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A SUMMARY OF DISPERSIVE SOIL AND ITS MANAGEMENT

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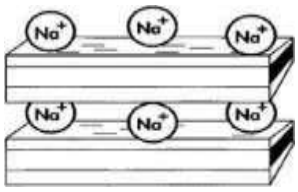
ABSTRACT
Dispersion is a phenomena that occurs when water molecules in between clay platelets in a saline-alkali (sodic) soil cause the clay to dislodge and the platelets to separate from the soil aggregate. Due to the dispersive qualities of soil, it seriously impairs the stability of earthretaining structures or any water retaining structures. Because it is easily erodible and deflocculated in water, structures like embankments, channels, and other regions are at risk of suffering major erosion. Therefore, it is crucial to check for erosion in these applications, especially during times of strong flow. Dispersive soil retains a high potential for swelling and contracting, has poor erosive resilience, and has limited permeability in an undamaged state. The goal of the current study is to investigate the primary characteristics of dispersive soil, identification techniques, issues caused by dispersive soil, and solutions.
Keywords: *Sodic soil, deflocculation, significant tendency for swelling and shrinking, and erosion, difficult and troublesome soils.*

Introduction:

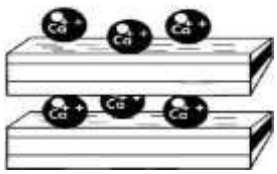
Even though studies have shown that clay is a highly erosive soil in nature, it was previously thought to be non-erosive and extremely resistant to water erosion. The chemistry of the soil, the mineralogy of the clay, and the amount of sodium in the pore and eroding water all have a role in how soils disperse or de-flocculate. Dispersive soils have caused major erosion issues for earth retaining structures, hydraulic structures, road embankments, and other construction projects, leading to their failure as well. Because dispersive clays have different electrochemical forces between particles, small soil particles in them are more repellent in nature. Dispersive clays are classified as CL under the Unified Soil Classification System because they have low to medium plasticity. Dispersive clays, however, may also be found in the ML, CL-ML, and CH categories. The primary distinction between ordinary and dispersive clay is based on the cation properties of the clay mass in the pore water. The dispersive clays contain excess sodium cations ($Na+$), while the conventional clays include excess potassium, calcium, or magnesium cations ($K+$, $Ca2+$, $Mg2+$). The dispersity of the soils can be measured using straightforward methods, but it is extremely challenging to quantify. Dispersive soils play a significant influence in the piping failure of embankment dams, according to Fell et al. (1992), especially for small dams built without filters. Foster et al. (2000) and Rosquoet (2005) conducted statistical analyses that showed that, out of 11,192 hydraulic structures in the ground, 136 had malfunctions, with 48% of them being caused by overflow, 46% by internal erosion, and 6% by landslides. According to Anand et al. (2015), the dispersive soils, which are present in many parts of the world and have erodible and deflocculated features, cause major stability problems in both the earth and earth-retaining buildings. Surface and interior erosion have been seen in earth dams built on dispersive soils. In order to identify between dispersive clays and regular clays,Dinesh et al. (2011) determined that the soil's particle size distribution, visual classification, and Atterberg limits are insufficient. The pinhole and double hydrometer tests are the most effective ways to identify dispersive soils. Dispersive soils' micro structural change and stability were demonstrated by Bhuvaneshwari et al. in 2007. The experiment's chosen soil was very dispersive. The soil's dispersive properties are significantly reduced when lime and fly ash are combined with lime. After adding lime, the percentage of dispersion in the soil, as measured by the double hydrometer method, fell from 71% to 9.5%. The soil was first identified as ND4 by the pin hole test, but with the addition of the right amount of chemicals, it became ND1. The crumb test and the results showed the same outcome chemical testing, too. The SEM study of the microstructural and mineralogical alterations also reveals the alteration in material and void spaces as a result of the chemical reactions started by the additions. For non-cohesive soils, Umesh et al. (2011) showed that erosion resistance comes from the weight of the deposit submerged in the soil (gravity forces). In contrast, cohesive soil erosion is primarily caused by the interaction of eroding fluids with soil structure near the surface. The researcher also looked at how shear stress, which is necessary to start the erosion process, will be affected by factors like the type and amount of clay, soil pH, the amount of organic matter, temperature variation, thixotropy, moisture content, and ionic concentration in the voids and eroding fluids.

SOIL BEHAVIOR IN WATER, SODIC AND NON-SODIC:



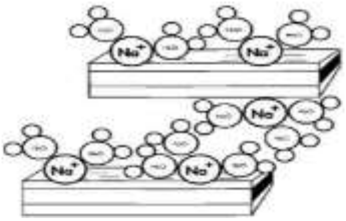
sodium adsorbed on the
surface of sodic soil

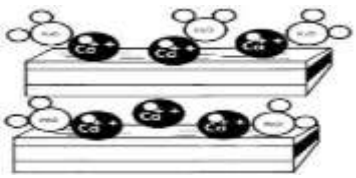
(SODIC SOIL)



calcium adsorbed on
the surface of clay

(NON-SODIC SOIL)





water is attracted towards sodium swelling is due to the interaction of water
When water is added to a sodic soil and the platelets in the
non-sodic soil

(SODIC SOIL+WATER) *(NON-SODICSOIL+WATER)*

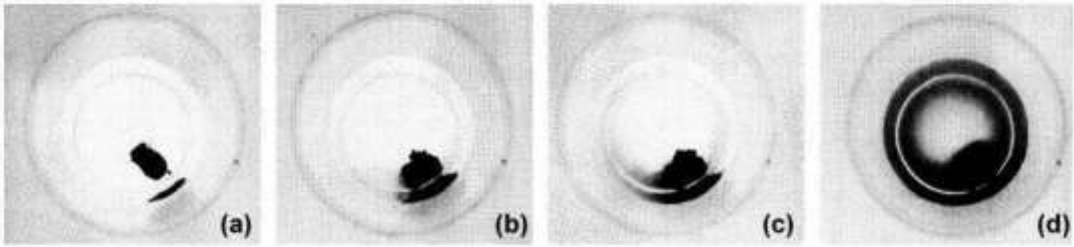
Figure 1: Interaction of water with sodic soil

DETERMINATION OF SOIL DISPERSION

Atterberg's limits, specific gravity, and particle size distribution are not sufficient criteria to distinguish between dispersive and regular resistant clays. As a result, many more useful laboratory studies are being carried out to assess the properties of dispersive clays. These tests include the SAR (sodium absorption ratio), double hydrometer, pinhole, and crumb tests as well as the measurement of dissolved salts in the pore water.

I. **CRUMB TEST:** The crumb test is regarded as the easiest technique for identifying dispersive clay and a good positive indicator when analysing the dispersive properties. A little piece of clay, measuring between 0.6 and 0.9 cm in diameter, is placed in a 250 ml transparent plastic glass that has been partially filled with distilled water to conduct the test. The use of other alternatives or dematerialized water must be avoided to prevent falsified test findings. If the soil doesn't become extremely wet, the lump or crumb must be at its normal moisture level. The crumbis was dropped on the glass' bottom edge and left there for at least an hour.

After that, the water and crumb are examined, and any colloidal cloud in the water is looked for. It is also advised to take another look after leaving the clod in the glass for the night because some soils react insignificantly after 60 minutes as opposed to significantly after the extended waiting period.



a) Non dispersive b) Intermediate c) Dispersive d) Highlydispersive

Figure 2: different result from crumb test

II. **PINHOLE TEST:** A needle is inserted in the centre of the soil sample to perform a direct way of testing the water flow through dispersibility of compacted fine-grained soils. The test is also used to determine the treatment rate needed to lessen the soil sample's susceptibility to erosion. Distilled water pours into the sample hole at the designated heads. The flow rate is carefully monitored to see if it is growing with erosion, and the water is carefully checked for turbidity. The efficiency of chemical alterations for dispersive clays is also evaluated using the pinhole test. Different soil samples are created using various degrees of a chemical additive treatment to determine at which rate the erodibility reduce

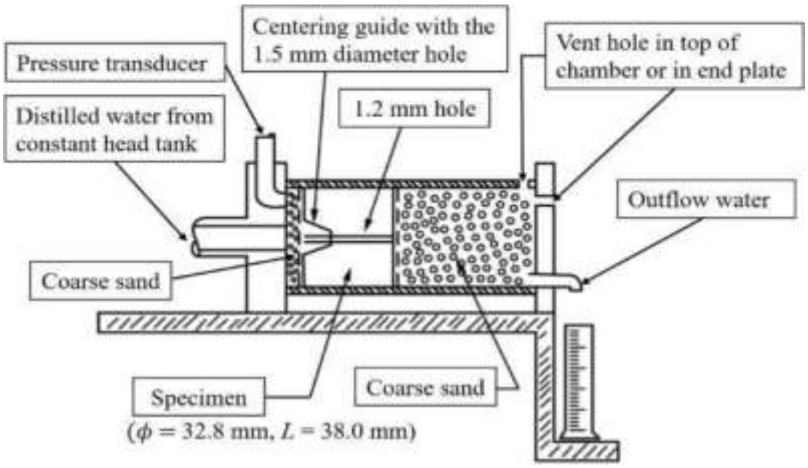


Figure 3: Pinhole Test Apparatus

Table 1: Interpretation of data from pinhole test

Rating	Nature of soil
D-1 / D-2	Dispersive but require special designs
ND-1	not dispersive
ND-2, ND-3 or ND-4	slightly or moderately dispersive

1) **SCS test or the DOUBLE HYDROMETER test:**

One of the tests to evaluate the dispersiveness of clay soil is the Soil Conservation Service (SCS) dispersion test, often known as the Double Hydrometer test. Essentially, this test is used in the lab to prepare and compare two samples. The first step in the study of grain size is to artificially disperse a soil sample in distilled water using a chemical dispersant before using a standard hydrometer to measure grain size. The results of the two samples are compared when another sample is created in the same way but without the addition of any chemical dispersion.

Table 2: Interpretation of degree of dispersion from double hydrometer test

% of dispersion	degree of dispersion
greater than 60 %	probably dispersive
30 % - 60 %	considered dispersive for design purposes
Less than 30 %	not dispersive

2) CHEMICAL TEST:

This test, which is frequently the least performed, is carried out in a lab to examine soil dispersion. In this test, a sample of pore water from a saturated slurry of soil is obtained for cation measurement. To determine the relative abundance of exchangeable cations, chemical analyses such as Exchangeable Sodium Percent and Sodium Absorption Ratio (SAR) can be carried out.

Table3: Interpretation of degree of dispersion fromchemical test at normal salt concentration

% of dispersion	degree of dispersion
more than 60 %	Dispersive
40 % - 60 %	Intermediate
Less than 40 %	not dispersive

a. ESP test (Exchangeable Sodium Percent) is frequently used to analyse dispersive soils.

$$ESP = \frac{Na^{+}}{+Mg^{2+} + K^{+} + Ca^{2+}} X\ 100Na^{+}$$

b. The SAR approach is typically used to quantify sodium's contribution to calcium and magnesium levels in order to assess soil dispersion.

$$SAR = \frac{Na^{+}}{\sqrt{0.5\ (Ca + Mg)}} meq/l$$

ENGINEERING ISSUES INVOLVING DISPERSED SOILS

Due to presence of dispersive clay soil many engineering problems may arise such asstructural failure, construction problems and internal erosions.

a) erosion-related gullies and rills on the slopes
b) Failure of the dam embankment
c) the tunnel eroding
d) the canal failing
e) the fill collapsing
f) the pipelines and cables failing
g) Breaching septic trenches
h) insufficient conduit compaction

PROCESS OF DISPERSIVE SOIL REMEDIATION

By adjusting the technical qualities of the soil through stabilisation, it is crucial to make dispersive soils suitable for building by enhancing their strength and durability and reducing their compressibility, swelling, or shrinkage. Typically, dispersive soil is treated by replacing the soil, but this is expensive, thus other solutions are used instead. employing sand filters and

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sand blocks, chemical stabilisation, novel compaction techniques, etc., for dispersive soil

1. **Chemical Stabilization:** Here, the original structure of the minerals is broken down into a fresh, stabilised mineralogical arrangement. The dispersive soil can be stabilised with the following substances to make it useful for construction.

a) **Calcium hydroxide or hydrated lime:** Lime is frequently used in earth dams to stop pipes. The rate of treatment has changed depending on the soil and level of compaction. Nearly 0.5 – 1.0% hydrated lime is needed to prevent dispersion. However, when there are issues with application and mixing, higher rates of application are needed. Up to a specific range known as the optimum lime percent, the strength of the clayey soil improves with an increase in lime percent and depends on the amount of clay and reactive silica in the soil. It has been observed that treating dispersive soil with lime increases the soil's strength by lowering settling.

b) **Gypsum/dihydrate calcium sulphate:** It is thought to be more successful than applying lime to treat dispersive soils because it raises the concentration of electrolytes and sodium-calcium that are displacing sodium in the soil solution. Gypsum is utilised less frequently than hydrated lime in the construction of dams and other construction projects due to its lesser solubility and greater rate. It has been shown from numerous research that gypsum should be used in building at a minimum of 2% by weight.

c) **Alum or Aluminum Sulphate:** It serves to protect embankments from erosion and prevent dam failure. It can be inferred from the limited research that combinations containing 0.6 to 1.5% of the total dry weight of soil are appropriate. Due to the high acidity of alum (pH 4 to 5), topsoil must be applied to soils treated with alum in order for vegetation to grow. Soil testing is necessary to determine application rates.

d) **Sulphuric Acid:** It is a caustic, oily liquid substance that is roughly 95% pure. When sulfuric acid is applied to soils containing calcium carbonate, the calcium carbonate rapidly reacts and forms calcium sulphate, which indirectly provides soluble calcium.

e) **Pozzolanic Materials:** When used as an additive material, natural pozzolana from various geographic regions exhibits a variety of qualities due to their varied chemical compositions. According to various test results, the biggest reduction in dispersion percentage occurs when 5% pozzolana material is added to the soil.

Compaction:

Ritchie (1965) asserts that the degree of compaction is the most important factor in minimizing the risk of dam failure due to piping or tunnel erosion. A high degree of compaction lessens the severity of dispersion, as well as reducing soil permeability and limiting the movement of water and scattered clay in the soil structure, according to several research. Dispersive soils should be compacted at water content between 1.5 and 2% above the OMC (optimum moisture content), according to Elges (1985), Bell & Bryun (1997), and Bell & Maud (1994), in order to obtain MDD (maximum dry density), which helps to reduce piping failure. Therefore, in order to attain that density, graders, bulldozers, and excavators do not adequately contribute to compaction effort. Therefore, to compact dispersive soil, a sheep-foot roller with an approximate weight (pressure9.3kg/cm2) is required.

2) **<u>Sand barriers and blocks:</u>** Sand filters can be used to prevent dam failure. The sand filter's mechanism is located at the tunnel's exit; it captures sand and silt that would otherwise block the tunnel and stop further tunnel expansion. Sand blocks and sand filters are slightly different from one another. Free water rises to the surface in sand blocks through the sand particles.
3) **<u>Other necessary measures:</u>** If at all feasible, the top soil and vegetation should be left in place, and the dispersive soil should have a sufficient layer of top soil on top of it. It is best to avoid using construction methods that expose dispersive subsoil. Runoff should not be dumped in regions with dispersive soils; instead, safe places should be established for the discharge of runoff. Drains and culverts built in dispersive subsoils need to be appropriately covered with non-dispersive clays blended with topsoil, plants, and gypsum.

CONCLUSION:

The structural stability of earth and earth retaining constructions is primarily impacted by dispersive soils. The description above provides a clear understanding of the dispersion mechanism. It can be said that dispersive clay cannot be distinguished from regular erosion-resistant clay just by visual classification, grain size distribution, or Atterberg's limit. Special tests including the crumb test, pinhole test, double hydrometer test, and chemical test are needed to identify dispersive soil. This essay demonstrates how sodic soil interacts with water, numerous ways to spot dispersive soil, engineering issues brought on by dispersive soil, and various solutions to these issues.

Strategies like chemical stabilisation, degree of compaction, and use of sand barriers are considered to be excellent methods for developing the engineering properties & strength characteristics. And as a result, the high value of sodium dissolved cations in their pore water can be lowered, allowing the strength to be increased. One or a combination of precise degree of compaction, chemical improvement, capping with non-dispersive clays, sand filters, and suitable top soiling can be used for the building of dams, highways, culverts, and tunnels in dispersive soil

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