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Improvement of a Sub Grade Strength by Lime & Rice Husk

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Abstract

The objective of this paper is to upgrade expansive soil as a construction material using rice husk ash (RHA) and fly ash, which are waste materials. Soil is a peculiar material. Some waste materials such Fly Ash, rice husk ash, pond ash may use to make the soil to be stable. Addition of such materials will increase the physical as well as chemical properties of the soil. Some expecting properties to be improved are shear strength, liquidity index, plasticity index, unconfined compressive strength and bearing capacity etc. The objective of this study was to evaluate the effect of Fly Ash and Rice husk ash to improve the performance of soil. In this paper soil is treated with fly ash (5%,10%,15%,20%,25%) and rice husk ash (10%,15%,20%,25%,30%) and examine after 28 days of curing.

Keywords: *Lime & Rice Husk, Soil Stabilization, Sub Grade Strength and Ground Improvement.*

1. Introduction

Practice of urbanization and industrialization is so rampant these days. Though there is bountiful supply of soil, the cheapest construction material , it may exhibit some uncovered properties for intended construction purpose at .Such as construction on soft soil like clay appears to be difficult and it causes substantial distress to the overlying structure as it possesses low shear strength , high compressibility. The 'shrink-swell' behavior of clayey soil can endanger the construction work causing excessive settlement at the site. Again soil can be collapsible or liquefiable which are difficult to handle.

In search of the suitable site, interference with natural stability is not recommended. Extirpation (Destruction) of forest and agrarian land, natural slope results in imbalance in wildlife, natural calamities like sudden flood (spate), land-slides etc. This is certainly minatorious to mankind and their survival. This problem needs serious attention.

Alternative solution is to be employed (adopted). Instead of searching a new land, one can go for the betterment for the soil properties by different means such as compaction, use of piles, replacement of soil, soil reinforcement etc. It can also be done by incorporating different materials such as fly ash, lime, rice husk ash, industrial wastes etc. having least or no production value. Hence problematic soil like clayey soil must be adequately treated before the erection of structure. Wide range of soil modification method is available. Selection of appropriate method should be based on the type of soil and its characteristics, type of the construction, time available, associated cost. It has been observed that industrial by-products can cause drastic change in the soil properties in terms of strength characteristics, density, and acidity and also serves agricultural benefits by increasing crop yield. Moreover utilization of these products is a better solution to disposal than heaving them up on land.

2. Ground Improvement and Its Necessity

It is a well established fact that the load coming from the superstructure is ultimately borne by the soil. Hence when a project encounters, soil feasibility is the first and foremost thing to be studied. The characteristics of soil vary from one place to another. Often soil at particular site lacks in desirable properties causing distress to the overlying structures. It may exhibit low shear strength, higher compressibility etc. such as Sandy soil has propensity to liquefaction whereas expansive soil imbibes lot of water posing threat to small structures, canal- linings, pavements. Hence when an unsatisfactory condition is met, possible alternative solution can be either of

- abandon the site
- remove and replace the soil
- redesign the planned structure accordingly
- treat the soil to modify its properties or Ground Improvement

The last method listed above is known as Ground Improvement Technique or Soil Stabilization. The 'Leaning

Tower of Pisa' is a classical example of such geotechnical Engineering Practice and Ground Improvement Techniques.

3. Methods of Soil Stabilization

Methods of stabilization can be broadly classified under two categories and these are as follows:

a. Stabilization without additives
b. Stabilization with additives

(a) Stabilization without Additives

- Mechanical Stabilization: This approach involves improvement of soil by compacting to denser state or by changing the gradation of soil. This can be achieved by either of following methods

  (i) Compaction
  (ii) Addition or removal of soil particles
  (iii) Blasting

- **Stabilization by Drainage :** The strength of soil depends upon the effective stress which in turn is adversely affected by ground water and hence excess pore water must be expelled out by using following methods

  (i) Application of external load
  (ii) Electro-osmosis
  (iii) Application of thermal gradient

- **Ground Reinforcement :** The following methods also help in increasing the shear strength of soil significantly

  (i) Stone columns and soil nailing
  (ii) Geo synthetics
  (iii) Grouting

(b) Soil Stabilization with Additives

So many additives have been employed with different type soil with varying degree of success. A additive is satisfactory when it upgrades the quality of soil but all the requirements cannot be met at a time. For better results more than one additive can be introduced checking the suitability.

(i) Cement Stabilization
(ii) Lime Stabilization
(iii) Bitumen Stabilization
(iv) Salt Stabilization
(v) Flyash Stabilization etc.

4. Need of Present Study

Many part around the globe such as India, U.S.A, Egypt etc are facing problems in construction work due to clayey soil. Damage to the light structures and road pavement has been reported. Replacement of soil with suitable one and disposal of the former is costly process and this is critical in developing country like ours where construction cost is quite high.
Moreover pavement on clayey soil requires a greater thickness of base and sub-base course which results increases the expenditure of project. To set right this problem it becomes mandatory to increase the strength of the soil which in-turn will help in lessening the thickness of the pavement layers and thus project cost.
Two common additives which are widely used in stabilizing the soil are cement and lime. Lime is preferred over cement stabilization because lime is cheaper than cement and Carbon-Di-Oxide (CO2), which causing detrimental to the environment, is emitted during the production of cement. Lime stabilization is requires adequate clay content and a relatively high curing temperature and hence it is more suitable for tropical and sub-tropical countries like India.

5. Objective of the Study

The study is focused on

1. Improvement of locally available soil using some eco-friendly and cheap waste materials.
2. Evaluation of strength characteristics of virgin as well as blended soil using different ratio of Blast Furnace Slag and lime.
3. Determination of appropriate soil, slag and lime content ratio to achieve the maximum gain in strength from the mixture.

6. Literature Review

The stabilization of soils has been recognized before the Christian era began and performed for millennia. Many ancient cultures including the Chinese, Romans and Incas utilized various techniques to improve soil suitability some of which were so effective that many of the buildings and roadways they constructed still exist today and some are still in use.

Jump forward a few years to the war in Vietnam, the US military were looking for methods for rapid stabilization of weak soils for support of its missions worldwide. Over the past 60 years they had used cement and lime and these being the most effective stabilizers for road and airfield applications. But efforts were being made to find a stabilizer that could be used quickly without having to carry out extensive site tests that would increase the strength of the prevalent soft clay type local soils rapidly to support the landing and take-off of aircraft traffic on their temporary airfields.

Laxmikant Yadu and Dr. R K Tripathy (2013) studied the effect of Granulated blast furnace slag and fly-ash stabilization on soft soil. The soil was classified as CI-MI as per Indian Standard Classification System. Different amount of GBS (3%, 6%, 9%, and 12%) and fly ash (3%, 6%, 9%, 12%) was mixed to the parent soil and both UCS and CBR are carried out. They found that there was an increase in maximum dry density but decrease in Optimum Moisture Content with increasing GBS content. Addition of GBS increased the UCS value and this increase was maximum up to 9% and then it started falling. In case of both soaked and unsoaked CBR samples, addition of GBS caused sharp increase in CBR value and it is maximum up to 6%. Hence they found out 3% fly ash + 6% GBS mix to be optimum.

Akinmusuru (1991) put his effort in finding out the effect of mixing of GGBS on the consistency, compaction characteristics and strength of lateritic soil. GGBS content varied from 0% -15% by dry soil weight. He observed a decrease in both the liquid and plastic limits and an increase in plasticity index with increasing GGBS portion. Further, he observed that the compaction, cohesion and CBR increased with increasing the GGBS content up to 10% and then subsequently decreased. The angle of friction was to be decreased with increasing percentage of GGBS.

Gupta and Seehra (1989) studied the effect of lime-GGBS on the strength of soil. They found that lime- GGBS soil stabilized mixes with and without addition of gypsum, or containing partial replacement of GGBS by fly ash produced high UCS and CBR in comparison to plain soil. They also concluded that partial replacement of GGBS with fly ash further increased the UCS.

Erdal Cokca, Veysel Yazici and Vehbi Ozaydin (2009) reported about an experimental study on the stabilization of expansive clays using granulated blast furnace slag (GBFS) and granulated blast furnace slag-cement (GBFSC). These were added to soil in proportions of 5–25% by weight. The effects of these stabilizers on grain size distribution, Atterberg limits, swelling percentage and rate of swell of soil samples were determined. Addition of GBFS and GBFSC altered the grain size distribution of expansive soil sample by decreasing clay fractions and increasing silt fractions. Plasticity index was decreased specific gravity was increased for all GBFS and GBFSC additions. GBFS and GBFSC additions decreased the swell percentage and the t_{50} values of specimens. 75% sample + 25% GBFSC gave 6% swell, which also almost satisfied the irrigation water standards. The addition of 20% GBFS and 15% GBFSC to the expansive soil after 7 days of curing, reduced the swell per cent from 29.4 to 10.9% and 3.1%, respectively.

A. Sreerama Rao, G. Sridevi and M. Rama Rao (2009) reported about heave studies on expansive clays with stabilized granulated blast furnace slag cushion. This study is conducted to find an alternative method to CNS layer technique which is used for stabilisation of black cotton soils. Cement-stabilized blast furnace slag in the form of a cushion has been placed over black cotton soil layer and the resulting heave was measured. Experiments were also conducted to study the effect of the cement content as well as the cushion thickness on the heave of the black cotton soil bed. The study also aimed at comparing the performances of Granulated Blast Furnace Slag (GBFS) and the ground granulated blast furnace slag (GGBFS) and to study the effect of cushion thickness on the swelling behaviour of black cotton soil. It was reported that both the slag cushions, stabilized with cement, are effective in minimizing the swell of black cotton soils. For GGBFS, there is a significant reduction of heave at low cement contents itself but for GBFS, as the cement content is increased, the swell potential decreased steeply. 6% to 8% cement content has been found to be optimum. No such optimum was observed in GGBFS. As the thickness of the cushion increased, there was a corresponding decrease in the swell potential.

Zore T. D and S. S. Valunjkar (2010) had reported about the utilization of fly ash and steel slag in road construction. In their study, it was aimed to replace natural aggregates in road construction, either for blanket courses, bases or sub bases using these waste by-products. It was concluded that steel industry waste by-product is suitable and economical for use in the road construction. Steel slag is easily available and has higher CBR value than fly ash hence saving is excess than fly ash use. The optimum mix was reported as 15% steel slag mix in sub grade and in sub base for road construction.

Mehmoud Reza Abdi(2010, 2011) reported about the efforts to extend the use of Basic Oxygen Steel (BOS) slag to soil stabilization by determining possible beneficial effects it may have on compressive strength and durability. Unconfined compression test and durability test were conducted. Tests determined strength development of compacted cylinders, moist cured in a humid environment at 35° C and durability by freezing and thawing method. Kaolinite treated with a particular percentage of lime and various amounts of BOS slag showed slight increase in MDD and reduction in OMC. Results of the investigation showed that using lime and BOS slag either singularly or concurrently for stabilizing kaolinite improves soil properties in terms of increased UCS and durability by resistance to freezing and thawing. The improvements are shown to be dependent on the lime and the BOS slag contents as well as the curing period.

R C Gupta, Blessen Skariah Thomas, Prachi Gupta, Lintu Rajan and Dayanand Thagriya (2012) reported about an experimental study of clayey soil stabilized by copper slag. In this study, index properties, compaction and shear characteristics of the soil mixed with copper slag were evaluated. The addition of copper slag increased the maximum dry density and decreased the optimum moisture content. Maximum dry density was obtained with 50% soil + 50% copper slag combination. Tri-axial tests were conducted and it was reported that as the percentage of copper slag increases, the angle of shearing resistance increases up to certain limit (48°) at 40% of combination and further it tends to decrease. The combination of 70% Clay with 30% Copper slag to 30% clay with 70% copper slag was most satisfactory combination to get good soil stabilizations.

K.V. Manjunath, Himanshu Shekhar, Manish Kumar, Prem Kumar and Rakesh Kumar (2012) reported about the stabilization of black cotton soil using ground granulated blast furnace slag. A series of compaction and unconfined compression tests were carried out on virgin as well as blended samples prepared. It was observed that with increase of slag, more stability of soil is achieved as compared to using lime alone. UCC strength of ordinary black cotton soil which was found out to be 188.5 kN/m^2, increased to 3429.37 kPa. The study recommended that for the proportion of (BC soil + 30% slag) + 4% lime @ OMC on 28th day with proper curing, UCC strength increased up to 18 times that of ordinary black cotton soil and the use of slag as an admixture was recommended for improving engineering properties of the soils as an economical solution to use the locally available poor soil.

Laxmikant Yadu and R.K. Tripathi (2013) reported an investigative approach in soft soil stabilisation with the help of granulated blast furnace slag. Different amounts of granulated blast furnace slag (3,6,9,12%) were used to stabilise the soft soil and the performance was evaluated using physical and strength performance tests like plasticity index, specific gravity, free swelling index, compaction, swelling pressure, California bearing ratio, and unconfined compressive strength. Liquid limit and plastic limit decreased with increasing percentage of slag. Maximum dry density increased and optimum moisture content decreased with increasing percentage of slag. Blended mix of 9% granulated blast furnace slag reduced the free swelling index and swelling pressure at about 67% and 21% respectively from its unstabilised state. It was also reported that there was a sharp increase in the unconfined compressive strength values with the addition of slag which was attributed to the formation of cementations compounds between the CaOH present in the soil and the pozzolana present in the slag. In case of CBR values, an increase was reported with addition of slag up to a certain point, and after that it started decreasing.

GyanenTakhelmayum, Savitha.A.L and Krishna Gudi (2013) reported their investigation on soil stabilization using fine and coarse ground granulated blast furnace slag (GGBS). Here compaction and unconfined compressive strength characteristics of black cotton soil blended with fine and coarse ground granulated blast furnace slag were evaluated. The black cotton soil with varying proportion of ground granulated blast furnace slag mixtures were prepared at the respective optimum moisture content and the characteristic compaction and unconfined compressive strength values were determined for different curing. In both of the cases it was found that the maximum dry density increased with increase in GGBS content but increase is more pronounced in case of soil-fine GGBS mixture. The increase in dry density was reported to be due to enhanced C-S-H formation compared to using Soil alone. The increase in the maximum dry unit weight with the increase of the percentage of GGBS mixture was attributed to high specific gravity and immediate formation of cemented products by hydration which increases the density of soil.

Noorina Tarannum and R.K. Yada (2013) have reported on their study on the effect of blast furnace slag on the consistency limits of the black cotton soil. The samples used in the study were prepared by blending black cotton soil with different percentage of blast furnace slag, using lime as stabilizer. The tests showed a decrease in the liquid limit with increase in quantity of blast furnace slag while shrinkage limit showed a decrease. The plasticity index was gradually decreased. It is recommended that for proper results the blending of black cotton soil and blast furnace should be done in presence of water to attain homogeneity.

7. Conclusion

The study shows an improvement in the soil sample when mixed with BFS and Lime. BFS causes a drastic change in the strength. But mixing BFS only cause minor change in strength property as there is formation of impermeable aluminium-silicate prohibiting further hydration of BFS. Lime not only acts as activator in this case but also reduces plasticity and makes soil friable and it becomes easy to work with. But adding these lime and BFS above a particular limit would not help. There is a particular ratio at which maximum benefit can be obtained. From CBR test the optimum value for lime is found to be 4.5 %. From the economy point of view soil and slag ratio is restricted to 50:50. As per the prevailing conditions and requirements the ratio can be changed.

8. Scope for Further Studies

Improving properties of soil becomes a matter of paramount importance today. Here an effort has been made to study the effect of BFS and Lime. There are many alternatives available for doing the same. Here are some suggestions made for further progress:

- Different wastes materials from agricultural land, municipality or industries can be used to improve the soil thus making them boon to the urbanization.
- Similar studies can be made at various water content.

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