Effect of Combination of Bagasse Ash And Zinc Slag on The Strength Enhancement of Coastal Sandy Soils

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Abstract- *Ground improvement refers to any procedure undertaken to increase the shear strength, decrease the permeability and compressibility, or otherwise render the physical properties of soil more suitable for projected engineering use. India has large coastline exceeding 6000kmps. In view of the developments on coastal areas in the recent past, large Number of ports and industries are being built. In addition the availability of land for the Development of commercial, housing, industrial and transportation, infrastructure etc. are Scarce particularly in urban areas. This necessitated the use of land, which has weak strata, where in the geotechnical engineers are challenged by presence of different problematic soils with varied engineering characteristics. The main objectives of the soil stabilization are to increase the bearing capacity of the soil, its resistance to weathering process and soil permeability. Soil stabilization techniques can considerably increase the profiles of the low strength soils to the desired extent. Further, these techniques are very economical and reduce the overall cost of a project. In recent years, soil stabilization by using various industrial and agricultural wastes was a most common practice. Keeping in view in the present research, experimentation was carried out to investigate the performance of agricultural waste like Bagasse Ash and industrial waste zinc slag on coastal sandy soils. To understand the performance of stabilized soil, its properties like Atterberg's Limits, Compaction Parameters, and Penetration Parameters were studied in the laboratory.*

Keywords- *clayey soil, Bagasse Ash, zinc slag, standard Proctor compaction test, California bearing ratio, unconfined compressive strength.*

I. INTRODUCTION

Nowadays, the development of constructions projects in India is rapidly increasing. However, the development of construction projects has to be followed by the development of the quality of the building. The quality of the building is very important in constructions project. One of the important factors that affect the quality of the buildings is soil strength in the construction sites. Some of construction project in India are built on the site that consist of soft soils. Clay is fine grain material that consists of very small particles. Because of its size, clay has small pore than other types of Soils. In the construction projects, clay materials considered as bad base-soil material. Clay soils usually cause some problem on the constructions site. Mostly the problem of clay soils is related to bearing capacity, settlement, swelling and shrinkage.

Single coastal sand can be defined as a mound or hill of sand, which rises to a single summit. They are accumulations of windblown sand, which change their position or their shape due to wind action as long as their surface consists of loose granular material of appropriate size.

Various remedial measures like soil admixture, moisture control, pre-wetting, lime stabilization have been practiced with varying degrees of success. However, these techniques suffer from certain limitations with respect to their adaptability, like longer time periods required for pre-wetting the highly plastic clays, difficulty in constructing the ideal moisture barriers, pulverization and mixing problems in case of lime stabilization and high cost for hauling suitable refill material for soil admixture etc.

Stabilization of soils is an alternative for geotechnical engineers considering the economics of construction with coastal sandy soils. Mechanical stabilization, such as compaction, is an option; however many engineers have found it necessary to alter the physicochemical properties of clay soils in order to permanently stabilize them.

1.2 OBJECTIVES OF THE STUDY

The objectives of present experimental study are to develop correlations between engineering characteristics of coastal sandy soils. The study is focused on

- Improvement of locally available soil using some eco-friendly and cheap waste materials.
- Evaluation of strength characteristics of virgin as well as blended soil using different materials like Zinc slag and Bagasse Ash.

- Determination of appropriate Zinc slag and Bagasse Ash content ratio co achieve the maximum gain in strength of soil.

II. LITERATUREREVIEW

Soil stabilization is a procedure where we improve engineering properties of soil with the use of natural or synthesized admixtures. In the past many researchers have carried out their research work for improving the strength of soil using different types of admixture at different percentages. A brief review of previous studies on residual soil is presented in this section and past efforts most closely related to the needs of present work.

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Gupta and seehra (1989) studied the effect of lime- Zinc slag on the strength of soil. They found that lime- Zinc slag soil stabilized mixes with and without addition of gypsum, or containing partial replacement of Zinc slag by fly ash produced high UCS and CBR in comparison to plain soil. They also concluded that partial replacement of Zinc slag with fly ash further increased the UCS.

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Akinmusuru (1991) put his effort in finding out the effect of mixing of Zinc slag on the consistency, compaction characteristics and strength of lateritic soil. Zinc slag content varied from 0% -15% by dry soil weight. He observed a decrease in both the liquid and plastic limits and an increase in plasticity index with increasing Zinc slag portion. Further, he observed that the compaction, cohesion and CBR increased with increasing the Zinc slag content up to 10% and then subsequently decreased. The angle of friction was to be decreased with increasing percentage of Zinc slag.

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Sreeramarao, g. Sridevi and m. Rama rao (2009) reported about heave studies on expansive clays with stabilized granulated blast furnace slag cushion. Experiments were also conducted to study the effect of the cement content as well as the cushion thickness on the heave of the black cotton soil bed. The study also aimed at comparing the performances of Granulated Blast Furnace Slag (GBFS) to study the effect of cushion thickness on the swelling behavior of black cotton soil. It was reported that both the slag cushions, stabilized with cement, are effective in minimizing the swell of black cotton soils. For GGBFS, there is a significant reduction of heave at low cement contents itself but for GBFS, as the cement content is increased, the swell potential decreased steeply. 6% to 8% cement content has been found to be optimum. No such optimum was observed in GGBFS. As the thickness of the cushion increased, there was a corresponding decrease in the swell potential.

Tapashkumarroy (april 29-may4th 2013) investigated the benefits of using Bagasse Ash (BA) with clayey soil as the subgrade material in flexible pavements with addition of small amount of lime. Four ratios of BA of 5%, 10%, 15% and 20% mixed with the clayey soil by weight of soil sample. Further for getting the better performance, lime has been added in this study in the varying proportions from 1% to 3% by weight of soil. The compaction characteristics and unconfined compressive strength tests were conducted on these different mixed soils. The test results shows that the Bagasse Ash can be used advantageously with addition of clayey soil and lime as cost effective mix for construction of subgrade of the roadway pavement.

Dr.D.koteswararao, G.V.V. rameswararao , P.R.T. pranav (April29-May 4th 2013) reported that The soil found in the ocean bed is classified as marine soil. It can even be located onshore as well. The properties of marine soil depend significantly on its initial conditions. The properties of saturated marine soil differ significantly from moist soil and dry soil. Coastal sands is microcrystalline in nature and clay minerals like chlorite, kaolinite and illinite and non-clay minerals like quartz and feldspar are present in the soil. The soils have higher proportion of organic matters that acts as a cementing agent. Clay is an impermeable soil, meaning it holds water, as opposed to permeable soil that allows water to rapidly drain, like a gravel or sand. It is also an expansive soil, such as the Coastal sands which predominates in almost all countries of the world, which when shrinking or expanding, can damage foundations and structures. The shrinkand swell movements are due to changes in soil moisture. Providing uniform soil moisture next to and under your foundation is the only best thing to reduce or minimize the damaging effects of expansive soil. Accumulation of various waste materials is now becoming a major concern to the environmentalists.

Bagasse Ash is one such by-product from Timber industries and Wood cutting factories. Bagasse Ash by itself has little cementitious value but in the presence of moisture it reacts chemically and forms cementitious compounds and attributes to the improvement of strength and compressibility characteristics of soils. So in order to achieve both the need of improving the properties of Coastal sands and also to make use of the industrial wastes, the present experimental study has been taken up. In this paper the effect of Bagasse Ash and Lime on strength properties of Coastal sands has been studied.

Jairaj and Prathap Kumar (2015), studied the effect of length of coir fiber on the strength of black cotton soil treated with lime. It was concluded that increase in length of fiber increases peak deviator stress for a given percentage of fiber content. However, when the length of fiber exceeds 20mm, there is marginal reduction in peak deviator stress. Singh and Mittal (2014) conducted an experimental study on clayey soil mixed with coir fibers in varying percentage. The test results indicate that both unsoaked and soaked values of CBR of soil increase with the increase in fiber content.

2.1 STABILIZATION

Soil stabilization may be defined as a modification of an existing soil so as to improve its bearing or load absorbing characteristics. Such an effect may be accomplished by mechanical consolidation (compaction) or by the incorporation within the soil of certain additives which would provide the desired qualities of permanent stability. Ever since the beginning of road building, it has been recognized that some soils were extremely unstable, particularly in the presence of moisture, and that other soils were stable and would support traffic with less deformation.

METHODS OF SOIL STABILIZATION

- Mechanical Stabilization.
- Soil Cement Stabilization.
- Soil Lime Stabilization.
- Soil Bitumen Stabilization.
- Thermal Stabilization.
- Chemical Stabilization.

III. METHODOLOGY

The overall flow of research is as illustrated in the given below table. The tests were conducted in accordance with Indian standard. Several physical tests had been conducted for clay sample, lime sample and mixes of clay, bagasse ash and zinc slag. The tests mentioned, Specific Gravity test, Sieve analysis, Compaction, CBR and unconfined compressive strength test. In Atterberg Limit tests, Liquid Limit (LL) and Plastic Limit (PL) were obtained. Then, Plasticity Index was determined based on Plasticity chart. The Liquid limit of clay, lime and lignosulfonate mixes is obtained by testing varies of percentages.

MATERIALS USED AND THEIR PROPERTIES

3.1 SOIL

The soil used was a typical Coastal sandy soil collected from 'Kakinada' in East Godavari District, Andhra Pradesh State, India. The properties of soil are presented in the Table All the tests carried on the soil are as per IS specifications.

Table 5.1 Proprieties of Coastal sandy soil

S. NO.	PROPERTY	VALUE
1	Specific gravity	2.64
5	Grain Size Distribution	
	i) Gravel Size Particles (%)	5
	ii) Sand Size Particles (%)	86
	ii) Silt & Clay Size Particles (%)	9
6	IS soil classification	CH
7	Compaction Parameters	
	i) Max. Dry Density (g/cc)	1.53
	ii) Optimum Moisture Content (%)	16.1
8	Penetration Parameters	
	i) CBR - Soaked (%)	3.4
	i) CBR - UnSoaked (%)	9.7
9	Unconfined compressive strength (kPa)	92

3.2 SUGARCANE BAGASSE (SCB)

Sugarcane bagasse (SCB) which is a voluminous by-product in the sugar mills when juice is extracted from the cane. It is, however, generally used as a fuel to fire furnaces in the same sugar mill that yields about 8-10% ashes containing high amounts of un-burnt matter, silicon, aluminum, iron and calcium oxides. But the ashes obtained directly from the mill are not reactive because of these are burnt under uncontrolled conditions and at very high temperatures. The ash, therefore, becomes an industrial waste and poses disposal problems. For obtaining amorphous and reactive sugarcane bagasse ash (SCBA), several trials were conducted to define optimum burning time and temperatures. SCBA used in this study was obtained by burning SCB at 600oC for 5 hours (James and Rao, 1986) under controlled conditions and its physical, chemical, and mineralogical characterization was done to evaluate the possibility of its use as binder partially replacing cement in the mortar applications.

Table 3.2Properties of Bagasse Ash

S. No.	Property	Value
1	Specific gravity	2.49
2	Atterberg's Limits	
	i) Plasticity index (%)	NP
3	Grain Size Distribution	
	i) Sand Size Particles (%)	32
	ii) Silt & Clay Size Particles (%)	68
4	Compaction Parameters	
	i) Max. Dry Density (g/cc)	1.34
	ii) Optimum Moisture Content (%)	17.5

Table 3.3 Chemical Properties of Bagasse Ash

S.No	Constituents	Percentage
1	SiO2	0.78
2	Al2O3	0.22
3	Fe2O3	0.07
4	CaO	54.82
5	MgO	0.26
6	SO3	0.25
7	Cl^-	0.06
8	SrO	0.05
9	L.O. I	43.22

3.3 ZINC SLAG

Zinc slag is a granular waste material generated during the manufacture of zinc which has the potential for utility in embankment and pavement construction.. The utilization of waste materials like zinc slag, copper slag, steel slags and coal ash in road construction industry is gradually gaining significant importance in India considering the disposal and environmental problem. Also, due to large scale infrastructure development in the country in the form of National Highway Development (NHDP) programs, natural construction materials like soil, aggregates etc. have depleted forcing the authorities to search for alternative road construction materials. Zinc slag is one such waste material generated during the manufacture of zinc which has the potential for utility in embankment and pavement construction. Zinc slag is a non-plastic poorly graded sand size material. Mechanically stabilizing this material with local soils improves its gradation and improves its shear strength characteristics.

IV. LABORATORY EXPERIMENTATION

The soil was initially air dried prior to the testing. The tests were conducted in the laboratory on the coastal sandy soilto find the properties of coastal sandy soil.

- Grain size distribution
- Specific gravity
- Index properties –liquid limit, plastic limit
- Compaction tests
- Penetration tests-California bearing ratio test.
- Unconfined CompressionTest-Triaxial

V. RESULTS AND DISCUSSIONS

5.1GENERAL

In the laboratory, various experiments were conducted by combination of different percentages of zinc slag and Bagasse ash in the coastal sandy soil. Compaction, CBR and UCS tests were conducted with a view to determine the optimum combination of zinc slag and Bagasse ash. CBR and UCS are conducted for curing studies. The influence of the above said materials on the Index, Compaction and Strength properties were discussed in following sections. In the laboratory, all the tests were conducted per IS codes of practice and the strength behaviour pertaining to unconfined compressive strength (UCS), Optimum moisture content (OMC), Maximum dry density (MDD) and Plasticity index (PI) of different combinations of soil and admixtures.

5.2 EFFECT OF COMBINATION PERCENTAGES OF ZINC SLAG + BAGASSE ASH IN IMPROVING THE COMPACTION PROPERTIES OF COASTAL SANDY SOILS: -

Density is an important parameter because it determines the load, which a structural fill will apply to itself and to its foundation, and because it influences the permeability, stiffness and strength of fill, thus affecting the settlement and ultimate stability. To assess the amount of compaction and water content required in the field, compaction tests are conducted. In the present study Standard Proctor Compaction test as per IS: 2720 (Part VII), 1980 was conducted on soil. The test is conducted on soil alone, soil with combination of Zinc slag and Bagasse ash. The optimum moisture content (OMC) and the maximum dry density (MDD) of the Coastal Sandy Soils was determined using the Standard compaction test.

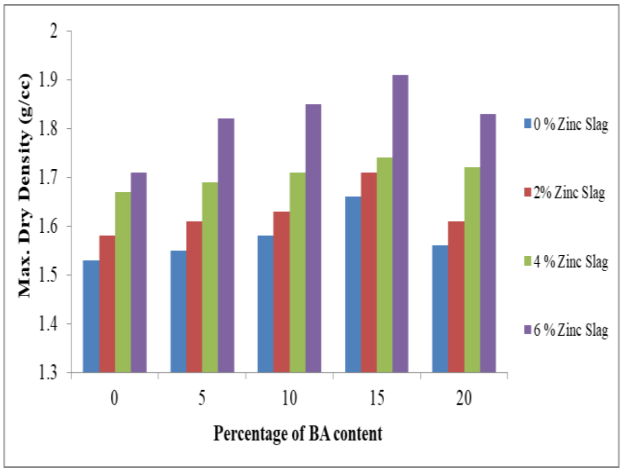

Fig 5.1shows the Variation in maximum dry density with percentage of Bagasse ash content

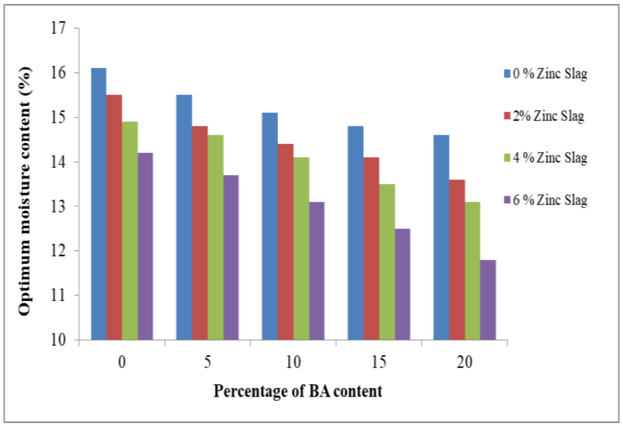

Fig 5.2 shows the Variation in optimum moisture content with percentage of Bagasse ash content

5.3 EFFECT OF COMBINATION PERCENTAGES OF ZINC SLAG AND BAGASSE ASH IN IMPROVING THE PENETRATION CHARACTERISTICS OF COASTAL SANDY SOILS

The CBR value for untreated soil remained constant for most of the time. When soil treated with Zinc slag and bagasse ash as the combination dosage was increased CBR values also increased for all curing periods. The test is conducted on soil alone, soil with combination of Zinc slag and Bagasse ash. The test results of CBR test with soil alone, soil with combination of Zinc slag and Bagasse ash dosages

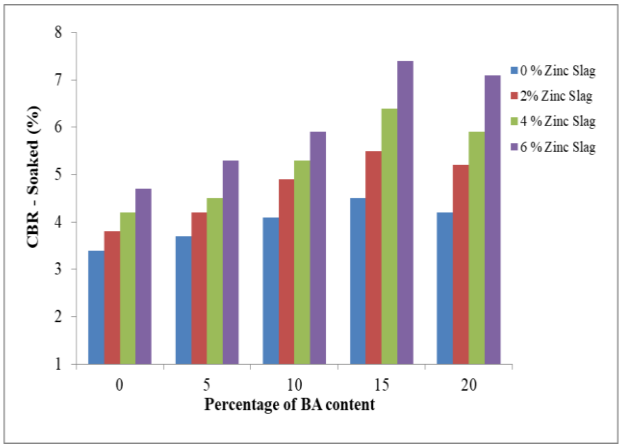

Fig 5.3 shows the Variation in CBR Values with percentage of Bagasse ash content

5.4 EFFECT OF COMBINATION PERCENTAGES OF ZINC SLAG + BAGASSE ASH IN IMPROVING THE UNCONFINED COMPRESSIVE STRENGTH OF COASTAL SANDY SOILS

Essentially, the unconfined compression test is a special case of the triaxial compression test of soils where the compression and shear strengths of a soil prism, or cylinder, are measured under zero lateral stress. The unconfined compression test is the simplest and quickest test for determining unconfined compressive strength of the cohesive soils. The shear strength of cohesive soils (cohesion) is taken as equal to half the compressive strength. The load readings were plotted against deformation and the point of failure was identified.

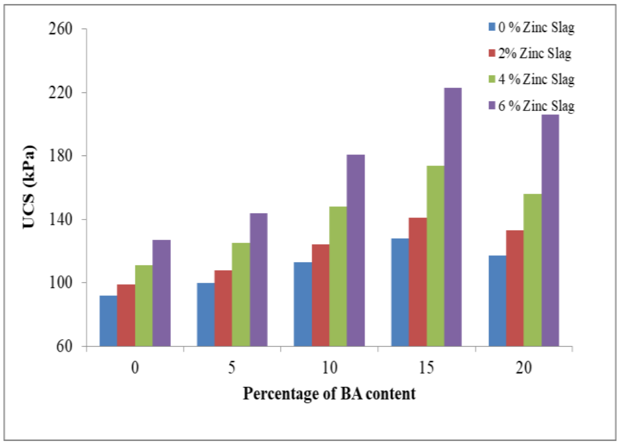

Fig 5.4 shows the Variation in UCS Values with percentage of BA content

From the above discussion on the results obtain from the laboratory experimentation done on combined percentages of Zinc slag and Bagasse ash yielded the significant improvement in the characteristics of Coastal Sandy Soils. The results clearly showed that the Coastal Sandy Soils with 6% Zinc slag + 15% Bagasse ash was the optimum. But the CBR achieved with this optimum is 7% which is not sufficient as the minimum required CBR as per IRC 37-2012 is 8%. Curing study was done on samples prepared with 6% Zinc slag + 15% Bagasse ash treated Weak Coastal Sandy Soils in order to achieve the required CBR value as per IRC 37-2012 which is Soaked CBR of 8%.

5.5 EFFECT OF CURING ON SAMPLES PREPARED WITH 6% ZINC SLAG + 15% BAGASSE AH

Variation of penetration and shear characteristics for different curing periods. From the figure. We can conclude that Coastal Sandy Soils when cured with 28 days had shown more pronounced improvement about 34% for CBR. Increase in curing periods had increased the CBR value for all the curing periods up to 28 days. Even at 7 days of curing, the minimum required CBR of 8% as per IRC 37-2012 was achieved.

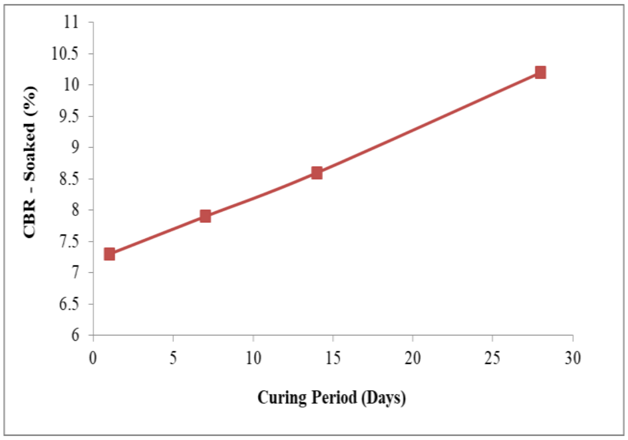

Fig 5.5 Shows the Variation in CBR Values with different curing periods

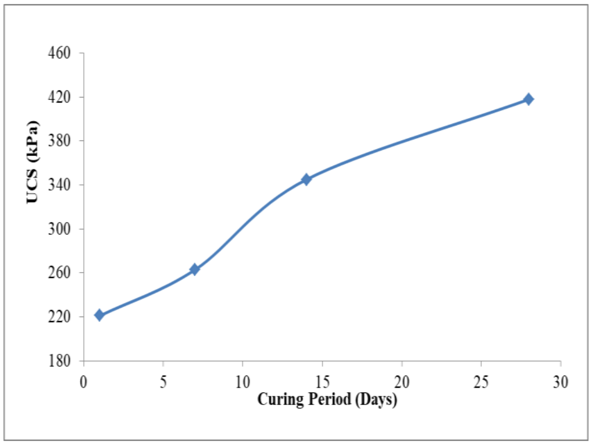

Fig 5.6 shows the Variation in UCS Values with different curing periods

Finally from the above discussions, it is clear that there is improvement in the properties of Coastal Sandy Soils stabilized with Zinc slag + Bagasse ash. It is evident that the addition of Zinc slag and Bagasse ash to the sandy soil showed an improvement in plasticity, compaction and strength properties. It can be summarized that the materials Zinc slag and Bagasse ash had shown promising influence on the properties of Coastal Sandy Soils, thereby giving a two-fold advantage in improving problematic Coastal Sandy Soils and also solving a problem of waste disposal.

VI. CONCLUSIONS

The following conclusions are made based on the laboratory

The results of this experimental investigation have shown that beneficial effects are obtained by treating Coastal Sandy Soils with Zinc slag and Bagasse ash. Therefore, the resulted geotechnical properties of treated soil have led to the following conclusions:

- From the studies, it is observed that the Coastal Sandy Soils was a problematic soil.
- The treatment of the samples with Zinc slag and Bagasse ash changed the optimum moisture and maximum dry density.
- It was observed that the CBR is increases with increase in combined percentages of Zinc slag and Bagasse ash.
- The unconfined compressive strength of treated soil specimen with Zinc slag and Bagasse ash was affected mostly by the amount mixed in soil mixtures. The unconfined compressive strength increased in association with increasing in combined percentages of Zinc slag and Bagasse ash.
- It was observed that the soil with a combined optimum dosage of 6% Zinc slag and 15% Bagasse ash has improved the properties of Coastal Sandy Soils.
- The optimum moisture content decreased and maximum dry density increased with increasing in combined percentages of Zinc slag and Bagasse ash contents. It can be inferred from the graphs, that there is a gradual improvement in the maximum dry density by an amount of 24.83%.
- The CBR increased for an optimum dosage of 6% Zinc slag and 15% Bagasse ash but not achieved the minimum required CBR as per IRC 37-2012 is 8%.
- The UCS increased about 142.4% for an optimum dosage of 6% Zinc slag and 15% Bagasse ash.

- Curing studies were done on samples prepared with 6% Zinc slag + 15% Bagasse ash treated Weak Coastal Sandy Soils in order to achieve the required CBR value.

From the curing studies it can be concluded increase in curing periods had increased the CBR values up to 28 days. Even at 7 days of curing, the minimum required CBR of 8% as per IRC 37-2012 was achieved. It is observed that the Coastal Sandy Soils when cured with 28 days had shown more pronounced improvement of CBR and unconfined compressive strength. Finally it can be summarized that the materials Zinc slag and Bagasse ash had shown promising influence on the properties of Coastal Sandy Soils, thereby giving a two-fold advantage in improving problematic Coastal Sandy Soils and also solving a problem of waste disposal.

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