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"STABILIZATION OF CLAYEY SOILS BY INCORPORATING WASTE GLASS AND PLASTIC CRUMBLES"

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ABSTRACT

For building and road construction activity, soil have 75% of total cost of work. The quality of soil is important for achieving strength of the construction work. The locally available material like clayey soil cannot satisfy the specifications of good earthwork and soil sub grade and in such cases stabilization of clayey soil becomes essential. Clayey soil is also known as expansive soil. Clayey soil has higher swelling and shrinkage property during dry and wet condition and poor strength. This type of nature of soil creates a great problem to the civil engineering structures constructed on them.For stabilizing clayey soil of intermediate compressibility it is very important to achieve higher strength in minimum time period for this waste material can be used efficiently which not only preserve the natural resource but also minimize the waste for disposal.The main reason for selecting glass and plastic granules for the stabilization is that these materials are becoming much difficult for their recycling or disposal and are becoming a great threat to the world causing pollution, especially plastic. Also these materials are locally available and are cheaper than any other conventional materials for stabilization.Experiment is conducted to evaluate the physical and mechanical properties of clayey soil. The test is conducted with the different percentage of waste crushed glass and plastic granules 0%, 2%, 4%, 6% and 8%, which is used to stabilize the clayey soil. Tests conducted on soil are Atterberg limits, plasticity index, free swelling index, optimum moisture content, maximum dry density and California bearing ratio test. The aim is to improve the clayey soil for good earthwork and soil sub grade for pavement design effectively.

Keyword: *Soil Stabilization; Waste Crushed Glass and Plastic Granules; Clayey Soil; Atterberg Limits; CBR; etc.*

I. INTRODUCTION

In building construction and highway the most prominent is a layer of soil above which construction is done. The foundation and pavement failure or success depends upon the underlying layer (sub grade) of soil and the material upon which the foundation or pavement structure is built. The underlying layer of foundation or pavement sub grade is composed of wide range of materials although some are better than others. Some aspects of materials that make them either undesirable or desirable and some experiments are required to characterize the underlying layer of soil. Performance of an underlying layer or soil or sub grade generally depends on three of its basic characteristics; Load bearing capacity; Moisture content; Shrinkage and swelling.Clayey soil is highly expansive soil. The soil is used for the testing is taken from the Malanpur in Bhind District of Madhya Pradesh. This soil is well known for their specific

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properties such as very small particle size, a great specific surface area and high level of cation exchange capacity.The concept of clayey soil can be utilized to include a significant amount of variation in volume describing in soil because of exchanging the amount of soil water content. (Nelson and Miller, 1992). Clayey soil is major concern to engineer for development of any infrastructure like, roads, building, bridges, etc and which leads to reduction of life span of such facilities. Since there is an increasing shortage of good construction materials within localities and the problem of soil is consider in addition to the high cost of delivery, usage of unsuitable materials with little modification is readily adopted. We can either replace it or to remove the existing soil or some other materials are used to improve the engineering properties of the existing soil by stabilization.Soil stabilization is a geotechnical technique of increasing and maintaining the stability of soil mass and chemical or mechanical alteration of soil to enhance their engineering properties. Stabilization process will increase soil strength, decrease plasticity, lowering or sometimes increasing permeability, hence resulting in higher soil strength, lower volume change due to temperature or moisture variations, increase workability of soil. Thus, it lowers the pavement thickness, when it is used in road construction.Therefore, the use of recycled materials to stabilized the soil offer a variable alternative from technical, economical, and environmental standpoint. Additional advantage of using waste material to stabilize the clayey soil is that it is cheap, easily available, eco friendly, and saves the disposal cost of waste material.There are various methods used to stabilize clayey soils, but they can be separated in two main groups: mechanical (physical) stabilization and chemical stabilization

II. LITERATURE REVIEW

Snethen et.al., 1975, The phyllosilicate group is the group of clay minerals which have high volume change. The phyllosilicate group basic unit structure is plate like structure and consists of two types of horizontal sheets. Silica tetrahedron block overcome by one of horizontal sheets and the second one is controlled by magnesium and aluminum octahedron block. One ion of silicon atom is surrounded tetrahedrally by four atoms of oxygen in silica tetrahedron block. In magnesium or aluminium octahedron block ions surrounded octahedrally by hydroxyl group or six oxygen atoms. The octahedral sheet is consisting of large number of octahedral join together horizontally. Dioctahedral or gibbsite [Al2 (OH)6] is a trivalent cation or only aluminium in a clay minerals and the structure is trioctahedral or burcite [Mg3(OH6)] when it contains magnesium or cation is divalent.

Fredlund and Rahardjo, 1993, Clayey soil is well known for its composition containing the clay mineral illite, kaolinite and montmorillonite. Montmorillonite include residual and sedimentary soils such as shales, clay stones. In different season clay soil are mainly observed in arid and semiarid zones subjected to large climate change. Near the ground surface they are naturally located and affected by the temperature and environmental changes.

Mitchell and Soga, 2005, Clay minerals commonly have some particular characterstics such as (1) small particle size, (2) unit cells with a negative electrical charge balanced by taking cation from solution, (3) posses plasticity when mixed with water and (4) relatively high weathering resistance.

C.J Bronick, R.lal, 2014, Clayey soil is composed of very small particles, and usually it contains silicates of aluminum and/or iron and magnesium. The flow of water impedes by clayey soil means it slowly absorbs water and then retains it for a long time. Clayey soil becomes heavy and sticky when it is in wet condition and tends to swell from the added water. Clayey soil shrinks and settles when it is in dry condition. The upper layer of soil can bake into hard concrete-like crust which cracks. Clayey soil size particles are commonly associated with aggregation by rearrangement and flocculation although swelling clay can disrupt aggregates.

J. Olufowobi, A. Ogundoju, B. Michael, O. Aderinlewo, 2014, The results showed improvement in the maximum dry density values on addition of the powdered glass and with corresponding gradual increase up to 5% glass powder content after which it started to decrease at 10% and 15% powdered glass content. The highest CBR values of 14.90% and 112.91% were obtained at 5% glass powder content and 5 mm penetration for both the unsoaked and soaked treated samples respectively. The maximum cohesion and angle of internal friction values of 17.0 and 15.0 respectively were obtained at 10% glass powder content.

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Anas Ashraf, Arya Sunil and others, 2011, The investigation was done by conducting plate load tests on soil reinforced with layers of plastic bottles filled with sand and bottles cut to halves placed at middle and one third positions of tank. The comparison of test results showed that cut bottles placed at middle position were the most efficient in increasing strength of soil. The optimum percentage of plastic strips in soil was found out by California Bearing Ratio Test and using this percentage of plastic, plate load test was also performed. The size and content of strips of waste plastic bottles have significant effect on the enhancement of strength of the soil.

Divya Patle, Mamta Burike, Sayli D. Madavi, Suvarna Raut, 2017, The new technique of soil stabilization can be effectively used to meet the challenges of society, to reduce the quantities of waste, producing useful material from non-useful waste materials. This study is focused to the problems experienced in Amravati, the capital of newly formed Andhra Pradesh State. In this study, an experimental program was conducted for stabilization of Black Cotton Soils in the Capital Region i.e., Amravati of newly formed Andhra Pradesh, with the utilization of Plastic waste as soil stabilizer. Different contents of plastic strips (% by weight varying from 0% to 8%) are added to the Black Cotton Soil and the optimum percentage of plastic strips in soil was found out by conducting California Bearing Ratio Test.

The main reason for using Glass and Plastic granules for the stabilization is that these materials are difficult in recycling or disposing and they are becoming a great threat to the world causing pollution, especially plastic. Also these materials are locally available and are cheaper than any other conventional materials for stabilization. Glass and Plastic has also proved to be efficient materials for stabilization. Hence Glass and Plastic are chosen forstabilization of Black Cotton soil.

III. EXPERIMENTAL STUDY

3.1 Sample Preparation
In this research work the soil investigated was brought from the eastern part of Malanpur region, Bhind District, Madhya Pradesh. The soil sample is clear of debris, vegetation and roots. The soil is kept for 4-5 days so that soil should be moisture free. To evaluate the physical properties of the soil number of tests were conducted to identify and classify it.

3.2. Properties of soil sample used for study
- The soil samples for moisture content determination are dried to the temperature at which only pore water is evaporated. This temperature is standardized 105ºC to 110 ºC.Specific gravity of soil sample is 2.66. The oven dry soil sample is accurately measured approximately 200 gm and passes through 4.75mm size sieve.
- The different Atterberg limits are

ATTERBERG LIMITS	PERCENTAGE (%)
Liquid limit	36%
Plasticity limit	20%
Plasticity index	16%
A-Line (I_p)	11.6%

- Free swelling index test the soil sample has 45% free swell index
- With the help of laboratory standard proctor test on the soil sample, maximum dry density and optimum moisture content of the soil is determined as 17.66 KN/m3 and 18.6%.

3.3.Objectives
- To compare the variation in all the properties like; Specific Gravity, Free Swelling Index, Maximum Dry Density (MDD) and Optimum Moisture Content (OMC) and the CBR Value of underlying layer of soil and the soil after the stabilization with Crushed Glass Powdered and Plastic Granules.
- To achieve the target strength values corresponding to the different selected moisture contents.

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- To evaluate the Economical and effective use of waste material and the effects of crushed glass powdered and plastic granules material on clayey soil.
- To evaluate the variation of physical and mechanical soil characteristics after mixing with different percentage of crushed glass powdered and plastic granules
  To mitigate the swelling- shrinking potential of clayey soil.

IV. RESEARCH METHODOLOGY

The main objective of this experimental study is to investigate the influence of the crushed glass powdered and plastic granules and in modifying clayey soil. The natural clayey soil sample were mixed with different crushed glass powdered and plastic granules percentages which includes 0%, 2%, 4% , 6%, 8% and 10% of dry soil mass. The soil used for testing is obtained from Malanpur, in Bhind District of Madhya Pradesh. To study the variations in physical, mechanical and hydraulic properties of the soil after mixing with different percentages of stabilizing material both treated and untreated soil samples were tested.

In this research work the methodology includes experiments to determine physical and mechanical properties of soil. All tests were carried out according to Indian Standard Classification System (ISCS). Liquid limit, plastic limit, plasticity index, specific gravity, free swelling index, standard proctor compaction, California bearing ratio test were conducted on both treated and untreated soil sample.

V. RESULTS AND DISCUSSION

In this section the experiments which have been conducted will be divided into three groups: The first series of experiments were conducted on raw soil sample for identifying the soil properties like; specific gravity, natural moisture content, plastic limit, liquid limit, plasticity index, optimum moisture content, free swelling index, maximum dry density and CBR value. The second series of experiments were conducted on soil mixed with different percentages (0%, 2%, 4%, 6%, 8%, and 10 %) of waste crushed glass powdered and plastic granules differently and the test are conducted on this sample to evaluate the reduction in swelling and optimum moisture content, increase in maximum dry density and CBR value. The third series of test were conducted on waste crushed glass powder and plastic granules mixed with soil at 0%, 2%, 4%, 6%, 8% and 10% to stabilize the soil for further improvement of soil properties.

5.1 Test Conducted on Soil

Table-1: Results of Compaction test (OMC and MDD)

S.No.	Particulars	10% of Wc	12% of Wc	14% of Wc
1	Weight of mould $W_{m,}$ (gm)	2220	2220	2220
2	Weight of mould + compacted soil (W_1), (gm)	4225	4314	4220
3	Weight of compacted soil $W=W_1-W_{m,}$ (gm)	2005	2094	2000
4	Wet density (y_t) =W/V, (gm)	2.005	2.094	2.000
5	Crucible No.	**A**	**B**	**C**
6	Weight of crucible + wet soil, (gm)	33	32.9	36
7	Weight of crucible + dry soil, (gm)	30	29	31
8	Weight of water (6 -7) ,(gm)	3	3.9	5
9	Weight of crucible,(gm)	8	8	8
10	Weight of dry sample (7-9), (gm)	22	21	23
11	**Moisture content (m_c) %** =(8/10)*100	**13.6**	**18.6**	**21.7**
12	Dry density (gm/cc)	1.765	1.766	1.643
13	**Dry density (y_d) KN/m^3**	**17.65**	**17.66**	**16.43**

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Table-2: Results of CBR Test

S.No.	Penetration (mm)	Proving ring reading	Load (Kg(f))
1	0.5	4	21.97
2	1.0	5	27.45
3	1.5	6	32.94
4	2.0	6.9	37.88
5	2.5	7.2	39.53
6	3.0	7.8	42.82
7	4.0	8.5	46.66
8	5.0	9	49.41
9	7.5	11	60.39
10	10.0	12.5	68.62
11	12.5	14.21	77.95

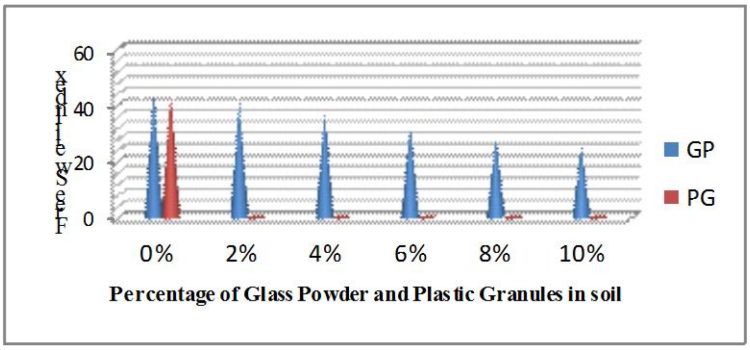

Fig. 1:Chart showing the variation in Free Swell Index

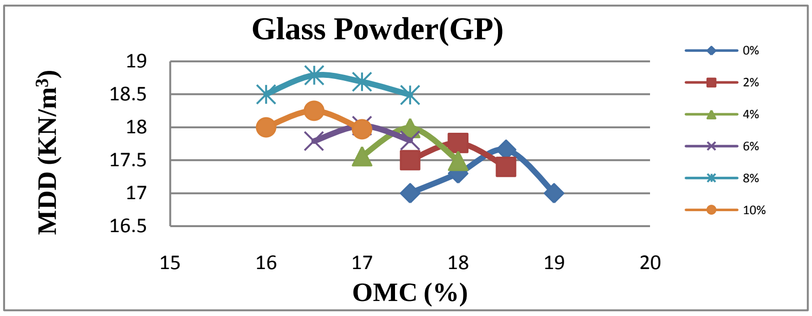

Fig. 2: Graph showing OMC and MDD of mix proportions of soil

Table-3: CBR Value for mix proportions of soil

Mix proportions with glass powder(GP)	CBR (%)	Mix proportions with plastic granules (PG)	CBR (%)
0% of GP	2.88%	0% of PG	2.88%
2% of GP	3.38%	2% of PG	3.03%
4% of GP	3.99%	4% of PG	4.67%
6% of GP	4.78%	6% of PG	6.61%
8% of GP	6.29%	8% of PG	9.30%
10% of GP	8.80%	10% of PG	10.59%

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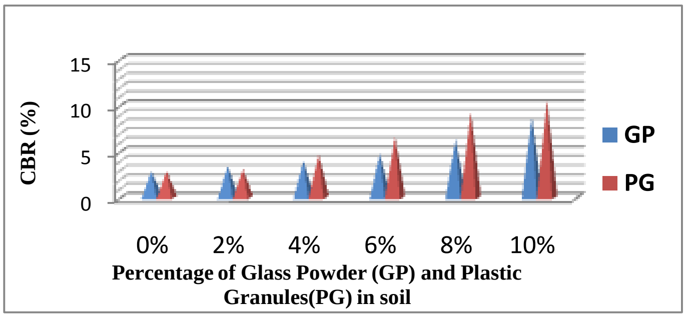

Fig. 3:Chart showing the variation of CBR Value for mix proportions of soil

5.2 Results of waste crushed glass powder and plastic granules mixed with soil at 0%, 2%, 4%, 6%, 8% and 10%

Table-4: Free swell index value for waste crushed glass powder and plastic granules

S.No.	Mix proportions with glass powder(GP) + plastic granules (PG)	Free swell index
1	0% of (GP +PG)	45%
2	2% of (GP +PG)	41.03%
3	4% of (GP +PG)	37%
4	6% of (GP +PG)	32.7%
5	8% of (GP +PG)	29.10%
6	10% of (GP +PG)	25%

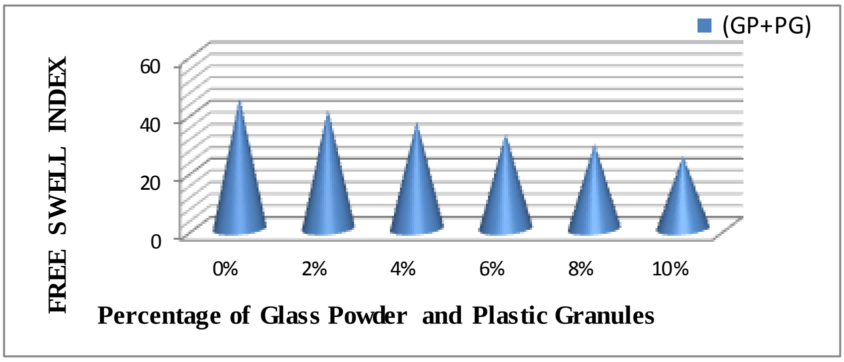

Fig. 4:Chart showing the variation in Free Swell Index

Table-5: Compaction Test value for waste crushed glass powder and plastic granules

S.No.	Mix proportions with glass powder(GP) + plastic granules (PG)	MDD(KN/m^3)	OMC (%)
1	0% of (GP +PG)	17.66	18.60
2	2% of (GP +PG)	17.82	17.72
3	4% of (GP +PG)	18.43	17.07
4	6% of (GP +PG)	18.87	16.64
5	8% of (GP +PG)	19.39	16.31

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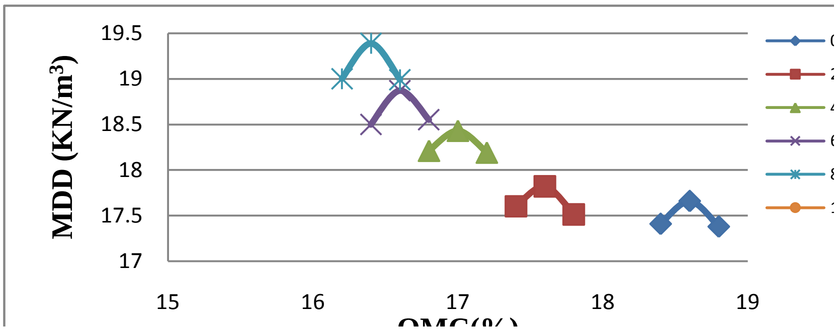

Fig. 5:Graph showing OMC and MDD of waste crushed glass powder and plastic granules

Table-6: CBR Value for waste crushed glass powder and plastic granules mixed with soil

Mix proportions with glass powder(GP) + plastic granules (PG)	CBR (%)
0% of (GP +PG)	2.88
2% of (GP +PG)	4.6
4% of (GP +PG)	6.21
6% of (GP +PG)	9.33
8% of (GP +PG)	11.76
10% of (GP +PG)	13.33

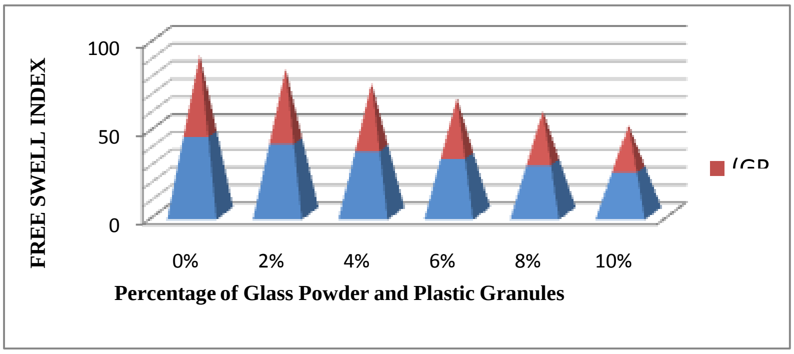

Fig. 6:Chart showing the variation in CBR Value

VI. CONCLUSIONS

This investigation provides the results of an experimental study on possible use of waste material like waste crushed glass powder and plastic granules for improving the characteristics of clayey soil.
In engineering applications using waste material plays a vital role in protection of environment from pollution and disposal problem, since huge amount of municipal and industrial waste are dumped into lands without taking any precautions for environmental protection. Glass powder and plastic granules is also the source of environmental pollution. Therefore, these wastes are recycled or reuse as a stabilizing agent for expansive clayey soil in construction works.

• In first group of study all soil properties are evaluated. The specific gravity of soil is 2.66, plastic limit and liquid limit is 20% and 36%. The plasticity index of soil is 16%. Therefore, the soil is clayey soil of intermediate compressibility (CI). The free swelling index of soil is 45%, optimum moisture content (OMC) and maximum dry density (MDD) is 18.6% and 17.66 KN/m3. California bearing ratio value of soil is 2.88%.

• In second group of study the waste crushed glass powder and plastic granules mixed with soil at 0%, 2%, 4%, 6%, 8% and 10% differently:

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1. On increasing the percentage of crushed glass powder and plastic granules the swelling of soil decreases.

2. The optimum moisture content (OMC) and maximum dry density (MDD) at 8% of glass powder with soil is 16.81% and 18.79 KN/m3 and when plastic granules is added the optimum moisture content (OMC) and maximum dry density (MDD) at 4% is 18% and 18.1 KN/m3

3. The CBR test is conducted on the same sample of waste crushed glass powder the CBR Value is 8.8% and when the same sample is tested with plastic granules the CBR Value is 10.59%.

• In third group of study, tests were conducted on waste crushed glass powder and plastic granules mixed with soil at 0%, 2%, 4%, 6%, 8% and 10% further improvement of soil properties.

1.The compaction test is concluded as that the optimum moisture content (OMC) and maximum dry density (MDD) of sample is16.3 % and 19.39 KN/m3.

2. The CBR test is conducted on waste crushed glass powder and plastic granules mixed with soil at 0%, 2%, 4%, 6%, 8% and 10%. The CBR Value increases to 13.33 %.

From all the investigation study the final conclusion come to know is that the waste material like waste crushed glass powder and plastic granules rubber at different proportions can be used to improve the soil sub grade of pavement.

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