 g	2012	2012	2012	2012	2012
Wt. of Mould + Compacted Soil W_2g	3770	3891	3909	3990	3964
Wt. of Compacted Soil, W=W_2-W_1g	1758	1879	1897	1978	1952
Bulk Density, $\gamma_b = \frac{w}{v}$ (g/cm^3)	1.76	1.88	1.89	1.98	1.95
Water Content	7.69	8	8.69	10.52	10.71
Dry Density, $\gamma_d = \frac{\gamma_b}{1+w}$	1.63	1.73	1.74	1.79	1.73



Graph 5.5.1: MDD Flow Chart



Graph 5.5.2: MDD Vs Glass % Flow Chart

5.6 California Bearing Ratio test (CBR):

California bearing test is one of the most essential for the soil stabilization. According to the data at table (5.6.1) and table (5.6.2) shows the penetration and load applied at constant rate of 1.2 rpm for the natural sandy soil and additive sandy soil, that the bearing capacity increases with adding of 15% Rice husk fly ash and Glass powder at different quantities. The bearing capacity at 10% additive component (Glass Powder) gives 5.8394 kN/cm^2 at 2.5mm penetration than the natural soil bearing capacity as shown below which could be taken for design purposes. For the natural sandy soil CBR values at 2.5mm penetration shows 4.45 kN/cm^2 and at 5mm the penetration shows 5.888 kN/cm^2.

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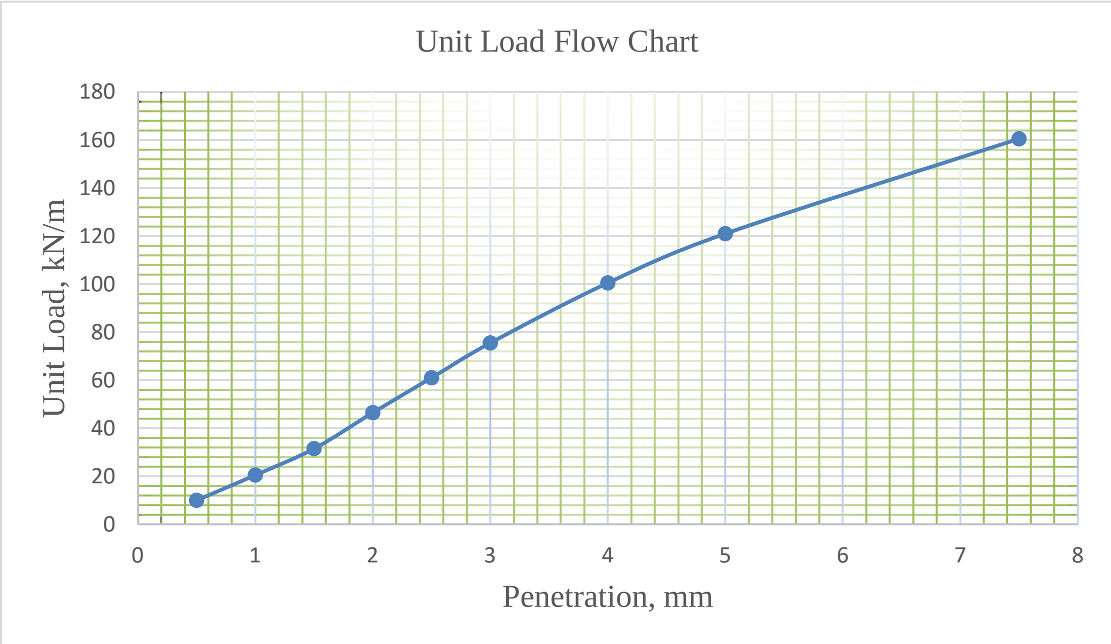
Table 5.6.1: CBR natural Soil

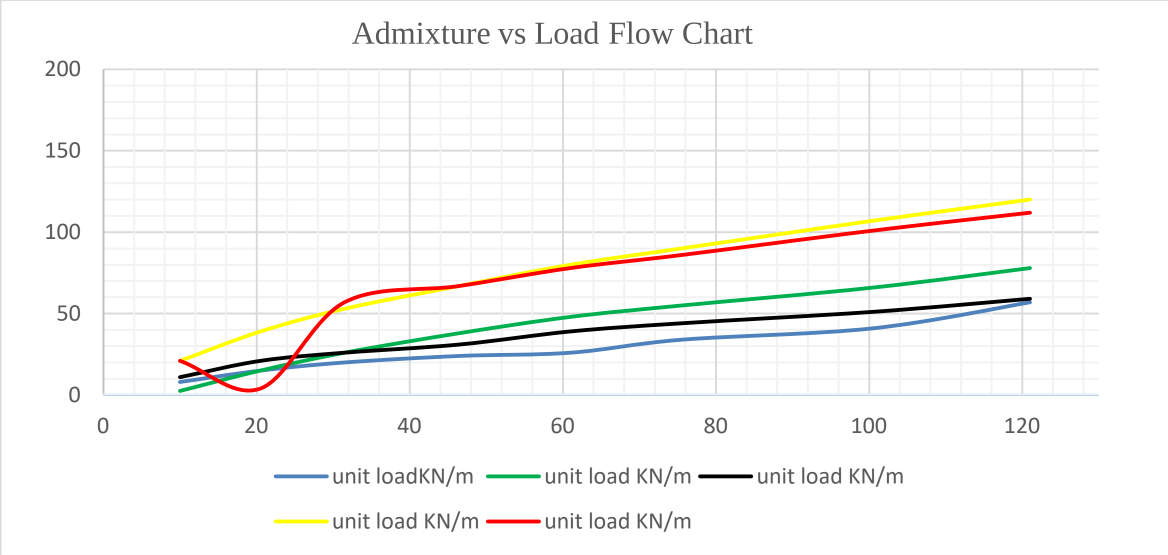
Penetration reading	Dial gauge reading	Unit load kN/cm^2 (Nil admixture)
0.5	2	10
1	4.1	20.5
1.5	6.3	31.5
2	9.3	46.5
2.5	12.2	61
3	15.1	75.5
4	20.1	100.5
5	24.2	121
7.5	35.3	176.5



Graph 5.6.1: Load Vs Penetration Flow Chart

Table 5.6.2: Data for CBR of Additive Mixture against soil

		Unitload Kg/m²		Unit load Kg/cm²		Unit load Kg/cm²		Unit load Kg/cm²		Unit load Kg/cm²
Penetration reading	Dial gauge reading	1% G.P+15% RHA	Dial gauge reading	2% G. P+15%RHA	Dial gauge reading	5% G.P+15% RHA	Dial gauge reading	10% G.P+15%RHA	Dial gauge reading	15% G.P+15% RHA
0.5	1.6	8	0.5	2.5	2.2	11	4.2	21	4.2	21
1		15	3	15	4.2	21	7.8	39	0.8	4
1.5	4	20	5.2	26	5.2	26	10.6	53	11.4	57
2	4.8	24	7.6	38	6.2	31	13.4	67	13.4	67
2.5	5.2	26	9.6	48	7.8	39	16	80	15.6	78
3	6.8	34	11	55	8.8	44	18	90	17.2	86
4	8.2	41	13.2	66	10.2	51	21.4	107	20.2	101
5	11.4	57	15.6	78	11.8	59	24	120	22.4	112
7.5	16	80	19.6	98	16	80	29.2	146	27.6	138
10	20.4	102	23.2	116	18.2	91	34	170	32.6	163
12.5	23.8		26.2	131	21	105	37.8	189	38	190

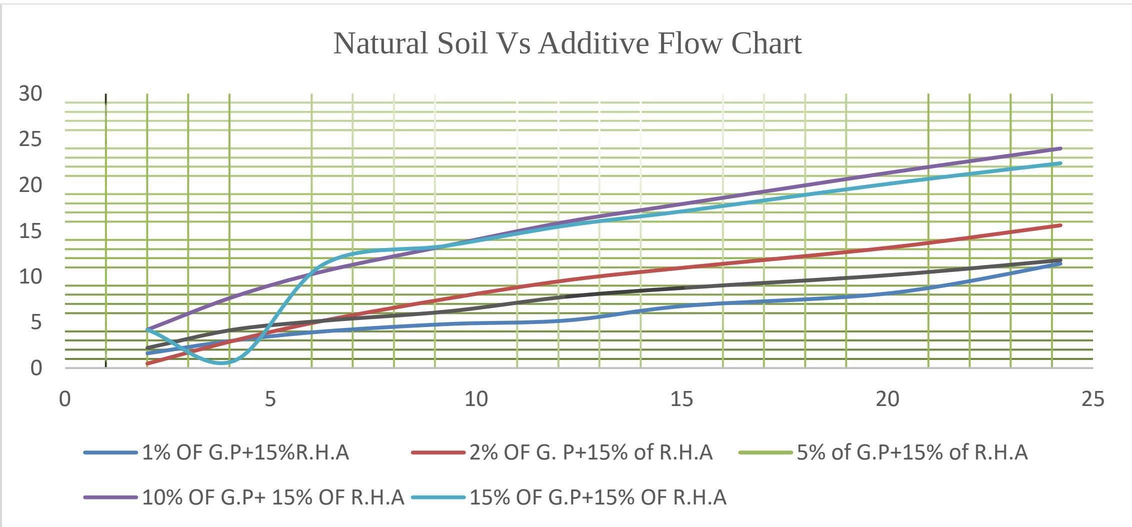


Graph 5.6.2: Soil Admixture Flow Chart

Table5.6.3: CBR values at different proportion

Mould	CBR at 2.5mmin %	CBR at 5mm%
1% G.P + 15% RHA	1.8978	2.7737
2% G.P +15% RHA	3.5036	3.7956
5% G.P + 15% RHA	2.8467	2.8710
10% G.P + 15% RHA	5.8394	5.8394
15% G.P + 15% RHA	5.6934	5.4501

Comparative graph between natural soil and additive component



Graph 5.6.3

VI. CONCLUSION

Incorporating with various materials in order to stabilize the soil we came across with different review papers. The papers helped us in pursuing the suitable method and analytics in various conditions to achieve the soil stabilization. Based on what we have read and understood we carried many different lab experiments for the normal soil with or without any additives. The basics lab analysis such as particle size distribution, Atterberg limit test, etc. was performed for the normal soil. Standard proctor compaction test and California bearing ratio test was also performed for analyzing of soil behavior.

Glass powder as well as Rice husk ash (RHA) was used for soil stabilization. We used both the specimen of additives simultaneously for the analysis of soil specimen. Rice husk ash (RHA) was taken at a constant rate of 15% by weight of the soil specimen.

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And at varying proportions of 1%, 2%, 5%, 10% & 15% respectively for glass powder by weight of soil specimen. There is an appreciable improvement in the optimum moisture content and maximum dry density for the soil treated with glass powder and rice husk ash. In terms of material cost, the use of less costly Admixtures can reduce the required amount of industrial waste, agricultural waste, etc. Soils had the greatest improvement with all soils becoming non-plastic with the addition of sufficient amounts of glass powder and rice husk. The study after conducting several experiments revealed the following significances in using glass powder and agriculture waste as a stabilizing agent. The addition of glass power and rice husk ash mixes to disturbed soil increases the compressive strength value more than that by ordinary methods. It can potentially reduce ground improvement costs by adopting this method of stabilization.

The improvements in the properties of the sandy soil obtained herein are more significant with the addition of the powdered glass. It seems that the percentage quantity of the powdered glass required achieving the best results in terms of the sandy soil properties lies between 5% and 10% by mass of the soil. This is because the corresponding maximum values from both the compaction and CBR tests were obtained at 5% glass powder content while the maximum values from the shear strength test were obtained at 10% glass powder content. Further better tests and analysis of the work we have performed would be most welcomed.

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