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Advancement in Properties of Clayey Soil using Sewage Sludge Ash And Plastic Waste

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Abstract

In order to stabilize clayey soil, Sewage Sludge Ash (SSA) and plastic waste are added in different proportions to the clayey soil. Sewage sludge ash in values of 4% to 20% i.e. 4%, 8%, 12%, 16% & 20% by weight of the total quantity of clayey soil taken is mixed with the soil and test is conducted to determine optimum SSA content. Optimum SSA is determined by performing Standard Proctor Compaction Test.Influence of plastic waste strips on various properties of clayey soil treated with sewage sludge ash is also studied. The optimum SSA content obtained is used in clayey soil along with plastic waste strips with 1, 1.5, 2, and 2.5% by weight of the total quantity of clayey soil taken and optimum plastic waste content to be used is also determined. Tests such as Compaction, Atterberg's limits, Specific Gravity, Unconfined Compressive Strength (UCS), and California Bearing Ratio (CBR) are performed to determine properties of clayey soil sample. The resultsindicate that Maximum Dry Density of untreated soil were greatly improved by the use of 12% SSA. Moreover, 1.5% addition of plastic waste in the form of strips enhanced the treated soil in terms of Maximum Dry Density. Furthermore, the optimum moisture content was effectively reduced by the use of 12% SSA as compared with untreated soil and the 1.5% plastic waste strips fraction offered the best performance. From this study, we conclude that 12% of SSA replacement could effectively stabilize clayey soil, and 1.5% of plastic waste strips may be the optimum amount to add to the soil.

Key words: Clayey soil, Sewage Sludge Ash, Maximum Dry Density, Plastic Waste, Optimum Moisture Content, Polyethylene Terephthalate

I. INTRODUCTION

The properties of soil play an important role to built structures. However, shear strength parameters for clayey soil can be a challenge for these sustainable structures. These parameters are susceptible to any water content change which resulted in most of the cases in significant reduction of the shear strength values. In addition to that, clayey soil is well known to have high compressibility and expansive properties, which causes major defects in any structure overlaying on such soil. Engineers all over the world used many materials with clayey soil to reduce its expansive properties and increase its shear strength. This technique is known as soil stabilization. The problems with expansive soil have been reported in many previous literatures. It is reported in the literature that this potential for swelling of the soil can be reduced or in many cases eliminated if treated with different materials such as waste ceramic, cement kiln dust and waste shredded rubber.Soil stabilization or improvement of engineering properties of soil for economic, safe and long lasting structures drew a lot of interest among the researchers in recent years. These studies are mostly focused on using waste materials as a stabilizing agent.Even though several materials were tried as a means to stabilize the soil, majority of them are chemical in nature and poor in terms of biological degradation. In this regard the bearing capacity of clayey soil can be increased by treating the soil with sewage sludge ash (SSA) reinforced with plastic waste strips. Sewage sludge is an organic waste generated during the wastewater treatment. In context with to use a material as the soil stabilizer, several literature surveys and past experiments revealed that SSA has the potential to stabilize cohesive soils. Past studies have also revealed that a substantial increase in the bearing capacity of expansive clayey soils can be done by reinforcing the soil. The soil can be suitably reinforced with plastic waste strips that are freely and economically obtained from waste plastic materials such as toys, plastic bottles etc.

Plastic have numerous physical properties such as transparency, elasticity, water resistant, flexibility etc. and chemical properties such as chemical resistance, thermal resistance, low toxicity etc. that make it superior to other materials. Plastic waste is abundandantly available that can be hauled for strengthening the soil. Engineers all over the world used many materials with clayey soil to reduce its expansive properties and increase its shear strength.One of the contributions to this is to stabilize the clayey soils with SSA and plastic waste. The net volume of sludge generated from waste water treatment is reduced by incineration of sewage sludge but the resulting biomass ashes must be committed to disposal or beneficial reuse alternatives. Disposal by traditional landfilling has associated costs and permitting obstacles. One way to dispose part of sewage sludge ash is to use it for clayey soil stabilization. Disposal of plastic waste is a real time challenge to the scientists. One method to reduce some portion of the plastic waste disposal problem is utilizing these materials for reinforcing the unstable clayey soils to increase their bearing capacities. The aim of this study is to maintain environmental balance and avoid problems of waste plastic disposal by using plastic waste for stabilization of clayey soil so that soil can be made to increase in its bearing capacity to obtain maximum stability of soil.

II.MATERIALS

Clayey Soil

Clayey soil is the one having clay as its basic constituent. Clay is a material which has fine grains of rocks or soil material which combines some clay minerals having some parts of oxides of metals as well as organic matter. Geologic deposits of clay are mainly composed of phyllosiicate minerals having water embedded in the structure of minerals and it keep on varying .The plastic nature of clays are due to the water content present in them. Clays become brittle , non - plastic and hard when they dry or they are fired. Based on contents of soil in which the clay is found, it appears in many colours such as white , brown, red etc. Clay could cause settlements which can be large under load, for whether it is soft clay or firm. The settlements areslow, most of the times because of poor drainage property of clay. Dissipation of pore pressures within the pores of clay particles occurs slowly, leading to consolidation settlement which is long term. Regionally, properties of clay are unique When clays are present in large loaded areas, settlement and scheduling problems could occur due to thicker deposits of clays particularly soft clays

Sewage Sludge Ash

Sewage sludge ash which is produced as by-product during the sewage sludge combustion. The sewage sludge is dewatered before combustion. The combustion is carried out in an incinerator. The sludge ash is mainly silty in gradation having some particles whose size is that of sand. The specific range of size of particles and sludge ash properties mostly depend on incineration system type as well as on chemicals which are used as additives during treatment of waste water. The systems of incineration which are major and employed at present are multiple hearth system and fluidized bed system.According to CPCB 2016,there are approximately 193 common effluent treatment plants and 920 sewage treatment plants in India, producing large amount of sludge that can be incinerated into ash to take various advantages out of it, one of which is to stabilize soil.

Plastic Waste

Plastic waste is the waste generated after using materials made up of plastic. Plastic has good durability, it is lightweight and it is inexpensive It can easily be moulded into various forms and products. Plastics find its use in various sectors, from one industry to another. But the waste generated after the use of plastic is a curse to the earth. As per data available on Municipal Solid Waste (MSW) 2016,approximately, 15000 tons per day plastic wastes are being generated in India. As a consequence, of its wide range of application plastic production increased in last 60 years and so as the waste associated with it. Today, plastic application has virtually revolutionized every that part of the economy which is vital. Plastics can remain unaltered for a very long time of about 4500 years, according to studies done. Use of plastic which is non-biodegradable material is increasing rapidly. The problem lies in to overcome the waste generated by its use.

III.OBJECTIVES OF RESEARCH

- To increase the Maximum Dry Density of clayey soil using SSA and plastic waste as admixtures.
- To determine the optimum SSA and plastic waste strips content to be used.
- To provide an alternative for disposal of Sewage Sludge Ash and Waste plastic.
- To strengthen the local available clayey soils to avoid their replacement by stable soils which is uneconomical

IV.METHODOLOGY ADOPTED

The sewage sludge ash is ground into fine powder particles. The plastic which was collected from waste is cut into strips of length approx.15mm and breadthapprox.4mm, having density varying between 0.35-0.65 g/cm^3 approx. In present investigation, to fulfill the objectives three set of tests were performed which are described below.

A. First Set of Test

The first set of test is performed to study the properties and behavior of clayey soil in natural conditions. Table 1 shows the properties of clayey soil.

B. Second Set of Test (Determination of optimum Sewage Sludge Ash)

The second set of test consists of StandardProctor CompactionTest is aimed at determining "Optimum Sewage Sludge Ash". Sewage sludge ash in values of 4% to 20% (multiples of 4) by weight of the total quantity of clayey soil taken is mixed with the clayey soil and test is conducted.

C. Third Set of Test (Influence of optimum plastic waste)

The third series of test which is again Standard Proctor Compaction Test is aimed at studying the influence of plastic waste strips on various properties of clayey soil treated with optimum sewage sludge ash. The optimum SSA obtained from second set of test is used in this set of test in clayey soil along with plastic waste strips at 1, 1.5, 2 and 2.5% by weight of the total quantity of clayey soil taken.

Table 1 Properties of clayey soil sample

S. No.	Laboratory Test	Result
1	**Specific Gravity**	2.44
2	**Sieve Analysis**	
	Gravel	0%
	Sand	9%
	Silt	26%
	Clay	65%
3	**Atterberg Limits**	
	Liquid Limit, LL	64%
	Plastic Limit, PL	36.7%
	Plasticity Index, PI	27.3%
4	**Standard Proctor Compaction Test**	
	Maximum Dry Density, MDD	1.56gm/cm^3
	Optimum Moisture Content, OMC	21.59%
5	**California Bearing Ratio Test**	
	CBR	5.96%
6	**Unconfined Compression Test**	
	Compressive Strength	0.197 N/mm^2

V.RESULTS

STANDARD PROCTOR TEST FOR SOIL - SSA MIXTURE

Table 2 MDD& OMC values with different Soil - SSA ratio

Ratio (Soil : SSA)	MDD (g/cm^3)	OMC (%)
100 : 0	1.54	21.59
96 : 4	1.56	21.10
92 : 8	1.57	20.47
88 : 12	1.59	19.43
84 : 16	1.49	22.54
80 : 20	1.44	23.31

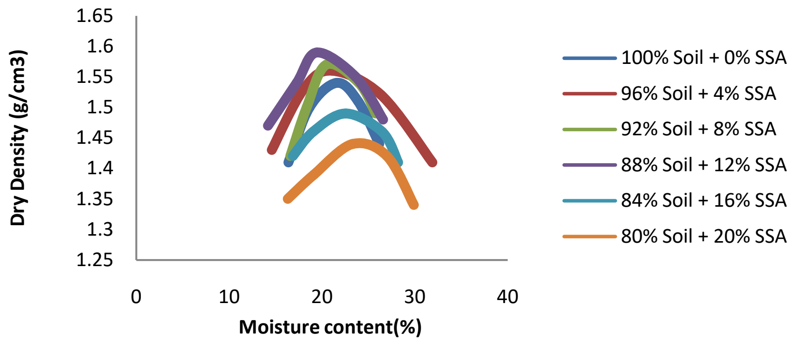

Fig.1 Compaction curves for different Soil - SSA ratios

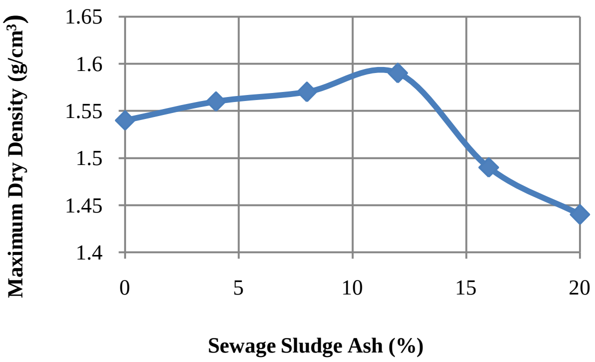

Fig. 2 Variation in MDD values with varying SSA content in soil

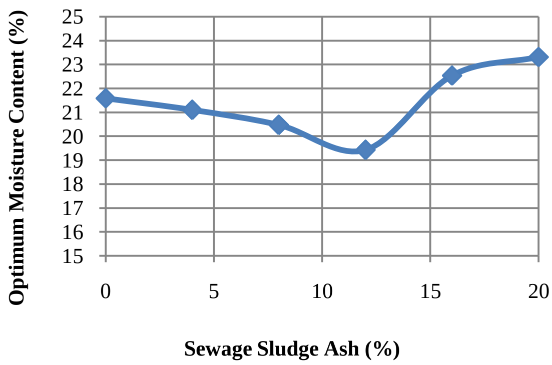

Fig. 3 Variation in OMC values with varying SSA content in soil

STANDARD PROCTOR TEST FOR SOIL – SEWAGE SLUDGE ASH – PLASTIC WASTE STRIPS MIXTURE

After performing Standard proctor test for clayey soil and sewage sludge ash mixture, it is found that 12% SSA by weight of clayey soil gives the Maximum Dry Density with minimum value. Now to study the effect of plastic waste on clayey soil, SSA with plastic waste in the form of strips are mixed in varying ratios with fix 12% proportion of SSA. Compaction test is performed at each ratio.

Table 3 MDD& OMC values of different Soil - PWS ratios & fix 12% SSA

Ratio (Soil : SSA : PWS)	MDD (g/cm^3)	OMC (%)
87 : 12 : 1	1.59	17.29
86.5 : 12 : 1.5	1.60	16.84
86 : 12 : 2	1.58	19.02
85.5 : 12 : 2.5	1.50	20.63

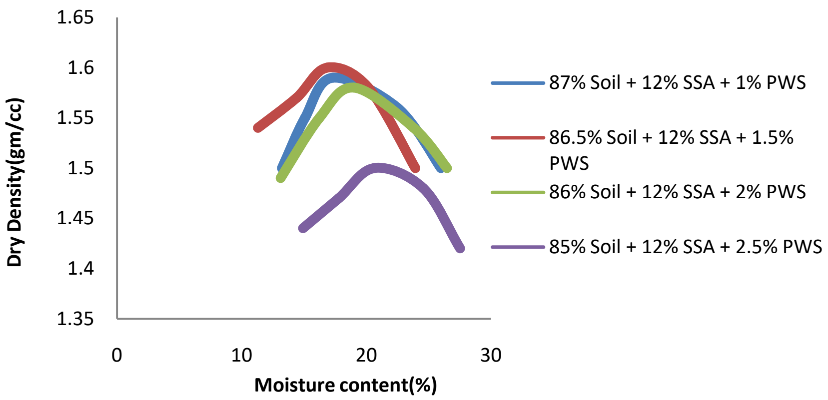

Fig. 4 Combined compaction curves for different Soil - PWS ratios & fix 12% SSA

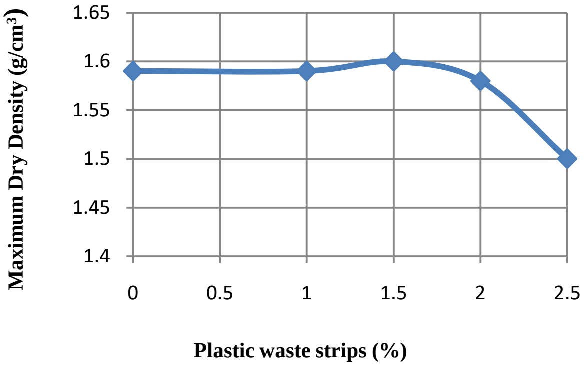

Fig. 5 Variation in MDD values with varying Soil – PWS ratio & fix 12% SSA

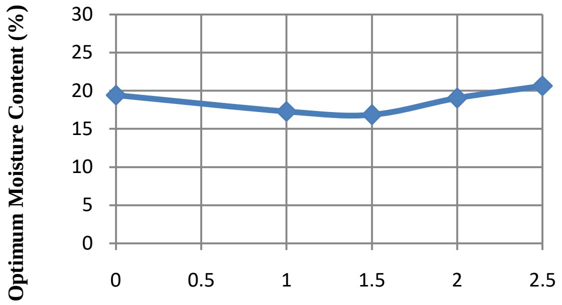

Fig. 6 Variation in OMC values with varying Soil – PWS ratios & fix 12% SSA

VI. CONCLUSION

The following conclusions are drawn:

1. The Maximum Dry Density (MDD) value of the clayey soil increases with the addition of different proportion of SSA upto a particular limit. The maximum value of MDD was observed for a mixture of 88% clayey soil + 12% of SSA content by weight. The MDD values consistently decreased thereafter.
2. It can be concluded that 12% SSA by weight is to be added in clayey soil to stabilize it.
3. The Maximum Dry Density (MDD) value of the clayey soil + 12% SSA mixture showed increment with the addition of plastic waste strips. The maximum value of MDD was observed for a mixture of 86.5% clayey soil + 12% SSA + 1.5% of plastic waste strips content by weight. The MDD values consistently decreased thereafter.
4. Thus 1.5 % plastic waste content and 12% content of SSA by weight are the optimum values to be added in clayey soil.

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