OPTIMUM FLYASH TO INCREASE THE STRENGTH OF SUBGRADE

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ABSTRACT

Stabilization of problematic soils with fly ash not only improves engineering properties of soil but also provides a solution to challenges of fly ash disposal. Approximately 52,000 tons of fly ash produced annually at Boropukuria coal-based power plant in Bangladesh require a huge disposal area and create environmental problems. This paper reports the results of laboratory investigation carried out on expansive soil collected from Rajendrapur area stabilized with fly ash in varying percentages. Here, 4% cement is used as an activator. The effect of cement with varying fly ash contents are correlated with soaked California bearing ratio (CBR) value, swelling index and Atterberg limits of stabilized soil. The study finds that soaked CBR value of the soil improves from 1.73% to 26.07% after adding 6% of fly ash for 14 days of curing. With increasing of more fly ash content, strength decreases. So optimum value of fly ash content is 6% for which highest strength is obtained. Moreover, swelling index of the collected soil with 4-days soaking condition is found to be decreased by 47% when 6% fly ash is added. The outcome of this study will guide road engineers of Bangladesh to use fly ash as a stabilizing agent to improve the properties of subgrade.

Keywords: subgrade, stabilization, fly ash, CBR, swelling index

INTRODUCTION

The Road agencies face challenges while constructing road on areas where natural subgrade is of problematic nature especially if it is expansive soil. Usually, expansive soils do not possess the strength to support road construction activities and traffic load but can be improved by stabilization (Şenol et al., 2005; Bert, 2005). For any pavement, the subgrade layer is very important and it has to be strong to support the entire wheel load (Sumayya et al., 2016). Using Fly-ash, an industrial waste to stabilize the expansive soil will be helpful to the transportation engineers for better economic and stable road construction.

Swelling potential of expansive clayey soils depends on reduction of overburden stress, unloading conditions, or exposure to water and increase in moisture content (Yilmiz, 2009). Fly ash treatment can effectively reduce the swell potential of highly plastic clays and increase the strength (Nalbantoglu, 2004;

Kolias, 2005). In Bangladesh, expansive soil usually occurs in Lalmai Hill areas, Gazipur, Rajendrapur, Cumilla and some portion of Tangail and in the Barind Tract of Rajshahi (Hossain, 2001).

Growing industrial wastes are a great concern for environment and fly ash is one of those wastes. 52,000 metric tons of fly ash are produced annually as a by-product at Barapukuria coal based power plant. Five more coal based power plants are in pipeline and likely to come in production in Bangladesh. In future, it will be difficult to manage the fly ash produced from power plants. Class C fly ash can be used as a stand-alone material because of its self-cementitious properties. Class F fly ash can be used in soil stabilization applications with the addition of a cementitious agent. The study attempts to utilize the fly ash in subgrade stabilization to achieve desirable engineering properties of the soil for road construction and also to minimize the construction cost. Soil improvement is often cost effective because it reduces the cost of the remaining construction (Coduto, 1999)

RESEARCH METHODOLOGY

Sample Collection

For the research work soils were collected from Rajendrapur Cantonment, Gazipur as shown in Photo 1. Soils were collected from approximate depth of 5 ft feet by excavation. Soils were collected from such great depth so that only inorganic soils could be found. Organic soils would hamper the results of the research work.

Fly ash is produced in power plants as a by-product from the burning of coal. Fly ash were collected from Boropukuria Power Plant, Dinajpur. Ordinary Portland Cement (OPC) of a brand was used for the research work.

Photo 1: Sample collection and preparation for tests

Details of Laboratory Tests

To determine the size distribution of soil sample sieve analysis and hydrometer tests were carried out. This procedure was done according to ASTM D6913 and D7928. The specific gravity of soil was was performed according to ASTM-D854.

Atterberg limits tests were done under some different percentages of fly ash with fixed percentage of cement and soil sample according to ASTM D4318. The Modified Proctor test was performed to determine the relationship between the moisture content and the maximum dry density according to ASTM D1557 for various combination of fly ash as it was done in case of lime stabilization by Molla (1997)

CBR test results were the most important parameter of the research work. The test was carried out under different percentages with different curing times. The percentage of fly ash was taken 2%, 4%, 6% with 4% Cement as activator as shown in Table 1. All the tests were done after 7 days and 14 days curing. The swell index for 4 days of soaking was calculated for all combinations to measure the swelling of the collected expansive soil. After every preparation of CBR mould a swell gauge was set up as shown in Photo 2. The tests were conducted according to ASTM D1883.

Table 1: Laboratory Tests Performed on different combinations

Name of Tests	Combination
Particle Size Analysis ,Specific Gravity, Modified Proctor	Only Soil
Atterberg Limits Test, CBR & Swelling Test	Only Soil Soil + 4% Cement Soil + 4% Cement + 2% FA Soil + 4% Cement + 4% FA Soil + 4% Cement + 6% FA Soil + 4% Cement + 8% FA

Photo 2 Assembly for finding swelling values and soaked CBR value

RESULTS AND DISCUSSION

Physical Characteristics of Collected soil

According to USCS, the collected soil was classified as CL, clay with low plasticity. It is found that 81 % of the soil sample passes through the ASTM sieve no. 200. Particle size distribution for the soil retained on no. 200 sieve is shown in Fig. 1.

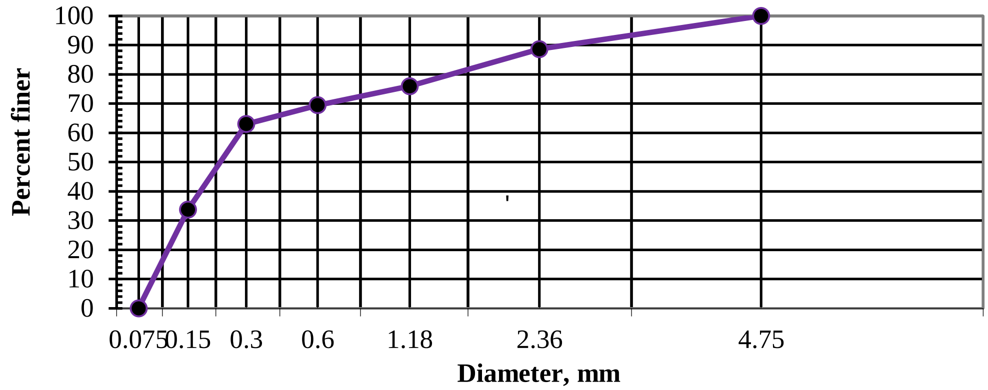

Figure 1 Grain size distribution of the collected soil.

Atterberg Limits

The Atterber limits values for all combinations are shown in Table 2. It is observed that plasticity index of the soil was reduced by 66% from the original.

Table 2 Atterber limits values for different combinations

Combination	Liquid Limit	Plastic Limit	Shrinkage Limit	PI
Soil , 0% Cement & Fly Ash 0%	48.56	29.5	41.24	19.06
Soil , 4% Cement & Fly Ash 0%	50.95	29.88	43.42	21.07
Soil , 4% Cement & Fly Ash 2%	49.2	30.86	36.69	18.34
Soil , 4% Cement & Fly Ash 4%	35.96	25.57	34.58	10.39
Soil , 4% Cement & Fly Ash 6%	24.72	18.29	31.76	6.43
Soil , 4% Cement & Fly Ash 8%	40.31	26.70	37.06	13.6

OMC and MDD

The OMC and MDD are found decreasing after addition of fly ash with the cement-soil mixtures as shown in Table 3.

CBR Values

The dry CBR value of the collected soil sample was found to be 41.4 %. However, the CBR value decreases to 1.73% when the test was done after 4 days of soaking. It proves that strength of the collected soil is highly influenced by moisture contents. Values of CBR are found increasing with addition of cement and fly ash as shown in Fig. 2. After 14 days of curing the soaked CBR value for the treated soil is more than that of 7 days curing. For soil, 4% Cement & Fly Ash 6% combination CBR values are the highest and the values obtained are 22% (7 days) and 26.05% (14 days). The CBR values decrease for soil, 4% Cement & Fly Ash 8% combination and become 12.56% (7 days) and 15.38% (14 days). For 6% fly ash highest strength is obtained. The stabilized subgrade has reached the CBR requirement for Sub-base i.e. 25% according to RHD (General Specifications, 2011).

Combination	MDD(pcf)	OMC(%)
Soil , 0% Cement & Fly Ash 0%	123.7	12.2

Table 3 MDD and OMC values for different combinations

Soil , 4% Cement & Fly Ash 0%	123.5	12.1
Soil , 4% Cement & Fly Ash 2%	123.1	12
Soil , 4% Cement & Fly Ash 4%	122.9	11.8
Soil , 4% Cement & Fly Ash 6%	122.6	11.6
Soil , 4% Cement & Fly Ash 8%	123.15	11.9

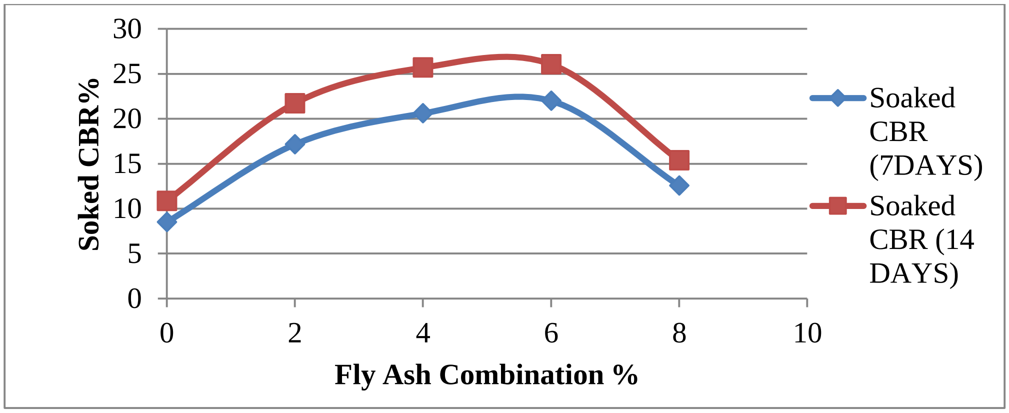

Figure 2 Influence of fly ash contents to CBR of the cement-soil mix

Swelling Index

The collected soil is found to have a swelling index of 4.95% when tested after 4 days of soaking and under a surcharge load of 4.54 kg. With an increase of fly ash content the swelling behavior reduces remarkably as indicated by the swelling index shown in Fig. 3. Swelling value is increasing with addition of more fly ash content upto 6% fly ash and the swelling index is found to be 2.6% .

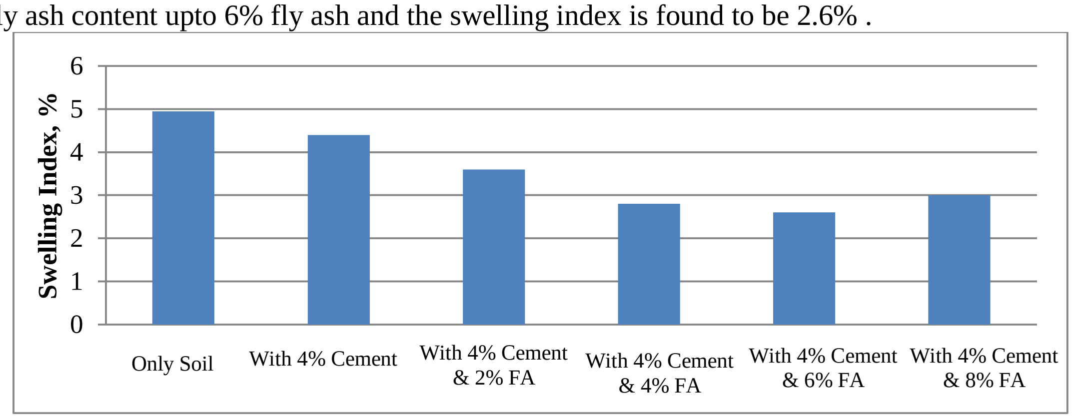

Figure 3 Effect of fly ash contents to swelling index of the cement-soil mix

CONCLUSION

This study was aimed to utilize the fly ash an industrial waste to improve the physical properties of Rajendrapur soil. The investigation was done by adding cement and fly ash with soil at different percentages. Major findings from this study are:

1. From soaked CBR test optimum fly ash content is found 6% for which maximum strength is obtained. The stabilized subgrade has reached the CBR requirement for Sub-base.

2. With addition of fly ash content the swelling index value decreases significantly. The fly ash stabilization has reduced the swelling index by 47%
3. Both liquid limit and plastic limit are found to be decreased at optimum fly ash content. Plasticity index of the treated soil is found to be decreased by 66% than that of the untreated soil.

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