DETERMINING THE SUITABILITY & THICKNESS OF CNS SOIL LAYER FOR CANAL LINING

BIRADAR SHARATH CHANDRA, NAKKA MONICA MADHURI, CHANDRAMOULI Y.J.,.P.SRAVANTHI, .P.ADIKALA KUMAR
Assistant Professor
Dept of Civil Engineering
Ellenki College of Engineering and Technology
Patancheru, Sangareddy,TS, India.

ABSTRACT:
The main project title is DETERMINING THE SUITABILITY & THICKNESS OF THE COHESIVE NON-SWELLING SOIL FOR CANAL LINING. Bureau of Indian standards evolved the guidelines for lining of canals in expansive soils by introducing cohesive non swelling soils (CNS) with a suitable thickness depending upon the swelling characteristics of the expansive soils. This CNS soil is introduced between the 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 possess the cohesive property (C) over and above 0.10 kg/cm2 depending upon the type of 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, sandy 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 10 KN/m2 as against 15KN/m2 specified in earlier code and also that most morum of laterities, laterite type and siliceous sandy clays exhibit CNS characteristics.

Keywords: Cohesive non swelling soil, Canal lining, swelling Properties

1. INTRODUCTION:

Soil is composed of articles of broken rock (materials) that have been altered by chemical and mechanical processes that include weathering with associated erosion. Soil is altered from its parent material by the interactions between the lithosphere, hydrosphere, atmosphere, and biosphere. It is a mixture and organic materials that are in solid, gaseous and aqueous states. Soil is commonly referred to as earth or dirt; technically, the term dirt should be restricted to displaced soil.

The physical properties of soils, in their order of decreasing importance are its texture, structure, density, porosity, consistency, temperature, color and resistivity. These determine the availability of oxygen in the soil and ability of water to infiltrate and be held in the soil. Soil texture is determined by the relative proportion of the three kinds of soil particles, called soil "separates": sand, silt, and clay. Larger soil structure are created from the separates when iron oxides, carbonates, clay and silica with the organic constituent humus, coat particles and cause them to adhere into relatively stable secondary structures called "peds". Soil density, particularly bulk density, is a measure of the soil compaction. Soil porosity consists of the part of the volume occupied by air and water. Consistency is the ability of soil to stick together. Soil temperature and color are selfdefining. Resistivity refers to the resistance to conduction of electric currents and affects the rate of corrosion of metal structures and concrete. Soil properties may change through the depth of a particular soil profile.

Many canals and dams fail due to improper assessment of effect of soil properties of borrow area and foundation soils on the stability of dams and canals appurtenant works. In this paper, an effort has been made to high light the different soil properties such as dispersivity and swelling pressure and their effect on canal design. This will help in safe design of dams and will reduce the number of dam failures. FIVE Annexes have been enclosed explaining soil classification including description, average properties for different type of soils, suitability of soils for construction of dams, degree of expansion of fine-grained soils and general guidelines for embankment sections. Generally the following soil tests are conducted before designing an earthen embankment. These tests should be conducted on soils in the borrow area, foundation and existing embankment (if any).

1. Particle size distribution
2. Atterberg limits
3. In situ moisture content and density test
4. Proctor maximum dry density and optimum moisture content
5. Specific gravity
6. Permeability of disturbed samples and field permeability
7. Triaxial shear test for cohesion and angle of internal friction
8. Free swell index
9. Swelling pressure
10. Compressibility

Index Properties:

Liquid Limit	60 to 100%
Plastic Limit	30 to 50%
Plasticity Index	30 to 40%
Shrinkage Limit	8 to 12%

Canal Lining

An impervious layer is provided at the bed and sides of canal to improve the life and discharge capacity of canal known as canal lining.

Should a canal be lined?

Before lining a canal the costs and benefits of lining have to be compared. By lining the canal , the velocity of the flow can be increased because of the smooth canal surface.

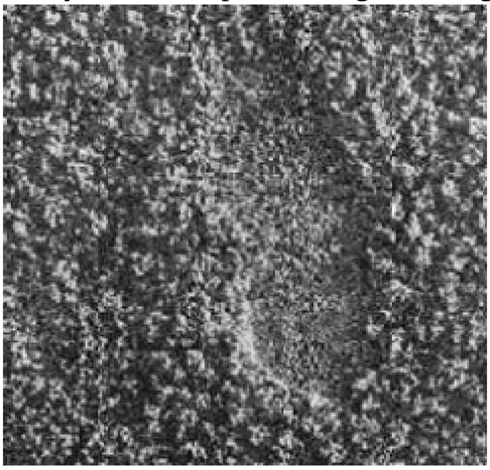
For example with the same canal bed slope and with the same canal size the flow velocity in a lined canal can be 1.5 to 2 times that in an unlined canal.

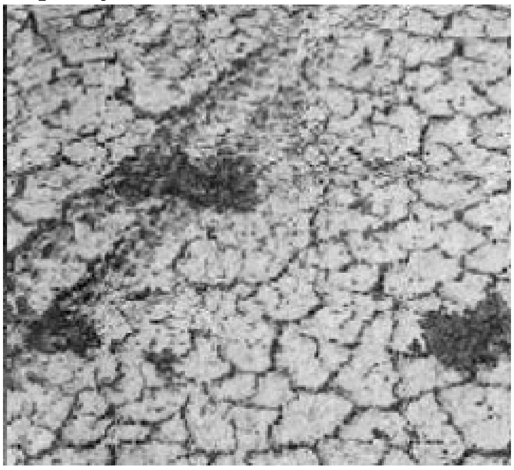
EXPANSIVE SOILS

Expansive soils popularly known as Black cotton soils in India are highly problematic, as they swell on absorption of water and shrink on evaporation thereof. Because of this alternate swell and shrinkage, distress is caused to the foundations of structures laid on such soils. Extensive research is going on to find the solutions to black cotton soils. The present paper reviews innovative solutions along with conventional foundation practices to counteract the dual problem of swelling and shrinkage posed by expansive soils. Besides, the present paper throws a light on causes of distress in lightly loaded structures founded on expansive soils and also various measures to rehabilitate the distressed structure founded on them.

Expansive soil is commonly known as black cotton soils, because of their color and their suitability for growing cotton. Black cotton soil is one of the major regional soil deposits in India, covering an area of about 3.0 lakh sq.km. Expansive soils are problematic soils because of their inherent potential to undergo volume changes corresponding to changes in the moisture regime. When they imbibe water during monsoon, they expand and on evaporation there of in summer, they shrink. Because of this alternate swelling and shrinkage, structures founded on them are severally damaged. The annul cost of damage to the civil engineering structures is estimated at £150 million in the UK, $1000 million in the USA and many billion of pounds worldwide (Gourley et al. 1993).

In India, black cotton soils have liquid limit values ranging from 50 to 100%, plasticity index ranging from 20 to 65% and shrinkage limit from 9 to 14%. The amount of swell generally increases with increase in the plasticity index. The swelling potential depends on the type of clay mineral, crystal lattice structure, cation exchange capacity, ability of water absorption, density and water content. Swell in the vertical direction is called heave. Among the illite, kaolinite and montmorillinite clay minerals, the montmorillinite possesses the greatest ability to swell by illite. The Kaolinite does not swell. Black cotton soils are very hard in dry state and possess high bearing capacity. In summer, it is very common to see shrinkage cracks with hexagonal columnar structure, with vertical cracks as wide as 10mm extending up to a depth of 3m or more. Soils containing expansive clays become very sticky when wet and usually are characterized by surface cracks or a "popcorn" texture (Fig.1) when dry. Therefore, the presence of surface cracks (Fig.2) is usually an indication of an expansive soil.





3. DISCUSSION OF THE TEST

Results:

Weight of sample washed W1 = 500gms
Flow index = p1/w1 = $\frac{100}{500} = 0.2$
% passing 75microns = 75%
Gravel = 0%
Sand: 4.75 to 2.00mm = 100-75 = 25%

Weight of sample washed W1 = 500gms
Flow index = $\frac{p1}{w1} = \frac{100}{500} = 0.2$
% passing 75microns = 77%
Gravel = 0%
Sand: 4.75 to 2.00mm = 23%

Hydrometer Results

Clay < 0.002mm = 19.83.
Silt: 0.075 to 0.002mm = 100-(25+19.83) = 55.17%
Clay<0.002mm = 20.2% (Average of$\frac{21.78+18.81}{2} = 20.2$)
Silt = 0.075 to 0.002mm = 100-(0+23+20.2) = 56.8%

Liquid Limit Results

Mass of water = wet soil – oven dry soil
Mass of oven dry soil = mass of crucible + oven dry soil – (mass of crucible)
Moisture content% =(mass of water *100)/mass of oven dry soil
Liquid limit = 52.5 moisture content at 25 No of blows from graph.
Plastic limit = 20 average of plastic limit
Plastic index = liquid limit-plastic limit = 32.5

Calculations:

Mass of oven dry soil at 1st point = 50.77-45.04 = 5.73
Moisture content at 1st point = (2.9*100)/5.73 = 50.61
Mass of oven dry soil at 2nd point = 36.31-30.33 = 5.98
Moisture content at 2nd point = (3.1*100)/5.98 = 51.83
Mass of oven dry soil at 3re point =54.71-49.98 = 4.73
Moisture content at 3rd point = (2.61*100)/4.73 = 55.17
Mass of oven dry soil at 4th point = 39.85-33.66 = 6.75
Moisture content at 4th point = (3.46*100)/6.75 = 55.89

Standard Proctor Results

Moisture content = $\frac{weig\ htofwater}{weig\ htofdrysoil} * 100$
Wet density =$\frac{weig\ htofwetsoil}{mouldvolume}$

maximum dry density = 1.65

Optimum moisture content = 20.08
Specific gravity = 2.69
Void ratio = (G/Md-1) = 0.63
Saturated moisture content = $\frac{G-Md}{G*Md}$
Calculations:
Mould volume = $\frac{\pi}{4}d^2h = \frac{\pi}{4}10.1^2 * 12.5 = 981.75cm^3$
Dry density = $\frac{wetdensity}{1+\frac{\%\ of moisture content}{100}}$

Triaxial test Result

For optimum moisture content:

Weight of sample = Md*mould volume = 1.65*87 = 143.6gms
Water to be added = wt of sample*$\frac{\text{moisture content}}{100}$ = 143.6*$\frac{20.08}{100}$ = 29.86cc
Water to be added = 90% of 29.86cc = 27cc

For saturated moisture content:

Saturated moisture content = $\frac{G-Md}{G*Md} = \frac{2.69-1.65}{2.69*1.65}$ *100= 23.43
Weight of sample = 1.65*87 = 143.6gms
Water to be added = wt of sample*$\frac{\text{saturated moisture content}}{100}$ = 143.6*$\frac{23.43}{100}$ = 33.46cc
Water to be added = 90% of 33.46cc = 30.11cc

Swell Pressure Result

Original thickness of pat = 20mm
Least count of dialguage = 0.002
Δ H (0.05) = 6
Δ H (0.25) = -16
Δ H (0.50) = -20
Δ H/H (0.05) = 0.3
Δ H/H (0.25) = -0.8
Δ H/H (0.5) = -1

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