POTENTIAL OF WASTE GLASS POWDER IN SOIL STABILIZATION USING CEMENT

G Venkatesh
Assistant Professor
Civil Engineering Department
RGUKT, RK Valley, Kadapa, India.

Abstract: The world is composed of different types of soils. Some of them are not fit for construction purposes because of their undesirable properties. They include expansive soils, collapsible soils etc. So, stabilization of those soils is necessary to improve their properties in order to make use of soils for foundations. The agenda is to stabilize the soils using waste glass powder as a replacement of cement. CBR test is carried out on soil samples with and without the addition of waste glass powder as partial replacement for cement which showed that upto 10% of glass powder can be replaced for cement for soil stabilization. This makes stabilization process economical, because crushed glass is a waste material.

1. Introduction: Expansive soils are those whose volume changes takes place while it comes in contact with water. It expands during the rainy season due to absorption of water and shrinks during summer season due to drying. Expansive soils cover nearly 20% of the landmass in India. The swelling soils are commonly known by the name of black cotton soils. General properties of the expansive soil are swell potential and swelling pressure which directly affect the bearing capacity and strength of foundation lying on such a soil. Typical behaviour of swelling and shrinkage of expansive soil develop problems like cracking in foundation. Hence, it is necessary to improve the properties of such a soil to avoid damages to the structure. Although mechanical compaction, dewatering and earth reinforcement have been found to improve strength of the soil, other methods like stabilization using admixtures are too advantageous. The different admixtures available are lime, cement, fly ash, blast furnace slag, coconut shell powder, bottom ash etc., In this study, waste glass is used as replacement of cement in soil stabilization because of its similar composition to cement. The main aim of using these products is to bring economy in cost of construction and effective utilization of waste products. Thousands of tons of glass bottles and jars enter landfills each day. Recycling of these materials is an excellent way to reduce waste, lower construction costs.

2. Literature Review

Soil stabilisation is the alteration of soils to enhance their physical properties. It can increase the shear strength of a soil, control its shrink-swell properties and improve its load bearing capacity. Soil stabilization can be utilized on roadways, parking areas, site development projects, airports and many other situations where sub-soils are not suitable for construction. It can also be used to treat a wide range of subgrade materials varying from expansive clays to granular soils as well as improve other physical properties of soils such as increasing their resistance to erosion, dust formation or frost heaving.

2.1 Methods of Stabilization

2.1.1 Mechanical Stabilization

Mechanical Stabilization is the process of improving the properties of the soil by gradation and by compaction using devices such as rollers, tempers, rammers. Two or more types of soils are mixed to obtain a composite material which is superior to any one of its components. To achieve the desired grading, sometimes the soils with coarse particles are added or the soils with fine particles are removed.

2.1.2 Chemical Stabilization

This method deals with improving the engineering properties of soil by adding chemicals or other such materials and it is generally cost effective. These additives react with the soil usually clay minerals, with subsequent precipitation of new and insoluble minerals, which bind the soil together. It is done to reduce permeability of soil, increase shear strength and enhance bearing capacity by using chemical agents such as calcium chloride, cement, lime, sodium silicate, bitumen etc.

Calcium chloride - It is mainly used in road construction work for stabilizing base and sub base course.

Cement - Cement being the oldest binding agent, is also considered as a primary stabilizing agent and is used to stabilize a wide range of soils. Stabilization process starts when cement is mixed with water, which results in hardening phenomena (hydration of cement). Setting of cement will enclose soil as glue, without changing the structure of soil.

Sodium Silicate – It is mainly used for fine and medium sands. Sodium silicate together with water and calcium chloride is injected for stabilizing soil deposit which improves the shear strength of soil.

Lime – lime is an economic way of soil stabilization, used mainly in black cotton soils which are highly unstable. Quicklime when mixed with wet soil, immediately takes up water from surrounding to form hydrated lime, generates heat which causes loss of water which in turn results into increased plastic limit of soil.

Bitumen -Bituminous materials used for coating the soil grains so as to retard or completely stop absorption of moisture. Bituminous stabilisation is best suited for sandy soils or poor quality base course materials and its benefit is derived by driving off the volatile constituents of the bitumen just prior to compaction.

3. Methodology and materials used:

The materials used in carrying out the project are powdered glass, cement, clay soil and water.

Glass is an amorphous non crystalline material which is typically brittle and optically transparent. The familiar type of waste glass materials found around are drinking vessel and windows, most of the readily available waste glass materials are soda-lime glass, composed of silica (Si0 2) plus Na_2O, CaO and several additives. This material is added to clay soil in its powdered form for soil stabilisation. The chemical composition of glass is as follows:

Table 1: Chemical composition of glass

S.No	Name of compound	% of compound
1	CaO	45 - 55%
2	SiO2	12 - 18%
3	MgO	3 - 8%
4	Al_2O_3	4 – 7%
5	Ferric oxide, inorganic compounds	12 %

Cement can be described as a material with adhesive and cohesive properties, which make it capable of holding material fragment into a compacted aggregate. It is manufactured from limestone and is added to an expansive soil to improve its engineering properties. It may be formed in place as residual deposits in soil while larger deposits usually are formed as the result of a secondary sedimentary deposition process after they have been eroded and transported from their original location of formation. PPC 43 grade cement is used in the work.

Clay soil used is a black soil having LL of 45%, PL of 20% and PI of 25%. From the plasticity index, the soil is classified as “Highly plastic soil”. OMC of the soil is found to be 22% with a maximum dry density of 16.4 kN/m^3.

Lastly, water is a universal solvent. The water used is obtained from bore holes and is free from suspended particles like organic matter and silt which might affect the hydration process of cement.

CBR testing procedure:

The California Bearing Ratio Test (CBR Test) is a penetration test used for evaluating the bearing capacity of subgrade soil for design of pavements. It is carried out on natural or compacted soils under soaked or un-soaked conditions and the results obtained are compared with the curves of standard tests to indicate the soil strength. The test is performed by measuring the pressure required to penetrate a soil sample with a plunger of standard area which is then divided by the pressure required to achieve an equal amount of penetration on a standard crushed rock material. In order to carry out this test, the same mix proportions used under the compaction test were used again in this test. 6 kg of dry soil was mixed thoroughly with calculated quantity of water to obtain moist soil with the required moisture percentage. The soil was compacted in three different CBR moulds, each in 3 layers and subjected 25 blows each using the standard rammer (4.5 kg and falling through 30 cm). The top surface was scraped and leveled after compacting the third layer. Sufficient surcharge mass was then placed on the soil surface to equal the actual or estimated mass of construction. The loading was applied at the rate of 1.25 mm/min. Readings of the load were taken at the following penetrations for both the top and bottom layers namely 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5 and 7.0. Immediately, after the penetration test, filter paper was placed on the compacted exposed surface (both at the top and bottom), closed with metallic cover to prevent direct influence of water and placed in soaking tank for 98 hours. Thereafter, it was removed and the corresponding soaked readings were taken at the same penetrations used under the unsoaked condition for both the top and bottom. The readings of load intensity were plotted against the readings of penetration and a smooth curve was drawn through the points. The values of the load at penetration of 2.5 mm and 5.0 mm are to be recorded. CBR value corresponding to the higher penetration values is considered to be the final CBR value. The CBR values were calculated by using the following equations:

$$\text{CBR value at 2.5 mm penetration} = \frac{load\ carried\ by\ sample}{standard\ load\ at\ 2.5\ mm\ penetration\ (1370\ kg)}$$

$$\text{CBR value at 5.0 mm penetration} = \frac{load\ carried\ by\ sample}{standard\ load\ at\ 5.0\ mm\ penetration\ (2055\ kg)}$$

CBR value of plain soil is found to be 2%. CBR test value of plain soil is tabulated below.

Table 2: CBR test values of plain soil

S.No	Dial guage reading (a)	Penetration in mm (a) * 0.01	Proving ring reading (b)	Total load (Pt) in Kg (b) * 0.861
1	50	0.5	5	4.30
2	100	1.0	12	10.33
3	150	1.5	18	15.49
4	200	2.0	25	21.52
5	250	2.5	38	32.71
6	300	3.0	40	34.44
7	350	3.5	42	36.16
8	400	4.0	47	40.46
9	450	4.5	54	46.49
10	500	5.0	61	52.51

From the above table, CBR value at 2.5 mm penetration is 2.38 % and at 5.0 mm penetration is 2.55%. From the previous work (Mohammed et al (2016)), it is found that addition of cement upto 15% showed increase in CBR value of soil upto 9%. CBR test is conducted on control sample (sample with 15% cement) and is tabulated below:

Table 3: CBR test values corresponding to 15% cement

S.No	Dial guage reading (a)	Penetration in mm (a) * 0.01	Proving ring reading (b)	Total load (Pt) in Kg (b) * 0.861
1	50	0.5	30	25.83
2	100	1.0	49	42.18
3	150	1.5	72	61.99
4	200	2.0	115	99.01
5	250	2.5	139	119.67
6	300	3.0	150	129.15
7	350	3.5	168	144.64
8	400	4.0	190	163.59
9	450	4.5	219	188.55
10	500	5.0	229	197.16

CBR value with the addition of 15% of cement at 2.5 mm penetration is 8.73% and at 5 mm penetration is 9.59%

4. Results and Discussions:

CBR test is conducted in different trails by mixing different proportions of glass powder for cement replacement. Trails were conducted by increasing the glass powder by 2%, 4%, 6%, 8% and 10% and 12%. Out of the trails conducted, CBR values increased with increase in glass powder upto 10% and afterwards showed a decreasing pattern. The results are tabulated as shown below:

Table 4: CBR test values correspomding to 5% cement and 10% glass powder

S.No	Dial guage reading (a)	Penetration in mm (a) * 0.01	Proving ring reading (b)	Total load (Pt) in Kg (b) * 0.861
1	50	0.5	27	23.24
2	100	1.0	52	44.72
3	150	1.5	78	67.15
4	200	2.0	109	93.84
5	250	2.5	143	123.12
6	300	3.0	156	134.31
7	350	3.5	172	148.09
8	400	4.0	188	161.86
9	450	4.5	210	180.81
10	500	5.0	225	193.72

From the above table, CBR value at 2.5 mm penetration is 8.98% and at 5.0 mm penetration is 9.42% which is similar to CBR value of soil mixed with 15% of cement. From the above table, it is clear that glass powder can be good replacement for cement.

5. Conclusions:

Based on the above study the following conclusions can be drawn:

- Glass powder can be a good alternative to cement because of its chemical composition.
- Glass powder can be effectively used as an additive for soil stabilization in the presence of cement.
- Soil stabilization with glass powder is economical because it is a waste material.
- Glass powder can be replaced for cement (upto 10%) for soil stabilization without any decrease in CBR value of soil

References

1. Hanifi Canakci a, Aram AL-Kaki a , Fatih Celik a, 2016, Stabilization of Clay with Waste Soda Lime Glass Powder.

2. Mwajuma Ibrahim Lingwanda, 10-04-2018, Use of Waste glass in improving subgrade soil properties.

3. Mohammed A. Al-Neami, Kawther Y.H. Alsoudany, Aram A. Dawod and Elaf A. Ehsan, Remediation of cohesive soils using waste glass, Conference of the International Journal of Arts & Sciences, CD-ROM. ISSN: 1943-6114 :: 09(01):125–138 (2016).

4. Olufowobi, A. Ogundoju, B. Michael, O. Aderinlewo, CLAY SOIL STABILISATION USING POWDERED GLASS, Journal of Engineering Science and Technology, Vol. 9, No. 5 (2014) 541 – 558.