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Stabilisation of Soft Soil using Ground Granulated Blastfurnace Slag and Lime

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Abstract - *Nowadays, flexible pavements with bituminous surface are widely used. Due to increase traffic intensity of roads, overloading of commercial vehicles and temperature variation of pavements due to climatic changes leads to formation of various distresses like rutting, bleeding, cracking and potholing of bituminous surfacing. Due to high temperature, bitumen become very soft in summer and brittle in winter. Also in a developing country like India, roadway construction is taking place at a very high speed which require large demand of construction material that too eco-friendly and economical. Several studies have revealed that properties of bitumen and bituminous mixes can be improved with addition of certain additives and the bitumen premixed with these additives is known as "modified bitumen". The present study aims for use of modified bitumen by using waste polyethylene terephthalate for road construction. Using waste polyethylene terephthalate as a secondary material in construction projects would be a solution to overcome the crisis of producing large amount of waste plastics in one hand and improving the structure's characteristic such as resistance against cracking on the other hand. The modified bitumen mix shows better binding property, density and more resistant to water.*

Key Words*: *Modified bitumen, Waste polyethylene terephthalate , Mixture properties

1. INTRODUCTION

The soil collected from the site is pulverised and then sieved to conduct various tests. The binder, GGBS is added in varying percentages; 15, 20, 25. Atterberg limits, Standard Proctor Tests and unconfined compressive strength tests were conducted to arrive at the optimum GGBS content. Optimum lime content is fixed by 5% conducting Eades and Grim test. Different combinations of GGBS and Lime are mixed with soil and UCS is conducted and optimum binder mixture is fixed. The CBR test of soil mixed with optimum binder combinations were also carried out to consider the use of this method in cost effective pavement construction environmental problem. Being a non-biodegradable material it does not decay over time and even if dumped in landfills, finds its way back in the environment through air and water erosion, can choke the drains and drainage channels, can be eaten by unsuspecting grazing animals causing them illness and death, can contaminate the construction fill, etc. The best way of disposal of waste plastic is its recycling to the maximum extent and many developed countries have recycled waste plastic to manufacture various products, including some used in heavy construction.

Soft soils are characterised by low shear strength, high compressibility and low bearing capacity. These soil experience very large settlement when loaded. The scenario is further worsened by the rapid urbanisation which demands the construction of infrastructures over such weak soil. Mechanical means of modifying the soil properties include replacing the soil, compaction, preloading or providing large diameter piles.

Moreover, ground improvement of soils using lime and cement leads to stabilisation induced cracking due to the exothermic reactions and release of moisture, occurring upon mixing with binder. Sustainable method of utilisation of any resource is the need of the hour. Hence the usage of waste based binders or industrial by-products like Flyash, GGBS can be a better option that serves the primary aim of improving the geotechnical characteristics of the weak soil along with preserving the cost effective strategies and environmental-friendly principles. Ground Granulated Blast furnace Slag (GGBS), a by-product of Iron industry is chemically rich in Calcium and Silica and has properties similar to that of Cement. When GGBS is added to the soil mixture, it reacts with silica in the soil to produce cementitious products resulting in improved strength.

An ever increasing demand for steel has led to a peak increase in the GGBS production but the utilisation of the same is less resulting in its disposal to landfills. Efficient utilisation of these materials could, in fact, be a step towards sustainable development. GGBS is a latent hydraulic product and it requires an alkaline environment for the breakdown of Al and Si bonds thereby enhancing its activity in the stabilisation process.

The reactions between binder involve GGBS-Lime, Soil-GGBS and Soil-Lime. The formation of deleterious compounds like ettringites and thaumasites in the lime-stabilisation of sulphate-rich soils were widely research upon. GGBS-lime mixtures produce strong forces through cementitious reactions which nullify the repulsive nature of ettringites thereby reducing the adverse swelling problems.

A huge reduction in the swell using GGBS is also noted. The swell reduction is controlled by cation exchange reactions whereas strength improvement is mainly controlled by pozzolanic reactions. The soaked CBR values showed considerable improvement for soil-GGBS mixes due to the reaction between silica, alumina and water. The durability studies on soil-GGBS mixes are quite a few and there is wide scope for in- depth studies on the same.

2. Materials and methods:-

The soft clay used in the study is obtained from khajod village, Surat district, Gujarat. Ground Granulated Blastfurnace Slag is obtained from RMC plant at Hajira port. Lime powder used in this study Is commercially available powdered quick lime. It is obtained from Ambanagar, Surat.

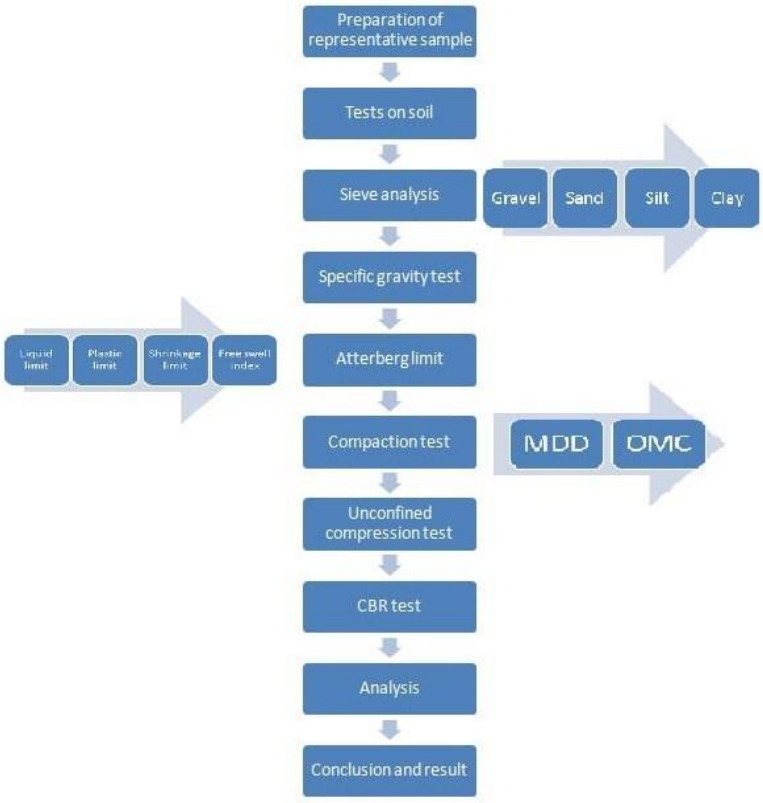

Fig 1- Methodology Flowchart

The test results are presented in table 1.

Table 1: Properties of soil

Properties		Soil	GGBS
Natural moisture content		*24*	-
Specific Gravity		*2.347*	*2.83*
	%sand	*11*	-
		34	*96**

Grain size distribtion	%silt	55	4*
	%clay		
Liquid limit %		39	30
Plastic limit %		22	NP
Plastic index %		17	NP
Shrinkage limit %		9	31.22

Soil classification	CI	-
CBR(soaked%)	10.65	-
Unconfined compression strength(kPa)	39	-
Optimum moisture content %	19.6	-
Maximum dry density(KN/m2)	1.7	-
Free swell index %	NIL	-

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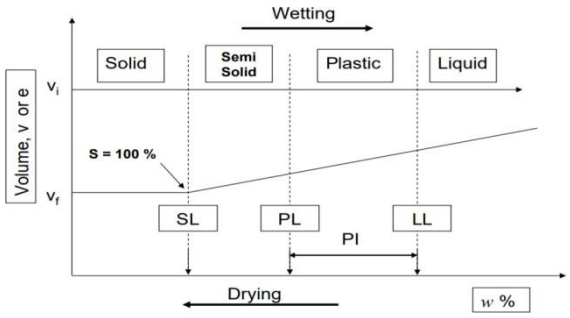

Fig 2- Atterberg limit

2.1 Consistancy and characteristics

The plasticity characteristics of the soils are determined by the diffused double layer surrounding the clay particles. A remarkable decrease in the consistency limits is observed on addition of GGBS to the virgin soil. Liquid limit, plastic limit value(Figure.3). A significant decrease in the liquid limit is observed till 20 percent of the binder content is added. The addition of the binder to the soil breaks apart the diffused double layer leading to flocculation of particles. This results in the reduced plastic behaviour of the soil shown by a decline in the plasticity index.

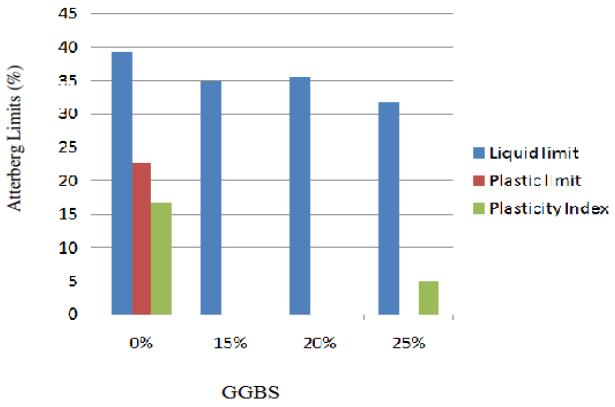

Fig 3- Variation in Consistancy limit

2.2 Compaction characteristics

Standard proctor test is conducted on the soil with different percentages of GGBS. The optimum moisture content required for maximum density under a particular compactive effort is obtained from the proctor curve. Optimum moisture content shows a declining trend in its value whereas values of maximum dry density have increased. The decline in the optimum moisture content is due to flocculation of particles which demands smaller percentages of water for full compaction. An increase in the maximum dry density is due to the better binding of the soil particles upon improved gradation of soil-binder mix [Sharma &Sivapulliah, 2016]. Compaction curve shows a sharp peak on addition of 15 percent binder (Figure4). More addition of silt size GGBS particles has led to poor bonding which further decreases the density of the soil. The compaction curve shown below in the figure shows a gradual shift to left side indicating that same amount of compactive effort can bring improved density to the soil.

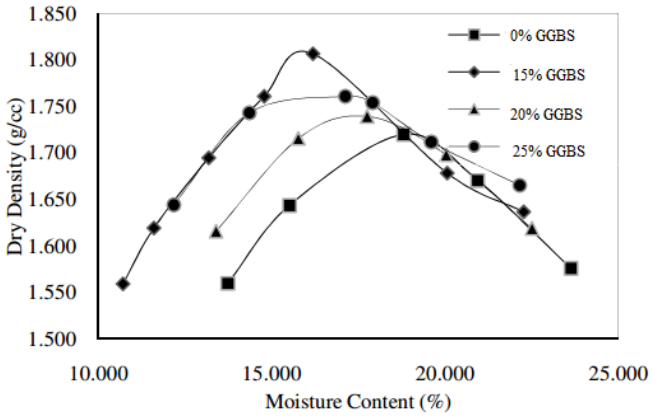

Fig 4- compaction curve with GGBS

2.3 California Bearing Ratio Test

The load carrying capacity of the soil under the pavements is measured by conducting CBR tests. The test is conducted on the virgin soil, as well as on the optimum mix with and without any addition of lime so as to study the improvement in strength characteristics of soil with the binder. The CBR test is conducted under soaked condition to consider the worst case strength. The CBR value has increased by 40 times and 60 times for the two mixes respectively. The improved CBR value of the optimum mix makes it suitable for pavement construction also.

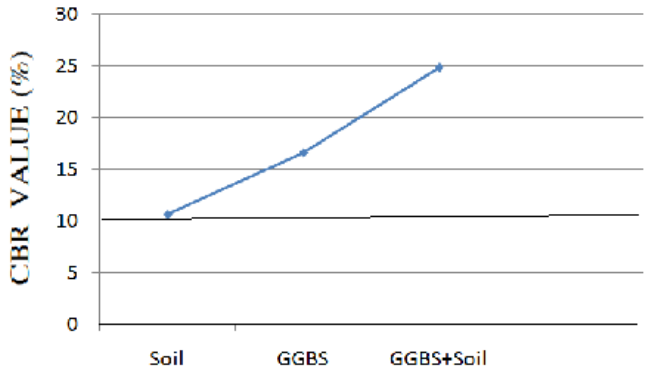

Fig 5- CBR value of soil on addition of different binders

3. Conclusion

The addition of GGBS as a binder to the soft soil resulted in a remarkable change in the plasticity, compaction and strength properties of the soil. The plasticity index shows a declining trend due to the disturbance of double layer on the addition of binder. Optimum moisture content decreased whereas maximum dry density increased. The unconfined compressive strength of the soil shows a huge peak for 28 days curing period when 15 percent GGBS is added to the soil. The strength improvement is further enhanced when 5 percent of lime is added as an activator. The CBR test done on the optimum mix shows are markable improvement in the value adding to its applications in improving the strength of subgrade soil. This shows that Ground Granulated Blastfurnace Slag- lime mixture can act as an excellent binder for improving the strength of soft soil. In depth studies on the durability of stabilised soil by comparing with any other binder could be done for assessing the long term strength of the soil under varied climatic conditions.

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