STUDY ON STABILIZATION OF ORGANIC SOIL WITH FLY ASH

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ABSTRACT

Any soil containing a significant amount of organic matter influences its engineering properties. Organic content in soil is a detrimental characteristics for stabilization. Increase in organic content of soil indicates that strength of the soil decreases exponentially. This study illustrates to characterize the stabilized organic soil prepared in the laboratory by using fly ash at varying percentages. To these attempts, different stabilized soils containing fly ash of 0%, 10% and 20% were prepared in the laboratory. Moreover disturbed organic soils were collected from two selected location named Shiromoni and Beel Dakatia at and near Khulna City Corporation Region of Bangladesh having organic content 18% and 16% respectively. In the laboratory standard methods were followed to determine unconfined compressive strength, Atterberg limits, specific gravity and ignition. Results show that unconfined compressive strength of untreated and stabilized soils at varying percentages of fly ash content increases with the increasing percentages of fly ash content but the amount of increase depends on the type of soil and characteristics of the fly ash. The increases in strength and stiffness are attributed primarily to cementing caused by pozzolanic reactions, although the reduction in water content resulting from the addition of dry fly ash solid also contributes to strength gain. The pozzolanic effect appears to diminish as the water content decreases. The significant characteristics of fly ash are to affect the increase in unconfined compressive strength. In addition, results also reveal that water content and optimum moisture content decreases while the liquid limit and plastic limit increase after increasing percentages of fly ash content. This causes because of the addition of the fine particles such as fly ash which caused more water to liquefy the soil.

Keywords: Fly ash, organic soil, stabilization, strain, strength

1. INTRODUCTION

The sub-soil of Khulna region consists of fine-grained soils with a considerable part of decomposed and semi-decomposed organic matter near shallow depth. This region is situated at the southwestern part of Bangladesh near the world largest mangrove forest, Sundarbans. The soft soil deposit extends up to a considerable depth and creates problem to Geotechnical Engineers in designing economic foundations to construct the required infrastructure (Alamgir et al. 2001). Due to presence of a thick organic soil layers, the civil engineering constructions in such sites need special attention against possible shear failure as well as total and differential settlements. To quantify the effects of organic deposits on the adopted foundation systems, it is required to establish the behavior of organic contents with the soil parameters.

In Khulna region, the organic soil layer exists in most of the places in between the depth of 10 to 25 ft below the existing ground surface. Moreover, the nature of organic contents and geotechnical properties are found to vary from place to place. The bearing capacity of this soil is very low and always leads to adopt a costly foundation for the construction of structures. To understand the characteristics of such organic soil deposits, the detailed information about the soil formation, composition and physical characteristics are required to evaluate. However, comprehensive data based on sub-soil information of the different organic deposits within the Khulna region and its environs are not available from any source. So, it is essential to conduct a comprehensive study for understanding the compressibility characteristics of soil in this region considering the significant variation of organic contents.

2. MATERIALS AND METHODOLOGY

2.1. Soil Samples and Fly Ash Used in this Study

Two disturbed soil samples were collected from Shiromoni and Beel Dakatia, near KUET campus, Khulna, Bangladesh at a depth of about 5 feet and about 7 feet respectively from the existing ground surface. Fly ash was collected from a Cement Factory. It was sieved by a sieve no. 200 and prepared for the required works.

2.2 Methodology

For preliminary investigations, the soil collected was air dried and then powdered mechanically. The coarse particles were removed by screening with a ASTM sieve no. 200. The following index properties of the screened soil were studied.

(i) Atterberg limits (Liquid limit LL, Plastic limit PL, Plasticity index PI)
(ii) Specific gravity G_s
(iii) Organic content OC

For the determination of index properties of the two collected soil samples, standard procedures (Bowles, 1979) were followed and the tests were performed in Geotechnical laboratory of Khulna University of Engineering & Technology (KUET), Bangladesh. The test results are presented in Table 1.

Table 1: Physical and index properties of two soil samples

Location	OC (%)	LL (%)	PL (%)	PI	Gs
Shiromoni	18	32	24	8	2.31
Beel Dakatia	16	31	27	4	2.49

Note: OC= organic content, LL= liquid limit, PL= plastic limit, PI=Plasticity Index, G_s =specific gravity

2.3 Preparation of Testing Samples

The air dry powdered soils and oven dried fly ash at 105°C were mixed thoroughly by hand in a large tray following a ratio as shown in Table 2. Three types of samples were prepared by varying fly ash in percentage with constant weight of soil sample.

Table 2: Combination scheme for Shiromoni Soil and Beel Dakatia Soil with Fly Ash

Samples ID	Samples Description		
	Soil (gm)	Fly Ash	% Fly Ash
A	1300	0	0
B	1300	130	10
C	1300	260	20

2.4 Unconfined Compression Testing

Unconfined compression tests were conducted on specimens prepared from the Shiromoni and Beel Dakatia soils and soil–fly ash mixtures. Test specimens were prepared by first mixing the dry soil and the dry fly ash on dry weight basis. Subsequently, the amount of water required was added, and after a wait of 2 h (to simulate field conditions) the mixture was compacted in a steel mold of diameter 35.56 mm and height 71.12 mm. The compactive effort for specimen preparation was adjusted in such a way that the same impact energy per unit volume as in the standard Proctor test was applied. After the compaction, the specimens were extruded with a hydraulic jack, sealed in plastic, and cured for 7 days in a room maintained at 100% relative humidity and 25°C. Although the tests were performed on specimens cured at 7 days to simulate the early curing conditions during construction, organic soils are expected to have significant strength gain with increasing curing time for calcium-based additives as mentioned by Edil et al. (2006) and Sakr et al. (2009).

2.5 Ignition Test

Loss on Ignition is a test used in inorganic analytical chemistry, particularly in the analysis of minerals. It consists of strongly heating ("igniting") a sample of the material at a specified temperature, allowing volatile substances to escape, until its mass ceases to change. This was done in air. The simple test consisted of placing a few grams of the material in a tarred, pre-ignited crucible and determining its mass, placing it in a temperature-controlled furnace for a set time, cooling it in a controlled (e.g. water-free, CO_2-free) atmosphere, and re-determining the mass. The process was then repeated to show that mass-change is complete. A variant of the test in which mass-change is continually monitored as temperature was changed, is thermogravimetry

3. RESULTS AND DISCUSSIONS

3.1 Compaction Characteristics

3.1.1 Effects of Water Content

The variations of optimum moisture content of untreated and fly ash treated Shiromoni and Beel Dakatia soils are shown in Figure 1 and Figure 2 respectively. These figures represent that optimum moisture content decreases gradually with the increase of fly ash content. The reduction in optimum moisture content is a result of flocculation and agglomeration of fine grained soil particles, which occupy larger space leading to a corresponding drop in optimum moisture content. It is also the result of initial coating of soils by fly ash to form larger aggregate, which consequently occupy larger spaces. Optimum moisture content decreases sharply.

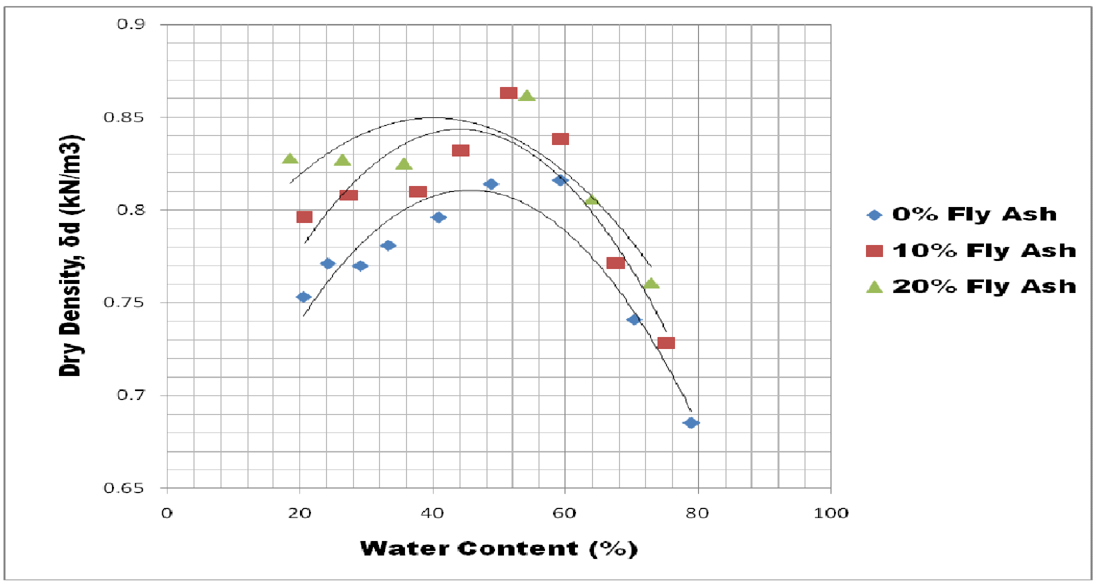

Figure 1: Variation of Optimum moisture content at various percentages of fly ash for Shiromoni Soil

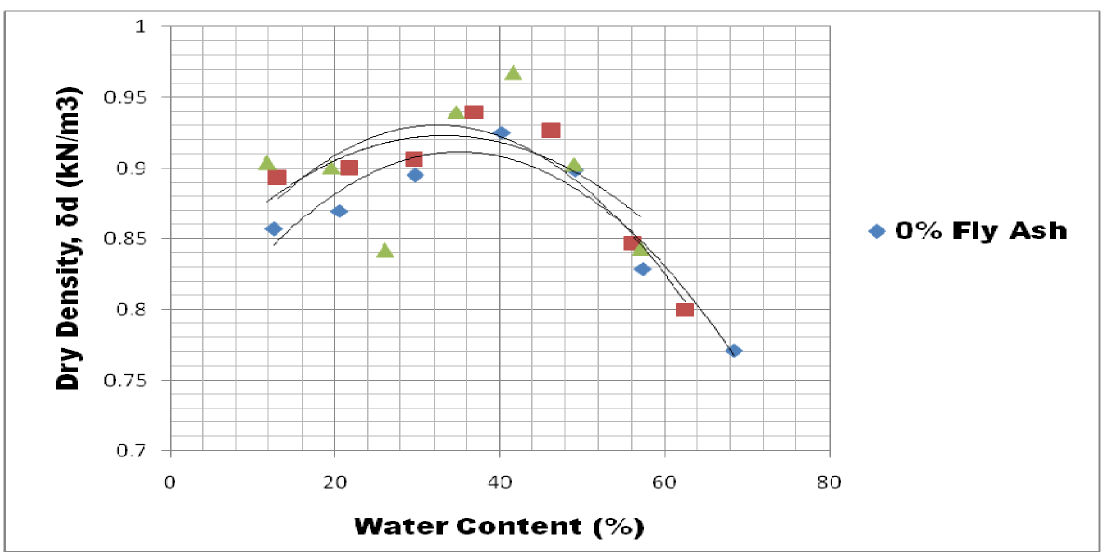

Figure 2: Variation of Optimum moisture content at various percentages of fly ash for Beel Dakatia Soil

3.1.2 Effects of Liquid Limit

Figure 3 represents the variation of liquid limit with fly ash content. Liquid limits of untreated soils and fly ash treated Shiromoni and Beel Dakatia soils increase gradually with the increase of fly ash content as shown in Figure 3.

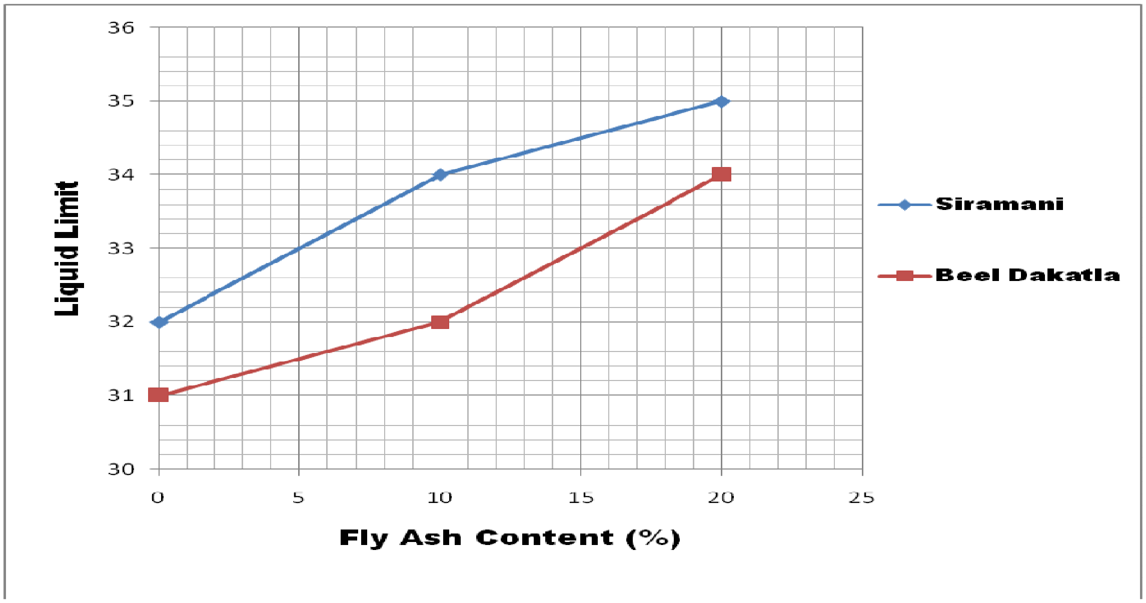

Figure 3: Variation of liquid limit at various percentages of fly ash for Siramani soil and Beel Dakatia Soil

This improvement of liquid limit attributed that more water is required for the fly ash treated soil to make it fluid because of the pozzolanic characteristics of fly ash content.

3.1.3 Effects of Plastic Limit

Similar trend as in case of liquid limit was obtained for plastic limit that the value of plastic limit increases with the increase of fly ash content due to pozzolanic characteristics of fly ash as shown in Figure 4.

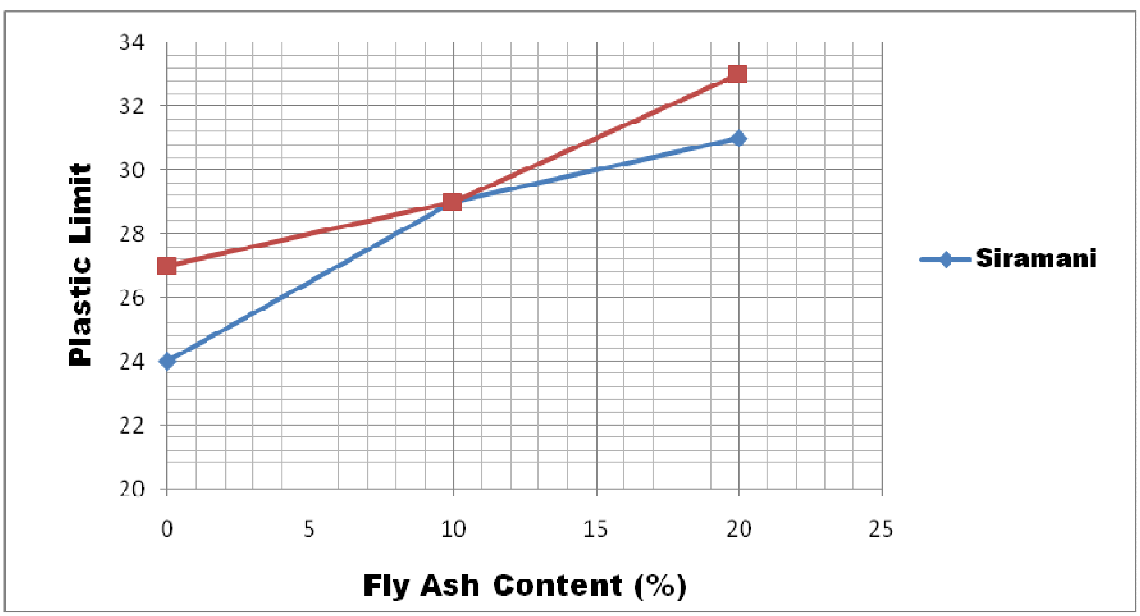

Figure 4: Variation of Plastic limit at various percentages of fly ash for Siramani soil and Beel Dakatia Soil

3.2 Effects of Unconfined Compressive Strength

The test results of unconfined compressive strength are shown in Ffigure 5. These figures illustrate the unconfined compressive strength variation of untreated (0%) and fly ash treated soil (10% and 20%). It can be seen that unconfined compressive strength increases with the increase of fly ash.

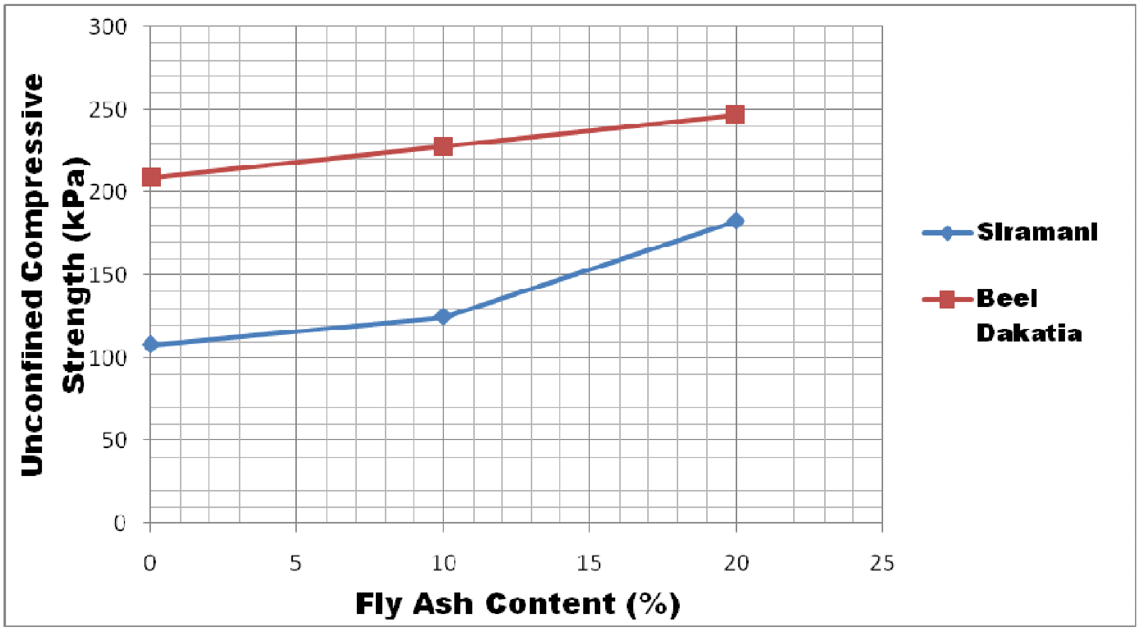

Figure 5: Unconfined compressive strength with various percentages of fly ash for Siramani Soil and Beel Dakatia Soil

3.3 Effects of Stress and Strain Behaviour

Figures 6 and Figure 7 shows the stress-strain behaviour of Shiromoni and Bill Dakatia samples. It is seen that stress increases with the increasing amount of fly ash content. This may be due to decrease of void with addition of water. Similar results were obtained by Bashar, M.A. (2002)

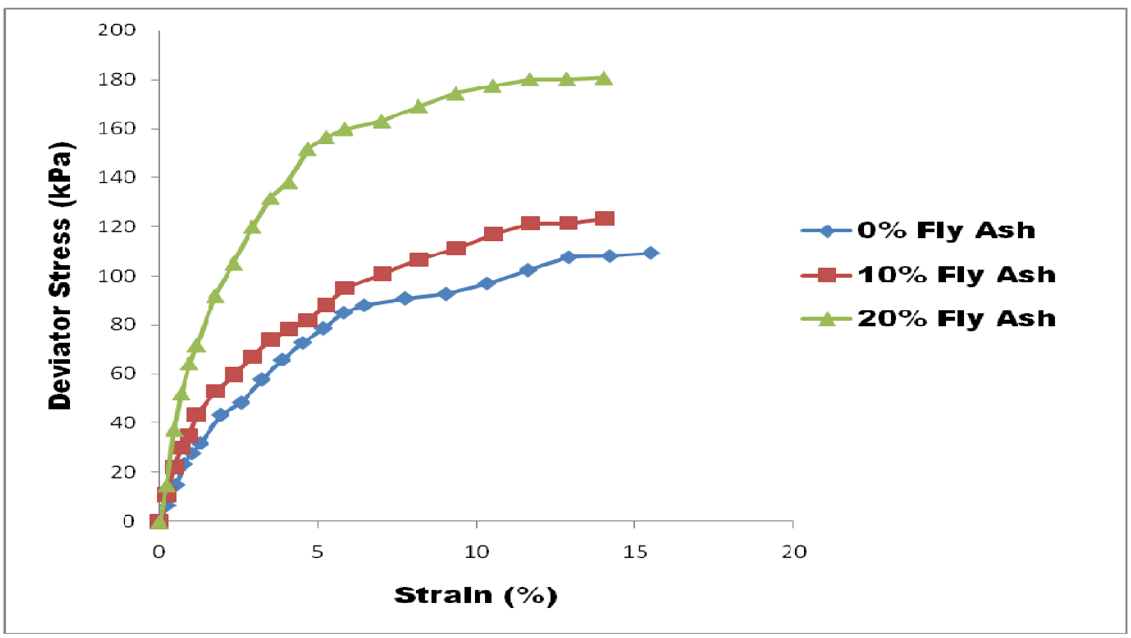

Figure 6: Stress-Strain relationship at various percentages of fly ash for Shiromoni soil

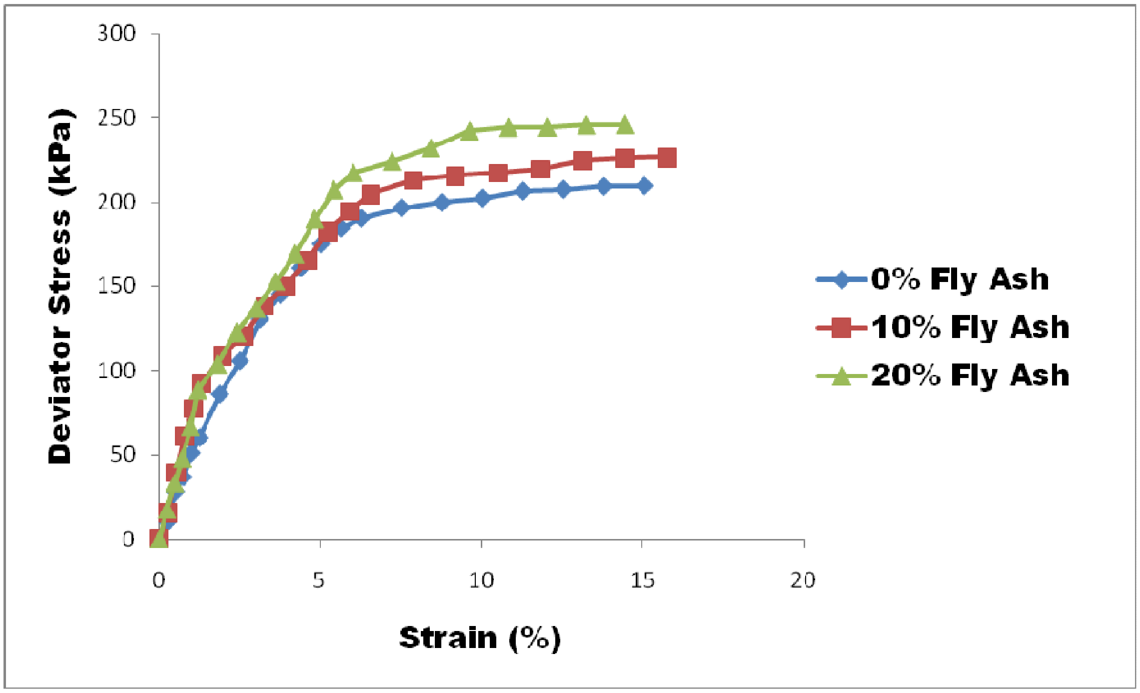

Figure 7: Stress-Strain relationship at various percentages of fly ash for Beel Dakatia soil

3.4 Effects of soil type

Figure 8 exhibits the variation of compressive strength with organic contents. From Figure 8 it can be seen that unconfined compressive strength decreases with increase of organic content. The influence of organic soil type was evaluated by plotting stress, q_u with strain and various percentage of fly ash. The effects of both the soils with respect to unconfined compressive strength showing in the figure below:

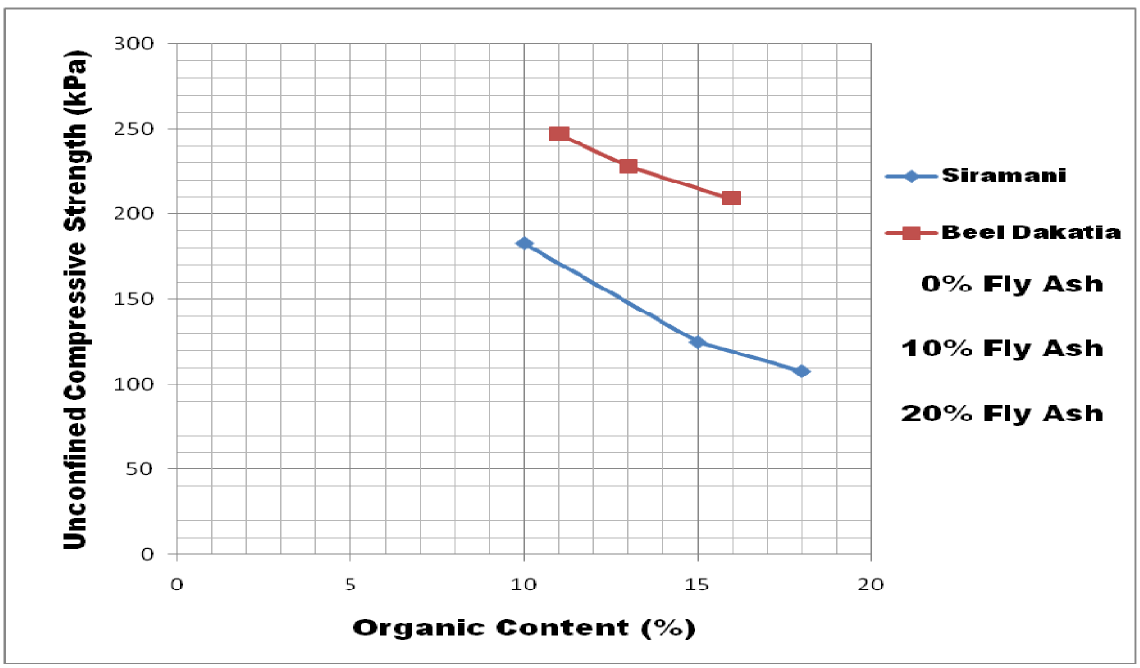

Figure 8: Variation of unconfined compressive strength with organic content of soil at various percentages of fly ash for Shiromoni and Beel Dakatia Soil

3.5 Effects of Plasticity Index

Figure 9 shows the variation of compressive strength with plasticity index. This figure represents that strength decreases with plasticity index. Here the reduction in plasticity index may cause due to significant removal of some water that may be absorbed by organic soils. This also improves the strength characteristics of soil.

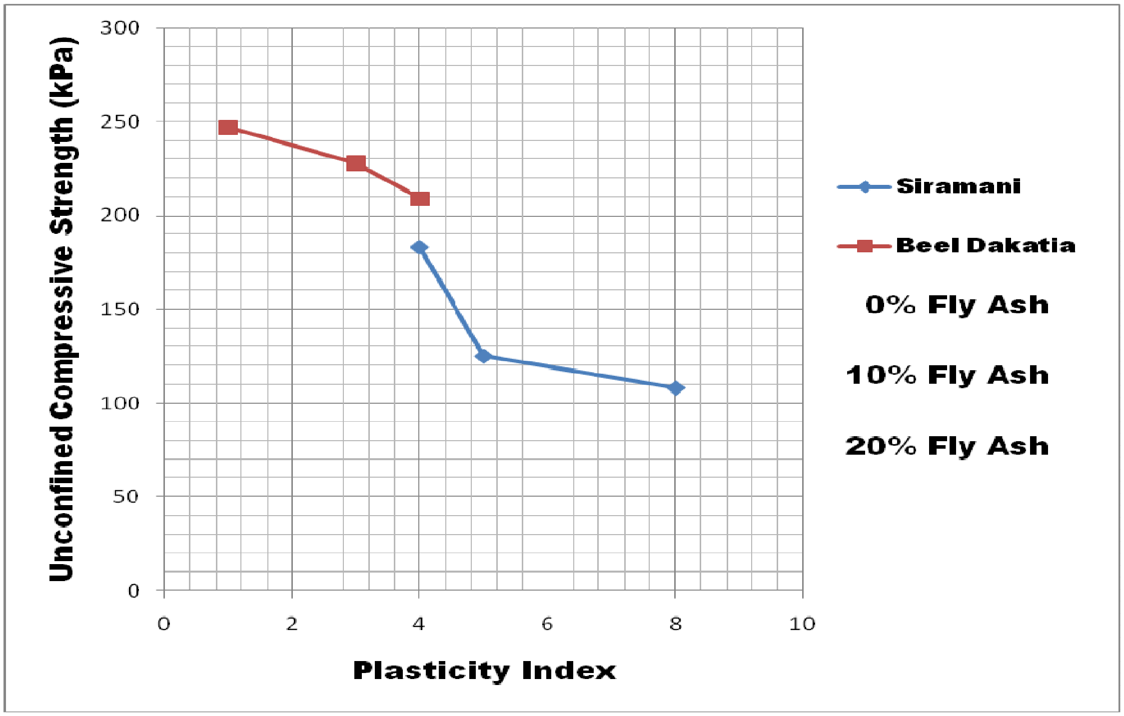

Figure 9: Variation of unconfined compressive strength with plasticity index of soil at various percentages of fly ash for Siramani and Beel Dakatia Soil

5. CONCLUSIONS

Based on the evaluated results, it can be seen that optimum moisture content of both the organic soils decreased with the addition of fly ash because of the disappearing of the pozzolanic effect due to reduction in water content. It is also revealed that the value of liquid limit and plastic limit of both the organic soils increased with the increasing percentages of fly ash while the value of plasticity index reduced. A reduction in plasticity index causes a significant removal of some water that can be absorbed by organic soils. This also improves the strength characteristics of soil. In this study unconfined compressive strength increased with the decrease of plasticity index. It can be said that unconfined compressive strength increases with the decrease of plasticity index. From unconfined compressive strength test it can also be seen that deviator stress and unconfined compressive strength increase with the increasing percentage of fly ash. The organic soil of Beel Dakatia gained more compressive strength than the organic soil of Siramani.

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