BRAHMAPUTRA SILT AS STABILIZER OF EXPANSIVE CLAY

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ABSTRACT

The mighty Brahmaputra is the largest river in Assam. It is known for the problem of excess siltation and hence its river bed has risen from time to time. It causes devastating flood on both the banks of the river and huge amount of losses has been occurred in terms of cultivation, livestock and human lives. Due to excess siltation problem the flood control embankments constructed for mitigation of flood hazard are to be risen from time to time to serve its primary needs. The problem of siltation were tried to mitigate in the past with the help of dredging of its river bed but it was observed that the amount of silt deposition were large as compared to the quantity of dredged materials. So, the only way to solve the problem is to use the Brahmaputra silt for some useful work like landfill engineering, stabilization of expansive clay etc. To have a remedial action to these problem, comprehensive experimental investigations were carried out in the laboratory to assess its suitability to stabilize expansive clay. Bentonite was used as expansive clay and silt was used as a stabilization agent. Series of investigations were carried out to determine the influence of silt on the Liquid limit, Plastic limit and Plasticity Index of the Bentonite. The amount of slit added to the Bentonite is initially 10% and in multiples of it. The index and other properties like consolidation and swelling of Bentonite-silt mixture was determined. It is observed that a linear relationship is exists between the liquid limit, plastic limit and the percentage of silt added to the Bentonite. The coefficient of regression was found to be 0.99. So it can be concluded that the Brahmaputra silt can be versatile stabilizing agent for the expansive clay.

Keywords: Brahmaputra, Expansive Clay,, Liquid Limit, Plastic limit, Stabilization

1. INTRODUCTION

Expansive soils causes lot of problems for the civil engineering structures built on it due to inherent properties of expansion and reduction of volume due to changes in its water content. It expands during the rainy season and shrinks during summer season. Expansive soils owe their characteristics to the presence of swelling clay minerals. Expansive soils cover nearly 20% of the landmass in India and include almost the entire Deccan plateau, Western Madhya Pradesh, parts of Gujarat, Andhra Pradesh, Uttar Pradesh, Karnataka, and Maharashtra. Bentonite is one of the bright examples of expansive soils. It has got very high liquid limit and hence high water absorption capacity.

There are various methods and techniques are available to the Geotechnical Engineering to modify its strength and deformation characteristics of problematic soils such as soft fine grained and expansive soils. One of the oldest methods in practice is to remove and replace the soft soils by a good quality of soils. Other methods of modifications of its properties are either by using mechanical and/or chemical stabilization. These methods include densifying treatments (such as compaction or preloading), pore water (such as dewatering or electro-osmosis), the bonding of soil particles (by ground freezing, grouting, and chemical stabilization), and use of reinforcing elements (such as geosynthetics and stone columns).

The comprehensive review of the reported literature shows that a considerable amount of work related to the stabilization of expansive clay to study the strength and deformation characteristics was extensively studied by various researchers throughout the world. From various contributions, the investigations on strength characteristics of expansive soil conducted by S.Narasimharao et.al (1987, 1996); Sridharan et.al (1989); Mathew et.al(1997); G.Raja Sekaran et.al(2002); Ali.M.A. Abd-Allah (2009) are worthy of note. Improving the strength of soil by stabilization technique was performed by Supakji Nontananandh et.al (2004) and Can Burak Sisman and Erhan Gezer(2011). The effect of electrolytes on soft soils were explained by Sivanna, G.S (1976);Anandakrishnan et.al (1966); Saha et.al (1991); Rao, M.S et.al(1992);Sivapullaiah, P.V. et al (1994); Bansal et.al(1996); S. Narasimha Rao et.al(1996); Appamma, P,(1998); Chandrashekar et.al (1999);G. Rajasekaran et.al (2000); J. Chu et.al (2002);Matchala Suneel et.al (2008). The effect of steel industrial wastes on soft soils were presented by Ashwani Kumar et.al (1998); Bhadra, T. K et.al (2002); Dr. D. D. Higgins (2005); Koteswara Rao (2006).

The Engineers are often faced with the problem of constructing roadbeds on or with soils (especially soft clayey and expansive soils). These problematic soils do not possess enough strength to support the wheel loads upon them either in construction or during the service life of the pavement. These soils must be, therefore, treated to provide a stable sub-grade or a working platform this is soil stabilization. The soil stabilization includes both physical stabilization such as dynamic compaction and chemical stabilization (Tests Division, Geotechnical Section, Indiana, 2002).

Chemical stabilization involves mixing chemical additives (binding agents) with natural soils to remove moisture and improve strength properties of the soil agent in the treatment process is either reinforcing of the bounds between the particles or filling of the pore spaces. The chemical stabilizing agents are relatively expensive compared with other methods of stabilization, so that the soil stabilization technique is an open the near future (Egyptian Code, 1995).

The quality of the sub-grade soil used in pavement applications is classified into very stiff, and hard sub-grade) depending on unconfined compressive strength values (Das, 1994). The quality the sub-grade soil used in pavement applications is classified into excellent) depending on the CBR values (Bowles, 1992). The modifications of the properties with the use of silt are not found in many literatures. Hence experimental investigations are carried out to have practical applications to use the river Brahmaputra Silt as a stabilizing agent to modify its index properties. The results are encouraging and the use of the Brahmaputra Silt may be one of the alternative solutions to modify the properties of expansive soils.

2. METHODS OF STABILISATION:

Expansive clay causes lot of problems for the structures constructed on it. Different methods are available for the stabilization of expansive clay. Following are the few of the methods and their relative merits and demerits.

- Lime stabilization
- Cement stabilization
- Fly Ash stabilization
- Polymer stabilization
- Chemical Stabilization
- Bituminous stabilization etc.

3. DETAIL OF EXPERIMENTAL INVESTIGATIONS:

A series of experimental investigations were carried out in the laboratory to assess the suitability of the brahmaputra silt as a stabilizer of bentonite clay. The details of test series under which the investigations were carried out as enumerated in table 1. The bentonite is mixes with in percentage of the silt in the order of 10% increase in its quantity by weight. The details of the test series are given in the table 1. The properties of the bentonite and the bentonite silt mixtures were studied systematically in terms of grain size, liquid limit, plastic limit and plasticity index. The properties of bentonite and bentonite silt mixture are given in table 2. During the preliminary investigations only the index properties of the bentonite and bentonite silt mixtures were studied in the laboratory. The grain size distribution of the silt used in this investigation as a stabilizer for bentonite is given in the Figure 1.

Table 1 Detail of the test series

Series No	Details of test series
Series 1	Bentonite+0% Brahmaputra silt
Series 2	Bentonite+10% Brahmaputra Silt
Series 3	Bentonite+20% Brahmaputra Silt
Series 4	Bentonite+40% Brahmaputra Silt

Table 2 Liquid limit and plastic limit of the mixture

Mixture Type	Liquid Limit (%)	Plastic Limit (%)
Bentonite+0% Brahmaputra silt	310	40
Bentonite+10% Brahmaputra Silt	280	25
Bentonite+20% Brahmaputra Silt	250	22
Bentonite+40% Brahmaputra Silt	170	17

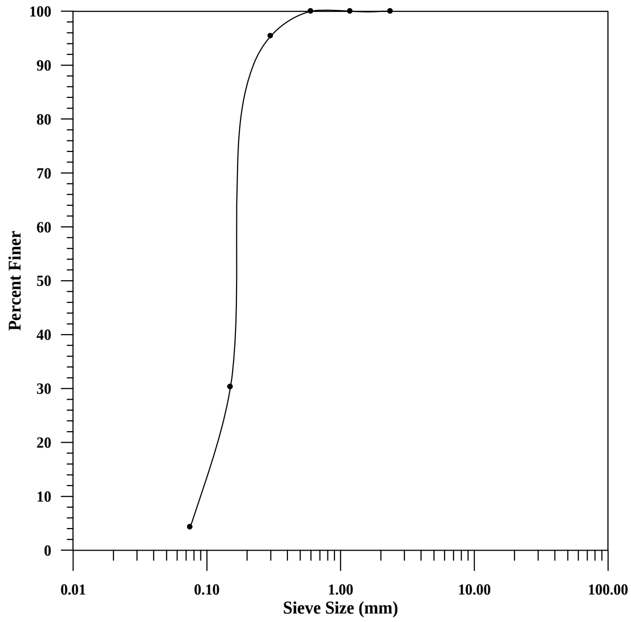

Figure1. Grain Size distribution of the Brahmaputra Silt

The test results indicates that the Atterberg's limit of the Bentonite clay changes with the addition of the Brahmaputra silt and it is found to be positive. The liquid limit and the plastic limit reduce drastically with increase in the addition of the silt. The liquid limit of the Bentonite has changes from 310 to 170 and the corresponding plastic limit changes from 40 to 17 respectively. Hence it can be concluded that the index properties of the Bentonite clay can be modified with the help of addition of the Brahmaputra silt. The regression equation fit to have a correlation between the water content vs liquid limit, water vs plastic limit and the relation between the liquid limit and plastic limit. The graph plotted with % age of Brahmaputra Silt with Liquid limit and plastic Limit shows good correlation and the regression equation can be written as given in Eq.1 and Eq. 2.

$$Y_1 = -3.45X_1+310 \quad (1)$$

Where

Y_1 is the Liquid Limit

X_1 is the % age of Brahmaputra Silt added.

This can be written as:

LL = -3.45*[%age of Brahmaputra Silt] + LL of Bentonite

Where LL stands for Liquid Limit

The regression equation for plastic limit is

$$Y_2 = -0.51X_2 + 407 \quad (2)$$

Where,

Y_2 is the plastic Limit of the Mixture

X_2 is the % age of Brahmaputra Silt Added.

This equation can further be written as:

PL = -0.51*[% age of Brahmaputra Silt) + PL of Bentonite

Where PL stands for Plastic Limit

Figure 2 shows the influence of the Brahmaputra silt on the Liquid Limit of the Bentonite. It can be observed that with the addition of 10% of the Brahmaputra silt the liquid limit decreases to nearly 275 and thereafter it decreases continuously. The plot of the influence of addition of the Brahmaputra silt shows a linear relationship and the regression equation is shown in equation 1. The coefficient of regression (R^2) is found out to be 0.99 and hence it can be concluded that this equation can be used to determine the amount of silt to be added to have a specified liquid limit of the silt stabilized Bentonite clay. So this can be said that for the stabilization of expansive clay, the Brahmaputra silt can be a economical solution. Also from the Eq.1 we can be able to determine the amount of silt to be added to have the required liquid limit. As we know that lot of correlations are exists between the Liquid Limit and Coefficient of correlation so we can directly get the consolidation parameters of the Bentonite-silt mixture.

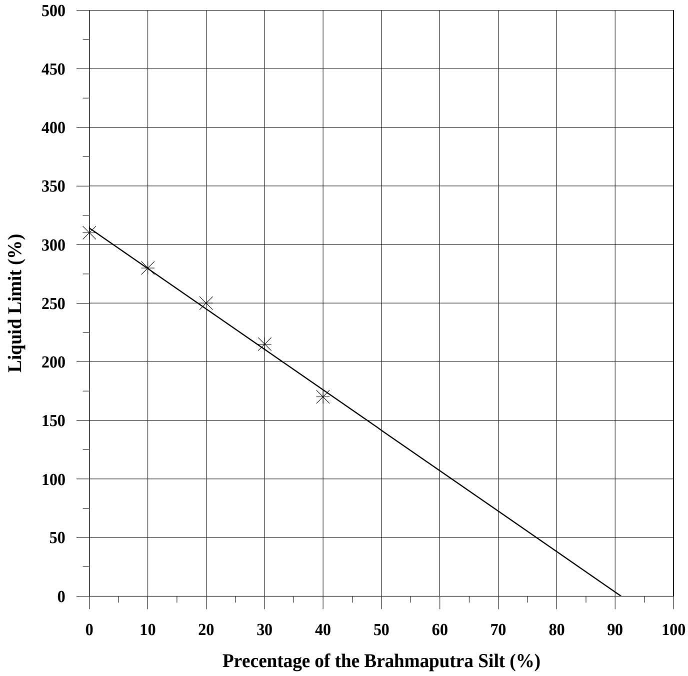

Figure 2. Influence of addition of the Brahmaputra on the Liquid Limit of Bentonite-Silt mixture

The influence of the addition of the Brahmaputra silt on the Plastic limit is depicted in Figure 3. It can be observed that a linear relationship is exists between the Plastic Limit and the percentage of the Brahmaputra silt added for the purpose of stabilization of expansive clay. The regression equation is given in Eq. 2. The coefficient of regression (R^2) as determined is found out to be 0.99 and hence it can be concluded that this equation is fit well for the purpose of determination of Plastic limit of the Bentonite-Silt mixture. Alternately we can be able to determine the consolidation parameters from the equations of Terzaghi and Peck (1948), in a continuation of work begun by Skempton (1944), state that the compression indices for clays in a remolded state ***(C,')*** increase consistently with increasing liquid limit Limit ***(w_L).***

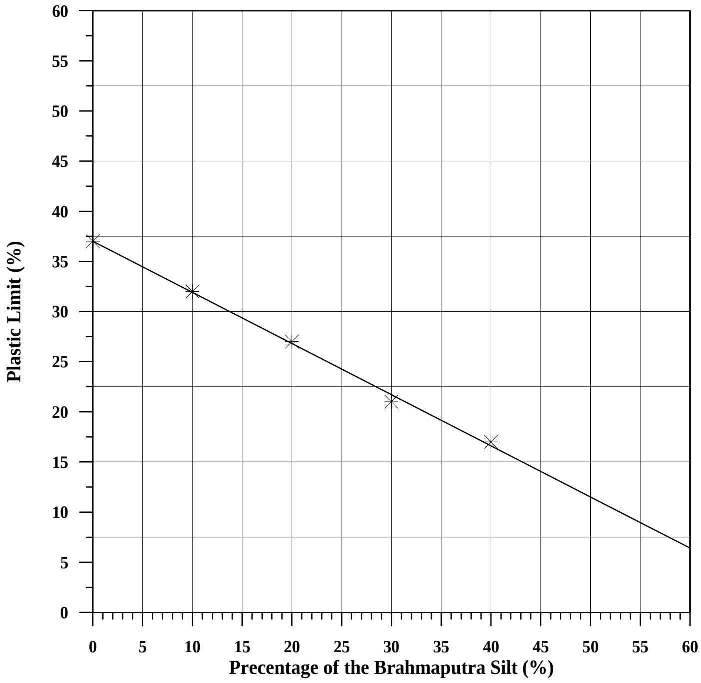

Figure 3: Influence of addition of the Brahmaputra on the Plastic Limit of Bentonite-Silt mixture

4. CONCLUSIONS:

From the experimental investigations carried out for the stabilization of expansive soil with the Brahmaputra silt, the following main conclusions can be drawn:

- Addition of Brahmaputra Silt can drastically improved the strength and deformation characteristics of the Bentonite Clay
- There is a correlation exists between the Liquid Limit, Plastic Limit and the % age of addition of Brahmaputra Silt
- As the Siltation is a great problem for the Channel depth of the Brahmaputra river and hence it can be a viable alternative for the improvement of soft and problematic soil like Bentonite.
- It will also reduce the silt burden of the mighty Brahmaputra River due to which the flood problem can be drastically reduced.
- As the soft clay is available in some other parts of the country and hence it will create an employment generation avenues for the unemployed youth for a state like Assam.
- If the Brahmaputra can be used for the stabilization of expansive soil as per the findings of the present investigations, it will make avenues for the employment of rural youths in the process of collection of silt for marketing to other areas for the purpose of soil stabilization.
- The regression equation so developed can be used to determine the required value of the %age of the Brahmaputra Silt to be added to get the desired Liquid Limit and Plastic Limit of the expansive clay.

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