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# Determining of Thickness of Cohesive Non Swelling Soil Layer for Canal Lining

**P.Sanjay Chandra**
**M.Tech – GEO-Technology**

**G.Venkatarathnam**
**Master of Engineering**

## Abstract:

The main aim of this project is “determining the thickness of cohesive non swelling soil layer for canal linings”. Bureau of Indian standards evolved the guidelines for canals in expansive soils by introducing cohesive non swelling soils (CNS) with a suitable thickness depending up on the swelling characteristics of the expansive soils. This CNS is introduced between expansive soil mass and the lining material to counter act the effect of swelling pressure. This code was introduced in 1985 as code no 9451. IS code prescribed the specifications of CNS stating that these soils should posses the cohesive property over and above 0.10Kg/cm2 depending upon CNS soil. This CNS soil shall be non expanding clay mineral having low plasticity and liquid limit not exceeding 50.

Some of the soils which may be considered as CNS are all adequately compacted clayey soils, silty clays and gravelly sandy clays exhibiting cohesive properties and containing predominantly non expanding clay mineral having a minimum of cohesion of 10KN/m2 (0.10Kg/cm2) and swelling pressure not more than 15KN/m2 (0.15Kg/cm2) for the soil compacted to MDD and OMC. Subsequently BIS 9451-1985 was modified and updated during 1994 and the following are the requirements specified, maximum swelling pressure should be 10KN/sq m as against 50KN/sq m specified in earlier code and also that most morrum of aterites, laterite type and siliceous sandy clays exhibit CNS characteristics.

## Keywords:
Canal Lining, SoilMechanics, Thickness, Plasticity, Cohesive properties, Swelling, CNS.

## Introduction:

Soil is a mixture of minerals, organic matter, gases, liquids, and countless organisms that together support life on Earth. Soil is a natural body called the pedosphere which has four important functions: it is a medium for plant growth; it is a means of water storage, supply and purification; it is a modifier of Earth's atmosphere; it is a habitat for organisms; all of which, in turn, modify the soil. Soil types are classified according to many more factors. They are classified on the basis of colour, depth, pH, productivity, texture and process of formation.

Soil types according to depth are as follows:
1)Shallow Soil - Soil depth less than 22.5cm. Only shallow rooted crops are grown in such soil, e.g. Paddy, Nagli.
2)Medium deep soil - Soil depth is 22.5 to 45cm. Crops with medium deep roots are grown in this type of soil e.g. Sugar cane, Banana, Gram.
3)Deep soil - Soil depth is more than 45cm. Crops with long and deep roots are grown in this type a soil e.g. Mango, coconut Major soil types in India
The main types of soil in India are as follows:
1)Red soils
2)Laterites and lateritic soil
3)Black soil
4)Alluvial soils
5)Forest & hill soils
6)Peaty and marshy soils

## Canal lining

Canal lining is the process of reducing seepage loss of irrigation water by adding an impermeable layer to the edges of the trench. Seepage can result in losses of 30 to 50 percent of irrigation water from canals, so adding lining can make irrigation systems more efficient. Canal linings are also used to prevent weed growth, which can spread throughout an irrigation system and reduce water flow. Lining a canal can also prevent water logging around low lying areas of the canal.

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## Canal lining types

### Concrete

Concrete canal lining is often used due to its high structural strength and longevity. Concrete used for canal lining is typically non-reinforced, as a way to reduce cost. A common method for constructing concrete lining is the use of slip forms, which are drawn down the length of the canal as the concrete is poured. Hand laying of concrete or prefabricated sections are also used when only a short distance needs to be covered.[ Certain additives, such as kankar lime and surkhi, are sometimes included in the concrete mixture to improve water retention.

### Compacted soil

Compacted clay is a simple form of soil canal lining, which serves as a relatively cheap alternative to other methods. Certain clays, such as bentonite, have high water absorption but then become impervious, which makes them an ideal soil lining. It has been shown through studies done in the U.S., that a layer of bentonite 2 to 5 cm thick, underneath a layer of earth 15 to 30 cm thick, makes for an adequate lining system. Typically, porous soils are removed before compacted clay is applied to the bed and sides of a canal.

### Plastic membrane

Plastic linings are often referred to as geomembranes or flexible membrane linings. Plastic linings are often covered with soil, rocks, brick, concrete or other material. This is done in order to anchor the lining down and to protect it from deterioration and disintegration. Plastic membranes are very thin, varying in thickness from 8 up to 100 thousandths of an inch. Low-density polyethylene (LDPE) film, similar to the material used in trash bags, is a common type of plastic membrane used. Plastic linings are also used as a method of retrofitting damaged concrete linings.

### Expansive Soil

Expansive soils contain minerals such as smectite clays that are capable of absorbing water. When they absorb water they increase in volume. The more water they absorb the more their volume increases. Expansions of ten percent or more are not uncommon. This change in volume can exert enough force on a building or other structure to cause damage. Cracked foundations, floors and basement walls are typical types of damage done by swelling soils. Damage to the upper floors of the building can occur when motion in the structure is significant. Expansive soils will also shrink when they dry out. This shrinkage can remove support from buildings or other structures and result in damaging subsidence. Fissures in the soil can also develop. These fissures can facilitate the deep penetration of water when moist conditions or runoff occurs. This produces a cycle of shrinkage and swelling that places repetitive stress on structures.

## CAUSES FOR DAMAGES DUE TO EXPANSIVE SOILS:

1) When a structure is built on the black cotton soil in the dry seasons, there may be no damage to the structure in that season. During the rainy season the moisture in the soil causes swelling and the load bearing capacity of the soil under the structure decreases, which causes uneven settlement leading to cracks in the walls.
2) Due to uneven settlement the beam gets deflected which endangers the safety of the structure.
3) Small fissure cracks are seen on the floors and on the walls.
4) Due to high degree of expansive soils, the buildings may fail which will be very dangerous.

## CNS TECHNOLOGY:

In this technology we intercept cohesive Non-Swelling soil layer below the shallow foundations on expansive soils. Thus CNS concept based on self equilibrating phenomenon with a difference that clay minerals present in CNS are non-expanding such as kaolinite and chlorite etc. the thickness of CNS needed to prevent transmission of swelling pressure and heave to the foundation. Thickness depends up on swelling pressure, heave, indeproperties, density and compression index of under laying expansive soil and also on the index properties, density and compression index of CNS material.CNS can be obtained as a natural material or can be made produced by blending two or more materials

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The CNS layer techniques have also been recently introduced in India for canal lining foundation of cross drainage structures and buildings on expansive soils. R.K.KATTI(1979) developed a technique by whereby removal of 1m expansivesoil and replacing it by cohesive non swelling soils (CNS) layer beneathfoundations has been yielded satisfactory results. Most mudrooms oflateritic, late rite type and siliceous sandy clays exhibit CNS characteristics.The cohesive bonds developed around the particles at a faster rate 5han theingress of water molecules into the expanding lattice of montmorillonite clay,thereby reducing heave. The heave of expansive soil underlying a CNS layerreduces exponentially with increase in thickness of the CNS layer and attainsa value of no heave around a depth of 1m the shear strength and ultimatebearing capacity have found to be increase than before.

## COHESIVE NON-SWELLING SOILS (CNS) FOR TREATMENT:

1. They are soils possessing the property of cohesion of varying degree and non expanding type clay minerals such as illite and kaolinite and their combination with low plasticity with liquid limit not exceeding 50percent.
2. Some of the soils which may be considered as cohesive non-swelling soils are all adequately compacted clayey soils, silty clays, sandy clays, gravelly sandy clays etc, exhibiting cohesive properties and containing predominantly nonexpanding type clay minerals.
3. CNS material should be non-swelling with a maximum swelling pressure of 10km/m2 when tested in accordance with IS 2720 (part 41): 1977 at optimum moisture content and minimum cohesion (unconfined compression strength on saturated compacted soil, remolded at OMC and compacted to standard proctor density) should be 10KN/m2 when tested according to IS 2720 (part 10): 1991.
4. If given CNS material is not available, designed mix to produce blended CNS many be used. The artificial CNS should satisfy all the requirements of CNS. If stabilizes material is to be used. Special mix design needs to be evolved.

## IDENTIFICATION OF CNS MATERIAL:

The CNS material can be identified by using A-line chart: Use of A line chart is made for general identification of the CNS material. In this method the data required is only liquid limit and Plastic index. The CNS soil as to resist internal erosion due to seepage and form suitable base for lining. The soil with liquid limit less than 30% and plastic index less than 15% is not considered suitable. The zone covered between liquid limit 30 to 50% and plastic limit 15 to 30% is shown hatched. Soils falling in this zone can be considered suitable to be used as CNS material. However, it is desirable to have a few representative samples tested for swelling pressure as a cross check. In case of sample failing in Zone A of the chart, it would be necessary to ascertain swelling pressure and cohesion of such sample before accepting the same as CNS material. CNS soil normally should not exhibit swelling pressure, but in exceptional cases swelling pressure less than 0.1 kg/cm2 is acceptable, minimum cohesion should be 0.1kg/cm2 (10kn/m2)

## PHYSICAL PROPERTIES OF CNS SOILS:

Most morums of the laterite, laterite type and siliceous sandy clay exhibit CNS characteristics, however some morums may be of swelling type. Unlike swelling soils, they do not exhibit cracking during summer, nor having and stickiness during rainy season structures constructed on such soil do not exhibit heave though they may sometime settle. The CNS are generally red, reddish yellow, brown yellow, white, whitish grey, whitish yellow, green and greenish grey in color. All though, several soils containing non-expanding type clay mineral exhibit CNS properties, the following range helps in locatingsuch types.

| Properties | Range |
|---|---|
| 1. clay(<2microns) | 15-20% |
| 2. Silt (0.06mm-0.002mm) | 30-40% |
| 3. sand (2.0- 0.06mm) | 30-40% |
| 4. Gravel (>2mm) | 0-10% |
| 5. liquid limit | 30-50% |
| 6.plastic limit | 15-30% |

## LABORATORY TESTS OF SOILS

## SIEVE ANALYSIS (IS: 2720 PART 4-1985)

## OBJECTIVE:

To determine the sand content in a given soil sample.
APPARATUS:

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1. A set of sieves 4.75mm, 2.36mm, 1.18mm, 0.6mm, 0.3mm, 0.15mm, 0.075mm and lid and pan conformed by (IS: 460(part 1)-1978).
2. Weighing balance: Sensitive to 0.1percent of the mass of sample to be weighed.
3. Balance of capacity 500grm and sensitivity 0.01grm.
4. Tray: two or more large metal or plastic watertight trays
5. Oven: thermostatically controlled to maintain the temperature between 105 and 110 degrees, with interior non-corroding material.
6. Brush: sieve brushes and a wire brush or similar stiff brush
7. Sieve shaker.
8. Pans.

**PROCEDURE:**

1. At first the soil sample that is brought from various places will be in red condition and allow it to dry for some time under atmospheric condition.
2. The samples sometimes will be in boulders form. So before going to test for mesh the soil with the help of wooden hammers and passing to the sieve of 4.75mm.
3. 500grm of soil passing 4.75microns sieve is taken in a tray
4. Now fill the water in to the tray and allow it settle for 24hrs.
5. After 24hrs take the tray and pour it into a bucket which contains 75mm sieve at the bottom of the bucket
6. Place the soil in the sieve and gently pour water over the soil so that it wets the soil and remove the fine particles in the form of mud, leaving only the sand and gravel size particles in the sieve.
7. Transfer the soil retained in the sieve after washing in to a tray. Invert the sieve into the tray and pour water gently so that all the soil particles retained in the sieve transferred in to the tray.
8. Keep the tray in the oven for 24hrs at 105 degrees it to dry it completely.
9. Now remove the tray from the oven and pass into the set of sieves and shake it with the help of sieve shaker.
10. Weigh the oven dry soil in the tray(w).
11. The weight of fine grained soil is equal to (500-w)gms.
12. Clean the sieve set so that no soil particles were struck in them.
13. Arrange the sieves in order such that coarse sieve is kept at the top and the fine sieve at the bottom. Place the closed pan below the finest sieve.
14. Take the oven dried soil obtained often washing in to the top sieve and keep the lid to close the top sieve.
15. Position the sieves setting the sieve shaker and sieve the sample for a period of 10minits.
16. Separate the sieves and weigh carefully the amount of soil retained on each sieve, this is usually done by transferring the soil retained on each sieve on a separate sheet of paper and weighing the soil with the paper.

**HDROMETER ANALYSIS (IS:2720 PART 4-1985)**

**OBJECTIVE:**

To determine the silt and clay content of the given soil sample.

**APPARATUS:**

1. Hydrometer
2. Dispersion cup.
3. Glass measuring cylinders: two of 1000ml capacity with ground glass or rubber steppers about 7cm diameter and 33cm high marked at 1000ml volume.
4. Sieves 2mm, 425micron, 75 micron, is sieves and receiver.
5. Balance: To weigh up to 0.001g.
6. Thermometer: to cover the range 0.50C accurate to 0.5C
7. Sodium hexametaphosphate solution: dissolve 33grm of sodium hexametaphosphate.
8. Glass rod: about 15 to 20cm long 4 to 5mm in diameter fitted at one end with a rubber policeman.
9. Wash bottle- containing distilled water
10. Stop watch.

**PROCEDURE:**

1. Take 50gm of soil sample in a cup and add 5gm of sodium hexametaphosphate.
2. Sodium hexametaphosphate is added I order to free the particles which are attached together.
3. Add 250ml of water to this mixture.
4. Keep this mixture aside for 24hrs.

5. After 24hrs, take 1000ml of jar and pour this soil sample into it.
6. Take another Hydrometer jar with 1000cc disliked water to store the hydrometer in between consecutive readings of the soil suspension to be recorded.
7. Fill the jar up to 1000ml.
8. With the help of wooden shaker disturb the particles in the jar by vibrating the wooden shaker.
9. After vibrating the wooden shaker, place the hydrometer in the jar and note down the initial reading.
10. Continue taking readings for every 1min, 2min, 5min, 15min, 30min, 1hr and 24hrs.
11. While testing four samples at a time, while carrying hydrometer from one jar another jar it must be washed in a water jar so that clay and silt will not be transferred to the different samples.
12. As the time elapses, because of the fall of the solid particles the density of the fluid suspension decreases readings, which should be checked as a guard against possible errors in readings of the hydrometer.

## CONSISTENCY LIMITS (IS:2720 part 5-1985)

### OBJECTIVES:

To determine the liquid limit and plastic limit of the given soil sample.

### APPARATUS:

1. Mechanical liquid limit device (Casagrande liquid limit device)- it shall conform to (IS: 9259-1979).
2. Spatula: Flexible, with the blade about 8cm long and 2cm wide (for mixing soil and water in the porcelain evaporating dish).
3. Grooving tool: It shall conform to (IS: 9259-1979).
4. Porcelain evaporating dish: About 12 to 15cm in diameter.
5. Flat glass plate: 10mm thick and about 45cm squire or larger (alternative to porcelain evaporating dish for mixing soil with water).
6. Balance: Sensitive to 0.01g.
7. Oven: thermostatically controlled with interior of non-corroding material to maintain the temperature between 105 and 110C.
8. Wash bottle and beaker: Containing distilled water.
9. Container: Air tight & non-corrodible for determination of moisture content.

### PROCEDURE:

### LIQUID LIMIT:

1. Adjust the cup of liquid limit apparatus with the help of grooving tool gauge and the adjustment plate to give a drop of exactly 1cm on the point of contact on the base.
2. Take about 120gm of an air dried soil sample passing 425mm sieve.
3. Mix the soil thoroughly with some distilled water to form a uniform paste.
4. Place a portion of the paste in the cup of the liquid limit device; smooth the surface with spatula to a maximum depth of 1cm. draw the grooving tool through the sample along the symmetrical axis of the cup, holding the toll perpendicular to the cup.
5. Turn the handle at a rate of 2 revolutions per second and count the blows until the two parts of the soil sample come in contact with each other, at the bottom of the groove, along a distance of 10mm.
6. Transfer the middle paste from the middle of the cup in to the crucible and place it in an oven.
7. Transfer the remaining soil in the cup to the main soil sample in the bowl and mix thoroughly after adding a small amount of water.
8. Repeat steps 4-7. Obtain at least five sets of readings in the range of 10-40 blows.
9. Record the observations.

### PLASTIC LIMIT:

1. Take about 30gm of air dried soil sample passing through 425 micron sieve.
2. Mix thoroughly with distilled water on the glass plate until it is plastic enough to be shaped into a small ball.
3. Take about 10g of the plastic soil mass and roll it between the hand and the glass plate to form the soil mass into a thread of as small diameter as possible. If the diameter of the thread becomes less than 3mm without
cracks, it indicates that the water added to the soil is more than its plastic limit; hence the soil is kneaded further and rolled into thread again.
4. Repeat this rolling and remolding process until the thread start just crumbling at a diameter of 3mm.
5. If the soil sample starts crumbling before the diameter of thread reaches

3mm (i.e, when the diameter is more than 3mm) in step 3, it shows that water added in step2 is less than the plastic limit of the soil. Hence, some more water should be added and mixed to a uniform mass and rolled again,
until the thread starts just crumbling at a dia of 3mm.
6. Collect the piece of crumbled soil tread at 3mm diameter in an airtight container and determine moisture content.
7. Repeat this procedure on the remaining masses of 10g.
8. Record the observations in Table and obtain the average value of plastic limit.

## CONCLUSIONS:

The following conclusions are drawn based on the laboratory studies carried out in these investigations.
The following results are observed from the sieve test, hydrometer test and consistency limits
The swelling pressure for soil sample is observed as 0.06kg/cm2 Thus the above mentioned results are satisfying the requirements and specifications of CNS soil and hence the given soil is CNS. And this soil is suitable as a CNS material for canal lining.

## THICKNESS OF CANAL LINING:

The swelling pressure of expansive soil samples are tested in soil mechanics lab. The swelling pressures of tested samples are in the range of 0.2 kg/cm2 and 0.32 kg/cm2. Hence a minimum thickness of 10cm – 15cm CNS soil layer is to be provided for the canal lining.

## PLACEMENT OF CNS MATERIAL:

The CNS layer should be firmly bonded at the interface of the CNS and expansive soil through provision of serrations in the expansive soil base and through compaction of the interface layers. Before placement of CNS material, the surface of the excavation or embankment to receive CNS should be thoroughly wetted to a depth of 6 inches. CNS soil should be compacted in suitable layers to the required density at its optimum moisture content. CNS layer should be carried at the sides above the full supply level at least 1m or the recommended free board (whichever is higher) and terminated with a berm formed of CNS soil of not less than 1m width and 1m thickness above the expansive soil. The outer canal slope length not covered by CNS should be turned to prevent erosion and sloughing.

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