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Stress Distribution Analysis of the Kaolinite Layer at the Kaolinite –Geotextile

Arvind Dewangan, D.P.Gupta, R.K.Bakshi, Ram K. Manchiryal

ABSTRACT- The analysis of stress within a body implies the determination at each point of the body of the magnitudes of nine stress components. In other words, it is the determination of the internal distribution of stresses. An alternative method used in stress analysis is the determination of the internal distribution of strains. The differences between kaolinite and smectite structures are notable, mainly as a result of the degree of weathering in the different compounds. Nevertheless, the kaolinite structure possesses great advantages in many processes due to its high chemical stability and low expansion coefficient. Bearing capacity factors are available in the literature for estimation of the load-carrying capacity of unreinforced and reinforced unpaved roads, i.e. for soil layers with a granular fill overlying soft soil. This paper present the the stress distribution on the kaolinite layer at the kaolinite-geotextile or kaolinitefurnace ash interface, it measured with increases in footing pressure in order to assess the load dispersion angle over the soil layer. The predicted load dispersion angle is then used to estimate the bearing capacity factors of the soil layer with increases in footing deformation. This paper also focus typical vertical stress distributions measured below the interface (on the top surface of the kaolin layer) for a fill thickness of 110 mm with different footing pressures .

Key words:1. Soil 2. Kaolinite 3. Geotextile 4. Clay 5. LayerSub Area: Soil Engineering Broad Area:Civil Engineering

I. INTRODUCTION

Soil mass is generally a three phase system that consists of solid particles, liquid and gas. The liquid and gas phases occupy the voids between the solid particles. For practical purposes, the liquid may be considered to be water (although in some cases the water may contain some dissolved salts or pollutants) and the gas as air. Soil behavior iscontrolled by the interaction of these three phases. Due to the three phase composition of soils, complex states of stresses and strains may exist in a soil mass. Proper quantification of these states of stress, and their corresponding strains, is a key factor in the design and construction of transportation facilities. The first step in quantification of the stresses and strains in soils is to characterize the distribution of the three phases of the soil mass and determine their inter-relationships.

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***Correspondence Author(s)**
Arvind Dewangan, Dr. Arvind dewangan- Associate Professor -Civil Engineering Deptt. Haryana College of Technology & Management,Kaithal.-136027(Haryana) INDIA.
D.P.Gupta, Dr.D.P.Gupta,Director-Haryana College of Technology & Management,Kaithal.-136027(Haryana) INDIA.
R.K.Bakshi, Dr. R.K.Bakshi, HOD Civil Engineering Deptt. Haryana College of Technology & Management,Kaithal.-136027(Haryana) INDIA.
Ram K. Manchiryal, Dr. Ram K. Manchiryal, Associate Professor -Civil Engineering Deptt. Haryana College of Technology & Management,Kaithal.-136027(Haryana) INDIA.

The inter-relationships of the weights and volumes of the different phases are important since they not only help define the physical make-up of a soil but also help determine the in-situ geostatic stresses, i.e., the states of stress in the soil mass due only to the soil's self-weight. The volumes and weights of the different phases of matter in a soil mass.

The differences between kaolinite and smectite structures are notable, mainly as a result of the degree of weathering in the different compounds. Nevertheless, the kaolinite structure possesses great advantages in many processes due to its high chemical stability and low expansion coefficient. As a consequence of adsorption, the kaolinite structure and the soil solution pH will change. To analyze the adsorption behaviour of kaolinite, Pb, Zn and Cd were studied at three different concentrations (1, 2 and 3 mmol/l) and over different periods of exposure (0.1, 1, 2, 4, 8, 12 and 24 h). The kaolinite retained up to 10.0 Amol/g of Pb, 8.40 Amol/g of Zn and 6.00 Amol/g of Cd when it was mixed with the 3 mmol/l concentration of heavy metals. In each case, the adsorption eventually reduced the solution pH from 4.6 to 3.7. The changes in pH over time indicated both the release and retention of hydrogen ions by the mineral, probably involving the hydroxyl edge sites and exposed hydroxyl planes. The size of the atomic radii are 1.81, 1.71 and 1.53 A ° for Pb, Cd and Zn, respectively, compared to the 0.79 A ° for H. This difference, along with the differences in hydrated radii, will affect the structure of the clay causing stress in the molecule. Changes in the mechanical and chemical properties of the clay are discussed as the interactions of the heavy metal cations with the kaolinite could affect the structure of the kaolinite and influence properties such as swelling capacity, compaction capability and the double-layer behaviour. The kaolinite in this study contained some illite which may have increased the pH 7 cation exchange capacity to 17.8 mEq/100 g. Using the adsorption data, the reactions at the clay water interphase and the probable effects on the physical properties and structure of kaolinite are discussed. Stresses on the kaolinite layer were not recorded for footing pressures greater than 90 kN/m^2. At a footing pressure of 45 kN/m2, the observed pressure distributions indicate rigid footing behaviour (Das 1985) for both with and without a geotextile. At footing pressures of 68 and 90 kN/m2, the reinforced soil layer acts as a rigid footing, while the unreinforced layer pressure distribution is similar to a flexible footing. The average pressures on the kaolinite layer, obtained from the measured interface pressure distributions, for different fill thickness values, are presented in Table.

II. POLYMORPHISM OF KAOLINE

The polymorphism is most easily analyzed in terms of two factors: 1) the direction and amount of the interlayer shift, and 2) the location of the vacant octahedral site in successivela yers. The similarities and differences in the structures of the three minerals caused by these two factors can be summarizedb y referencet o their f-ray powder patterns.K aolinite and dickite have identical interlayer shifts and give powder patterns that are similar with respectt o most of the strongerr eflections.T he difiering location of the vacant octahedral site in the two structures governs the symmetry and the Z-axis periodicity of each mineral and accounts for the observed differences in the powder reflections of medium to weak intensity. Nacrite has a sequenceo f interlayer shift s that is entirely different from that in kaolinite and dickite, and its powder pattern is also markedlydifferent.

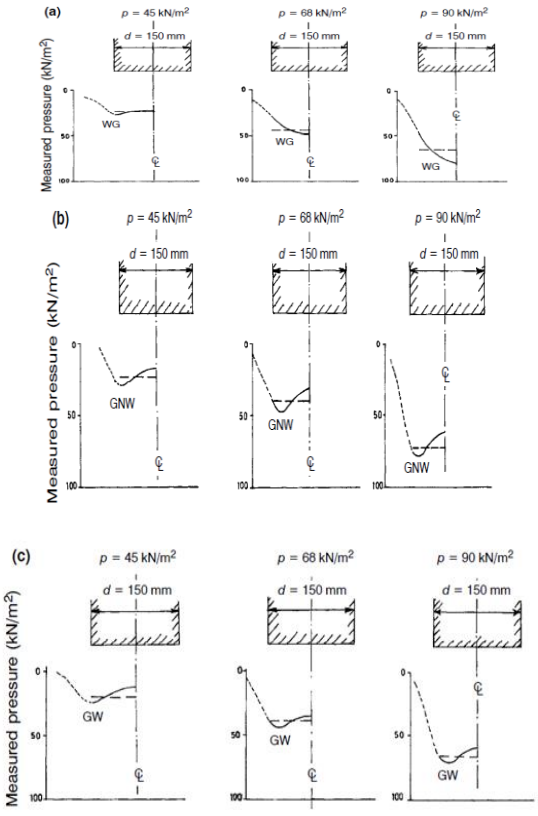
Preparation Before Practical – Sample reading: Dr. Arvind Dewangan and another staff member at Soil Mechanics Lab at HCTM Kaithal, Haryana

Load Dispersion

The contacts between soil grains are effective in resisting applied stresses in a soil mass.

Under an applied load, the total stress in a saturated soil sample is composed of the intergranular stress and the pore water pressure. When pore water drains from a soil, the contact between the soil grains increases, which increases the level of intergranular stress.

This intergranular contact stress is called the **effective stress**. **The effective stress, po, within a soil mass is the difference between the total stress, pt, and pore water pressure,**. The **principle of effective stress** is a fundamental aspect of geotechnical engineering and is written as follows: po = pt – u From the average pressure on the kaolinite layer for different fill thicknesses, the load dispersion values have been assessed and are presented in Table8. From Table, it is seen that the load dispersion is on the order of 4:1 for fill thicknesses of 40 and 75mm at an average footing pressure of 45 kN/m2.Beyond this footing pressure, it is found that the load dispersion varies between 7:1 to 12:1 (vertical:horizontal). Similarly, for a fill thickness of 110 mm, the load dispersion ranges from 3:1 to 5:1, up to an average footing pressure of 68 kN/m^2. For a fill thickness of 150 mm, the maximum load dispersion within the range of measured pressures is found to be 3:1.



Pressure distribution on the kaolinite layer for a fill thickness of 110 mm: (a) without a geotextile, WG; (b) with a nonwoven geotextile, GNW; (c) with a woven geotextile, GW.

Figure-1

Average pressure on the kaolinite layer from the measured interface pressure distribution values.

Fill thickness (mm)	Average measured pressure on kaolinite layer (kN/m^2)								
	$p = 45$ kN/m^2			$p = 68$ kN/m^2			$p = 90$ kN/m^2		
	WG	GNW	GW	WG	GNW	GW	WG	GNW	GW
40	38	35	34	62	64	63	--	81	81
75	30	29	23	52	54	52	--	75	74
110	24	22	20	42	40	40	66	72	66
150	11	11	13	18	18	18	30	30	32

Note: p = average footing pressure; WG = without geotextile; GNW = with nonwoven geotextile; GW = with woven geotextile.

Predicted load dispersion values for the kaolinite layer.

Fill thickness (mm)	Predicted load dispersion								
	$p = 45$ kN/m^2			$p = 68$ kN/m^2			$p = 90$ kN/m^2		
	WG	GNW	GW	WG	GNW	GW	WG	GNW	GW
40	5:1	4:1	4:1	12:1	12:1	12:1	--	10:1	10:1
75	4:1	4:1	3:1	7:1	8:1	7:1	--	10:1	10:1
110	4:1	3.5:1	3:1	5:1	5:1	5:1	9:1	12:1	9:1
150	2:1	2:1	2:1	2:1	2:1	2:1	3:1	3:1	3:1

Note: p = average footing pressure; WG = without geotextile; GNW = with nonwoven geotextile; GW = with woven geotextile.

Table-1

Comparing these observations with the load-carrying capacity of the soil layer for different fill thicknesses at different footing settlements, it can be concluded that the load dispersion angle for the present investigation is on the order of 4:1 up to a maximum settlement of 10 mm. Beyond 10 mm of settlement, it appears to lie in the range of 7:1 to 12:1 (with an average of 10:1).

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Figure 2: Dr. Arvind Dewangan is taking result from an experiment in HIET Kaithal at HCTM Technical Campus Kaithal with Dr. R.K.Manchiryal

Bearing Capacity Factor, *po* / *cu*

The concept of shear strength described in the previous section can now be used to
understand the phenomenon of lateral earth pressure in a soil mass, which is related to
problems of slope stability and earth retention. From a theoretical viewpoint, problems in
these three areas (earth pressures, slope stability, and retaining structures) fall into a class of
problems involving plasticity theory and are best solved by some form of equilibrium
solution. Many geotechnical engineering text books (e.g., Lambe and Whitman, 1979; Holtz
and Kovacs, 1981) deal with these solutions extensively. From a practical viewpoint, values
of earth pressure are needed either directly or indirectly to determine:

a) If an unrestrained slope is stable and

b) If not, what kind of retaining structure will be required to stabilize the slope.

The simplest consideration of earth pressure theory starts with the assessment of the vertical
geostatic effective stress, po, at some depth in the ground (effective overburden pressure) as
considered in Section 2.3. The lateral geostatic effective stress, ph, Bearing capacity factors are available in the literature for estimation of the load-carrying capacity of unreinforced and reinforced unpaved roads, i.e. for soil layers with a granular fill overlying soft soil. These bearing capacity factors multiplied by the cohesion of the soft subgrade, along with the dispersion effect, give the maximum load on the fill layer. No recommendation has been given for the behaviour of a soft soil layer at different levels of deformation. An attempt has, therefore, been made to estimate the soil layer bearing capacity factors, i.e. *po* / *cu* , where *po* is the pressure on the kaolinite layer after dispersion and *cu* is the cohesion of the kaolinite layer, for different footing settlements. The load dispersion angle, was taken as 4:1 for settlements of 5 and 10 mm, and 10:1 for settlements of 15 mm and greater. The bearing capacity factor values, *po* / *cu* , calculated for different fill thicknesses and footing settlements are given in Table 7. The values presented for 5 and 10mmof settlement are the average values for the unreinforced and reinforced soil layers. For a settlement equal to or greater than 15 mm, the values for reinforced soil layers are given. Comparing the values presented in Table 9with the load-carrying capacity proposed by Giroud and Noiray (1981) andMilligan et al. (1989), it is seen that the average value of *po* / *cu* for a settlement of 10 mmis comparable with the bearing capacity factor π and (π/2 + 1) for unreinforced soil layers, while the same bearing capacity factor value for 15 mm of settlement is close to (π + 2) for reinforced layers. Higher values of *po* / *cu* , observed at greater amounts of settlement, are probably due to the lateral restraint mobilized through interface friction at the geotextile-soft soil (i.e. kaolinite) interface and tension induced in the geotextile.

CONCLUSION

This paper reveals the stress distribution on kaolinite along with bearing
capacity factor. soil is three phase system that consists of solid particles, liquid
and gas. Classical soil mechanics concentrates primarily on the behavior of saturated or dry soils, i.e., a two phase system. Horizontal stresses induce tension in the geotextile to maintain equilibrium. If the undrained shear strength remained the same, an increase in the horizontal stress, σh , would cause an increase in the vertical stress, σv. Vertical stresses mobilized on the surface of the kaolinite layer may, therefore, be considered as the sum of the increased horizontal stresses and twice the cohesion of the soil layer. . The average pressures on the kaolinite layer, obtained from the measured interface pressure distributions, for different fill thickness values. The descriptions in the literature of the individual kaolin structures do not attempt to analyze the relationship of the sequence of interlayer shifts in one mineral to those in the other two. An understanding of the relative Iayer sequencesis necessary,h owever, if one is to appreciatef ully the structural reasons for the polymorphism of the kaolins. The aim of the analysis is usually to determine whether the element or collection of elements, usually referred to as a structure, behaves as desired under the prescribed loading. For example, this might be achieved when the determined stress from the applied force(s) is less than the tensile yield strength or below the fatigue strength of the material.Analysis may be performed through classical mathematical techniques, analytic mathematical modelling or computational simulation, through experimental testing techniques, or a combination of methods.

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REFERENCES

1. S. W. Barrnu, Polymorphism of the Kaolin Minerals, Vol. 48, Nov. Dec, (1963) 1196 - 1209
2. Giroud and Noiray, Planar reinforcement, such as geogrid and geotextile, has been widely used in unpaved roads with established design methods. An analytical approach to the design of geotextile-reinforced unpaved roads was first introduced by them. 1981

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3. M. R. Hausmann, Geotextiles for Unpaved Roads A Review of Design Procedures, 1987
4. Jorge C. Miranda-Trevino1, Cynthia A. Coles, "Kaolinite properties, structure and influence of metal retention on pH" Applied Clay Science 23 (2003) 133– 139
5. G. Basu, A.N. Roy et al, Construction of unpaved rural road using jute–synthetic blended woven geotextile – A case study 2009.

AUTHOR PROFILE

Dr. Arvind Dewangan, Associate Professor in Department of Civil Engineering, Haryana College of Technology & Management, Technical Campus KAITHAL. His highest academic qualification is PhD in Mining & Geological Engineering. He has 12years of experience in teaching and research. He has published 37 papers in International and National journals and won more than 15 times NATIONAL LEVEL ESSAY COMPETITION.

Corresponding Author: At present **Dr. Arvind Dewangan** is working as an Associate Professor in Civil Engineering Department in HCTM TECHNICAL CAMPUS, Kaithal; Haryana, INDIA since July 2008. Various articles about Technical & Higher education have been published in national level competition magazine like – Competition Success Review, i-SUCCEED, Civil Services Chronicle, Pratiyogita Sahitya, Pratiyogita Vikas, and Pratiyogita Darpan, and various research paper have been published in National and International Journals like- CSVTU RESEARCH, Bhilai, IE[India], IeJMAE, IJCTEE[US]; IJMTAH, JERAD, ENGINEERING TECHNOLOGY IN INDIA, Research India Publication- Journal[IJAER etc.] in various civil engineering fields.

Co-Author Dr. D.P. Gupta is working as a Director of HCTM TECHNICAL CAMPUS, Kaithal, Haryana, INDIA. His research paper have been published in various National and International Journals like- CSVTU RESEARCH, Bhilai, IE[India], IeJMAE, IJCTEE[US]; IJMTAH, JERAD, ENGINEERING TECHNOLOGY IN INDIA, Research India Publication- Journal[IJAER etc.] in various civil engineering fields.

Co-Author Dr. R.K. Bakshi is working as an HOD in Civil Engineering Department in **Haryana Department College of Technology & Management Kaithal**- Haryana -136027,

Co-Author Dr. Ram K. Manchiryal is working as an Associate Prof. in Civil Engineering Department in **Haryana Department College of Technology & Management Kaithal**- Haryana -136027

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