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To investigative the geotechnical properties of soil by adding plastic waste as stabilizers (A solution to the clean & green environment)

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ABSTRACT:

As a result of the increasing amount of plastic waste, such as bottles, polythene bags, and packing strips, which is also a hindrance in this research work an effort has been made to use these plastic wastes for improving ground and also solution to the environmental problems. Soil reinforcement is utilized in geotechnical engineering applications for a number of ground improvement schemes, including sub-grades for footings and pavements, landfill liners and covers, failed slopes, and backfill for earth retaining structures.. The goal of the study is to determine how plastic waste affects the stability and improves the engineering properties of the chosen soil. The physical, chemical, and designing properties of the soil were considered, and the soil was treated with additional.

Key Words: Plastic powder. Plastic sheet, CBR, UCS and CBR

1. INTRODUCTION

Normal soil is an extremely complex and multifaceted substance. Given its complete accessibility and low effort requirements, it presents fantastic opportunities for effective utilization as a building or establishing material. The weathered material of the earth's exterior, with or without natural problems, is called soil for a geotechnical build. Soil is composed of distinct particles that are not unquestionably cemented together. The reason for their poor mechanical qualities is that they are free to move in relation to one another. In order to design geotechnical applications that include refilling earth holding structures, repairing fizzled slopes and inclines, repairing landfill liners and spreads, and adjusting soil layers and levels for footings and asphalts, soil support is tried for a wide range of ground change conspires. The normal given its complete accessibility and low effort requirements, it presents fantastic opportunities for effective utilization as a building or establishing material. The weathered material of the earth's exterior, with or without natural problems, is called soil for a geotechnical build. Soil is composed of distinct particles that are not unquestionably cemented together. The reason for their poor mechanical qualities is that they are free to move in relation to one another. In order to design geotechnical applications that include refilling earth holding structures, repairing fizzled slopes and inclines, repairing landfill liners and spreads, and adjusting soil layers and levels for footings and asphalts, soil support is tried for a wide range of ground change conspires. Normal soil is an extremely complex and multifaceted substance.

Plastic waste causes major environmental problems. They obviously don't actually harm people's health, but they need a huge amount of space to reach at their destination and also consume a lot of energy for their generation. In the same way, waste plastic blocks seepage channels, which frequently results in water confinement and waste logging in cities and towns. Over the years, the Environmental Department has established accepted guidelines for managing plastic trash and has proposed further feasible waste reuse. From a variety of angles, plastic garbage and waste are being recycled as a cost-effective asset management technique. In 2002, the Plastic trash Administration Foundation found that around 55% of plastic trash is being used effectively for sustainability stock reuse and vitality recovery. Each and every kind of plastic is they obviously don't actually harm people's health, but they need a huge amount of space to reach at their destination and also consume a lot of energy for their generation. In the same way, waste plastic blocks seepage channels, which frequently results in water confinement and waste logging in cities and towns.

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2. PROPLEM STATEMENT:

It seems hard to impose a restriction on the outline requirements in this rapidly evolving world. This undermines the fundamental reason the structure was built on such soil. Furthermore, when large quantities of the material are present, it is not cost-effective to remove it from the site. Perhaps it's challenging to find the most that being said, most developing nations find it difficult and costly to adopt those traditional methods. Plastic packs, however, are a prevalent and reasonably priced waste item.. Reducing the amount of waste that ends up in landfills could be achieved by finding another use for them in structural design projects. It seems hard to impose a restriction on the outline requirements in this rapidly evolving world.

3. RESEARCH OBJECTIVES:

The following are the main objectives of this research work

- Enhance the soil engineering properties.
- To provide alternate remedy for plastic waste disposal
- Decreasing cost of soil stabilization by using cheaper material

4. RELATED WORK:

Subhash (2016) the author carried out an experiment on stabilizing soil using a proportionate blend of plastic and glass. To look at OMC and CBR, several tests, including the Proctor Tests, were modified. The study's findings indicate that as the amount of glass and plastic increases, the Maximum Dry Density (MDD) level decreases. Glass and plastic make up around 6% of the total, and their maximum dry density was measured at 1.51 gram per centimeter. When the admixture was blended at 5.9%, the maximum OMC was observed at 22.4%. Furthermore, an increase in the OMC level was observed, reaching a peak of 22.5%. Based on 0.610 kg/cm2 to 3.022 kg/cm2, the unconfined compressive strength is more than 4.5 times that of the sample of the author carried out an experiment on stabilizing soil using a proportionate blend of plastic and glass. To look at OMC and CBR, several tests, including the Proctor Tests, were modified. The study's findings indicate that as the amount of glass and plastic increases, the Maximum Dry Density (MDD) level decreases. Glass and plastic make up around 6% of the total, and their maximum dry density was measured at 1.51 gram per centimeter. When the admixture was blended at 5.9%, the maximum OMC was observed at 22.4%.

In 2016, Mallikarjuna The author tried stabilizing soil in black cotton fields by using plastic waste. The author primarily accommodates the trials to address the challenges in Amaravathi, the capital of Andhra Pradesh, India. A soil sample made of black cotton is mixed with varying percentages of plastic strip weight, ranging from 0.0% to 8.5%.Soil and the optimal ratio of plastic waste strips were analyzed using the CBR Test. Samples of plastic from discarded chairs are separated into many strips. Density of 0.40 gm/cc plastic strip combined with black cotton soil in varying amounts (1%, 3%, 5%, and 7%). In this study, the soil sample was subjected to a modified Proctor test and a number of CBR tests. The author claims that the worth of the author tried stabilizing soil in black cotton fields by using plastic waste. The author primarily accommodates the trials to address the challenges in Amaravathi, the capital of Andhra Pradesh, India.

N.M. Ilies (2017) there are two methods to improve the qualities of soil in this research report. Using plastic waste to improve soil mixing was the initial method. A further cement-improvement technique. The source of the plastic garbage used in this experiment is polyethene waste. Shear strength metrics are examined in the study as they change with varying additions of cement or polyethene, such as 2%, 4%, 6%, and 8%. The silty clay used for the investigation was used. When 4% Polyethene was added to the soil, different changes were seen. When compared to the same amount of cement soil combination, the 4% Polyethene soil mixture has a lower cohesiveness of around 51% and a lower internal friction angle of about 62%. In the end, polyethene was more effective even though the soil cement sample did better. There are two methods to improve the qualities of soil in this research report. Using plastic waste to improve soil mixing was the initial method.

Kiran (2017) Stabilization procedures aim to increase the soil's bearing capacity and stiffness. The soil must have both workability and build ability. Using strips of plastic bottles and shopping bags, the experiment's creator investigated ways to improve the many engineering properties of soil. This study indicates that soil CBR values rise, reaching their maximum when 0.74% of plastic bottle strips are added to a soil sample. As the number of strips increases, the CBR value decreases. In the second example utilizing dirt, it was found that the ideal quantity of plastic bag strips is around 2% of the total weight of the soil. Plastic bottle strips, the author concluded, increase the soil sample's Stabilization procedures aim to increase the soil's bearing capacity and stiffness. The soil must have both workability and build ability.

Table-1: CBR Values with plastic strip

Value of CBR	Strip Length (in cm)
3.33	0
5.22	2.4
6.21	5.1
5.22	7.4

This experimental research work (N. Vijay Kumar, 2017) deals with the observation of plastic garbage used as a soil stabilizer, primarily in black cotton soil. This soil's shortcomings included uneven surface settlement, shrinkage, and swelling when hit by precipitation. A variety of engineering experimental tests, such as the plastic limit, liquid, and standard proctor tests, are conducted for soil stabilization in this research paper. Additionally, tests for unconfined compressive strength and the California bearing ratio are conducted to verify the changes made to the technical properties of the soil. In order to boost the soil sample's bearing capacity, the research piece uses plastic and bottle strips. The CBR value is shown as a function of plastic strip length in Table 3. The CBR. This soil's shortcomings included uneven surface settlement, shrinkage, and swelling when hit by precipitation. A variety of engineering experimental tests, such as the plastic limit, liquid, and standard proctor tests, are conducted for soil stabilization in this research paper. Additionally, tests for unconfined compressive strength and the California bearing ratio are conducted to verify the changes made to the technical properties of the soil. In order to boost the soil sample's bearing capacity, the research piece uses plastic and bottle strips. The CBR value is shown as a function of plastic strip length in Table 3.

*(*Peddaiah, 2018) He uses a number of studies, including the direct shear test, the California Bearing Ratio test, and the compaction test, to investigate how plastic bottles affect silty sand. Plastic waste strips measuring 15.0 mm by 15.0 mm, 15.0 mm by 25.0 mm, and 15.0 mm by 35.0 mm were combined with plastic components in the percentages of 0.20%, 0.40%, 0.60%, and 0.80%. As the amount of plastic material increases, properties such as the maximum dry unit weight and shear strength characteristics also rise. The CBR values of the soil sample for 0.20% and 3.2 percent plastic, respectively, range from 3.2 to 7.2, according this study. For a plastic content of 0.40% to 16.4. When the amount of naturally silty plastic in this study he uses a number of studies, including the direct shear test, the California Bearing Ratio test, and the compaction test, to investigate how plastic bottles affect silty sand. Plastic waste strips measuring 15.0 mm by 15.0 mm, 15.0 mm by 25.0 mm, and 15.0 mm by 35.0 mm were combined with plastic components in the percentages of 0.20%, 0.40%, 0.60%, and 0.80%. As the amount of plastic material increases, properties such as the maximum dry unit weight and shear strength characteristics also rise. The CBR values of the soil sample for 0.20% and 3.2 percent plastic, respectively, range from 3.2 to 7.2, according this study for a plastic content of 0.40% to 16.4.

(Tarun Kumar (2018) He added that using plastic strips of varying diameters is an alternate technique for stabilizing soil. Numerous studies are performed to examine stabilization caused by the impacts of various mixed strips of plastic, including modified proctor exams and unsoaked California bearing ratio tests. The result shows that when the quantity of plastic waste strips increases, the MDD of the plastic mixed soil sample decreases. CBR rises in tandem with the proportion of plastic waste strips that fall within an ideal range. According to research, MDD levels decrease as Optimal Moisture Content values increase. The degree of CBR values of the plastic strip composed of residual plastic components has been found to rise. He added that using plastic strips of varying diameters is an alternate technique for stabilizing soil. Numerous studies are performed to examine stabilization caused by the impacts of various mixed strips of plastic, including modified proctor exams and unsoaked California bearing ratio tests.

The experiment by (Abdelsalam, 2019) involved adding a tiny quantity of High-Density Polyethylene (HDPE) to cohesive soil. The direct shear test and the one-dimensional consolidation test were among the several experiments the author experimented with. to ascertain the shear strength and consolidation engineering properties of the soil sample. 5.0%, 10.0%, 15.0%, and 0.0% HDPE content additions. They range from 25 KPa and 36° to 44 KPa and 45°, respectively, for cohesiveness and internal friction angle. HDPE content ranged from 15% to 0%. The soil sample's coefficient of permeability and compressibility are improved by a small addition of 5.0% HDPE.

5. RESEARCH METHDOLOGY:

In this research workTwo soil samples, designated soil samples **A** and **B,** were gathered and brought into the lab. The qualities of clayey soil were investigated using locally available material plastic waste in the form of powder and plastic sheet in order to achieve the examination's goals. By weight of dry soil, the amount of added material is 0%, 0.5%, 1%, and 1.5% in the form of powder and plastic sheets of dimension 5mm*7.5mm, 10mm*15mm and 15mm*20mm. The mixing percentage by weight were 0.5%,1% and 2%. The results obtained using the ASTM principles were examined in order to investigate the geotechnical qualities and develop conclusions. Selecting the best additional material and suitable offer to use would be difficult due to the wide range of soil types and conditions as well as the various types of added chemicals. The qualities of clayey soil were investigated using locally available materials plastic bags in order to achieve the examination's goals.

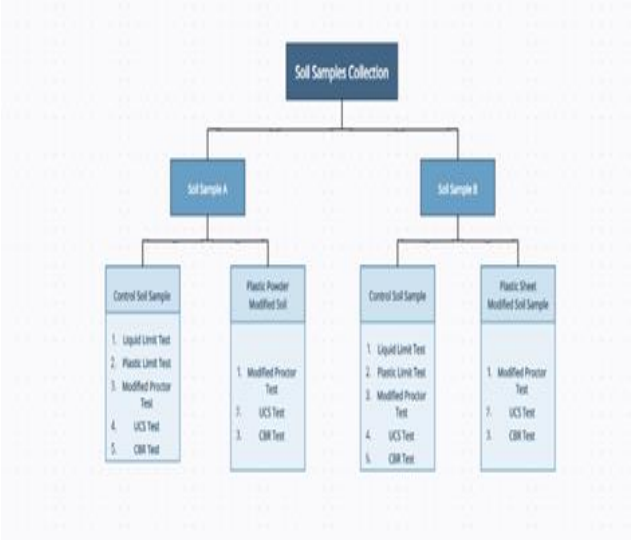

Fig-1: Flow Chart Diagram

5.1 Collection of soil sample:

This section will outline the specific tactics used in each test conducted at the research institution to achieve the examination's goals. All of the examples used in this examination were created in the laboratory using readily available standard techniques, and the clay was collected from the agricultural side of Peshawar from a 3x3-foot trial pit depicted in figure 3.1. Specimens are to be collected from 4 trial pits. Admixture was regarded as a promising stabilizer to treat or improve the qualities of soil for the testing program at the research facility.

Fig-2: Soil sample collection

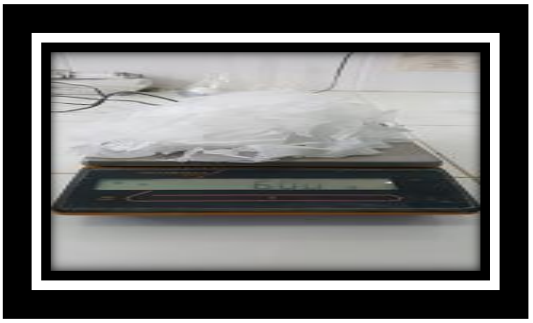

Fig-3: weight Balance with plastic

Fig-4: Mixing of plastic with soil

Fig-5: soil sample with Plastic

Fig-6: Plastic sheet with soil

The study is separated into four groups according to the mix admixture added as a percentage of the dry soil's weight. The dirt was set to air dry overnight in a big container before being divided to fit through the 3/8" sieve. To get rid of the larger particles, ASTM D 2216 wetly sieved the soil test over a #40 sieve. Since the #40 strainer utilizes less material than the #10 sieve, it was used instead. The substance was separated and then subjected to several testing, including atterberg,s limits and strainer analysis..

Table-2: Properties of Control soil sample

Soil properties	Values
Moisture content	6.70
Liquid Limit	25.96
Plastic Limit	24.30
Plasticity index	1.70
Specific gravity	2.60
Maximum dry density	2.272
Optimum moisture content	8.9
USCS Classification	CL-ML

4. EXPERIMENTAL TESTS AND RESULTS

Results obtained from the experiments performing in laboratory have been discussed in this section. Different experiments were conducted on soil by adding plastic powder as stabilizer in 0.5%, 1% and 1.5 % at control level the MDD , UCS & CBR values were recorded as o.127, 59.72 & 3.62 respectively when the glass powder was added the these values were observed to increase from its original values as shown in table-

Table -4: Mix Proportions for soil sample-A

Plastic %	MDD	UCS	CBR
0%	0.127	59.72	3.62
0.5%	1.73	61.09	5.68
1%	1.74	67.76	6.27
1.5%	1.76	81.04	7.89

Table -3: Test Name & Codes

TEST	ASTM CODE
MDD	D422
UCS	D4318
CBR	42216

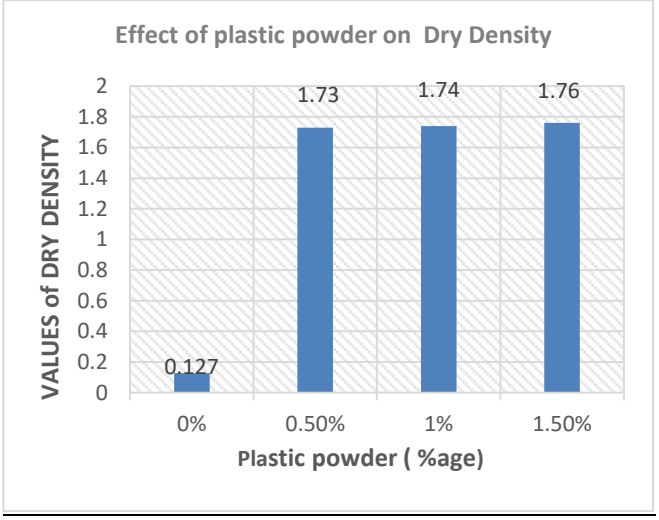

Fig*-7: Effect of P.P on Dry Density*

From the above figure can be observed that the Maximum dry density value increase with the increase of glass powder content at 0% the value was recorded as 0.127, at 0.5% the value was recorded 1.73 at 1% was 1.74 and at 1.5% was 1.76. it mean that the maximum dry density of soil increase with stabilizer glass powder.

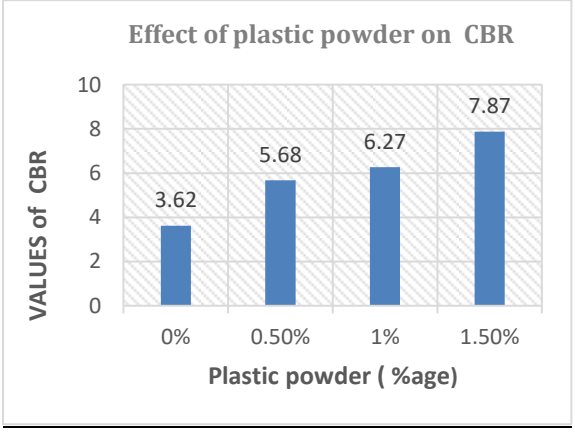

Fig-8: Fig-7: Effect of P.P on CBR

Similarly the value of CBR for pure soil is 3.62 when glass powder was added to it its value increases at 0.5% it was recorded 5.08 at 1% it was recorded 6.27 and 1.5% it was observed 7.87. It mean that with addition of glass powder the strength of subgrade increases.

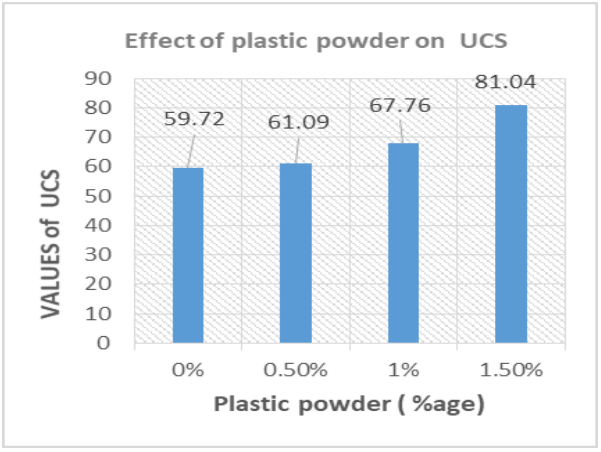

Fig-9: Effect of P.P on UCS

Same for UCS its value in pure soil is 59.72 when glass powder was added to it its value increases at 0.5% it was recorded 61.09 at 1% it was recorded 67.76 and 1.5% it was observed 81.04. It mean that with addition of glass powder the strength of soil increases.

From the above result discussion it is concluded that the plastic in the form of powder is best stabilizer for improving the geotechnical properties of soil.

Now for soil sample –B the plastic sheets were added to the soil sample in different percentages 0.50%, 1% and 2%. The mentioned percentage of plastic sheets were kept constant only the dimension of plastic sheet were changed which are 5mm*7.5mm, 10mm*15mm & 15mm*20mm as shown in the table below

Table -5: Mix Proportions for soil sample -B

Sheet Size(mm)	Plastic %	MDD	UCS	CBR
5*7.5	0%	12.82	151.8	1.58
	0.5%	11.97	257.2	1.71
	1%	12.56	273.7	2.09
	2%	12.8	304.4	1.96
10*15	0%	12.82	151.8	1.58
	0.5%	12.38	316.4	2.28
	1%	12.12	287.5	2.66
	2%	11.92	246.3	2.47
15*20	0%	12.82	151.8	1.58
	0.5%	12.22	173.4	2.85
	1%	12.25	153.4	3.23
	2%	12.18	134.5	3.04
	0%	12.82	151.8	1.58
	0.5%	11.97	257.2	1.71

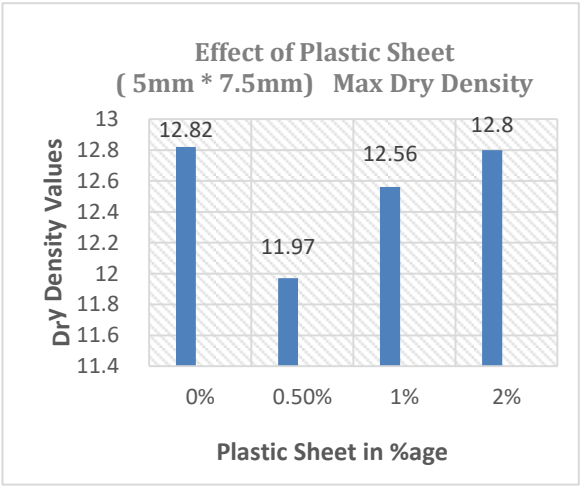

Fig-10: Effect of P.sheet on Dry Density

Form the Figure it can be observed that when the size of the plastic sheet is the MDD value decrease with in size of the plastic sheet is 5mm* 7.5mm at 0% its value was 12.82 when the percentage was 0.50% its value reduced to 11.97 at 1% its value was 12.56 which is again less than 12.82 while at 2% its value was recorded 12.8.

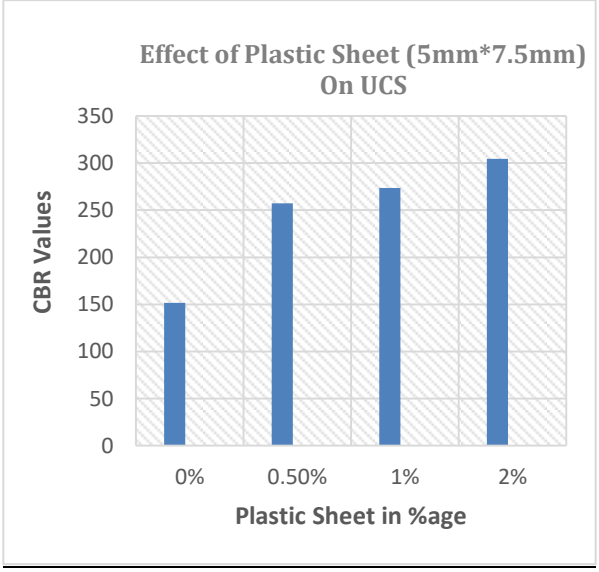

Fig-11: Effect of P.sheet on UCS

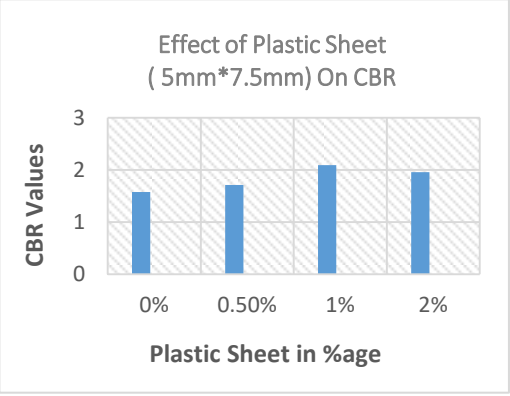

Fig-12: Effect of P.sheet on CBR

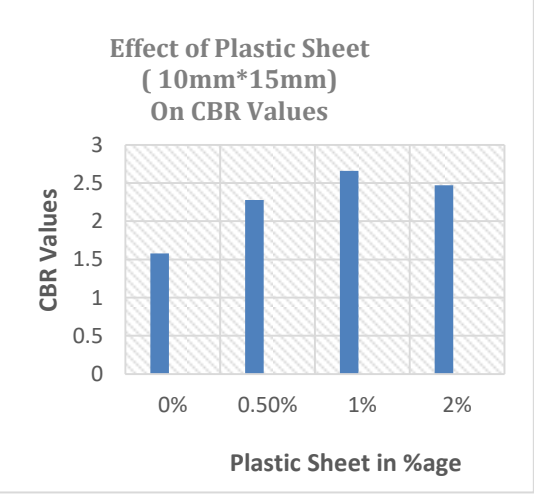

Fig-13: Effect of P.sheet on CBR

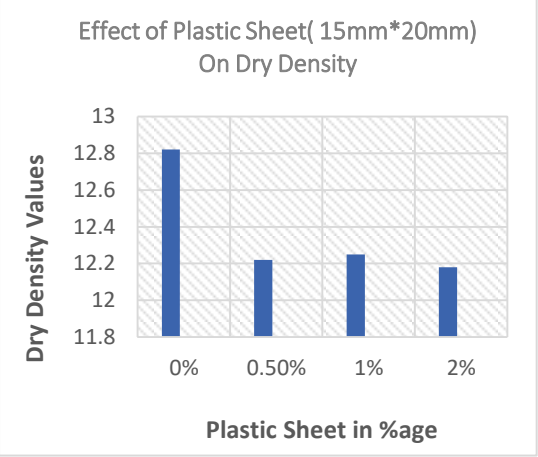

Fig-14: Effect of P.sheet on Dry Density

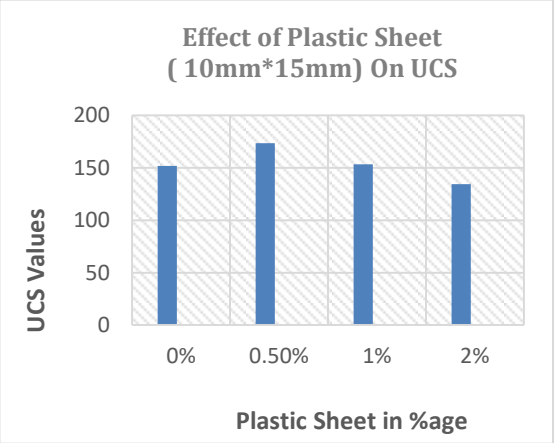

Fig-15: Effect of P.sheet on UCS

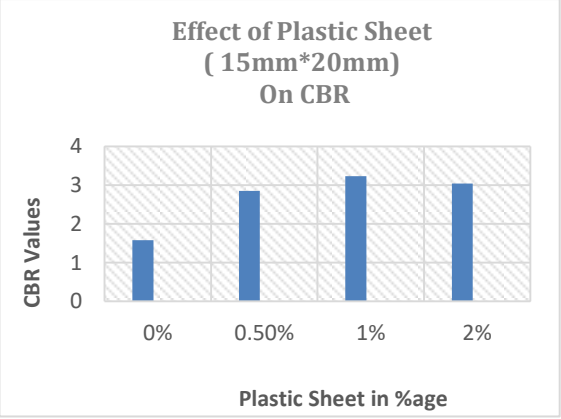

Fig-16: Effect of P.sheet on CBR

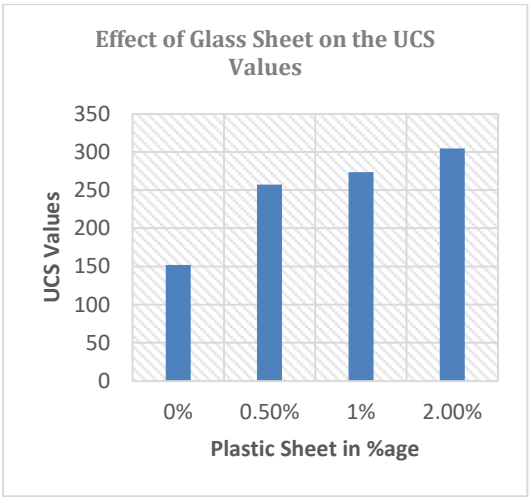

Fig-17: Effect of P.sheet on UCS

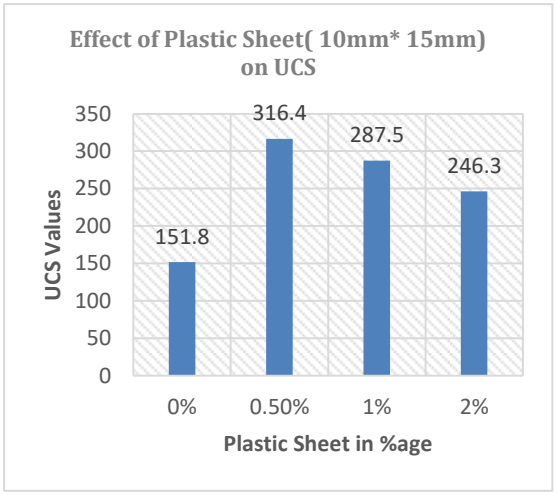

Fig-18: Effect of P.sheet on UCS

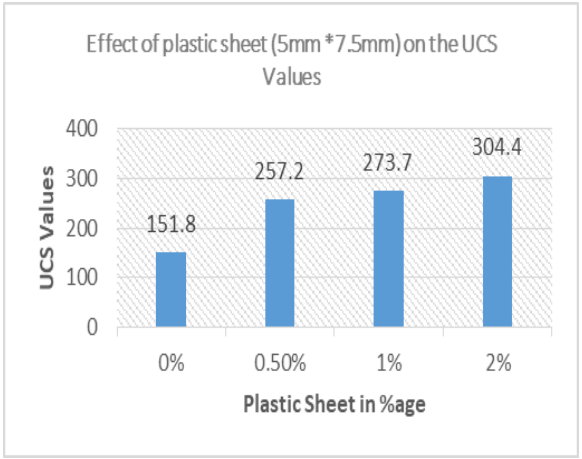

Fig-19: Effect of P.sheet on UCS

Form the above Figures it can be observed that the CBR value is 1.58 for pure soil sample-B when the plastic sheet of size 5mm* 7.5mm is added it value increases to 1.71 at 0.50% and 1% value was its value increases to 1.71at 1% its value was 2.01 and 2% its value was recorded 1.96 . it can be observed that when the size of the plastic sheet is the MDD value decrease with in size of the plastic sheet is 5mm* 7.5mm at 0% its value was 12.82 when the Percentage was 0.50% its value reduced to 11.97 at 1% its value was 12.56 which is again less than 12.82 while at 2% its value was recorded 12.8. It can be observed that the UCS value is 59.72 for pure soil when the plastic sheet of size 5mm* 7.5mm is added it value increases at 0.50% its value increases to 257.2 at 1% its value was 273.7 its value was recorded 304.4. From this result discussion it is concluded that the plastic in the form of powder is best stabilizer for improving the geotechnical properties of soil. it can be observed that when the size of the plastic sheet is the MDD value decrease with in size of the plastic sheet is 5mm* 7.5mm at 0% its value was 12.82 when the percentage was 0.50% its value reduced to 11.97 at 1% its value was 12.56 which is again less than 12.82 while at 2% its value was recorded 12.8. From the above result discussion it is concluded that the plastic in the form of sheet is best stabilizer for improving the CBR value of soil.

CONCLUSION

By using appropriate ground improvement materials and processes, the quality of the ground must be improved for construction safety. The soil that needs to be improved, the resources that are available, and the cost-effectiveness all influence the ground restoration approach that is used.

In order to stabilize soil and enhance its engineering qualities, plastic waste can be used in the form powder and sheets of different sizes.. These admixtures are regarded as one of the most widely used and reasonably priced ground improvement methods for stabilizing weak soil deposits. It is anticipated that adding plastic powder and plastic sheets to less suitable soil may increase its porosity, decrease its durability, and weaken its cohesiveness, among other effects. The soil that needs to be improved, the resources that are available, and the cost-effectiveness all influence the ground restoration approach that is used.

The following conclusions are derived from this study based on the observations and conclusions.

1. According to the Maximum dry density of soil can be enhanced both through plastic powder and plastic sheet.

2. Designing and building subgrade, embankment, and structural fills for the use of plastic powder and plastic sheet, as stabilizing agents will benefit from the data derived from the conducted investigations.

3. Reusing waste materials such as plastic powder and plastic sheets has financial benefits and poses no environmental risks, which is a key finding of this study..

4. Based on numerous investigations, it has been determined that plastic materials like plastic powder and plastic sheets are inert and beneficial in all types of weather. They are the most advantageous option for stabilizing soil because they are economical and non-biodegradable. The inclusion of several types of plastic. It has been observed that the soil is suitable for construction due to its engineering properties. As the strip length grows, so do the California Bearing Ratio (CBR) and shear strength ratings. Finally, for a range of soil stabilizing applications, including pavement subgrade, a number of plastic materials can be used.

5. Based on the aforementioned findings, it may be concluded that plastic wastes in the form powder and sheets can be utilized as stabilizing admixtures in less desirable clayey soil.

6. RECOMENDATIONS

According to a number of studies, plastics like plastic powder and plastic sheets are beneficial in all types of weather because of their inertness. They are the most advantageous option for stabilizing soil because they are economical and non-biodegradable. The incorporation of different plastic materials. It has been observed that the soil is suitable for construction due to its engineering properties. Maximum dry density and the California Bearing Ratio (CBR) it must be established whether stabilized plastic waste can withstand the durability constraints of freeze, thaw, shrinkage, moisture, etc. before being used as a base material.

REFERENCES

[1] Consoli, N.C., da Silva Lopes Jr, L. and Heineck, K.S., 2009. Key parameters for the strength control of lime stabilized soils. Journal of materials in Civil Engineering, 21(5), pp.210-216.

[2] Correia, A.A., Oliveira, P.J.V. and Custódio, D.G., 2015. Effect of polypropylene fibres on the compressive and tensile strength of a soft soil, artificially stabilised with binders. Geotextiles and Geomembranes, 43(2), pp.97-106.

[3] Chebet, F.C and Kalumba, D., 2014. Laboratory Investigation on Re-Using Polyethylene (Plastic) Bag Waste Material for soil reinforcement in Geotechnical Engineering. Civil Engineering and Urban Planning: An International Journal (CIVEJ), 1.

[4] Diambra, A., Ibraim, E., Wood, D.M. and Russell, A.R., 2010. Fibre reinforced sands: experiments and modelling. Geotextiles and geomembranes, 28(3), pp.238-250.

[5] Hataf, N. and Rahimi, M.M., 2006 Experimental investigation of bearing capacity of sand reinforced with randomly distributed tire shreds. Construction and Building Materials, 20(10), pp.910-916.

[6] Hejazi, S.M., Sheikhzadeh, M., Abtahi, S.M. and Zadhoush, A., 2012. A simple review of soil reinforcement by using natural and synthetic fibers. Construction and building materials, 30, pp.100-116.

[7] Ibraim, E., Diambra, A., Russell, A.R. and Wood, D.M., 2012. Assessment of laboratory sample preparation for fibre rein Consoli, N.C., Vendruscolo, M.A., Fonini, A. and Dalla Rosa, F., 2009. Fiber reinforcement effects on sand considering a wide cementation range. Geotextiles and Geomembranes, 27(3), pp.196-203.forced sands. Geotextiles and Geomembranes, 34, pp.69-79.

[8] Kalumba, D., 2013. Using shredded plastic shopping bags wastes in soil improvement.

[9] Miller, C.J. and Rifai, S., 2004. Fiber reinforcement for waste containment soil liners. Journal of Environmental Engineering, 130(8), pp.891-895.

[10] Mender, F.N.. 2015. Stabilization of Clayey Soil Using Polyethylene and Polypropylene (Doctoral dissertation, UMP).

[11] Makusa, G.P., 2013. Soil stabilization methods and materials in engineering practice: State of the art review.

[12] Mandal, J.N. and Labhane, L., 1992. A procedure for the design and analysis of geosynthetic reinforced soil slopes. Geotechnical engineering, 10(4), pp.291-319.

[13] Maher, M.H. and Gray, D.H., 1990. Static response of sands reinforced with randomly and geological distributed fibers. Journal of Geotechnical Engineering, 116(11), pp.1661-1677. Morel, J.C. and Goure, J.P., 1997.

[14] Mechanical behavior of sand reinforced with mesh elements. Geosynthetics International, 4(5), pp.481-508,

[15] Nacini, S.A. and Sadjadi, S.M., 2008. Effect of waste polymer materials on shear strength of unsaturated clays. Electron J Geotech Eng, 13, pp.1-12.

[16] Perern, A.S.R., Al-Tabbaa, A., Reid, J.M. and Johnson, D., 2005, April. State of practice report UK stabilization/solidification treatment and remediation, Part V: long- term performance and environmental impact. In Proceedings of the International Conference on Stabilization/Solidification Treatment and Remediation. Cambridge (pp. 437-457),

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