Stabilization of Expansive Soil Using Ground Granulated Blast Furnace Slag And Polypropylene Fiber

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Abstract- *Expansive soils cause serious problems and produces damage to many civil engineering structures due to swelling and shrinkage. Properties of soil directly influence the bearing capacity which influences the loads of super structure. A strong soil aids in large structures where as a weak soil hinders the constructions of structures. Hence to overcome is deficiencies of the presence of weak soil; soil is stabilized to improve its properties. This study focuses on the use of mixture of "GROUND GRANULATED BLAST FURNACE SLAG (GGBS) and POLPROPYLENE FIBER (PPF)" as a suitable stabilizer.*

In this study various mixtures of GGBS with constant Polypropylene fiber percentage is added to the collected soil sample and their index properties and strength properties are studied.

Keywords- soil stabilization, GGBS, PPF, Compaction, CBR Test, UCC Test.

I. GROUND GRANULATED BLAST FURNACE SLAG (GGBS)

Introduction:

Ground Granulated Blast furnace Slag is a by-product of iron manufacturing industry. Iron ore, coke and limestone are fed into the furnace, and the resulting molten slag floats above the molten iron at a temperature of about 1500 0C to 1600 0C. The molten slag has a composition of 30% to 40% Silicon Dioxide (SiO_2) and approximately 40% Calcium Oxide (CaO), which is close to the chemical composition of Portland cement. After the molten iron is tapped off, the remaining molten slag, which mainly consists of siliceous and aluminous residues, is then rapidly water- quenched, resulting in the formation of a glassy granulate. This glassy granulate is dried and ground to the required size which is known as Ground Granulated Blast furnace Slag. It has been reported that the manufacture of one ton of Portland cement would require approximately 1.5 tons of mineral extractions together with 5000 MJ of energy, and would generate 0.95 tons of CO_2 equivalent.

As GGBS is a by-product of iron manufacturing industry, it is reported that the production of one ton of GGBS would generate only about 0.07 tons of CO_2 equivalent and consume only about 1300 MJ of energy. The replacement of Portland cement with GGBS will lead to a significant reduction of carbon dioxide gas emission.

India, we produce about 10 million tons of GGBS. The disposal of such slag even as a waste fill is a problem and may cause serious environmental hazards with the projected economic growth and development in the steel industry. The amount of production is likely to increase many folds and environmental problem will thus pose a large threat. It is seen that high volume eco-friendly replacement by such slag leads to the development 4 of concrete which not only utilizes the industrial wastes but also saves a lot of natural resources and energy.

The use of GGBS is well established in many applications where it provides for good durability, high resistance to chloride penetration, resistance to sulphate attacks and protection against alkali silica reaction (ASR). GGBS has also been used for many years in road bases. Its use in soil stabilization is however still a novel process in the U.K, although it has been used in South Africa. GGBS has also never been used in Egypt.

POLYPROYLENE FIBER (PPF): It is used variety of applications such as retaining structures, embankments, stabilization of subgrade and improvement of soil beneath pavements and footings. These fibers are improving properties if soil.

PHYSICAL PROPERTIES OF POLYPROPYLENE FIBER:

Tensile strength (gf/den)	3.5 to 5.5
Elongation (%)	40 to 100
Abrasion resistance	Good
Moisture absorption (%)	0 to 0.05
Softening point (ºC)	140
Melting point (ºC)	165
Chemical resistance	Generally excellent
Relative density	0.91
Thermal conductivity	6.0 (with air as 1.0)
Electric insulation	Excellent
Resistance to mildew, moth	Excellent

Table 8: Properties of POLYPROPYLENE FIBER

Dry the specific gravity bottle and weigh it with its cap (w1). Take about 200 g to 300 g of oven dried soil passing through 4.75MM sieve into the specific gravity bottle and weigh again (w2). Add water to cover the soil and screw on the cap. Shake the gravity bottle well and connect it to the vacuum pump to remove entrapped air for about 10 to 20 minutes. After the air has been removed, fill the gravity bottle with water and weigh it (w3). Clean the gravity bottle by washing thoroughly. Fill the cleaned gravity bottle completely with water up to its top with cap screw on. Weigh the Specific gravity bottle after drying it on the outside thoroughly (w4)

Formula for calculating the Specific Gravity:

Specific Gravity (G) = (W2−W1) / ((W4−W1)−(W3−W2))
W1- Weight of bottle in gms
W2- Weight of bottle + Dry soil in gms W3- Weight of bottle + Soil + Water gms W4- Weight of bottle + Water gms

Atterberg Limits

The test includes the determination of the liquid limits, plastic limits and the plasticity index for the natural soil and the soil, saw dust ash admixtures and cement as an additive mixture The tests are conducted on soil samples according to IS –

California Bearing Ratio (CBR) Test

The California bearing ratio (CBR) is a penetration test for evaluation of the mechanical strength of road sub grades and base courses. It was developed by the California Department of Transportation. CBR is defined as the ratio of force per unit area required to penetrate a soil mass with a circular plunger of 50mm diameter at the rate of 1.25mm/min to that required for corresponding penetration of a standard material. The ratio is usually determined for penetrations of 2.5mm and 5mm. When the ration of 5mm is consistently higher than at 2.5mm, the ratio at 5mm is used

C.B.R. = (Test load / Standard load) *100

Standard load is defined as the load obtained from the test on crushed stone which has a CBR value=100%.The following table gives the standard loads adopted for different penetrations for the standard material with a C.B.R. value of 100%.

Generally, the CBR value at 2.5mm penetration will be greater than that at 5.0mm penetration. In such cases, the CBR2.5mm is selected for design. If CBR 5mm> CBR 2.5mm, the test is repeated. If the identical results follow, the bearing ratio at 5mm penetration is taken for the design

Penetration of plunger (mm)	Standard load (kg)
2.5	1370.0
5	2055.0
7.5	2630.0
10	3180.0
12.5	3600.0

Optimum Moisture Content

The corresponding value of moisture contents at maximum dry densities, which is deduced from the graph of dry density against moisture content, gives the optimum moisture content.
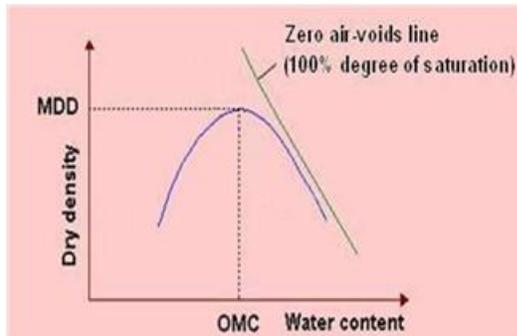

Figure 8: Sample graph of compaction to get MDD and OMC

Standard Proctor Compaction Test

This experiment gives a clear relationship between the dry density of the soil and the moisture content of the soil. The experimental setup consists of Cylindrical metal mould Detachable base plate, Collar (5 cm effective height), Rammer (4.54 kg)

Height of fall (45.7cm) Capacity of mould (944 ml).

The modified compaction energy is **4.55 times** that used in the standard compaction test.

Compaction process helps in increasing the bulk density by driving out the air from the voids. The theory used in the experiment is that for any compactive effort, the dry density depends upon the moisture content in the soil. The maximum dry density (MDD) is achieved when the soil is compacted at relatively high moisture content and almost all the air is driven out, this moisture content is called optimum moisture content (OMC). After plotting the data from the experiment with water content as the abscissa and dry density as the ordinate, we can obtain the OMC and MDD. The equations used in this experiment are as follows:

Wet density =weight of wet soil in mould (gms) / volume of mould (cc) Moisture content % = (weight of water (gms) / weight of dry soil (gms)) X 100
Dry density γd (gm/cc) = wet density / (1+moisture content)

Liquid Limit (WL)

The soil sample for liquid limit is air dried and 200g of the material passing **through No. 40sieve (425μm aperture**) was obtained and thoroughly mixed with water to form a homogeneous paste on a flat glass plate. A portion of the soil water mixture is then placed in the cup of the Casagrande apparatus, leveled off parallel to the base and divided by drawing the grooving tool along the diameter through the center of the hinge. The cup is then lifted up and dropped by turning the crank until the two parts of the soil come into contact at the bottom of the groove. The number of blows at which that occurred was recorded and a little quantity of the soil was taken and its moisture content determined. The test is performed for well–spaced out moisture content from the drier to the wetter states. The values of the moisture content (determined) and the corresponding number of blows is then plotted on a semi–logarithmic graph and the liquid limit is determined as the moisture content corresponding to 25 blows. The same procedure is also carried out for the treated soil with increment of saw dust ash content. The Casagrande tool cuts a groove of size 2mm wide at the bottom and 11 mm wide at the top and 8 mm high. The number of blows used for the two soil samples to come in contac**t** is noted down. A graph called **'flow curve'** is plotted taking number of blows on a logarithmic scale and water content on the ordinate. Flow curve is obtained as straight as possible.

$$WL= ((w2-w3) / (w3-w1)) * 100$$

Where w=moisture content

Plasticity Index (IP)

The plasticity index of the natural soil and the soil, saw dust ash mixture and cement as an additive mixture is the difference between the liquid limits and their corresponding plastic limits. The plasticity indexes of the samples are calculated as:
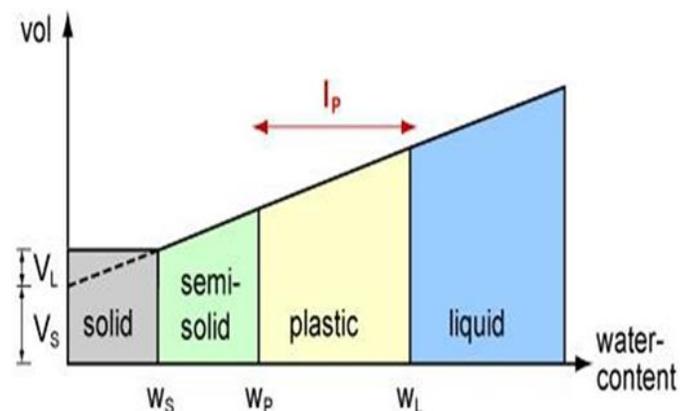
$$IP = WL – WP$$

Figure 6: Atterberg's limits chart