A review of using the waste in soil stabilization

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***Abstract*— Soil stabilization means alteration of the soils properties to meet the specified engineering requirements. Methods for the stabilization are compaction and use of admixtures. Lime, Cement was commonly used as stabilizer for altering the properties of soils. From the recent studies it is observed that, waste materials such as flyash, rice husk ash, Waste Stone Powder and Waste tire cord are used for this intended purpose with or without lime or cement. Disposal of these waste materials is essential as these are causing hazardous effects on the environment. With the same intention literature review was undertaken on utilization of waste materials for the stabilization of soils and same is presented here.**

***Keywords*— stabilization, Waste materials, environment, ground improvement.**

I. INTRODUCTION

Soil stabilisation is a technique introduced many years ago with the main purpose to render the soils capable of meeting the requirements of the specific engineering projects. In this work review of the possibility of stabilising fine-grained plastic soils with waste materials and without cement is investigated. These stabilised materials may be used as improved subgrades or capping layers or sub-bases for road or airfield pavements.

On the other hand, Marginal soils, including loose sands, soft clays, and organics are not adequate materials for Highway construction projects. These marginal soils do not possess valuable physical properties for construction applications. The usually methods for remediation of this weak subgrade such as remove the soil and change to the new one is typically expensive. Waste materials such as fly ash, bottom ash offer a cheaper method for stabilizing marginal soils [(KoteswaraRao. D et al, 2011and 2012)]. As an added benefit, utilizing waste materials in soil stabilization applications keeps these materials from being dumped into landfills, thereby saving already depleting landfill space. Included in this report is an extensive investigation into the current state of research on waste and recycled materials in construction applications. Changes in the engineering properties of soils as a result of adding these waste materials were studied and recommendations on implementing these effects into construction applications are offered.

Mohammad Jafari et al in 2012 were investigated on Effect of waste tire cord reinforcement on unconfined compressive strength of lime stabilized clayey soil under freeze–thaw condition. In their paper, stabilization and fiber reinforcement are simultaneously examined as a soil modification method. A series of unconfined compression tests was carried out to investigate the effects of tire cord waste products on mechanical characteristics of a lime stabilized and unstabilized clayey soil subjected to freezing and thawing cycles. Several specimens were prepared at three percentages of lime (i.e. 0%, 4%, and 8%) and four percentages of discrete short nylon fiber (i.e. 0%, 0.5%, 1%, and 1.5%) by weight of dry soil.

Ezekwesili Ene et al in 2009, were investigated on Some basic geotechnical properties of expansive soil modified using pyroclastic dust. they reports an investigation of the influence of pyroclastic rock dust on the geotechnical properties of expansive soil. The plasticity, linear shrinkage, compaction, California bearing ratio (CBR) and shear strength characteristics of the soil when mixed with varying proportions of pyroclastic rock dust were investigated. The results show significant reduction in plasticity and linear shrinkage of expansive soil with increasing amount of pyroclastic rock dust. The maximum dry density, optimum water content, shear strength and CBR all increased with increasing pyroclastic rock dust content.

S. Koliaset al in 2005, were discussed on Stabilization of clayey soils with high calcium fly ash and cement.in their research the effectiveness of using high calcium fly ash and cement in stabilizing fine-grained clayey soils (CL,CH) was investigated in the laboratory. Strength tests in uniaxial compression, in indirect (splitting) tension and flexure were carried out on samples to which various percentages of fly ash and cement had been added. Modulus of elasticity was determined at 90 days with different types of load application and 90-day soaked CBR values are also reported.

Also Muntohar in 2005 and 2009 studied the influence of molding water content and lime content and the Influence of Plastic Waste Fibers on the Strength of Lime-Rice Husk Ash Stabilized Clay Soil, Which concluded that the clay soil was stabilized with lime and rice husk ash mixtures. The effect of the fiber length and content on the compressive and split tensile strength was investigated. The laboratory investigation results show that inclusion of the plastic waste fiber increased significantly both the unconfined compressive strength and tensile-split strength of the stabilized clay soil. The fiber length plays a significant contribution in increasing the soil strength. Also the results showed that the water content determines the UCS characteristics of unstabilized and stabilized soils. The UCS of stabilized soils decreased with increasing molding water content, but it is still higher than of the un-stabilized soils.

Armin Roohbakhshan et al in 2013, were experiments on influence of lime and waste stone powder on the pH values and atterberg limits of clayey soil. Then in 2014 were investigated on the effect of lime and waste stone powder variation on the pH values, moisture content and dry density of clayey soil. They investigated on the percentage of lime and WSP used on the samples varied from 0 to 11%, which treatment of the samples with lime and WSP content show that the optimal moisture and maximum dry density values of the samples were changed. The results show increasing in the pH value of clayey soil with increasing amount of waste stone powder and lime. And the optimal moisture content increased with increasing lime and WSP content for all the samples. Also the maximum dry density decreased with increasing lime, whereas the maximum dry density increased with increasing WSP content.

Industrial wastes are the waste arising from industrial activities and are hazardous in nature due to presence of toxic substances. Flyash (FA) is an industrial waste being generated from thermal power plants and it is available in fine dust form. FA contain trace amount of toxic metals such as Cr, Th, Pb, Hg, Cd, etc. which may have negative impact on the health of humans, animals and plants growth too.

Rice is the primary source of food for billion peoples across the world. At present around 600mt of paddy produced annually. India is second largest producer of rice next to china. Yearly production of rice is about 0.32 million tons resulting huge husk production. Rice husk is the shell produced during dehusking of paddy. Rice husk being agricultural waste dumped near the mills or burnt in open fields.

The other stabilizing material is Waste stone powder (WSP). Waste stone powder, derived from waste slab marble was used as sludge. Waste stone powder cause great amount of environmental pollution that by reusing and recycling these waste materials as an additive in the improvement of geotechnical properties of soils will greatly contribute to the economy and to the environment by minimizing polluting effects coming from stone quarries and

stone plants.

Different ways are available for enhancing engineering performances of soils are soil stabilization, soil reinforcement, etc. Admixtures like lime, cement were used traditionally for stabilization purposes. Recent studies shows waste alone or in combination with lime or cement can be used for effective stabilization of weak soils to a great extent. With the same intention author have undertaken review of utilization of these waste materials as stabilizer and same is presented here. This may found to be an economical treatment method for soils as these materials are available locally and such solution will definitely found beneficial for the developing countries like India where economy is the prime concern for adopting any new method or technique. Additionally, safe disposal mechanism can be suggested for the waste being generated which will help in reducing the hazardous effect on the environment of the region.

II. Review of Soil Stabilization Using Waste tire cord:

The fiber is derived from waste material of tire cord factory products. The main constitutive substance of this fiber is nylon 6–6. High resistance against heat, fatigue, impact, and sunlight, and high resilience are some of the valuable characteristics of this fiber, which is usually used in tire and seat belt of vehicles, fishnet, reinforced hoses, and so on. In tire cord company, quality control unit regularly tests samples of productions based on tensile strength, tensile strain at failure point, H-adhesion test, absorption percentage of resorcinol formaldehyde latex (RFL) which is used for adhesion between the interface of fiber and rubber, and hot air thermal shrinkage. The products which do not satisfy particular standards and also, some fibers which become torn in tire production process are discarded as waste products. Usually 10% of nominal production capacity of tire cord factories is waste material. Fig..1 shows tire cord with 20 mm length.

Fig..1. Tire cord with 20 mm length.

Effect of fiber content on unconfined compressive strength values of unstabilized specimens is presented in Fig. 2.Inclusion of fiber increases the unconfined compressive strength(UCS) until 1.5%, while further values decrease it. Excessive contents of fiber increases probability of fiber agglomerating which means reduction of effective interfacial contact area between fibers and matrix.

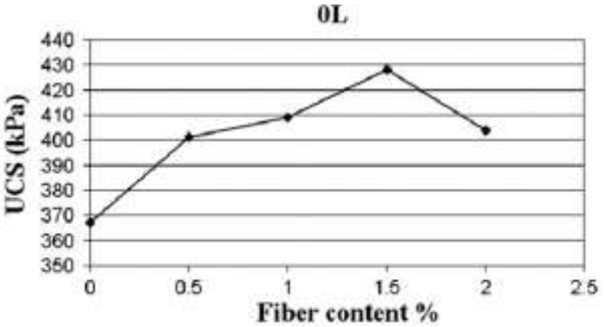

Fig. 2. Unconfined compressive strength (UCS) values for unstabilized specimens versus fiber content.

Thus, interruption of reinforcement mechanism leads to decrease of compression strength. The UCS of untreated soil is 367 kPa and it is increased to 428 kPa by reinforcing with 1.5% fiber content.

III. Review of Soil Stabilization Using Fly Ash

Flyash is the finely divided residue that results from the combustion of pulverized coal. Flyash is most commonly used as pozzolan in PCC applications. Pozzolans are siliceous or siliceous and aluminous materials, which in a finely divided form and in the presence of water, react with calcium hydroxide at ordinary temperature to produce cementitious compounds. Flyash is typically finer than Portland cement and lime. Flyash consists of silt-sized particles which are generally spherical, typically ranging in size between 10 & 100 µm. Fineness is one of the important properties contributing to pozzolanic reactivity of flyash. Flyash consists primarily of oxides of silicon, aluminum, iron and calcium. Magnesium, potassium, sodium, titanium and sometimes sulfur are also present to a lesser degree.

Flyash used as mineral admixture are classified as either class C or class F based on its chemical composition. American Society for Testing and Materials (ASTM) specification C618 suggested the chemical composition of class C and class F flyash. Class C ashes are generally obtained from sub-bituminous coals and consist primarily of calcium alumino-sulfate glass as well as quartz, tricalcium aluminates and free lime (CaO). Class C ashes contain more than 20%CaO. Class F ashes are typically derived from bituminous and anthracite coal and consist primarily of an alumino-silicate glass, with quartz, mullite and magnetite also present. Class F has less than 10% CaO.

Fig.. 3 show the development of the unconfined compressive strength in relation to curing time for Soil respectively. The soil properties and chemical analysis of flyash that use in Fig..3are given in table 1 and 2.

Table1-Atterberg limitsand soil classification of soil

SOIL SAMPLES	ATTERBERG LIMITS			AASHTO CLASSIFICATION	UNIFIED SOIL CLASSIFICATION	
	PL	LL	PI		GROUP SYMBOL	GROUP NAME
SOIL 1	20	38	18	A-6	CL	LEAN CLAY

Table2-Chemical analysis of Kardia's fly ash

Oxide	Percentage
	Fly ash 1
SiO_2	19.9
Fe_2O_3	5.72
MgO	3.65
CaO	48.97
Na_2O	0.6
K_2O	0.45
Al_2O_3	9.26
SO_3	7.25
Loss of ignition	3.01
Free Cao	18.31

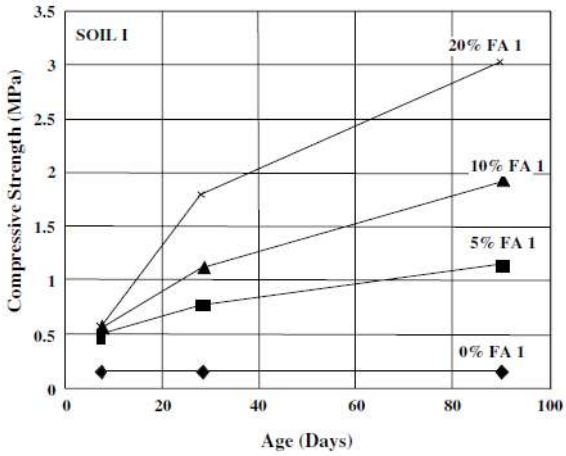

Fig. 3.Effect of fly ash addition on uniaxial compressive strength soil.

The use of high percentages of fly ash is, in certain cases, more effective than the combination of FA and cement but the problems associated with the use of large quantities of fly ash would need to be addressed.

IV. Review of Soil Stabilization Using Waste Stone Powder

The other stabilizing material is Waste Stone Powder (WSP). The Waste stone powders are derived from waste slab marble as sludge. Waste stone powder cause great amount of environmental pollution that By reusing and recycling of these waste materials as an additive in the geotechnical properties of soils have great contribution to the economy and to the environment by minimizing polluting effects coming from stone quarries and stone plants. Recycled stone powder used in research was produced in slab stone processing and plant.

Standard Procter compaction tests were conducted to determine the optimal moisture content and maximum dry density for soil stabilized with different contents of lime and WSP. The clay soil mixed with lime and WSP. Waste stone powder was added in varying proportions of 0, 3, 6 and 9% and Lime was added in varying proportions of 0, 3, 6, 9% and 11%. The treatment of the samples with lime and WSP content changed the optimal moisture and maximum dry density values of the samples, and the optimal moisture content increased with increasing lime and WSP content for all the samples. Also the maximum dry density decreased with increasing lime and the maximum dry density increased with increasing WSP content. The procedures used in carrying out these tests were the ASTMD698- 78 Standard Test Method for compaction of Soils. It is observed that by increasing lime content, maximum dry density decreases and optimum moisture content increases. Also, when lime is added to soil, instantaneous reaction as cation exchange occurs, and clay particles flocculate together. This process leads to formation of air voids among particles and makes creation of a porous medium with lower maximum dry density. These mentioned effects are combined in lime–waste stone powder–soil mixture are shown in Fig..4.

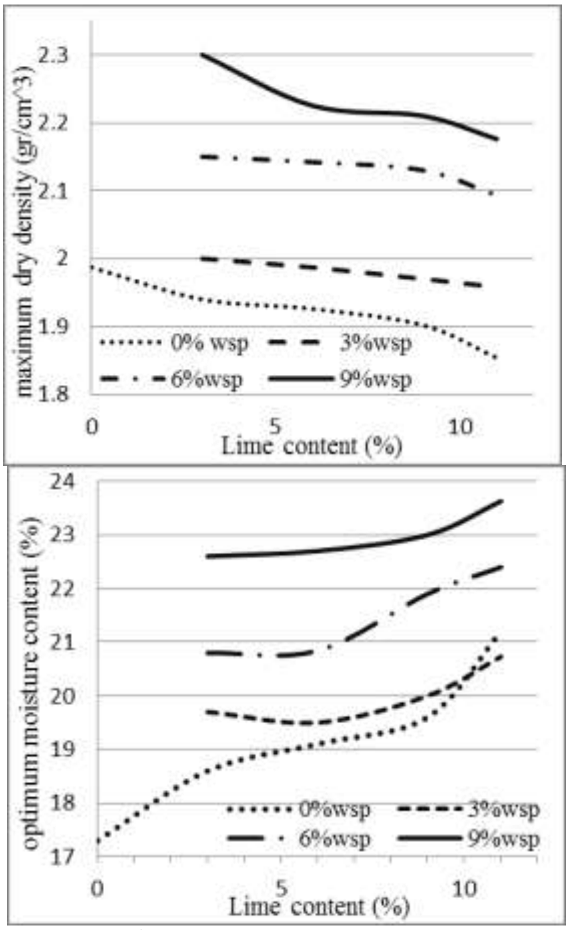

Fig. 4. Variation of maximum dry density and optimum moisture content with varying percentages of lime and WSP.

V. Review of Soil Stabilization Using Rice Husk Ash

Very little information has been published on the engineering properties of pozzolanic stabilized materials using RHA as additive. Lazaro and Moh (1970) examined the use of RHA in combination with lime for clay stabilization. They concluded that the addition of RHA in combination with lime to both Thai soils and Philippine soils could not produce any significant increase in strength as compared to the use of lime alone. Compared to the equivalent strength values, the amount of lime in a lime-ash soil mixture is significantly less than that required in a lime-soil system.

In this research, hydrated lime was used as the stabilizing agent. The major chemical constituent of the lime is calcium hydroxides [Ca(OH)2]. To reduce the carbonation effect due to humidity, the lime is kept in the airtight plastic drum. The other stabilizing material is rice husk ash, RHA. For this research, merely the grey color ashes were chosen. An amount of 5kg RHA was then ground by 40 mild steel balls in the Los Angeles abrasion machine. The grinding took 3 hours to equal 5000 revolutions. This period produces suitable fineness and proper surface area of RHA respectively about 12.4% and 25 mm2/g. The ground RHA is then transferred into plastic bag and stored in the airtight container at room temperature to prevent atmospheric humidity absorption.

Fig. 5 shows the unconfined compressive strength of stabilized soil with varies of lime and RHA ratio at different water content. The soil strength raise significantly 500% (600% when it was blended with lime) RHA ratio of 1:3 for all molding water content. The Fig. depicts obviously, for molding water content of w = 14% and w = 19%, that the lime and RHA ratio of 1:2 attained maximum strength gain as 995 kPa and 767 kPa respectively for w = 14% and w = 19%. Further reducing the RHA content, for lime – RHA ratio of 1:1, tends to decrease the unconfined compressive strength of the stabilized soils to become 865 kPa and 697 kPa respectively for w = 14% and w = 19%. However, a different characteristics was observed at higher water content (w = 24%) in which the unconfined compressive strength increase marginally up to the lime – RHA ratio of 1:1. The result is in accordance with theory of lime-soil reaction of which need additional water to establish a modification and stabilization process.

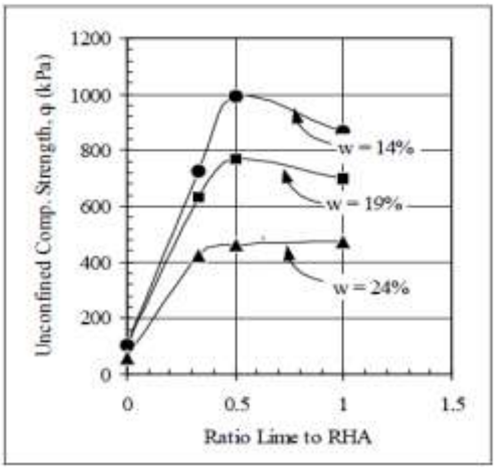

Fig. 5. Unconfined compressive strength of stabilized soil for lime content at LRS.

VI. Conclusions

The results of this investigation have shown that beneficial effects are obtained by the addition of lime and waste to soil. Therefore, On the basis of literature survey carried out following concluding remarks are made:

1. Fly ash can be used for variety of civil engineering applications like lower layers of road pavement, in the development of low permeability flowable fill, material, as a dike material, and as reclamation material.
2. Cement/ lime stabilized soil-waste mixtures can be used in a variety of civil engineering applications.
3. Rice husk ash an agricultural waste can be effectively used for stabilization of soils using cement or lime as additive.
4. The treatment of the samples with lime and WSP content changed the optimal moisture and maximum dry density values of the samples.
5. The optimal moisture content increased with increasing lime and WSP content for all the samples. Also the maximum dry density decreased with increasing lime and the maximum dry density increased with increasing WSP content.
6. The contribution of fiber in increasing strength is enhanced as the cycles of freeze–thaw increase.

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