A REVIEW ON EFFECT OF VARIOUS ADDITIVES ON DISPERSIVE NATURE OF EXPANSIVE SOIL

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Abstract - *Expansive soil tends to erode internally when it comes in contact with water. This phenomenon is closely linked to its composition and its dispersivity. Dispersivity is the property of soil by virtue of which soil break down into their component particles when wet. Dispersive clays have a preponderance of sodium cations, whereas ordinary clays have a preponderance of calcium, potassium, and magnesium cations in the pore water. Once a dispersive soil is exposed to water, clay particles may disperse and remain as suspended particles in water. The common soil classification index tests do not distinguish between dispersive and non-dispersive clay soils. The recommended tests for the identification of dispersive clay soils are pinhole test, crumb test and double hydrometer test. In appearance, dispersive clays are like normal clays that are stable and somewhat resistant to erosion, but in reality they can be highly erosive and subject to severe damage or failure. Some natural clay soils disperse or deflocculate in the presence of relatively pure water and are, therefore, highly susceptible to erosion and piping. Dispersivity can be decreased by using several additives like lime, gypsum, polyvinyl alcohol, Nacl etc. In this report the nature of dispersive soil and their resistance to internal erosion with and without various dosages of additives are studied.*

Key Words: **Expansive soil, Dispersivity, Pinhole test, Crumb Test, Double Hydrometer Test, Defloculate**

1. INTRODUCTION

Clay is considered to be highly resistant to erosion by flowing water, however in the last few years it is recognized that highly erodible clay soil exist in nature. Some natural clay soils disperse or deflocculate in the presence of relatively pure water and are, therefore, highly susceptible to erosion and piping. The erosion due to dispersion of soil depends on mineralogy and clay chemistry and the dissolved salts in pore water. These soils are found extensively in United States, Australia, South Africa, Greece, India and Thailand. The principal difference between dispersive clays and ordinary erosion resistant clays appears to be the nature of the cations in the pore water of the clay mass. Dispersive clays have a preponderance of sodium cations, whereas ordinary clays have a preponderance of calcium, potassium, and magnesium cations in the pore water.

1.1 DISPERSIVE SOILS

The soil that are highly susceptible to erosion and containing high percentage of exchangeable sodium ions are known as dispersive soil. Dispersivity of soil is the process in which aggregate in the soil break down into their component particles when wet. The soil particles may be detached from a soil mass and carried off by flowing water. For example, low plasticity silts are composed of single – grained particles that are much larger than water molecules, and the ionic materials in their pore water are chemically inert. These individual particles have little attraction for one another. The erodibility of soil depends on the inter particle attraction and unit mass of the particles. When dispersive soil wets, the structure of the soil collapses and are filled by dispersive clay particles. Sodic topsoil is proved to surface sealing when they dry. This reduces infiltration and aeration leading to poor crop emergence, root penetration and water logging or perched water table.

Dispersive clays erode as the individual colloidal clay particles go in to suspension in still water, whereas considerable velocity in the eroding water is required to erode normal clays. Once a dispersive soil is exposed to water, clay particles may disperse and remain as suspended particles in water. In appearance, dispersive clays are like normal clays that are stable and somewhat resistant to erosion. But in reality they can be highly erosive and subject to severe damage or failure.

2. LITERATURE REVIEW

In recent years, many studies were conducted by various researchers on dispersive clay and their treatment using various additives. Some of the additives are gypsum, lime, polyvinyl alcohol etc. The goal which is expected from the paper is to study the properties of various additives when added to dispersive soil.

2.1 Characterisation of Dispersive Clay

Anand B et.al (2015) aims on the characterization of dispersive soils. Dispersive soils which occur in many parts of the world are easily erodible and deflocculated in water causing serious problems of stability of earth and earth retaining structures. Earth dams constructed on dispersive soils have suffered internal and surface erosion. This paper deals with the best possible evaluation of test methods for confirming and characterizing the dispersive soils. The available test methods for dispersive soils are Crumb Test, Pinhole test, SCS double hydrometer test. Crumb test gave a visual identification on soil dispersivity. Pinhole and double hydrometer test was more reliable in confirming and characterising the dispersive nature.

Dinesh et.al (2011) tell that visual classification, Atterberg's limits and particle size analysis do not provide sufficient basis to differentiate between dispersive clays and ordinary erosion resistant clays. Pinhole test and double hydrometer test are the only two tests that are in vogue to identify the dispersive soils. This paper explores the possibility of using other standard tests such as shrinkage limit and unconfined compressive strength tests to quantify the dispersivity of the soils.

2.2 Additives for Stabilisation of Dispersive Clay

Chegenizadeh. A, et.al (2016) investigated the effect of the partial substitution of lime with ground granulated blast furnace slag (GGBFS) on the strength and mechanical properties of lime stabilised clay by performing a total of 246 volumetric shrinkage strain (VSS), unconfined compressive strength (UCS) and ring shear (RS) tests. The VSS results demonstrated that the addition of GGBFS to lime is very effective in reducing the volumetric shrinkage of lime stabilised clay, and that the reduction in volumetric shrinkage behaviour is linearly related to curing period. The UCS results revealed that the partial replacement of lime with GGBFS led to significantly higher compressive strength for all ageing periods. The ring shear results also demonstrated that the partial replacement of lime with GGBFS led to greater shear strength. Moreover, microstructural studies were performed to better understand the reactions of the mixtures.

Civelekoglu. B and Yilmaz. I (2009) deal with the performance of the gypsum as an additive for treatment of the expansive clay soils by means of swell potential and strength. Optimum water content for the best compaction of the bentonite was first determined by standard compaction tests. Different quantities of gypsum such as 2.5%, 5%, 7.5%, and 10% by mass were added to bentonite and compacted in optimum water content obtained.

Gahlot. P, et.al (2018) explores the characterization, problems due to dispersive soils and their remedial measures to stabilize it. It has been concluded that dispersivity ascertained from strength tests is more reliable. Dispersive soils erode under small seepage velocity leading to problems of stability of earth and earth retaining structures. No concurrences exist in identifying dispersivity of soil by all the four tests. It has to be arrived at by consensus of test results. The Double Hydrometer test and Chemical analysis of pore water extract test are more conservative in showing the dispersion of soil. The pinhole test is more reliable as it simulates field conditions. The crumb test gives a good indication of the soil for potential tendency to erosion. The strength of dispersive soil increases with increase in lime, alum and gypsum content up to certain limit.

Murthy GVLN, et. al (2016) investigates the effect of adding different compounds including Gypsum & NaCl on the engineering properties of silty clay soil. Gypsum is a source of calcium which is major mechanism that binds soil organic matter to clay in soil which gives stability to the soil aggregates. Adding gypsum to soil improved soil structure. Significantly for alkaline soil gypsum is a suitable chemical for improvement of bearing capacity. In this study an attempt is taken to analyse the properties of soil using gypsum and Nacl.

Pavan and Roth (1991) explained the incorporation of lime into samples of an Oxisol can lead to short-term detrimental effects manifested by increased clay dispersion and decreased infiltration, whereas the incorporation of gypsum shows only slight detrimental effects. At the same time, gypsum can decrease the level of exchangeable Al3+ and raise the amount of available phosphorous. Infiltration rates were determined with a rainfall simulator and clay dispersion by measuring clay concentration in runoff.

Phougat N, et. al (2011) explains the necessity to stabilize such soils either mechanically or chemically before using for any construction purpose. Chemically these soils can be stabilized by addition of chemicals like lime, flyash, alum, molasses, cement, bitumen or polymers etc. Polymers show remarkable soil stabilization effect because of formation of bond between clay mineral and polar end groups of polymer. In the present study the dispersive soil obtained from Dundiya Dam, Udaipur, Rajasthan, India has been stabilized using different polymers. The degree of improvement in the engineering properties of such soil has been discussed. By adding polymer, it was noticed that the aggregate size of soil is increasing thus the polymer used for study are effective in binding soil particles. Lowering of LL, PL and PI indicate that on wetting of soil by rain water it will soften to a lesser extent thus making it more suitable for construction of road or lining of dam.

2.3 Estimation of Dipersivity

Isik. N. S, et.al (2017) aims to investigate various factors used for identification of dispersivity and to develop some new approaches for the prediction of dispersivity of clays. To achieve this purpose, physical and index properties, as well as degree of dispersivity of 29 clay samples taken from five different locations in and around the city of Ankara were determined. In addition, crumb and pinhole tests were performed by using test waters with varying total dissolved salts (TDS) values on five selected samples to find the impact of water chemistry on dispersivity. It is concluded from all dispersivity tests that TDS values and sodium percentage (SP) remarkably affect the degree of dispersivity, and the use of these two parameters give more reliable results for the determination of dispersivity.

Itami. K and Kyuma. K (1995) studied the characteristics of soils from a reclaimed area with constraints on the cultivation of fruit trees by comparing with a forest soil that was derived from the same parent material. The reduced plant growth in the reclaimed area was attributed to the poor physical properties of the soil owing to low aggregate stability and high dispersibility of clays. To analyze the factors affecting the dispersion and flocculation behavior, the structural stability of the soil samples before and after Na saturation treatment was investigated. After the treatment, some samples showed a much higher dispersibility than untreated ones, presumably due to the displacement of exchangeable Aluminium as the binding agent by Na. The importance of organic matter is also indicated.

2.4 Management of Dispersive Clay

Arab et.al, (2015) investigated on a dispersive soil treated with lime and pozzolan, experimental measurements of permeability were carried out with varying curing times and percentages of the additives. The results from these measurements were used in establishing an artificial neural network model meant to predict the permeability of more samples while being treated as carrying out laboratory measurements would be time consuming. Six parameters namely percentage passing of the 0.005 mm size (p), plasticity index (PI), maximum dry density (MDD), lime percentage (L), pozzolan percentage (pp), and curing time (t) were the inputs to the model while the output was permeability value. The results show that the multilayer perceptron (MLP) neural network model with nine nodes in the hidden layer was desirable for predicting permeability of dispersive soils while being stabilized by lime and pozzolan, separately or simultaneously.

Chenu et.al (2013) in their work, the proportion of water dispersible clay (WDC), which is considered a good indicator of soil structural stability and sensitivity to crusting and erosion, was determined in all plots of the experiment. The results showed the influence of the valence of cations and pH on soil structure and clay dispersability. Application of sodium or potassium salts deteriorated the degree of soil aggregation, with increased bulk density and WDC values, whereas amendment with manure or calcium salts ameliorated soil aggregation, with decreasing bulk density and WDC. This study emphasizes the role of potassium and ammonium, associated with fertilizer additions, on the deterioration of soil structure and on the increase of the risk of erosion. The strong acidification of the soils receiving ammonium-based fertilizers was another factor related to the increase of water dispersible clay, and therefore the deterioration of soil structure.

Dehghani. and Sayehvand (2014) tells that dispersive clay soils collapse or disperse to form dissolved slurry when in contact with water. In the past dispersive clay soils were not recognized, and failure of several structures occurred before dispersive action was identified. This article presents description of characteristics and problems of dispersive clay soils, tests for identifying and approaches for minimizing erosion risk in dispersive soil. The extent of dispersion depends on the mineralogy and the clay chemistry as well as the dissolved salts of the pore field. In the past, the dispersive clay soils were not recognised, and failures of several structures before dispersive characteristics was identified. In their study, the various tests for characterising soils were discussed. Pore water extract test and chemical tests were also explained in addition to Crumb Test, Pinhole test, SCS double hydrometer test.

Fine et.al (2006) considers the potential of four types of soil amendments, namely gypsum, organic polymers, organic matter waste materials, and fly ash, as soil stabilizers. Addition of gypsum to soil can limit clay swelling and dispersion, and thus improve soil structural stability, by both soil solution electrolyte effects and cation-exchange effects. Synthetic organic polymer addition to soil surface aggregates leads to their stabilization, improved bonding between adjacent aggregates, and clay flocculation. Organic matter, also used for promoting aggregate stabilization, enhances soil microbial activity that transforms the newly added organic matter into polysaccharides and long chain aliphatic compounds capable of binding and stabilizing aggregates. Fly ash additives can improve soil physical characteristics including texture, structure, water holding capacity, hydraulic properties, and aeration. However, fly ash has a number of inherent qualities that under certain circumstances may limit its usefulness for soil stabilization, and which may even result in increased erosion and soil loss.

Adams. T. B, et.al (2013) presents the findings of a preliminary research program that aimed to investigate the mechanisms governing the progression of piping erosion in organic soils and attempted to use the findings to reduce the severity of piping erosion of sand. The research was split into five test phases. In Phase 1, the influence of grain-size distribution was eliminated to develop an understanding of the role that organic matter plays in the erosion process and the results indicated that organic matter likely reduce piping erosion. The second phase excluded both grain-size distribution and individual particle shape and the results further confirmed the connection between organic matter content and erosion resistance. The third phase revealed the positive correlation between the reduced piping erosion and increased organic matter content. The fourth phase investigated the quantitative relationship between certain biologically derived substances (polysaccharides and glomalin) and piping erosion reduction. The final phase comprised of introducing organic matter into mineral soil and quantifying the subsequent changes in geomechanic properties. The results suggested that the introduction of organic materials into mineral soil decreases strength, increases consolidation settlement, and reduces permeability.

3. CONCLUSIONS

Following are the predominant conclusions obtained from the literatures studied:

Dispersive soils occur in many parts of the world are easily erodible and deflocculated in water causing serious problems of stability of earth and earth retaining structures. When the dispersive clay comes in contact with water, the clay fraction behaves more like a single-grained particle with a minimum electrochemical attraction and there by does not adhere or bond with the other soil particles [1, 12, 9]. When dispersive soil wets, the structure of the soil collapses and are filled by dispersive clay particles which ultimately get eroded. The erodibility of soil depends on the inter particle attraction and unit mass of the particles. This causes various structures like earth dams constructed on dispersive soils to suffer internal and surface erosion [4].

Visual classification, Atterberg's limits and particle size analysis do not provide sufficient basis to differentiate between dispersive clays and ordinary erosion resistant clays. Pinhole test and double hydrometer test are the only two tests that are in vogue to identify the dispersive soils. The crumb test gives a good indication of the soil for potential tendency to erosion [10,12]. Lowering of LL, PL and PI indicate that on wetting of soil by rain water it will soften to a lesser extent thus making it more suitable for construction of road or lining of dam.

Polymers are reported to show remarkable soil stabilization effect because of formation of bond between clay mineral and polar end groups of polymer. Chemicals used are effective in binding soil particles and on wetting of soil by water it will soften to a lesser extent thus making it more suitable for construction of road or lining of dam [21]. Gypsum improves the expansive clay soils significantly only up to an addition of 5% and swelling clay soils can be effectively treated by gypsum. It is more effective than lime for the treatment of dispersive soils as it increases the electrolyte concentration. Gypsum can decrease the level of exchangeable Al^{3+} present and raise the amount of available Phosphorous [12, 8, 20]. The minimum addition of lime for dispersive clay treatment is about 2% [20].Synthetic organic polymer addition to soil surface aggregates leads to their stabilization, improved bonding between adjacent aggregates, and clay flocculation [11].

From this review it is clear about various dosages of additives and its effects on the dispersive clay. The properties and their variation under different criteria are studied and well understood from this study.

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