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SUSTAINABLE SOLUTION OF SOIL POLLUTION DUE TO ACID RAIN: MONGLA PORT INDUSTRIAL AREA, BANGLADESH.

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Abstract: *Analysis of the historic properties of soil due to acid rain at Mongla industrial area, Bangladesh was investigated in the study. This study steps are: (1) the rain water of the catchment area was analyzed for the confirmation of the acidity. (2) Then, the Atterberg Limit and particle size distribution was carried out. (3) Besides, unconfined compression test and tri-axial test were done. The outcomes are: (1) (a) Acidity test showed, the efficiency of acid sensitivity of this in-situ soil is reducing. (b) A new sustainable solution lime treatment can used rather than emission control from the industries which can reduce soil pollution. (2) The acidity effects the historic high plasticized silty soil (MH) to low plasticized acidic silty soil (ML) defines punching shear failure. (3) Reduction of the bearing capacity of the historic soil results acidity increase provided that the stress-strain relationship for the acidic soil behaves linearly.*

Keywords: Acidity, Rain water, Sensitivity, Stress-strain.

1. INTRODUCTION

The gaseous pollutants released during industrial processes are continuously adopting alarming proportions to soil. These when absorbed by rain water reduces its pH [1]. The direct effect of acid rain on various types of soils needs to be evaluated. Although the H^+ content of acid rain falling for a short duration is very low compared to the cation exchange capacity (CEC) of the soil yet its influence on the physico-chemical and engineering properties of soil will be alarming in near future as ever growing industrialization/pollution will keep on decreasing its pH. The enhanced rate of leaching of cations and absorption of H^+, SO_4^{2-}, NO_3^- and CO_3^{2-} will alter its physico-chemical and engineering properties [2]. Environmental Geo-technology is emerging as an interdisciplinary science, aiming at forecasting, analyzing and solving the geotechnical problems involving the influence of environmental factors [3]. The chemical analysis of water and soil indicates that the leaching of metallic cations could take place under acidic conditions [4]. The magnitude of the deterioration in soil properties will depend on persistence and strength of acid rain [5].

2. STUDY AREA AND DATA

Mongla is an Industrial Area, Bangladesh whose geographical coordinates are 22° 28' 0" North and 89° 37' 0" East. Two soil samples are collected from here. One near cement factories and another collected from the Mongla residential area. The collected data of the experiment are given in Table. 1

3. METHODOLOGY

3.1 Visual Classification of Soil

On the basis of visual classification of soil (ASTM D 2488-00) some tests like angularity, shape, color, odor, moisture condition, consistency, cementation, range of particle size, dry strength, dilatancy, toughness and plasticity are carried out. The acidic soil was counted as sandy silt and the residential area soil as silty sand. This practice is to be used not only for identification of soils in the field, but also in the office, laboratory, or wherever soil samples are inspected and described. The descriptive information required in this practice can be used to describe a soil to aid in the evaluation of its significant properties for engineering use.

3.2 Acidity/ Alkalinity Test

Generally, the acidity test of the soil is carried out by placing the soil in water and keeping it for 24 hours. The pH meter is then placed to the water sample to notice the pH of the specimen.

3.3 Particle size Distribution

According to ASTM D 422 – 63 (reapproved 2002) suggested to use a set of sieves 75 mm, 50 mm,25mm, 19 mm, 9.5 mm, No.4, No.10, No.20, No.40, No.60, No.140 and No.200. The rest materials are then used for the hygrometer test.

3.4 Atterberg Limit

According to ASTM D 4318 – 00 has stated the standard procedure of testing the liquid limit, plastic limit and shrinkage limit for clay of fine grained soils. Hand operated

liquid limit device, grooving tool with plastic limit rolling device and mercury method of determining shrinkage limit are used for the test. The liquid limit, plastic limit, and plasticity index of soils are also used extensively, either individually or together, with other soil properties to correlate with engineering behavior such as compressibility, hydraulic conductivity (permeability), compactibility, shrink-swell, and shear strength.

Table 1: Collected Data

Criteria	Soil Parameter	Industrial Area Soil	Residential Area Soil
		Values / Comments	
Visual Classification	Type of Soil	Sandy Silt	Silty Clay
Acidity/Alkalinity	pH	6.82	7.79
Atterberg Limit	Liquid Limit (LL)	26.22 %	37.50 %
	Plastic Limit (PL)	13.58 %	20.30 %
	Shrinkage Limit (SL)	27.64%	15.29 %
Shear Strength	Unconfined Compression (UC)	92.85 KPa	98.97 KPa
	Triaxial Test (UU)	73 KPa	84 KPa

3.5 Unconfined Compression (UC) Test

The primary purpose of the unconfined compression test is to quickly obtain the approximate compressive strength of soils that possess sufficient cohesion to permit testing in the unconfined state. The test method use for the determination of unconfined compressive test is ASTM D 2166. Samples of soils having slicken sided or fissured structure, samples of some types of loess, very soft clays, dry and crumbly soils and varied materials, or samples containing significant portions of silt or sand, or both (all of which usually exhibit cohesive properties), frequently display higher shear strengths when tested in accordance with Test Method D 2850. Also, unsaturated soils will usually exhibit different shear strengths when tested in accordance with Test Method D 2850.

3.6 Triaxial (UU) Test

The test covers the unconfined and undrained condition of soil for triaxial test. In this test method, the compressive strength of a soil is determined in terms of the total stress, therefore, the resulting strength depends on the pressure developed in the pore fluid during loading. In this test method, fluid flow is not permitted from or into the soil specimen as the load is applied, therefore the resulting pore pressure, and hence strength, differs from that developed in the case where drainage can occur. If the test specimens are 100 % saturated, consolidation cannot occur when the confining pressure is applied nor during the shear portion of the test since drainage is not permitted. Therefore, if several specimens of the same material are tested, and if they are all at approximately the same water content and void ratio when they are tested, they will have approximately the same undrained shear strength. The Mohr failure envelope will usually be a horizontal straight line over the entire range of confining stresses applied to the specimens if the specimens are fully saturated. The test method covers ASTM D 2850 – 3a.

4. RESULT AND DISCUSSION

4.1 Confirmation of Acidity

From the test result it is found the industrial area having the pH value of 6.82 which is slightly acidic in nature. Such acidic soil makes the clay particles to fine grained sand which effects largely over the properties of the soil.

4.2 Atterberg and Particle size distribution Test

The Atterberg Test (liquid limit, plastic limit and the shrinkage limit) for the industrial area soil is most vulnerable. Due to slight acidic soil condition the risk is growing.

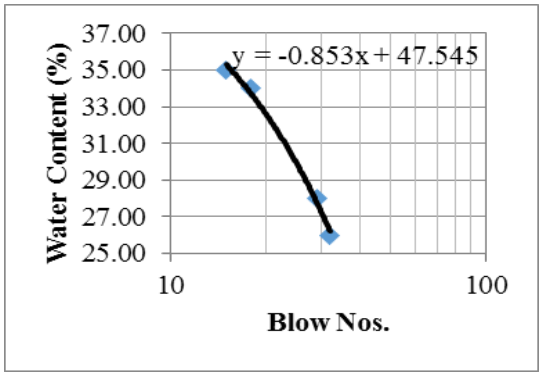

Figure 1: Liquid Limit of Industrial Area Soils

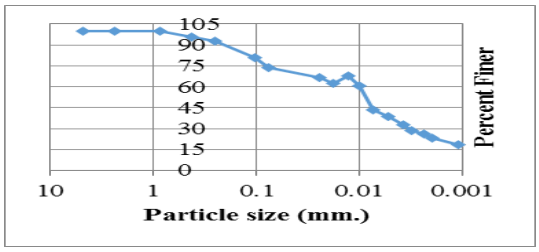

Figure 2: PSD of Industrial Area Soils

The particle size distribution of the soil samples from the industrial and residential area soils is analyzed to determine the co-efficient of uniformity and concavity. The particle size distributions of the soils are shown in the Figure 2.

4.3 Unconfined compression and Triaxial Test

The unconfined compression test involves with the graph of deviator stress versus axial strain. From the test, the both soils show the same pattern of semi-plastic or intermediate failure. Form the graph it is seen that the industrial areas soil having smaller strength than the residential area soils due to acid rain and conversion of the clayey particle to fine grained soils. The maximum value of the stress the strain of 15 % is taken as the standard one. The triaxial test follow the same method as the UC test while there is a confining pressure is applied by pumping. It is observable that, the industrial area soils having smaller value than the residential area soils.

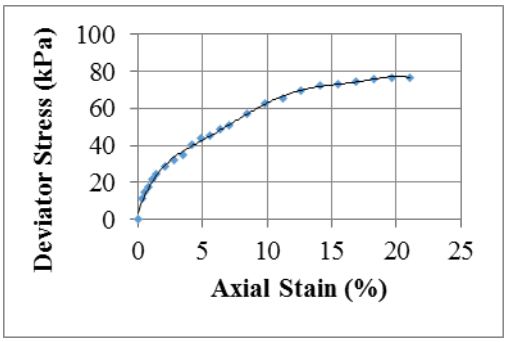

Figure 3: Triaxial Test of the Industrial area soils

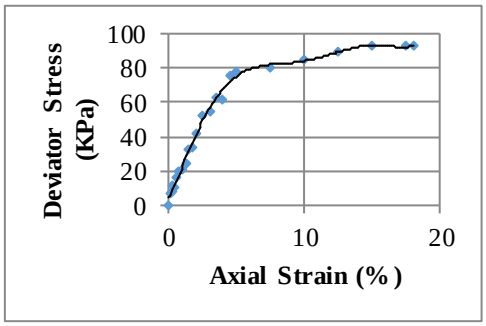

Figure 4: UC Test of the Industrial area soils

Table 2: Tons of ECCE* Lime Required to Rise Soil pH of a 6 – 7 Inch Furrow Slice to pH 6.8 or 6.4 [6].

Buffer Index	Lime Required	
	pH 6.8	pH 6.4
Over 7.1	None	None
7.1	0.5	None
7.0	0.7	None
6.9	1.0	None
6.8	1.2	0.7
.67	1.4	1.2
6.6	1.9	1.7
6.5	2.5	2.2
6.4	3.1	2.7
6.3	3.7	3.2
6.2	4.2	3.7

5. CONCLUSION

1. The abnormality of the pH in the industrial area soils shows the change of soil physiological properties. The soil is a buffer till pH of 6.5. As a result, its acid sensitivity reduces when it reaches to 6.7 - 6.8. At this stage the venerability begins. So, the industrial effect on the soils makes the acid sensitivity to decrease.

2. Since, the possibility of reducing the acid sensitivity makes the clay to sandy particle thus lime treatment can be used to reduce the soil pollution.

3. The triaxial test and the unconfined compression test show the reduction of the stress carrying capacity in the nature of the historic soil physical properties. Since, bearing capacity is directly related to the foundation engineering thus, the foundation of the structures will be in a risk for the acidity in the soil. Thus lime treatment can help the soil to be treatmented.

6. REFERENCES

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