

DISPERSIVE CLAY SOILSINTRODUCTION

Dispersive clay soils can be a problem for many practices or structures. In appearance, they 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. It is important to understand the nature of these soils and to be able to identify them so they can be treated or avoided.

PROPERTIES OF DISPERSIVE CLAYS

Dispersive clays differ from ordinary, erosion resistant clays because they have a higher relative content of dissolved sodium in the pore water. Ordinary clays have a preponderance of calcium and magnesium dissolved in the pore water.

Ordinary clays have a flocculated or aggregated structure because of the electrochemical attraction of the particles to each other and to water. This accounts for these soils' cohesive, nonerosive behavior.

Dispersive clays have an imbalance in the electrochemical forces between particles. This imbalance causes the minute soil particles in a dispersive clay to be repulsed rather than attracted to one another. Consequently, dispersive clay particles tend to react as single-grained particles and not as an aggregated mass of particles.

Dispersive clays are most easily eroded by water that is low in ion concentration, such as rain water. Runoff water has the opportunity to attain ions from land surface contact making it more in ionic balance with the dispersive clays and less erosive.

Typically, dispersive clays are low to medium plasticity and classify as CL in the Unified Soil Classification System (USCS). Other USCS classes that may contain dispersive clays are ML, CL-ML, and CH. Soils classifying as MH rarely contain dispersive clay fines.

INVESTIGATING AND SAMPLING FOR DISPERSIVE CLAYS

Observation of the project area for dispersed soils indicators, such as "badland" erosion or multiple rills with close spacing, should always be a part of the investigation process for a structure. Local knowledge of a project area is often the best source of information on the existence of soils with a dispersive behavior.

Color is not a reliable distinguishing feature for identifying dispersive soils.

Sampling for dispersion testing should recognize that dispersive clays often occur as random lenses in soil profiles. A number of samples may be required to determine the extent of dispersive soils in a project area.

A minimum of 10 pounds of moist soil must be collected. Samples collected for dispersion tests must be maintained at their natural water content until tests can be performed. Collected samples should immediately be placed in a good quality plastic bag that can be sealed for shipping.

TESTS FOR DISPERSION AND RESULT INTERPRETATION

Standard soil mechanics tests, such as gradation and Atterberg limits, do not distinguish dispersive clays from ordinary clays. A special group of tests is needed to identify dispersive clays.

1. Crumb test

The crumb test is the simplest of the tests used for detecting dispersive clays. Crumb tests are often performed during an investigation to supplement laboratory information on samples collected.

The test is performed by gently placing a clod of soil about 1/4 to 3/8 inch in diameter into a transparent plastic glass partly filled with distilled water. Using demineralized water or other substitutes gives misleading test results. Typical glasses have a capacity of 9 fluid ounces. The clod or crumb should be at natural water content unless the soil is very wet. Very wet soils may be air-dried to about their plastic limit before performing the test. The crumb is dropped at the edge of the glass bottom and left in the glass undisturbed for a minimum of 1 hour. At the end of the waiting period, the clod and water are observed and the presence of any colloidal cloud in the water is evaluated. A second observation is recommended after leaving the clod in the glass overnight. Some soils have no reaction after 1 hour, but have a significant reaction after the longer waiting time.

A grade is assigned to the test result using the following criteria:

1. No colloidal cloud develops. Even though the crumb may slake and particles spread away from the original clod because of this slaking activity, no trace of a colloidal cloud is observed in the water.

2. A colloidal cloud is observable, but only immediately surrounding the original clod. The cloud has not spread any appreciable distance from the crumb.

3. A colloidal cloud emanates an appreciable distance from the crumb. However, the cloud does not cover the bottom of the glass, and it does not meet on the opposite side of the glass bottom from the crumb.

4. The colloidal cloud spreads completely around the circumference of the glass. The cloud may not completely obscure the bottom of the glass, but the cloud does completely cover the circumference of the glass. In extreme cases, the entire bottom of the glass is covered by the colloidal cloud.

Figure 1 illustrates the four grades of the crumb test.

The crumb test is a good positive indicator for dispersive characteristics, but may be a poor negative indicator. Soils that have a 3 or 4 reaction in this test are almost always dispersive in other tests and in field performance. Special design features should be incorporated if these soils are to be used in a project.

Soils that have a 1 or 2 crumb test reaction occasionally are shown to be dispersive in other tests or field performance.

A second test, such as the double hydrometer test, should be performed to verify the dispersion characteristics of soils grading as a 3 or 4 in the crumb test and to detect any dispersive properties of soils grading as a 1 or 2.

2. SCS double hydrometer test

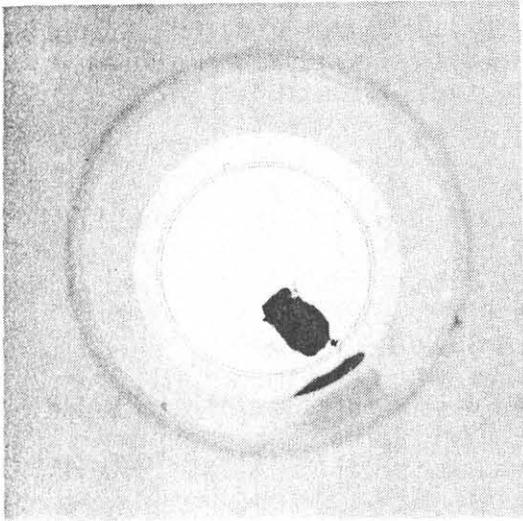
This test is performed in the laboratory. Basically, the test compares the measured percentage of clay in a sample that has been artificially dispersed to that of a companion sample which has no artificial dispersing agent added.

Based on SCS experience correlating test results and field performance, the following general guidelines have been developed for interpreting the test results:

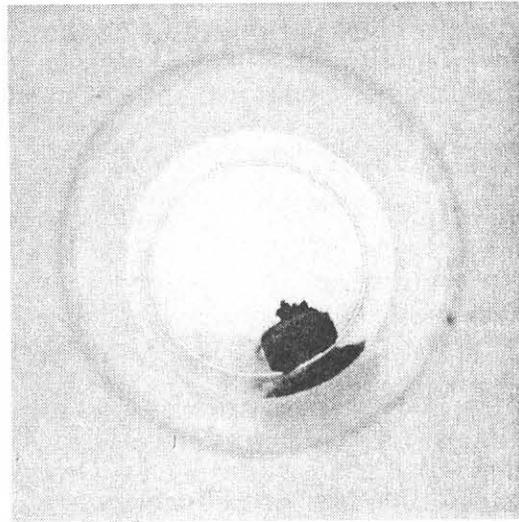
% Dispersion >60 - The soil is probably dispersive. Avoid use of the soil or incorporate special design features in the project.

% Dispersion <30 - The soil is probably not dispersive.

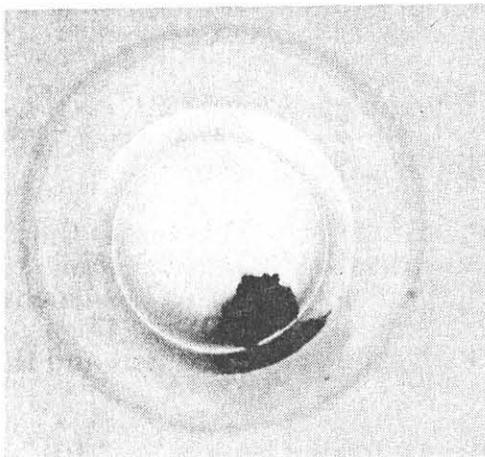
30% to 60% Dispersion - Other tests may be needed to establish whether the sample is significantly dispersive. The soil should be considered dispersive for design purposes.



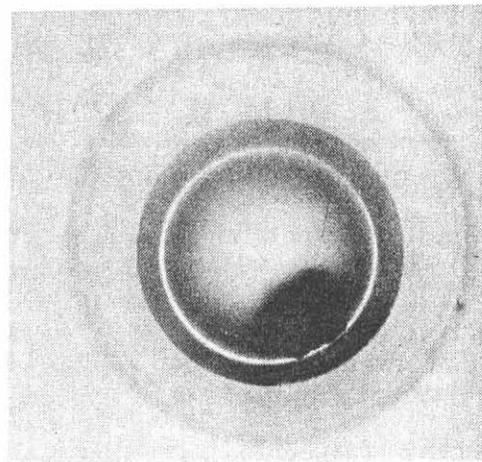
Grade 1 - No reaction



Grade 2 - Slight Reaction



Grade 3 - Moderate Reaction



Grade 4 - Severe Reaction

Figure 1. Typical Crumb Test Reactions

3. Pinhole test

The pinhole test is performed in the laboratory and is a direct, or performance, test. Comparison of field performance to pinhole test results have indicated an excellent correlation.

Another important use of the pinhole test is to determine efficiency of chemical amendments for dispersive clays. Soil samples are prepared with a range of treatment rates of a chemical additive, and the pinhole test is used to determine what rate of treatment is necessary to achieve erodibility reduction.

In the pinhole test, a sample of soil at its natural water content is compacted into a plastic cylinder. A hole is formed in the specimen by inserting a needle through the center of the specimen. Distilled water under specified heads flows through the hole in the specimen. The water is carefully observed for turbidity, and the flow rate is closely monitored to determine if the hole in the sample is enlarging by erosion.

Dispersive clays will rapidly erode as water flows through the 1 millimeter hole under a small water head pressure. Rapid enlargement of the hole is reflected in an increasing flow rate and the turbidity of the collected water.

Pinhole tests results are recorded and interpreted using the following system:

A rating of D-1 or D-2 indicates the soils are dispersive enough to require special designs if the soils must be used in the project.

A rating of ND-1 indicates the soil is not dispersive.

A rating of ND-2, ND-3, or ND-4 indicates the soils are slightly to moderately dispersive. Some defensive measures may need to be incorporated into the design.

4. Chemical test

This laboratory test is the least frequently performed of the dispersion tests. In this test, a sample of pore water is extracted from a saturated slurry of a soil sample and analyzed for cations.

At normal salt concentrations, soils with more than 60 percent of their total salts being sodium are dispersive. Soils with less than 40 percent of their total salts being sodium are usually not dispersive. Soils with 40 to 60 percent sodium are transition in dispersive characteristics.

ENGINEERING PROBLEMS ASSOCIATED WITH DISPERSIVE SOILS

Dispersive clay soils have contributed to the failure of many conservation practices. These problems range from the complete breaching of embankment, to severe erosion of earth fills and excavations. The problems may be placed into two broad categories.

Erosion of external soil slopes

Rainfall and runoff on exposed slopes of dispersive clays can cause severe erosion. Cut slopes in natural soils and slopes of earthfills may both be affected. The erosion usually results in severe rilling and gulying on the slopes.

Clay liners are often constructed in animal waste storage ponds to prevent seepage of the wastes to groundwater. Clay liners that contain dispersive soils may erode rapidly and lose effectiveness.

Internal erosion

Earthfills constructed of dispersive clays have failed because of internal erosion through cracks or other openings in the fill. Water flowing through a crack rapidly enlarges the crack, creating an irregularly shaped tunnel through the fill. The primary causes of cracking in earthfills are drying, differential settlement, and poor compaction around conduits. Failures usually occur when the fills are first subjected to water storage.

DESIGN MEASURES FOR DISPERSIVE CLAYS

When dispersive clays are detected in a site investigation and verified by testing, defensive measures must be incorporated into the design. The designer must base any special design features on the severity of the dispersive characteristics of the soil. Some of these measures are summarized below.

Embankments

If nondispersive soils can be located, designate that borrow source for construction of the entire embankment. If the volume of nondispersive soils in the borrow area is not adequate to construct the entire embankment, the construction plans should designate nondispersive materials as a blanket for the embankment. The blanket thickness should be 12 inches. The blanket protects the underlying dispersive clays from drying cracks and erosion by rainfall.

Internal erosion will still need to be addressed. The most effective design measure for preventing internal erosion of earthfills is a sand chimney filter. Sand diaphragms around the conduit are an effective method of controlling internal

erosion in that area. Detailed procedures for designing sand filters are given in Soil Mechanics Note SM-1.

Placement of dispersive soils into specified zones of an embankment may be incorporated in the design if the zone is not relied upon as a barrier to seepage or internal erosion. If this is not the case, sufficient quantities of nondispersive clays must be located to construct a low permeability foundation cutoff and core zone in the earthfill.

Exposed slopes of the fill can be treated with chemical amendments to alter dispersive clays and make them suitable for use on external slopes of embankments. Laboratory pinhole tests are needed to determine the amount of chemical to be added to the soil to achieve the desired result. Some chemical amendments that may be considered are hydrated lime, alum, fly ash, gypsum, agricultural lime, and magnesium chloride.

Waste storage pond liners and excavated slopes

Dispersive soils can be overexcavated and replaced or blanketed with nondispersive soils to the lines and grades required on the construction plans. This is the recommended design feature for waste storage ponds.

Chemical amendments described under "Embankments" may be used to treat exposed dispersive soils on excavated slopes. This treatment is not recommended for waste storage ponds.

4-WI-56

This page intentionally left blank.

EFH NOTICE 210-WI-62