Effect of Ground Granulated Blast Furnace Slag and fly ash on the CBR and UCS of clayey soil

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Abstract

Nowadays there is immense problem to harmless disposal of industrial wastes. Lots of waste resources are non-biodegradable so they make a environmental contaminated in the locality. Some studies show that in earlier period, manufacturing wastes can be used successfully in road construction. In the process of road making, the use of unwanted material is based on some industrial, monetary and ecological criteria. Like India is a rising country and has a vast network of manufactories that are positioned in different parts of country and May more are to establish in next few years. Industrial wastes are formed in huge amount from these industries in huge tons. The disposal and pollution problems may be controlled by suitably utilizing the waste material in construction sites. It is very crucial to test the materials properly and to build up a methodology and specifications, to increase the utilization of the industrial wastes for their successful use in road construction.

This paper describes the use of Ground Granulated Blast furnace Slag and fly Ash for soil stabilization. Modified proctor test, California bearing ratio test and unconfined compression strength test were carried out. The fraction of Ground Granulated Blast Furnace Slag is used in this paper is 5, 10, 15 and 20 along with fixed value of fly ash 20%.The different percentage were determined which showed considerable enhancement in strength of treated soil. The maximum value of C.B.R is at 5% Ground Granulated Blast Furnace Slag and fly ash 20%, additional increase in ratio of Ground Granulated Blast furnace Slag the C.B.R value decreases. The maximum value of U.C.S. is also at 15% Ground Granulated Blast Furnace Slag and fly ash 20%. Experiment results show that Ground Granulated Blast Furnace Slag and fly ash enhances the strength properties of soil along with use of economical materials and also solve the environment problems.

Keywords

Clayey soil, Fly Ash, Ground Granulated Blast Furnace Slag, soil Stabilization.

Introduction

Soil is considered by the engineer as a complex material formed by weathering of solid rock. It is the only cheapest and easily accessible material for construction purposes besides its behaviour reasonably complex. We cannot judge soil behaviour suitably in different conditions because soil is naturally obtainable material. The characteristics of soil vary with the variation of topography and its location. Same kind of soil may carry on various in two distinct conditions. Here the work of Geotechnical Engineer winds up noticeably most extreme essential, who needs to confirm whether the current soil can withstand the heap originating from superstructure or not.

Some factors like drainage, pressure, moisture conditions are highly influence the strength component and behaviour of soil, so on working with soil these factors play major role. Relationship between stress and strain is not straight; subsequently we can’t have any significant elasticity theory. The properties of soil change with movement of soil particles from their original position because of soil is grainy material. Due to most of soil is underneath so proper inspection of soil is difficult. Hence soil analysis needed to be done.

LITERATURE REVIEW

Degirmenci et al., (2007)

In this examination paper it can be watched that when versatility of treated soil is decreased, as far as possible esteems rise. Investigation with bond and Ground Granulated Blast Furnace Slag by and large diminishes the versatility of soil. Versatility file was resolved alongside including of 10% and 15% bond of this paper. This exploration paper demonstrates the most ideal measure of bond (2.5-5%) and Ground Granulated Blast Furnace Slag (2.5-5%) to diminish the pliancy of soils. At the points when dry unit weight increment and diminishing in ideal water content happened, bond and Ground Granulated Blast Furnace Slag constituents’ increment for all dirt’s. At the same point when dry unit weight of soil expands it shows change in soil properties.

Shen et al., (2007)

Describes new type of binder that was prepared for semi unyielding road base material cover in China to enhance the working of lime and fly red hot remains latch.

The perfect meaning of cover was creating 8- 12% changed lime. 18-23% Ground Granulated Blast Furnace Slag and 65-74% fly powder. This shows that the lime-fly ash Ground Granulated Blast Furnace Slag cover has greater quality than standard lime, cement and fly powder. For some values of binder when the percentage of modified lime is just below or equal to 10% the strength of binder rises with increasing of percentage of modified lime in binder is 10% the maximum strength is achieved, when the percentage of modified lime just increases 10% and 28 days strength binder is reduces with increases of modified lime percentage.

Haung et al., (2010)
In this, the contents of Ground granulated Blast Furnace Slag and lime stone in examples S1, S2, S3, and S4 were settled at 45% and 10% proportions. In this, different ratios of PG, SS, GGBFS and LS are used. For Ground Granulated Blast Furnace Slag (PG) proportions varied from 25%-65%. For steel Slag (SS) proportions varied from 5%-20%. For Ground Granulated Blast Furnace Slag (GGBFS) proportions varied from 25-40%. And for limestone (LS) proportions varied from 5-15%. The cement has low 3 days strength with 45% of Ground Granulated Blast Furnace Slag that as it may, given important quality increment at 7 day. At 28 days of example age it had the most elevated quality, however quality of S2 test marginally less than S1.

Krishnan.K et al., (2014)
Impacts of various settling materials like Ground Granulated Blast Furnace Slag and fly ash have been analysed in various rates for quality change. It depicts a review to dissected the improvements in the properties of soil with Ground Granulated Blast Furnace Slag in various rates (i.e., 2, 4 and 6%) with settled amount of fly ash 5%. In this, results indicate that there is an increase in stress with the adding of different ratios of fly ash and Ground Granulated Blast Furnace Slag. The peak stress is reached at 0.044% strain, while for treated soil sample the peak stress was found at lesser strain of 0.033% and 0.025%.

Ashish Kumar Pathak, et.al. (2014)
GGBFS are added from 0% to 25% by dry weight of soil, first of all check the soil property at 0% and then compare after addition of GGBFS from 5% to 25%. The investigations showed that generally the engineering properties which improved with the addition of GGBFS. The addition of GGBFS resulted in dramatic improvement with in the test ranges covered in the programme. The maximum dry density increased and the optimum moisture content decreased with increasing GGBFS content and at 25% we got the maximum value of dry density.

Oormila.T.R. el. (2014)
Stabilization of soil is studied by using fly ash and Ground Granulated Blast Furnace Slag. This also includes that evaluation of soil properties like unconfined compressive strength test and California bearing ratio test. The soil sample was collected from palur, Tamil Nadu and addition to that, different percentages of fly ash (5, 10, 15, and 20) and GGBFS (15, 20, 25) was added to find the variation in its original strength. Based on these results CBR test aw conducted with the optimum fly ash, optimum GGBFS (15, 20, 25). From these results, it was found that optimum GGBFS (20%) gives the maximum increment in CBR value compared with all other combinations.

Rashad et al., (2015)
it is vital to make utilization of these waste as building material to secure the ecology from degradation. In this, the possibility of reusing calcined PG (CPG) as an incomplete substitution of FA in alkali activated FA (AAFA) glue was considered. FA was halfway changed with CPG at purpose of 0%, 5%, 10% and 15%, by weight. Compressive quality at ages of 3, 7 and 28 days was figured. The execution of explored blends subsequent to being presented to 400, 600, 800 and 1000 °C for 2 hours was order by measuring the lingering compressive quality.

Sharma et al., (2016)
By mixing of fly ash and Ground granulated Blast Furnace Slag binder was formed. In the beginning the initial strength test was done on different ratios of fly ash and GGBFS mixture. It was watched that 70:30 mix fly ash and GGBFS given the higher strength than individual fly ash and GGBFS, even in the lack of any chemical activators. When the binder content increases the OMC decreases while the MDD increases. In order to achieve the strength characteristics of every combination of soil binder samples, the tests were done on different curing periods that is 7, 14 and 28 days. From this it can be found that strength increases up to 20 % of the binder content and there after It increases.

Dayalan et al., (2016)
In this, different amount of fly ash and GGBFS are added separately i.e. 5, 10, 15 and 20% by dry weight of soil are used to study the stabilization of soil. The performance of stabilized soil are evaluated using physical and strength performance tests like specific gravity, atterberg limits, standard proctor test and California bearing ratio test at optimum moisture content. From the results, it was found that optimum value of fly ash is 15% and GGBFS is 20% for stabilization of soil based on CBR value determined.

MATERIALS AND METHODS

SOIL

Source of soil

The soil used in study was obtained from village in district Jammu. As per IS classification of soil, the soil used is intermediate clayey soil.

The soil properties are given in the table as under.

Properties of soil used in study

S.NO	PROPERTIES	VALUE
1.	*Specific gravity*	*2.56*
2.	*Liquid limit (%)*	*36*
3.	*Plastic limit (%)*	*21.5*
4.	*Plasticity index (%)*	*14.5*
5.	*Optimum moisture content (%)*	*14.06*
6.	*Maximum dry density(KN/m³)*	*19.3*
7.	*C.B.R (soaked)*	*3.1*
8.	*U.C.S (KN/m³)*	*84.62*
9.	*Classification of soil (according to ISE)*	*CI (clay of medium compressibility)*

FLY ASH

Source of fly ash
Fly ash used in this research work was taken from concrete batching plant of ACC Ltd. The fly ash was dried in oven and then it was sieved for the removal of foreign particles then it was packed in polythene bags to protect it from moisture and further use in the study
Properties and composition of fly ash as obtained from ACC Ltd. In table

S.NO	PROPERTIES OF FLY ASH	VALUE
1.	*Colour*	*Whitish grey*
2	*Specific gravity*	*2.2*
3.	*Liquid limit*	*45*
4.	*Maximum dry density (KN/m³)*	*12.24*
5	*Optimum moisture content (%)*	*36*

Chemical compositions of class C fly ash

S.NO	NAME OF CONSTITUENT	PERCENTAGE
1.	*Silica (SiO_2)*	*35.2*
2.	*Alumina ($AL_2 O_3$)*	*17.6*
3.	*Iron Oxide ($Fe_2 O_3$)*	*18.8*
4.	*Calcium Oxide (CaO)*	*20.2*
5.	*Magnesium Oxide (MgO)*	*4.9*
6.	*Potassium Oxide ($K_2 O$)*	*3.3*

Ground Granulated Blast Furnace Slag
Source
The material GGBFS was taken from Delhi by courier.

Chemical composition of GGBFS

S.NO	NAME OF CONSITUENT	PERCENTGE
1.	*SiO_2*	*33.67*
2.	*$Al_2 O_3 + Fe_2O_3$*	*19.18*
3.	*Calcium oxide (CaO)*	*36.2*
4.	*Magnesium Oxide(MgO)*	*8.18*
5.	*SO_2*	*0.2*
6.	*$Na_2 O$*	*0.14*
7.	*$P_2 O_5$*	*0.05*

EXPERIMENTAL PROGRAMME

The experimental programme for this study includes the processing of material and their mix proportion to be used for finding engineering properties of soil-fly ash-GGBFS. The procedure for conducting tests i.e. modified proctor test, California bearing ratio test and unconfined compressive strength is discussed in this chapter. All the tests were conducted according to IS code.

Processing of materials
Sufficient quantity was taken from these bags and dried in oven for conducting each test. In the same manner fly ash was collected and oven dried for 24 hours. The desired quantity of fly ash was taken and mixed uniformly with the soil. The desired amount of GGBFS was then added to the soil-fly ash mix. Due care was taken so that a uniform soil-fly ash-GGBFS mixture can be obtained.

Laboratory tests
The following tests were performed for the present study.

1. Pycnometer test
2. liquid limit test
3. Plastic limit test
4. Modified proctor test

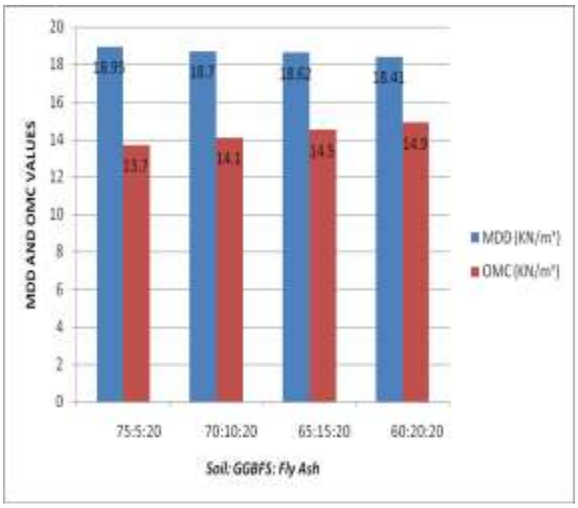
5. California bearing ratio test
6. Unconfined compressive strength test

Mix proportions of Soil (S), Fly Ash (F) and Ground Granulated Blast Furnace Slag (G).

S.NO	***Designation (S:G:F)***
1	***100:0:0***
2	***90:10:0***
3	***80:20:0***
4	***70:30:0***
5	***85:0:15***
6	***80:0:20***
7	***75:0:25***
8	***75:5:20***
9	***70:10:20***
10	***65:15:20***
11	***60:20:20***

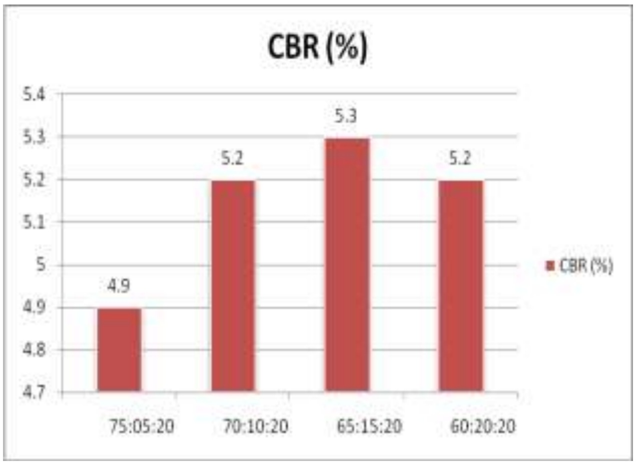
MODIFIED PROCTOR TEST

Soil: GGBFS: Fly Ash	***MDD (KN/m^3)***	***OMC (KN/m^3)***
75:5:20	***18.95***	***13.7***
70:10:20	***18.70***	***14.1***
65:15:20	***18.62***	***14.5***
60:20:20	***18.41***	***14.9***



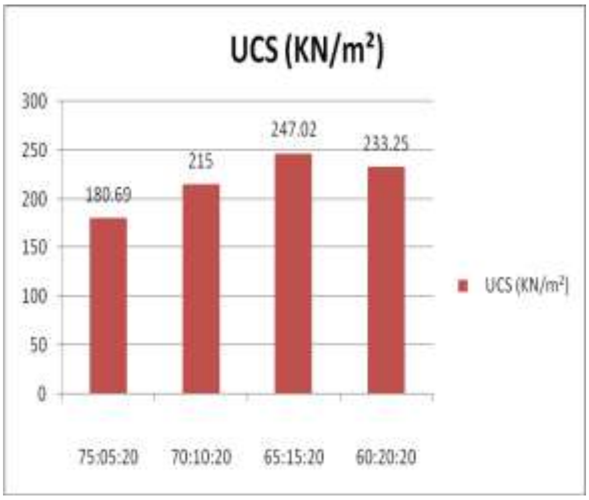
CALIFORNIA BEARING RATIO TEST

Mix Proportion (S:G:F)	***CBR (%)***
75:05:20	***4.9***
70:10:20	***5.2***
65:15:20	***5.3***
60:20:20	***5.2***



UNCONFINED COMPRESSIVE STRENGTH TEST

Mix proportions (S:G:F)	***Curing period (days)***	***UCS (KN/m^2)***
75:05:20	***7***	***180.69***
70:10:20	***7***	***215.00***
65:15:20	***7***	***247.02***
60:20:20	***7***	***233.25***



Conclusions

The conclusions drawn from the experimental investigation are as under:

- From this study it is concluded that Fly ash and Ground Granulated Blast Furnace Slag are waste products from industries that can be used as stabilizers to clay soil and this would help to solve the conventional problem of disposal of them
- The optimum value of fly ash is used for this work was 20% because of the optimum value of C.B.R is found at 20% of fly ash when added to soil.
- The C.B.R value increases with increase of Ground Granulated Blast Furnace Slag along with fixed quantity of Fly ash. It increased 1.71 times from the untreated soil.
- The optimum value of Ground Granulated Blast Furnace Slag and Fly ash required for soil stabilization is 15% and 20% by weight of soil respectively.
- Unconfined compressive strength increases with increase of quantity of Ground Granulated Blast Furnace Slag and with fixed quantity of Fly ash. The value of Unconfined compressive strength is increased 2.92 times from the untreated soil.

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