Soil stabilization by Construction and Demolition waste: A Review

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Abstract

According to a survey, tons of construction and demolition waste is left over after construction projects.Therefore, for sustainable development, where investment in economy is in resonance with environmental stability, like, green field projects. We try to find ways and methods to put this enormous waste generated to use. This paper studies about the Stabilization of soil and the effectiveness of various methods used by different scholars to find the best way to use this waste in order to save our resources and conserve nature, simultaneously.

Index terms : Waste, Construction, Soil Stabilization, Demolition, Plastic.

1. Introduction

In the past few years, the process of re-utilizing waste materials into new construction materials regarding sustainability has been one of the main objectives of certain countries. The paper solely aims at the reuse of recycled construction and demolition wastes by the method of stabilization of soil.

Soil plays a very important role in giving strength to the foundation of a structure in order for it to support the entire structure. Therefore, it is essential to have a clear knowledge about the properties and types of soil and how certain factors affect its behavior. Soil stabilization is a process which helps in achieving the needed properties for soil stabilization in the finest way. In short, it helps in enhancing the properties of the soil and makes it more suitable for the construction process.

With the passage of time, soil was used in the construction of roads, canals, bridges, foundations. As soil play a critical role in construction, it can make or break the structure. Constructing buildings on the wrong soil, leads to cracked foundations and leaking landfills and deformed dams. With the right soil, the structures will be firm with minimal flaws.

During ancient civilizations, The Romans and Chinese have used various methods to improve the properties of soil. The modern era of stabilization of soil started in early 1970's in India. The people adopted methods and means to improve the properties of soil for construction due to the was shortage of aggregates as it was wiser and sufficient to improve the quality rather than replacing them.

Thus, soil stabilization plays a major role in construction. Now, scientists have found out new ways and techniques to meet the growing demands of raw material and different methods to reuse the waste generated.In this paper, the focus will be on enhancing the properties of the soil and aggregates from construction and demolition wastes, implying to recycling and reusing of resources, which is sustainable and healthy for economy and the environment.

2. Literature Review

Soil stabilization is the altering of chemical and physical properties to get a strong foundation soil so that our structure stays safe.the material should be used in such a way that it is cost effective and saves nature. The paper will give us an over view of studies done on the stabilization of soft soil using industrial wastes..

Choudhary et al. (2010) evaluated the use of plastic wastes for improving the subgrade in flexible pavement

In this study, the effect of waste plastic strip content (0.25 % to 4.0 %) and strip length on the CBR and secant modulus of strip reinforced soil was investigated. The study reveals that the addition of waste plastic part of appropriate size and proportions in soil results in an appreciable increase in both the CBR value and secant modulus of soil.

Rao et al. (2011) performed a laboratory evaluation on utilization of industrial waste in the pavement laid over expansive clay sub grades.

The waste materials tested were granulated blast furnace slag and fly ash. These 2 materials were tested to the most minute detail to know the properties so they can be used. The results showed us that they increased the CBR value. Thus they can be used in the sub grade of construction of flexible pavement.

Yadu (2013) evaluated the potential of granulated blast furnace slag (GBS) with fly ash to stabilize clay.

Study shows that clay can be effectively stabilized with the addition of fly ash-GBS mixture. Ransinchung et al. (2013) evaluated the efficacy of fines obtained from demolished concrete slabs as a soil stabilizer. The demolished concrete slabs were collected from Shabzi Mandi of Roorkee. In addition to FDCS, ordinary Portland cement 43 grade was chosen as base stabilizer so that the findings obtained out of FDCS admixed soil shall be compared with.. The clayey soil used in the present investigation belongs to CI soil group when classified by IS: 1498. Cement and FDCS were admixed with clayey soil separately at equal increments of 3 percent upto 15 percent. Reductions in dry densities and plasticity indices were observed on admixing of both cement and FDCS. Admixing of FDCS enhances the soaked CBR value, unconfined compressive strength, and split-tensile strength.

Kumar (2015) conducted a study on the use of construction and demolition waste.
The study concludes that construction and demolition wastes like bricks, concrete, tiles etc. may be used for mechanical stabilization of very poor soils, by adding extra cementitious materials or commercial stabilizers accredited by IRC as per IRC:SP:89. The C&D waste material shall have gradation as per IRC: SP: 89. Alternatively, it may be used partly as soil after doing testing on leach ability, durability in addition to unconfined compressive strength. After satisfactory trial results, this type of mixed material may be used for stabilization of poor soil alone or by mixing with some good soils and/or with suitable additives. The unconfined compressive strength obtained shall be 0.8 MPa for sub-base and 1.75 MPa for a base course as per revised MORTH and IRC: SP: 89.

Henzinger C and Heyer D (2015) Use of demolish waste in soil improvement in geotechnical engineering for infrastructure and development:
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Anas Ashraf in 2011 : His paper focuses more on the Physical Properties of the material like soil bearing, capacity, shear strength etc. He used waste material like lime, fly ash, cement etc. His research opened gates to new development in this field and helped us make new discoveries. Use of plastic product like synthetic resin product, bottles, PVC, etc., has hyperbolic venturesome urge to varied environmental burdens; that's why plastic used is disposed in the most sustainable way because it can harm the environment. Therefore, use of plastic is an excellent idea and is cost effective , becoming an excellent quality soil for embankments. Results are as shown in below table:-

% of Plastic Content	0.0	0.2	0.4	0.6	0.8	1.0
CBR Value	1.9	1.7	1.8	2.5	1.3	1.3

Table1

It was observed from the test results shown in table 1 that for soil which is mixed with plastic strips, the soaked CBR values have increased from 1.967 to 2.479 with 0.6% of plastic content and then gradually decreased. Therefore, the optimum value in percentage of the plastic strip in soil was found to be 0.6%. One significant aspect which was observed, that there was a slash in the CBR value for plain soil i.e. 1.967 to 1.687 on the addition of 0.2% plastic. This seems to happen because of the inclusion of minute amount of plastic strips in the soil leading to a dispersed and disturbed soil structure mass, when compared to its compact form. While keeping the optimum moisture content maintained same as the initial value, as a resultant, it decreased the value.

Dr. Babitharani H. *et al* **(2017) [4]:** With respect to plastic wastes, his work mentions about the usage of plastic for soil stability. Prices of introduction of additives of plastic wastes seems to have increased in recent decades opening the door for non-conventional ways for boosting soil stability. This new technique of soil stabilization will bridge the gap between the challenges and prosperity of society. Reusing the quantities of waste in manufacturing soil stabilization via plastic waste. The proper scientific plastic waste disposal with least negative ecological impacts has become a critical environmental issue. Hence, the exploitation of plastic as soil stabilizer is associated with its ecological utilization.

Prof. Harish C., Ashwini H. M. (2016) [6]: This study talks about the advancement of suitable admixtures such as plastic wastes and such materials, like plastic bottles in strip forms. Their addition in the soil mass by varying percentages, and later conducting various experiments such as liquid limit test, plastic limit test, compaction test, CBR test etc., have inferred it out to be an extremely efficient methodology. The load bearing capacity of the soil increases drastically as well as the strength properties are also improved. The results of the tests performed are shown below :-

% of Plastic Content	0.0	0.2	0.4	0.6	0.7	0.8	1.0
CBR value	2.3	2.0	2.1	2.4	2.9	1.8	1.7

Table 2

% of Plastic Content	0.0	0.2	0.4	0.6	0.8	1.0
CBR value	2.7	2.5	2.6	3.3	2.1	2.1

Table3

Rituparna Das ***et al*** **(2017) [10]**: Plastic strips from polythene bags are used as a stabilizer of soil. Here, the implementation of plastic waste as a stabilizer is economic and eco-friendly. Several tests were done on fiber-reinforced soil with varying aspect ratio and fiber content. Its detailed analysis shows that, plastic can be used effectively and economically in fields as a reinforcing material. The plastic strips of varying

aspect ratios were mixed randomly throughout the soil and California Bearing Ratio (CBR) tests were performed. And, the Aspect Ratio was calculated by varying the length and width of these strips. It was found that after reinforcement, the soil strength increased. This talks about the performance of plastic fiber as a soil stabilizer.

The replacement of 0.5% fibers of plastic with that of clayey soil reduces its OMC while increasing its Maximum Dry Density. The unconfined compressive soil strength increased by 0.5%. With 1% replacement, it was observed that the MDD & UCC was less than the 0.5% replacement but was greater than the untreated soil. Further increase in the plastic replacement showed a decrease in the MDD and the Unconfined Compressive Strength of the soil.
Hence, on the basis of non-problematic soil criteria, the optimum plastic percentage is recommended as 0.5% enhancing the engineering properties of silty clay.

N. **Vijay Kumar *et al* (2017) [8]**: Use of non biodegradable polymers like plastic bags, bottles and other plastic products has been on increase since last few decades. This has led to various ecological imbalances as a result of improper waste disposal. Therefore, it focuses on soil stabilization by using waste plastic products. This study elucidates the problem of foundation with the loose soil especially black cotton soil. The problems identified were swelling, unequal settlement and shrinkage. Several tests such as liquid limit test, plastic limit test, standard proctor compaction test, California bearing ratio (CBR) test and unconfined compressive strength (UCS) were conducted to check for any improvement in the properties of black cotton soil.

The Table below and graph shown in figure 2 shows the variation of CBR value in accordance with the length of strips

CBR value	3.34	5.23	6.20	5.20
Length of plastic	0	2.5	5.0	7.5

table 4 comparison of CBR value and length of strips

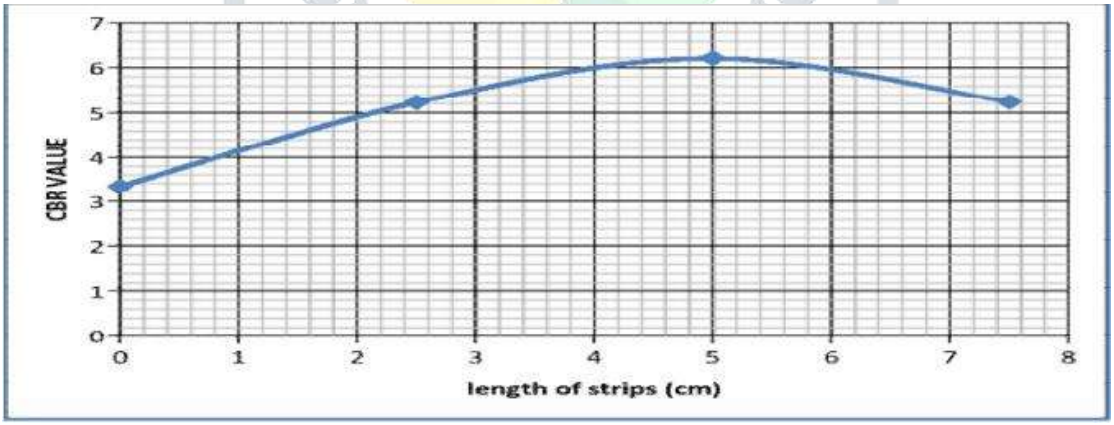

figure 2 graph CBR value vs length of strips (cm)

Values with different lengths like 2.5cm, 5.0cm and 7.5cm, here 2.5cm to 5.0cm has CBR value 5.23 to 6.20 increasing respectively, and 5.00cm to 7.50cm length has CBR values which decreases from 6.20 to 5.24 respectively. The CBR value for 5.00cm is 6.20 which is optimum length of strips used for sub grade design. The results also show that shear strength of the soil increases up to 5.00cm length of strips and after decrement vice–versa.

A. **Burman, (2018) [1]:** This paper talks in detail about the study on the behavior and use of waste plastic strips in soil improvement. The results showed that we can use plastic an important material to restore the scientific waste disposal state, associated with economical resolution for improving poor soil framework. The soil which is filled with plastic content behaves same as fiber-reinforced soil.

It involves the investigation and analysis of the aftermath of plastic bottle strips on loose sand. A series of compaction, direct shear and CBR tests were performed with varying content percentages of plastic strip,

having different side ratios. The results shows an enormous increase in moist dry measure weight, Shear Strength Parameters, and cosmic background radiation price with plastic bolstered within the soil mass. The intensity of improvement of soil properties depends on the type of soil used, percentage of plastic content, the soil mass, and the strip size.

It's concluded that, the improvement in properties of loose sand is achieved at 0 with 4% plastic content with a stripe size of (15 millimeter nine fifteen mm). A dry sieve analysis was performed and the proportion of soil passing through 0.075 mm is over five hundredth, so the soil is classed as fine-grained soil.

Sagar Mali, Sachin Kadam, Sagar Mane (2019) [11]: Soils with huge water holding capacity such as black cotton soil show problems of swelling, shrinkage, & unequal settlement. This leads to cracking of soil and causing droughts.

At the same time, plastic waste has become a nuisance for the sustainable development.

With the advancement in technology and waste to energy efficiency conversion measures, plastic waste can be used as stabilizers for various soils. This prompts the researches on soil stabilization using waste material while improving its strength. No experiments have been performed under this study. Rather, It was a analytical descriptive research paper based on various methodologies and experimental investigations which have been known to improve various soil properties.

Varshik Manikanta *et al* **(2018):** This study evaluates the issues of black cotton soil realted to its swelling, shrinkage and crack formation on drying. With the usage of some external agents mixed with soil, it can be made more useful. Usage of coal, fly ash, bagasses, and plastic.Various soil experiments like the liquid limit check, plastic limit check, Golden State bearing magnitude relation (CBR) check square measure conducted for the stable soil were done. These experiments are principally designed to target the performance of plastic wastes as a soil stabilizer. The improved CBR values of the soil are because of the addition of plastic strips

table 5 CBR value for red soil

% of Plastic Content	0.0	0.2	0.4	0.6	0.7	0.8	1.0
CBR Value	2.5	2.1	2.2	2.4	2.95	1.9	1.68

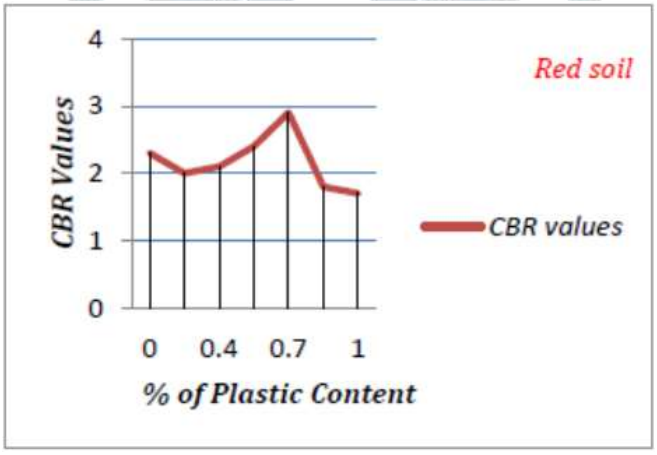

figure 3 graph of CBR value vs plastic content for red soil

% of Plastic Content	0.0	0.2	0.4	0.6	0.7	0.8
CBR Value	2.85	2.51	2.5	3.31	2.2	2.1

table 6 CBR value of black cotton soil

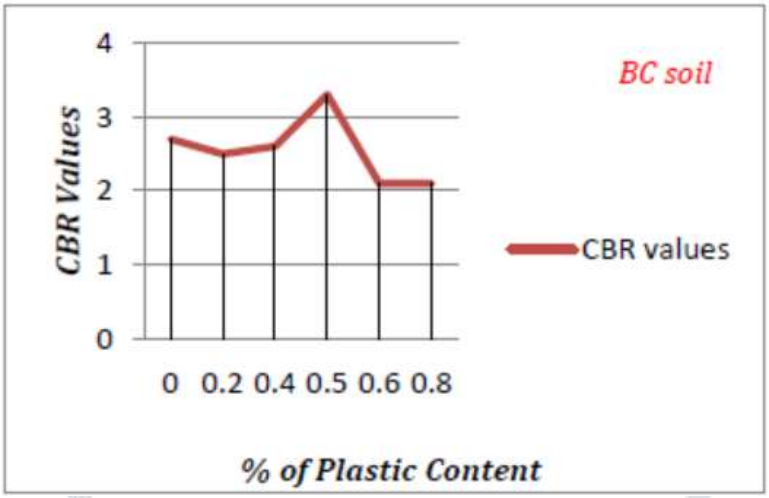

figure 4 graph of CBR value vs plastic content for black cotton soil

P. **Mohan Kumar (2018) [9]:** In few regions, the soil mass has poor properties because of its structure or the aquifers below, moist runny soil and the hard rocky layers , affecting various engineering properties like working ability, low bearing capacity and robust ability of soil to squeeze. Thus, engineers have to face such issues with respect to construction and different varieties of related errors. Therefore, the soil stabilization is employed to increment the strength of the soil. Here the soil stabilizers used are polymeric waste material.

The testing result for clayey soil pavements mixed with plastic soil stabilizers have been done per area unit, and are shown below

Sr.no	Description	Specific Gravity
1	Clay	2.33
2	Clay+ waste Plastic (0.6%)	2.35
3	Clay + waste plastic(0.8%) 2.37	2.37
4	Clay + waste plastic (1%)	4

table 7 comparative study of specific gravity

Waste material used

Clay soil

The soil used in this study was collected from Agricultural area of Lovely Professional University, Jalandhar and around its vicinity. This soil sample was oven-dried, weighed properly, and stored in sterile containers at room temperature. Its general properties were thoroughly studied. The soil was tested for liquid limit, plastic limit optimum moisture content, maximum dry density, permeability, etc.

Industrial waste sand (IWS)

Industrial waste sand is high-quality oxide sand with uniform physical characteristics. It's a byproduct of the metal and nonferrous metal casting business, wherever sand has been used for hundreds of years as a molding material attributable to its distinctive engineering properties. In manufacturing trend, sand is often recycled and reused through several production cycles business estimates square measure that roughly a hundred million plenty of sand square measure utilized in production annually. Of that, four (4) to seven (7) million tons square measure discarded annually and square measure offered to be recycled into different product and industries.

Lime

It is a calcium-containing inorganic material during which is a mix of carbonates, oxides, and hydroxides. It originated as a building mortar and has the properties of adhering to the base material and being molded in any form . it is mixed in soil to make it more alkaline and give suitable pH for cultivation.These materials are utilized in huge quantities as construction materials in building (including sedimentary rock product, concrete and mortar), feed stock, and sugar purification are among its alternative uses.

Rice Husk Ash

Rice husk is an agricultural residue abundantly available in rice-producing countries. RHA is obtained from the burning of rice husk which is the byproduct of rice milling. The chemical properties of RHA are mentioned in Table 2 as per IPSIT. From Table 2 it is clear that silica is the major constituent of the rice husk ash. The RHA used in this investigation is obtained from a nearby industry. The pH value of the RHA used in this work is 10.96.

Fly Ash

Fly ash has been obtained from the electrostatic precipitator hoppers of Vijayawada thermal power station (VTPS), Ibrahim patnam about 18 km away from Vijayawada, India. VTPS consumes about 20,000 tones of coal per day, out of which 5,500 tones of fly ash is produced. The chemical composition of this fly ash consists of 64.08% silica, 20.21% of alumina, 4.17% of ferric oxide, and 6.20% of calcium oxide. The fly ash used in this investigation comes under category of Class-F. The specific gravity of fly ash is 2.10, fraction finer than 75 μ is 79.93% rest being coarser than 75 μ but finer than 425 μ, maximum dry unit weight is 13.63 kN/m3, and optimum moisture content is 21.4%. The pH value of the FA is 9.64.

EXPERIMENTAL WORK.

The endeavor have crystal rectifier totally different examination to find the adjustment of the sub-base utilizing the mechanical waste and concrete the various take a look at directed to find the adjustment of the sub-base in light-weight of the ASTM methodology

LIQUID LIMIT: Liquid purpose of confinement is characterised because the damp content at that soil starts to act as a fluid material and starts to stream. the importance of as so much because the doable take a look at is to rearrange soils. Distinctive soils have unsteady fluid points of confinement. Likewise, one ought to utilize as so much as doable to determine its pliancy file.

PLASTIC LIMIT: Plastic edge is outlined because the damp content and communicated as tier of the project of the broiler dried soil at that the dirt is touched into the strings eighth in. in an exceedingly distance across while not the dirt breaking into items. this can be likewise the damp substance of a robust at that a speck of dirt changes from a plastic state to a solid state.

STANDARD PROCTOR COMPACTION TEST: Compaction is that the procedure of compaction of soil mass by decreasing air voids beneath powerful stacking. This take a look at is directed keeping in mind the tip goal to find out the best damp substance and greatest dry thickness of the dirt.

CBR TEST: CMB is that the magnitude relation expressed in share of force per unit space needed to penetrate a soil mass with a regular circular plunger of fifty metric linear unit diameter at the speed of one.25 mm/min thereto needed for corresponding penetration in an exceedingly normal material. The

magnitude relation is sometimes determined for penetration of two.5 and 5 mm. once the magnitude relation at five metric linear unit is systematically over that at two.5 mm, the magnitude relation at five metric linear unit is employed.

CONCLUSION

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 is a byproduct of burning coal in thermal electric power generating plants. Its called fly as as it is transported from combustion chamber by exhaust gases and is collected via electrostatic precipitators. It is composed of oxides of silica, aluminium, calcium and ferric. It can be used for various constructional applications like Portland cement, lower layers of road pavement, low permeability flow-able fill, material, as a dike material, and as reclamation material. It will pave its way for efficient and ecological friendly transportation. Recently,National Thermal Power Corporation has developed its infrastructure to transport fly ash, in line with its commitment towards 100% utilization of fly ash from power plants.

2) Cement/ lime stabilization soil-waste mixtures can be used to improve soil traits, compaction, moisture content, density, strength, permeability, plasticity index, etc,. this is usually done to enable their use in pavements and areas like dam foundations and site pad building.the use of cement as binder further increases its strength and durability.

3) Rice husk ash is a by product of rice milling. It is used as soil stabilizer because of its ecological benefits. Although this agricultural waste is not self cementing, a hydraulic binder like lime is used and thus can be effectively used for stabilization of soils.

4) Treatment of the soil samples with varying quantities of lime and WSP content drastically changes the optimal moisture level and their maximum dry density values. There is an increase in moisture as well as dry density level when increasing lime and WSP content for all the samples. and the maximum dry density increased with increasing WSP content.

5) The contribution of fiber(coconut husk/banana fibre reinforcement) with or without sodium silicate has shown increase in strength as the cycles of freeze–thaw increase. This makes the stabilized soil become more suitable for road pavement applications, as sub-base material.

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