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Effect of Soda Lime Glass Dust on the Properties of Clayey Soil

By Md. Nuruzzaman & Dr. Md. Akhtar Hossain
Rajshahi University of Engineering & Technology, Bangladesh

Abstract- The research was carried out with an intention to observe any sign of improvement of clayey soil due to the addition of soda lime glass dust with it. In this thesis work clayey type soil has been chosen. The reason behind choosing clay is that it has some problems. The main problem is that it undergoes consolidation settlement due to the application of long term loading. Another problem is it shrinks significantly if it is dried and expands significantly if it absorbs moisture which exerts much pressure on the substructure. Glass dust is chosen to check the improvement because it is cohesionless material. Addition of cohesionless material to the cohesive soil means it will lessen the consolidation settlement and expansive nature of soil. To investigate the effect traditional methods of analyzing the effect of additives on soil has been adopted i.e. conducting several tests of untreated soil and soil treated with glass dust and then comparing the results. The tests that were carried out in this study are Compaction test, Atterberg test, Consolidation test, Unconfined compression test. Before this to know the type of soil grain size analysis and specific gravity tests were performed. From the test results it is observed that the maximum dry density increases, optimum moisture content decreases, liquid limit decreases, plastic limit increases, plasticity index decreases, compression index and swell index decreases with the addition of glass dust with soil. Unconfined compressive strength decreases at zero day and after curing for some days the unconfined compressive strength increases with the addition of glass dust with soil.

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I. Introduction

It is necessary for designers to take into consideration local economic factors as well as environmental conditions and project location in order to make prudent decisions for design and construction. Soil modification may have to be considered in many projects. Soil index properties get transformed by adding additives. This leads to the alteration of the physical and chemical properties of the soil. Soil improvement, in the broadest sense, is the alteration of any property of a soil to improve its engineering performance. It also comprises any process which increases or maintains the natural strength of the soil. Although soil stabilization was originally done to increase the strength or stability of soil, gradually, techniques of soil treatment have been developed until soil stabilization is now used to increase or decrease almost every engineering property of soil. The necessities to improve soil properties for construction works result in the use of various stabilizers. Some of these stabilizers are either costly or scarce. For example, cement stabilization was adjudged the most viable due to its abundance; however the growing cost of cement has limited its use. It therefore became necessary to utilize the excellent properties of the common materials. There is a wide range of material available for the construction industries. The choice and sustainability of a particular material depends largely on its availability, nature of project, individual preference, durability, proximity and economic consideration. Solid wastes are inevitable by products of human activities. Due to increase in population, urbanization, industrialization and change in lifestyle, there has been a radical change in the quantity and characteristics of the solid wastes. Hence solid wastes become more hazardous to environment and demands careful disposal practices. Waste materials having qualities to improve engineering properties of soil may be used as admixtures. Broken pieces of glass are waste products. Glass dust is a cohesionless material which can improve the quality of soil.

II. Literature Review

A lot of research work has been done in the past to improve engineering properties of soil using additives. The additives used in the past were lime, cement, saw dust, fly ash, rice husk ash etc. Chemical additives were also used to improve the quality of soil and induce binding action in soil like Sodium Bentonite. A list of researchers is given below who have used certain additives to improve soil. Emad Akawwi and Atef Al-Kharabsheh (2000) has shown the influence of lime on optimum moisture content and consistency index. According to them optimum moisture content of soil treated with lime may increase or decrease depending upon the type of soil. But they have not shown any effect of lime on the compressive strength of soil. Anagnostopoulos and Maria Chatziangelou (2008) worked on compressive strength of cement stabilized soils and have shown that cement admixture increases the unconfined compressive strength of soil significantly. They have also developed a non linear regression model

Author α: Department of Civil Engineering, Rajshahi University of Engineering & Technology, Rajshahi, Bangladesh.
e-mail: mnz_ruet@yahoo.com
Author σ: Assistant Professor, Department of Civil Engineering, Rajshahi University of Engineering & Technology, Rajshahi, Bangladesh. e-mail: akhtar412002@yahoo.com

to predict the behavior of cement stabilized soil. Their work was limited only to the compressive strength of cement stabilized soil. Brooks has shown that the unconfined compressive strength of clayey soil increases with the addition of fly ash upto a certain limit and then it decreases. He has also shown the swelling index variation of clayey soil due to the addition of fly ash. It has been found that fly ash decreases the swelling index of soil. He has performed CBR test using fly ash and rice husk ash both mixed with soil. His finding was an optimum value of rice husk ash and fly ash for CBR. Brooks (2009) has shown that the unconfined compressive strength of clayey soil increases with the addition of fly ash upto a certain limit and then it decreases. He has also shown the swelling index variation of clayey soil due to the addition of fly ash. It has been found that fly ash decreases the swelling index of soil. He has performed CBR test using fly ash and rice husk ash both mixed with soil. His finding was an optimum value of rice husk ash and fly ash for CBR. Henry Tolulope (2012) has shown that saw dust additive changes properties of soil. It increases maximum dry density and optimum moisture content and decreases unconfined compressive strength of clayey soil. He has also perfomed CBR test and shown that CBR is also improved considerably due to the addition of saw dust. However, no research has done yet using glass dust as an additive to improve the quality of soil. This study is based on the technique used by other researchers to study the improvement caused due to the addition of additive

III. Materials and Procedures

For this research work soil sample was collected from Godagarithana of Rajshahi district. The soil sample was collected at 2ft below the ground level so as to ensure that particles other than soil are not included in the soil sample. If this occurs then there will be error in the results of the experiment done on the original soil sample as well as on the treated soil sample. The color of the soil sample was brown and was different from other types of soil in Rajshahi. When the soil was mixed with water it formed a paste like material and felt very sticky in between fingers. Visual identification of the soil showed no sign of gravel in the soil. The glass was collected from a vangri shop in Vodra at a rate of 7 taka Per kg for small scale purchase which were broken pieces of waste glass. Then the broken pieces of glass were washed and dried to remove foreign materials in it. After that it was crushed to dust by using mortar and hammer. This is done for a small scale laboratory tests. But if glass is to be crushed to dust on a large scale then crusher machine should be used. Otherwise it will be risky to do the job manually. The glass dust was obtained by crushing it into dust and passing it through 300 μm sieve. Glass is an amorphous (non-crystalline) solid material. Glasses are typically brittle and optically transparent. The most familiar type of glass, used for centuries in windows and drinking vessels is soda-lime glass composed of silica 72% + sodium oxide (Na_2O) 14.2% + magnesia (MgO) 2.5% + lime (CaO) 10.0% + alumina (Al_2O_3) 0.6%. Soda-lime glasses account for about 90% of manufactured glass. It has a high thermal expansion and poor resistance to heat (500–600 °C). It is used for windows, containers, light bulbs, tableware etc. Silica is the main composition of sand which is cohesionless. When glass is crushed to dust it acts as a cohesionless material. And when this glass dust is mixed with cohesive and expansive fine grained soil it will improve the consistency of soil. Also glass dust contains 10% of lime in it. This will provide with some extra strength to the soil if hydrated.

To investigate the effect of glass dust on soil sample tests were done on

a) Untreated soil Sample
b) Treated soil sample with different percentages of glass dust

In the work physical identification test, grain size distribution test, specific gravity test, Atterberg limit test, compaction test, consolidation test, unconfined compression test were performed for the untreated soil sample as well as for treated sample except grain size distribution test which was performed for various percentages of glass dust mixed with soil sample. To identify the maximum dry density and optimum moisture content standard proctor test was. For treated soil the percentage of glass dust content were 3%, 6%, 9% and 12%.

IV. Results and Discussion

a) Properties of Soil Sample

The grain size analysis of soil is shown in the figure 1 and the basic engineering properties are shown in the table 1.

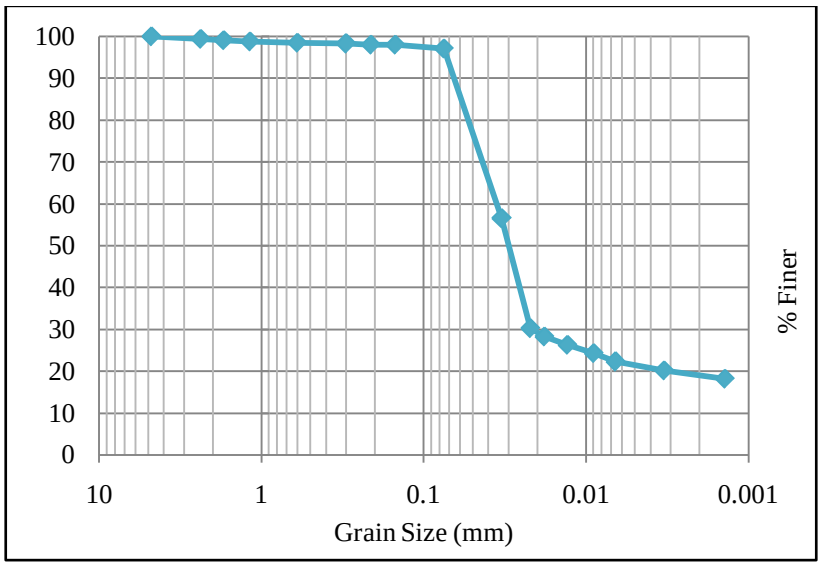

Figure 1 : Grain Size Distribution Curve of Soil

According to Unified Soil Classification System the soil type is Clayey. The group symbol of soil is CL where C stands for clayey and L stands for low plasticity.

Table 1 : Properties of Soil Sample

Specific Gravity	2.49
Maximum Dry Density	1.79 gm/cm^3
Optimum Moisture Content	14.6%
Liquid Limit	27.38
Plastic Limit	15.76
Plasticity Index	11.62
Type of Soil	Clayey (Unified Soil Classification System)

b) Variations

i. *Compaction Characteristics*

The test performed to determine the compaction characteristics of untreated and treated soil was Standard Proctor Test. The variations of maximum dry density and optimum moisture content are shown in figure 2 and 3 respectively.

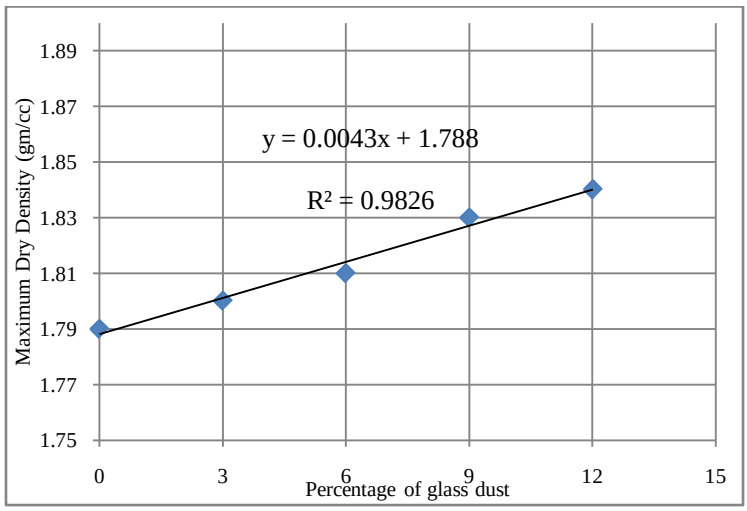

Figure 2 : Variation of Maximum Dry Density with Percentage of Glass Dust

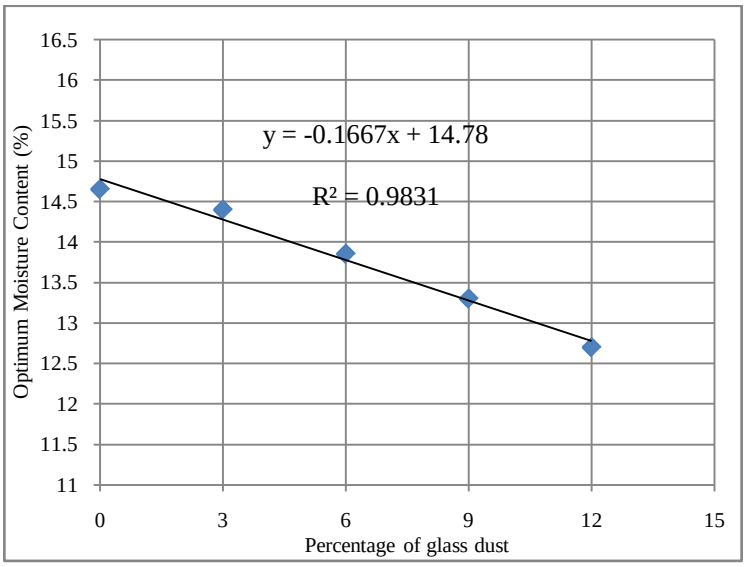

Figure 3 : Variation of Optimum Moisture Content with Percentage of Glass Dust

From the data obtained by standard proctor test for untreated soil and soil treated with different percentage of glass dust it has been found that the maximum dry density of soil increases with the addition of glass dust. Also it has been found that the optimum moisture content decreases with the addition of glass dust. The reason behind the result is the higher specific gravity of glass dust than soil and the fineness of glass dust.

ii. *Plasticity*

The variation of plasticity index of soil after mixing with glass dust is shown in the figure 4 by performing Atterberg limits test.

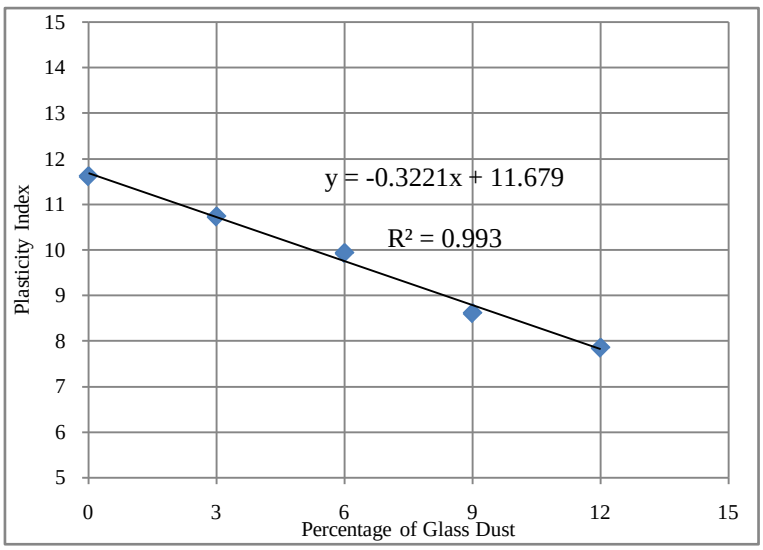

Figure 4 : Variation of Plasticity Index with Percentage of Glass Dust

Plasticity index of soil decreases due to the addition of glass dust and a decrease in plasticity index of soil is a sign of improvement of soil. As glass dust is cohesionless it was expected that it would reduce the plasticity index of soil and the result satisfies the expectation.

iii. *Consolidation Properties*

The amount of settlement of a particular type of soil depends upon its consolidation properties. In the figures 5 and 6 the variation in these properties obtained by mixing glass dust with soil for different percentages are shown.

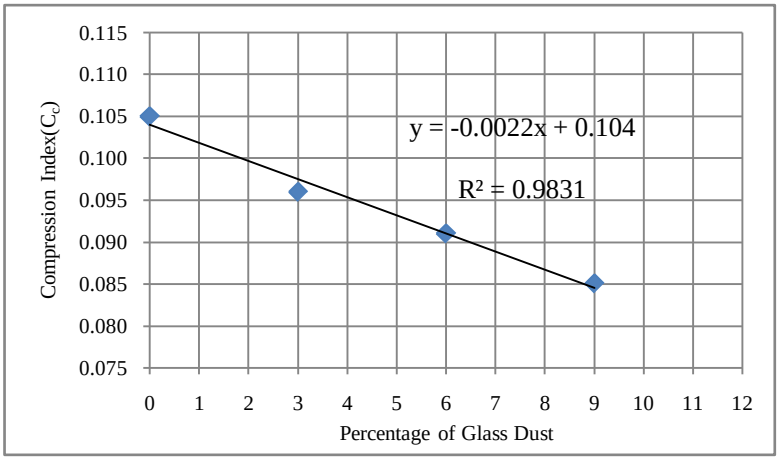

Figure 5 : Variation of Compression Index with Percentage of Glass Dust

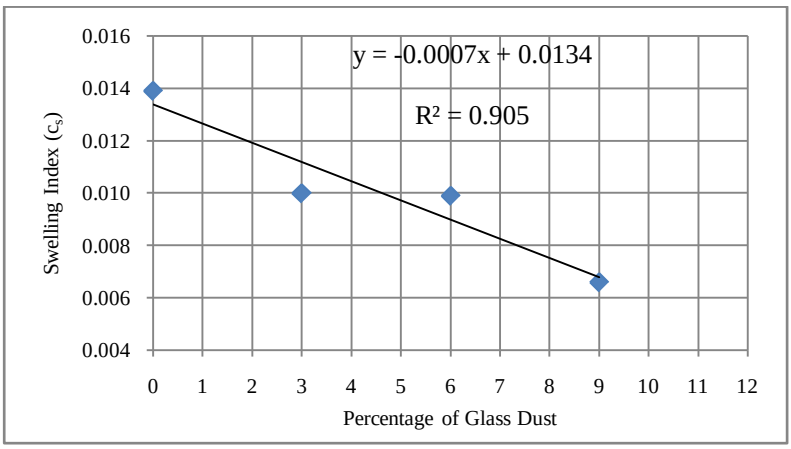

Figure 6 : Variation of Swelling Index with Percentage of Glass Dust

Consolidation test yields that both the compression index and swell index decreases with the addition of glass dust. Decrease in these two indices means that the property of the clayey soil has been improved. The non-cohesive property of glass dust reduces these two indices.

iv. *Unconfined Compressive Strength*

The variation in the unconfined compressive strength of untreated and treated soil is shown in the figure 7.

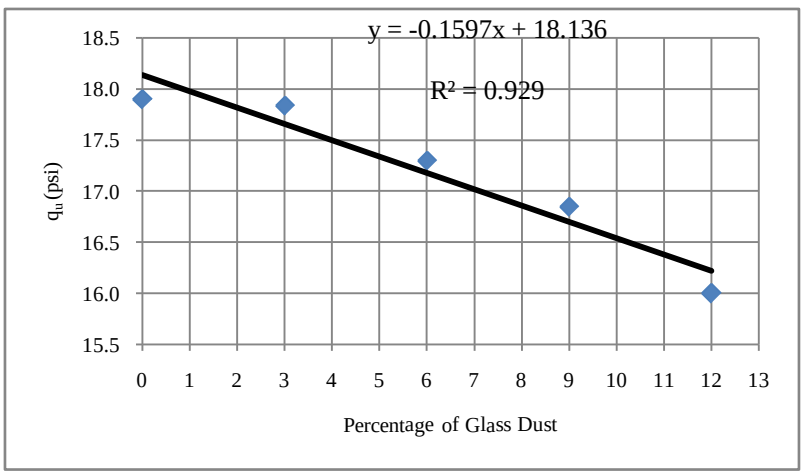

Figure 7 : Variation of Unconfined Compressive Strength with Percent Glass Dust

From the results of unconfined compression test it has been found that the unconfined strength of soil decreases with the addition of glass dust with no curing.

All the variations of these properties have been found to follow a linear relationship as the regression value is so very clos to 1. So no optimum amount of glass dust could be found in this work. It will depend upon the degree of improvement required and cost of glass dust stabilization.

V. Conclusions

After conducting several tests of untreated soil and the glass dust treated soil for different percentages the following conclusions can be drawn.

- From the test results it is clearly seen that properties of soil has been improved by the addition of glass dust to the soil by comparing the behavior of treated and untreated soil. The improvement of these properties are not drastically and also it is not insignificant.
- The results of the tests also draw another conclusion that the more percentage of glass dust we add to the soil the properties of clayey soil improves more rapidly.

VI. Recommendation for Future Study

The following recommendations can be made for future research:

a) Soil sample from other places can be tested to have a better knowledge about the behavior of soil with glass dust.

b) Soil can be heated with glass dust at a temperature of the melting point of glass and the change in strength properties of soil can be tested.

c) The cost of glass dust stabilization of soil can be assessed and compared with other stabilizing agents.

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