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STABILIZATION OF BLACK COTTON SOIL WITH PARTIAL OF MARBILE DUST AND GEO-GRID

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***Abstract*—**Soil stabilization refers to the process of enhancing the engineering qualities of soil and improving its stability. Soil stabilization is necessary when the building soil is unsuitable for its intended use. Stabilization, in its most comprehensive definition, comprises a variety of analogous processes, including as compaction, pre-consolidation, drainage, and several others. Nevertheless, the word "stabilization" usually refers to acts that specifically modify the physical composition of the soil in order to improve its characteristics. In order to achieve soil stabilization, a cementitious substance or chemical additive is used, or alternatively, geosynthetic materials are employed. Additionally, it can be utilized to improve the load-bearing capability of the soil on which a foundation is built. Soil stabilization is primarily employed to enhance the inherent qualities of natural soil in the building of highways and embankments.

Geogrid has been utilized to enhance the load-bearing ability of black cotton soil. Various experiments have been conducted to determine Atterberg's limits, free swell index, maximum dry density, optimal moisture content, and CBR value test. These trials involved the use of partial replacement of marble dust. The optimum content of marble dust was determined based on the results of the CBR test.

Geogrid is now incorporated into a soil-marble dust mixture at various levels and tested to determine the CBR value. After conducting a 4-day soaking CBR test, it was determined that the greatest CBR value is reached at a height of 0.2H from the top of the mould.

Following are the findings from this study-

I. Optimum percentage of marble dust is obtained as 17% which increase the CBR value from 4% to 7.9%.

II. Geogrid placement at 0.2H height from the top of the CBR mould increases the CBR Value of soil & Marble dust mix from 7.9% to 18.4%.

***Keywords*— Stabilizations, Stability, Cementitious substance, Chemical additive, Geosynthetic material, Geogrid, Bearing capability (CBR),**

INTRODUCTION

Soil stabilization is the process of modifying the properties of soil by mechanical or chemical means to enhance its engineering characteristics. Soil stabilization is a process that enhances the strength, durability, bearing capacity, compressibility, permeability, and resistance to erosion and dust generation in soil. It also helps manage the shrink-swell qualities of the soil. The primary objective is to develop a soil material or system that can withstand the specified usage conditions and remain functional for the whole lifespan of an engineering project. The characteristics of soil exhibit substantial variation across different locations, and in certain instances, even within a single location. The efficacy of soil stabilization is contingent only upon soil testing. There are several techniques for soil stabilization, and it is important to confirm the suitability of a method by testing it in the laboratory using the same kind of soil before implementing it in the field.

Geosynthetics

Over the past four decades, there has been an increasing utilization of geosynthetics in the fields of environmental and geotechnical engineering. These products have helped designers and constructors solve many technical challenges throughout the years, especially when utilizing traditional building materials would have been forbidden or far more costly. Geotechnical and environmental engineering involve a wide range of geosynthetic types and applications. Geosynthetics, including polymeric reinforcing materials, are a notable and recent development in civil engineering materials. Geosynthetics refer to planar materials composed of synthetic polymers, which are commonly employed in civil engineering projects and systems, alongside conventional geotechnical materials such as rock andsoil.

Geosynthetics have been extensively employed to serve many purposes that significantly enhance the effectiveness of road systems. The attributes comprising them include protection, drainage, barrier, strengthening, stiffening, filtration, andseparation. Various types of geosynthetic materials,including metal strips, geotextile, geostrap, and

geogrid, have been created and are now employed in building projects.

Need of Present Study:

Because soil qualities vary widely and the carrying capacity of the soil is crucial for the construction of structures, soil stabilization is necessary to both forecast and even increase the soil's capacity to support loads.While working with soils, one other crucial aspect to consider is the soil's gradation. The soils may be well-graded which is desirable as it has a smaller number of voids or uniformly graded which though sounds stable but has more voids. To increase the qualities of soil strength, it is therefore preferable to combine several types of soil. In these situations, soil stabilization is what you should look for because it is quite expensive to replace the deficient soil completely.

LITERATURE REVIEW

A summary of the previously published works on a subject is called a literature review. The phrase can refer to an entire academic paper or to a particular section of a book, article, or other academic work. In either case, the goal of a literature review is to givethe reader and the researcher/author ageneralunderstanding of the body of knowledge already known about the subject at hand.This studies that researchers have written about certain challenges and how they were resolved. These study that have concerns below discuss some of the study articles that follow.

Dhatrak, A.I. et al., (2024) In the current study, thermal waste is used as a stabilizing material to stabilize the locally accessible clayey soil. Fly ash was used to stabilize expansive soil in various concentrations, including 5%, 10%, 15%, 20%, 25%, and 30%. Fly ash possesses no plastic characteristic, the plasticity index (P.I.) of fly ash mixtures decreases as the fly ash content increases. As the doses of fly ash grows, the compaction characteristics, UCS and CBR values of stabilized soil increase up to specific percentages.It is shown that the overall qualities of tested clayey soil are greatly increased by the addition of fly ash. It may be inferred from the laboratory research that 20–25% of fly ash can be used to stabilize black cotton soil and to enhance its engineering properties.

Tewodros Tsegaye., (June 2023) The aim of this study was to improve the strength of black cotton soil for its suitability for road subgrade construction using wastes from plastic bottles and glass waste powders. The glass powder (WGP) and the plastic chips were mixed with the soil sample with a percentage by dry weight of 6%,12%,18%,and24% of WGP and 2%,4%,6%,and 8%of plastic chips, respectively.
Laboratory tests for soil-mix physical properties and strength parameters were conducted.

ParwatiThagunna et al., (April 2023) This study aims at using Fly Ash (FA), Marble Powder (MP) and Geogrid to stabilize Black Cotton (BC) Soil for vertical construction. Fly Ash and Marble Powder were used to determine UCS (Unconfined Compressive Strength), Consistency Limit, free swelling and Compaction Parameter while Geogrid with Fly Ash and Marble Powder were used for CBR (California Bearing Ratio) in single as well as double layers. The percentage taken for conducting various laboratory tests were 5%, 10%, 15% and 20% as (Soil: FA), (Soil: MP) and (Soil: FA+MP) with respective ratio as (95:5), (90:10), (85:15) and (80:20).

A Ahalya et al., (2022) This research is aimed to stabilize the expansive soil with KSS powder and coir fibre. In this research work Kota stone slurry is adopted in powder form to stabilize the expansive soil in the proportion 5%, 10%, 15% and 20%. The optimum results were recorded at 15% KSS powder.Further coir fibre was also added to improve the engineering properties of expansive soil to the mix specimen of expansive soil and 15% KSS powder, in the proportion as 0.5%, 1%, 1.5%, and 2%. The optimum results were recorded at the addition of 1.5% coir fibre.

Prabhakar et al., (JAN 2020) In this Study deals with the entire analysis of the enhancement of black cotton soils properties and its stabilization using Quarry Dust and industrial Foundry sand. The basic tests were carried out on soil, quarry dust and foundry sand are Atterberg’s Limit, Modified Proctor Compaction and CBR Test with addition of 5%, 10% and 15 % of Quarry Dust to soil sample after result analysis, obtained keeping Quarry Dust 15% constant and addition of Foundry sand 5%, 10%, 15% and 20%.

P. Naga Venkata Sai et al.,(June 2020) The present study aimed at determining the behaviour of black cotton soil reinforced with geogrids. And we conduct the CBR test with geogrid in soil sample at random positions. Due to increase in CBR value, even we can reduce the pavement thickness, it will serve similar functions while compared with greater pavement thickness.

Objectives of Study:

The core objective of this study is to increase the bearing capacity of soil by introducing the geogrid and marble dust in different combination in economical and efficient way. The percentage of quantity used for marble dust are 2%, 5%, 8%, 11%, 14%, 17% & 20% and geogrid placed in different-different height from top of the CBR mould. Including this following are the objective of the work:

Including this following are the objective of the work:

1 To reduce the thickness of Pavement. So, as to reduce the cost of road construction
2 Increase the Service Life of Road
3 Increase the CBR value of soilby adding the combination of geogrid & Marble dust.

MATERIAL METHODOLOGYUSED IN STUDY

A Material:

1)Black Cotton Soil: The Black Cotton soil used for testing was procured from the Landmark material testing & Research laboratory, Mansarover, Jaipur, Rajasthan. Soil sample was taken and run through a 4.75 mm sieve to ascertain its natural moisture content. The geotechnical characteristics of soil were determined in the laboratory. The soil colour is Black or Dark brown which signifies a good organic matter.

Fig. 1 Black cotton soil

2)Polypropylene Biaxial Geogrid: The Biaxial Geogrids (PP) used for testing was procured from the Landmark material testing & Research laboratory, Mansarover, Jaipur, Rajasthan. Superior polypropylene grades are used in the precision punching and drawing operations to create these products. The placement of TechGrid PP Biaxial Geogrids (manufactured by Techfab India) lead to enhanced structural capacity, strong contact, mostly through the interlocking of particles within the geogrid apertures, in a layer of granular material. The mechanical improvement of the soil-geogrid system results from the development of four distinct mechanisms, as follows:

1. Separation
2. Lateral Restraint
3. Tensioned Membrane
4. Enhanced Bearing Capacity

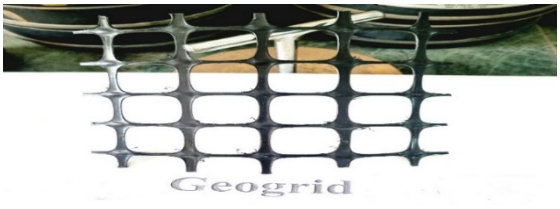


Fig.2Biaxial Geogrid(PP)

3Marbledust Waste marble dust is a byproduct of the mar ble industry, generated during the cutting, sawing, and poli shing of marble blocks.It's an environmental concern due to the large quantities produced, but it also offers several pote ntial applications:

i. Waste marble dust can be used as a partial replace ment for cement in concrete, improving its strengt h and durability.
ii. It can be mixed with soil to enhance its bearing ca pacity and reduce erosion.
iii. Marble dust can be used as a filler material in road construction, improving the stability and longevit y of the pavement.

Material Collection-The Marble dust used for testing was procured from the nearest market.

B. Methodology: This study adopted the methodologies either the experiment or modelling based. Use of the geogrid in Black Cotton Soil at different depth enhanced the bearing capacity of Black Cotton Soil. For bearing capacity of soil, researchers used the CBR value test for determining the bearing capacity of soil. Partial replacement of other ingredients like: - cement, fly ash etc. also improved the bearing capacity of soil and reduce the plasticity and free swell index properties of the Black Cotton soil. So, we are partially replacing marble dust to soil so that it could be partially used in construction of highways & roads and provide maximum benefit with combination of geogrid. It can be great help to use industrial waste (marble dust) in construction and also save the construction cost of the same.

Following tests had been conducted by this study for testing the soil with combination of geogrid and other ingredients:

A. Liquid Limit Test
B. Plastic Limit Test
C. Sieve Analysis
D. Maximum Dry Density (MDD) Test
E. Optimum Moisture Content (OMC) Test
F. Free Swell Index Test
G. California Bearing Ratio (CBR) Test

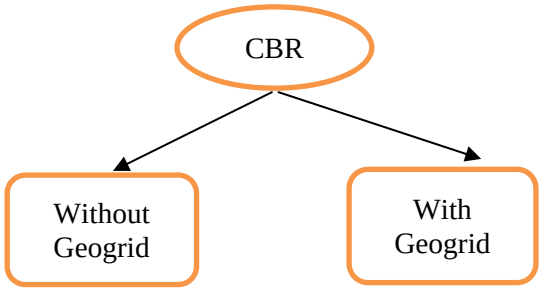
S.No.	Test	Result	Unit
1	Liquid Limit	36.9	%
2	Plastic Limit	19.0	%
3	Plasticity Index	17.9	%
4	Free Swell Index	20	%
5	Optimum Moisture Content (OMC)	11	%
6	Maximum Dry Density (MDD)	1.99	g/cc
7	California Bearing Ratio (CBR)	4	%

TEST RESULT AND ANALYSIS

In this study experimental based result are found.

Experimental Details

The experimental study-based result has been compared on the basis of



Test Result of Black Cotton soil:

For evaluation of properties of soil, we have conducted Liquid Limit, Plastic limit. Free Swell Index, Proctor Test and California Bearing Ratio test as per relevant Indian Standards. Results of these tests are following:

Table1 Test Results of Black Cotton Soil

Sieve Analysis:

Table2 Sieve Analysis Black Cotton Soil

Test Results of Marble Dust:

IS Sieve Designations (mm)	Method of Test	Percentage Retained	Cumulative Percentage Retained	Percentage Passing
4.75	IS: 2720 (Part-4)-1985	0.00	0.00	100
2.00		1.48	1.48	98.52
0.425		2.90	4.38	95.62
0.075		29.68	34.06	65.94
Silt Content	25.92%			
Clay Content	40.02%			

Marble dust used as partial replacement of black cotton soil is tested for chemical properties and particle size distribution. Test results obtain of marble dust are following:

Table3 Chemical Properties of Marble Dust

S.N.	Test	Result	Unit
1	Silica +Insoluble Residue	63.58	%
2	Alumina	13.19	%
3	Magnesium Oxide	3.41	%
4	Calcium oxide	9.21	%
5	Ferric oxide	6.17	%
6	Sulphuric trioxide	3.42	%

Table4 Sieve Analysis of Marble Dust

IS Sieve Designations (mm)	Method of Test	Percentage Retained	Cumulative Percentage Retained	Percentage Passing
4.75	IS: 2720 (Part-4)-1985	4.09	4.09	95.91
2.00		4.34	8.43	91.57
0.425		12.65	21.08	78.92
0.075		13.64	34.72	65.28

Test Results of Polypropylene Geogrid (PPGeogrid):

PP Geogrid used as a reinforcing material in the soil is tested for tensile strength and junction efficiency test. Tests results obtain of PP Geogrid arc following:

Table5 Test Results of Geogrid

Product Code	Mechanical Properties							Dimensions	
	Unit Tension (KN/m)						Junction Efficiency	Aperture Size (mm)	
	Ultimate		Load@2.0%		Load@5.0%				
	MDS	TDS	MDS	TDS	MDS	TDS		MDS	TDS
Tech Grid PP3030	32.78	31.76	10.64	10.60	19.87	19.13	96.32%	30	30

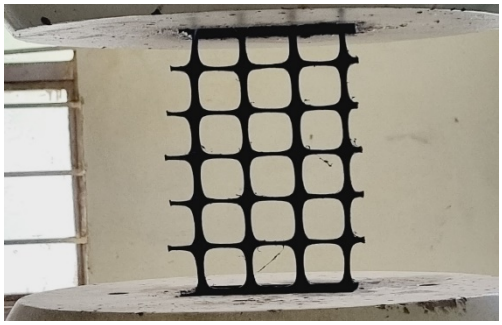


Fig. 3 Tensile Strength of Geogrid

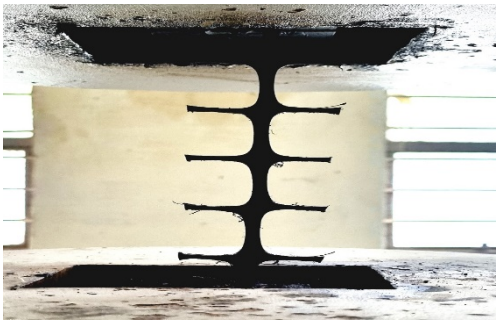


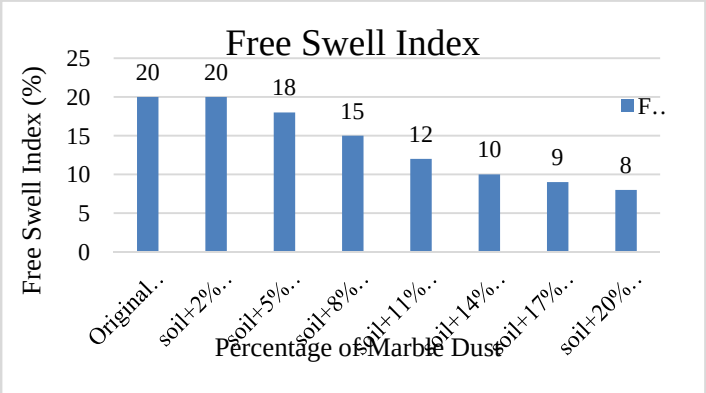
Fig. 4 Junction Efficiency of Geogrid

Test Results of Soil & Partial Mix of Marble Dust

Marble dust used as partial replacement in the soil is mixed by different percentages i.e. - 2%, 5%%, 8%, 11%, 14%, 17% & 20% and tested for optimum content at which maximum CBR value is achieved. Test results of soil & partial mix of marble dust are following:

Table 6 Test Result of Mixture of Black Cotton Soil and Marble Dust

S.N.	Test	Result							Unit
		soil+ 2% MD	soil+ 5% MD	soil + 8% MD	soil + 11 % MD	Soil+ 14 % MD	soil + 17 % MD	soil + 20 % MD	
1	Liquid Limit	35.9	36.6	35.8	35.2	35.2	35	33.8	%
2	Plastic Limit	19	19	19	19	19	19	19	%
3	Plasticity Index	16.9	17.6	16.8	16.2	16.2	16	14.8	%
4	Free Swell Index	20	18	15	12	10	9	8	%
5	Optimum Moisture Content (OMC)	11	11	11	12	13	13	13	%
6	Maximum Dry Density (MDD)	1.99	1.99	1.99	1.98	1.97	1.97	1.96	%
7	California Bearing Ratio (CBR)	4.1	4.2	4.4	4.9	6.4	7.9	7.1	%



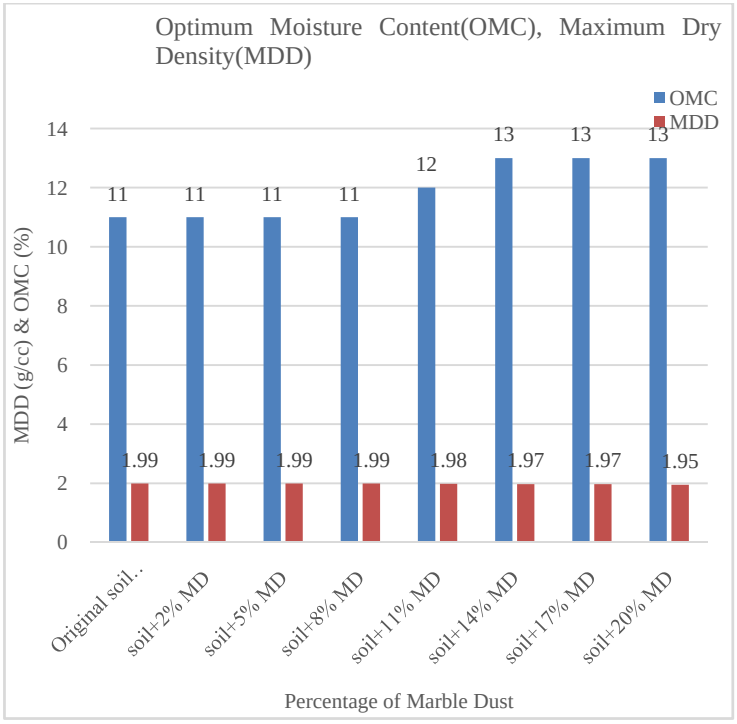
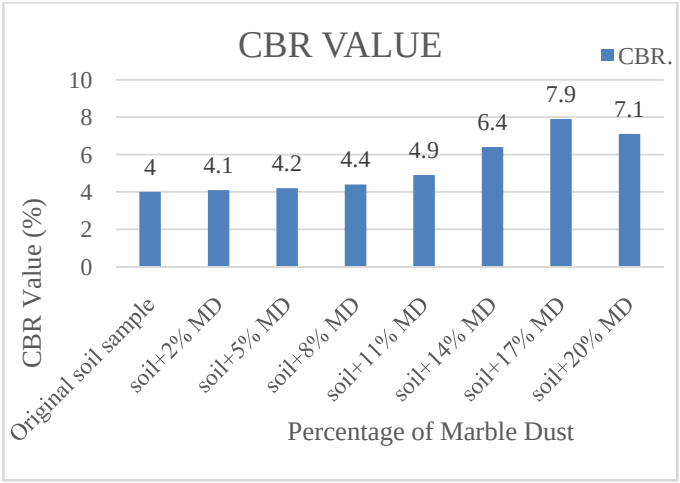


Fig. 5 OMC & MDD with partial mix of marble dust

above graph shows the change in OMC & MDD with mixing of different percentage of marble dust. In this study we have mixed the marble dust in soil from 2% to 20% with the interval of 3% From this experiment we can see that as we increase the percentage of marble dust the amount of moisture content increases and the density decreases

Fig. 6 Free swell index with partial mix of marble dust

From the above figure FSI it can be seen that after mixing of different percentage of' marble dust starting from two percent to twenty percent inoriginal soil as a partial replacement we canobserved



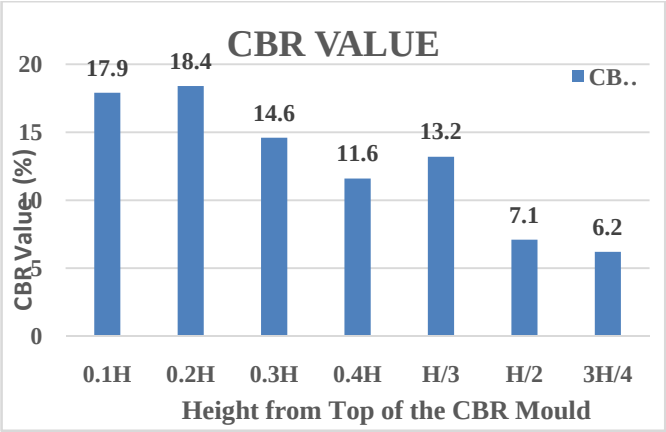


Fig. 8 CBR test results with marble dust & geogrid

From the above graph it is concluded that effect of geogrid is maximum at height of 0.2H from the top of the CBR mould after this, as we keep the geogrid at a greater depth, the CBR value decreases.

Fig. 7 CBR with partial mix of marble dust

From the above graph it is observed that maximum CBR value is achieved with 17% mixing of marble dust and after this, a decrement in CBR value was observed on increasing the percentage of marble dust.

Test Results of Soil & Partial Mix of Marble Dust with Geogrid

After optimum percentage of marble dust in black cotton soil i.e.17% PP geogrid is placed at different heights in the CBR mould and CBR value is determine. Test result of CBR value using geogrid at different height are following:

Table 7 CBR value for Mixture of Black Cotton Soil & Marble Dust with Geogrid at Different Height

Test	Position of Geogrid							Unit
	0.1H	0.2H	0.3H	0.4H	H/3	H/2	3H/4	
California Bearing Ratio (CBR)	17.9	18.4	14.6	11.6	13.2	7.1	6.2	%

Conclusion:

The main objective of this experimental design study i.e. partial replacement of Marble dust with polypropylene geogrid in black cotton soil for improvement the bearing capacity of soil to obtained the experiment basis results with the CBR value test.

1. Optimum percentage of marble dust is obtained as 17% which increase the CBR value from 4% to7.9%
2. Geogrid placement at 0.2H height from the top of the CBR mould increases the CBR value of soil & Marble dust mix from 7.9% to 18.4%.
3. As per this study the bearing capacity of poor soil in change up to 460% with partial mix of marble dust and providing the polypropylene geogrid.
4. The thickness of pavement section and the cost of construction is reduced with providing the geogrid and partial mix of marble dust.
5. Thus, the serviceability of road section is increased.
6. This study will be expected to be useful in designing better subgrade strength of road pavements for areas that are occupied by poor soil.
7. Thus improves the life of the pavements with economical construction.
8. Hence it is clear that the soil can be effectively stabilised by the inclusion of Geogrid.

Future Scope of study:

1 This study proposes that the addition of marble dust, geogrid, coconut shell powder, and waste paper sludge can effectively stabilize black cotton soil.

2 Furthermore, the utilization of geogrids, which are artificial materials employed to strengthen soils, offers a great opportunity to improve soil characteristics.

3 Marble dust may be used with waste paper sludge to improve the engineering characteristics of black cotton soil.

4 Additionally, the utilization of other stabilizing agents like lime, iron dust, and brick dust along with marble dust also demonstrates encouraging outcomes in enhancing the geotechnical characteristics of black cotton soil.

5 For advance research, it is recommended that the effect of combining the plastic bottle strips and kota stone slurry with additives such as lime or cement can be investigated that can further improve the properties of black cotton soil.

6 Comparatively study on soil treated with natural fibers and mane made fibers may be done.

7 Soil partical size chart can be made with addition of waste material to see the differences obtained with the help of them.
8 More waste material combination can be used in the soil stabilization.

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