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Research article

MODELLING NICKEL TRANSPORT INFLUENCED BY DEGREE OF SATURATION IN MONTMONORITE CLAY FORMATION, AHOADA WEST, RIVERS STATE OF NIGERIA

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Abstract

The deposition of nickel on montmonorite clay has been mathematically evaluated, the study were to monitor the deposition of nickel on montmonorite clay in other to determine the behaviour of nickel in the formation, clay of such type is predominant in deltaic environment thus the clay minerals may react with the substance and can developed more challenges in any construction activities, the study is to generate various negative impact on construction methods that has face challenges from the deposition of montmonorite clay, soil and water on construction approach may face these challenges either increase in contamination, while that of structural and road construction may experiences expansive of clay base on the reaction with other minerals increasing it of plasticity, these will definitely developed serious challenges in construction methods. The developed model will support construction engineers to monitor the rate nickel reaction and its migration in soil and water environment.

Keywords: modeling nickel transport, degree of saturation montmonorite clay

1. Introduction

Damage from Expansive soil caused destruction to the light structures built upon it, these are pavements, inhabited structures, and underground utilities (e.g., Chen, 1975; Petry, 2002 Honghua et al 2014 Jan; 2012). Consequently, a variety of systems have been developed to tackle this difficulty as well as mechanical compaction, surcharge loading, pre-wetting, lime stabilization including cement stabilization, fly ash stabilization, chemical stabilization, and organic compounds treatment (Nelson and Miller, 1992). Lime stabilization is accomplished through calcium fixation, ion crowding and erosion of clay particle surface of expansive soils (due to the high pH value of the lime slurry). Lime can be applied either in the powder form, slurry form or through lime-slurry pressure injection. Bell (1996) investigated lime stabilization on till and laminated clay. The plasticity of the lime treated montmorillinite was reduced. Liquid limit increased with addition of lime for kaolinite and decreased for that of montmorillinite. The injection of chemicals to stabilize clay subgrade below foundations was first introduced by Blacklock et al. (1988). After their pioneering work, a variety of chemical agents have been applied through intimate mixing with the soil, injection into the subgrade and surface treatment (Shondeep et al., 2000; Katz et al., 2001; Petry, 2002; Zhang et al., 2003; Geng, 2009; Eisazadeh, 2010; Fattah, 2010; Fityus et al., 2011; Gueddouda, 2011; Liu et al., 2011; Mutaz et al., 2011, Jan; 2012). Shondeep et al. (2000) investigated the effects of the HIExC (a hydrogen ion exchange chemical) solution on the expansive clay after a two year's treatment, using X-ray diffraction, zeta potential, transmission electron microscopy/energy dispersive X-ray analysis and environmental SEM (Scanning Electron Microscope). They found that zeta potential is lowered by 32% for the HIExC treated soil sample, where the HIExC treatment changes the surface chemistry of clays through a complex precipitation dissolution process. It further reduced the swell-shrink potential of the expansive clay. Katz et al. (2001) investigated the stabilization mechanism using a liquid ionic stabilizer, sulfonate limonene. They carried out a detailed physical-chemical study on one class of montmorillinite by chromatography, spectroscopy, X-Ray diffraction, electron microscopy, and standard titration analyses. They found that this ionic stabilizer would alter the clay lattice and result in a more highly weathered, less expansive clay structure. Liu et al. (2011) investigated the physicochemical behavior of an ionic soil stabilizer on Nanyang expansive clay. Testing results showed that water retaining ability of Nanyang expansive clay decreased and swelling potential became weaker after the treatment. No major mineral component changes occurred.

2. Theoretical background

In the rock medium and mainly in their weathering e.g. in marl alluvium, swelling brings about nonstop changes in fissures or in spaces between larger rock remains, applying an influence on the strength of a medium, and also leads to the nonstop variations of the medium which is rubbish under extreme moisture conditions and which in proper, changes in moisture content, precede by the periods of drought, becomes similar to cohesive soil. The fact of swelling and shrinkage may bring them to the external states. First of all it should be stressed out, that the fact of swelling occurs only in the aeration zone identified with zone of fluctuation of the level by underground water and foundation layer. It has been explained that there is maximum swelling or soil shrinkage if near to the outer surface of the ground soils (or rock weathering) have minerals of definitely high negative charges montmorillinite, illite, baidelite etc. and when the environmental conditions of soil permit moisture to change the vital variations in maximum swelling occurred in the plan area of impended building. Finding the best foundation level and the choice of the most suitable foundation method remain also troublesome. With the change in the natural moisture content these soils expand or shrink intensively. Considerable changes of volumes, which accompany these processes, result in serious damages of various constructions such as foundations of buildings aerodromes, roads, underground installations and systems. Generally speaking the phenomenon of expansion is noted in many countries of the world with a specific geologic structure of the subsoil in accompanied by climatic conditions that favour significant periodical variations of the water contents soils. It has been fund that expansion or shrinkage of soils depend on possibility of contain in the minerals which a distinctly high negative charge (montmororillonite, illite) close to the land surface. Significant changes of potential expansion occurred in the plan areas of most highly expansion were noted after 10 years since the construction works began but already after 2 years culminant impendency could also occur [1]. The damages due to expansion of clays start to be more and more careful recorded as use on these clays for construction works becomes more popular.

3. Developed Governing Equation

$$Vt\frac{\partial c}{\partial L} = \frac{\partial c}{\partial t}\frac{Vw}{V} + Kt\frac{\partial c}{\partial L} \qquad \textbf{(1a)}$$

Nomenclature

C	=	concentration $[ML^{-3}]$
Vt	=	Velocity of flow $[LT^{-1}]$
$S = \frac{Vw}{V}$	=	Degree of saturation [-]
Kt	=	Permeability $[LT^{-1}]$
L	=	Depth [L]
T	=	Time [T]

The expressed governing equation show the parameters that pressure the deposition of nickel in deposited soil formation, the clay formation deposited minerals that will react with nickel and these may either increase the activeness of nickel or reduces, these implies that there tendency of one inhibiting another or absorbing another, base on this condition the behaviour of nickel deposition should be thoroughly evaluated, in most condition this reaction of both substances may developed long time effected on the formation in any construction activities, these condition were evaluated to develop the system producing the governing equation.

Simplifying the expression, let $\frac{Vw}{V}$ denote as τ so that the equation can be written as:

$$Vt\frac{\partial c}{\partial L} = \tau\frac{\partial c}{\partial L} + Kt\frac{\partial c}{\partial L} \qquad (1b)$$

$$Vt\frac{\partial c}{\partial L} - \frac{\partial c}{\partial t} = \frac{\partial c}{\partial t} + \tau + Kt \qquad (2)$$

$$(Vt-1)\frac{\partial c}{\partial L} = \frac{\partial c}{\partial L} + \tau + K \qquad (3)$$

$$(Vt-1)\frac{\partial c}{\partial L} = \frac{\partial c}{\partial t} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

$$0 = \frac{\partial c}{\partial L} + \tau + K \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

i.e. $\frac{\partial c}{\partial t} = -\tau - Kt$ .... (6)

From (5) integrate directly, we have

$$S = (-\tau - Kt)t + S_1 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (7)$$

From (6)

$$\frac{\partial s}{\partial L} = \frac{\partial c}{\partial t}$$

Let $C = LT$ .... (8)

$$\frac{\partial c}{\partial L} = Z^1 T \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (9)$$

$$\frac{\partial c}{\partial L} = ZT^1 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (10)$$

Substitute (9) and (10) into (3), we have

$$(Vt-1)Z^1 T = (\tau - Kt)ZT^1 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (11)$$

$$(Vt-1)\frac{Z^1}{Z} = (\tau - Kt)\frac{T^1}{T} = \phi \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (12)$$

$$(Vt-1)\frac{Z^1}{Z} = \phi \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (13)$$

$$(\tau - Kt)\frac{T^1}{T} = \phi \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (14)$$

From (13) $\frac{Z^1}{Z} = \frac{\phi}{(Vt-1)} z$ ....

$$Ln Z = \frac{\phi}{(Vt-1)} z + S_2 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (16)$$

$$Z = A\ell^{\frac{\phi}{(Vt-1)}z} \qquad \text{................................} \qquad (17)$$

From (14)

$$(\tau + Kt)\frac{T}{T} = \phi$$

$$T = \frac{\phi}{(\tau + Kt)} \qquad \text{................................} \qquad (19)$$

$$Ln\,T = \frac{\phi}{(\tau + Kt)}t + S_3 \qquad \text{................................} \qquad (19)$$

$$T = B\ell^{\frac{\phi}{\tau + Kt}t} \qquad \text{................................} \qquad (20)$$

The behaviour of montmonorite clay in deltaic formation must be pressure by some other characteristics of the soil, the derived solution generate model with time predominant, the study were able to monitor the deposition of the system on time of saturation with it rate of permeation, such condition were establish to determined the rate porosity in the deposited formation under time predominance, the deposition of nickel in montmonorite clay formation may developed different reaction that will determined the rate the soil stability base on compressibility of the formation, in construction activities these condition of the soil will generate lots of challenges the rate compressibility are reflected on the deposition of nickel integrated with montmonorite.

Put (17) and (20) into (8), yield

$$S_2 = A\ell^{\frac{\phi}{(Vt-1)}z} \bullet B\ell^{\frac{\phi}{\tau + Kt}t} \qquad \text{................................} \qquad (21)$$

$$S_2 = AB\ell^{\left(\frac{z}{(Vt-1)} + \frac{t}{\tau + Kt}\right)^{\phi}} \qquad \text{................................} \qquad (22)$$

Hence general solution becomes:

$$C\,[LT] = S_1 + S_2$$

$$C\,[LT] = AB\ell^{\left(\frac{z}{(Vt-1)} + \frac{t}{\tau + Kt}\right)^{\phi}}$$

The deposition of nickel in montmonorite deposition has been mathematically expressed. The study were to monitor the deposition of the clay with other deposited substance on the compressibility in terms of construction activities and rate of migration contaminating soil and water environments, the study expressed various condition that will definitely generate serious challenges in the deposition nickel on montmonorite in the study location, such application implies that reaction with clay mineral will definitely generate challenges in any of the construction activities. The developed model will definitely predict the rate of concentration with the deposition of clay minerals in deltaic formation.

4. Conclusion

Expansive clays are present on many areas of the hot temperate zones, also in many enclaves of soils and rock eluvia containing minerals belonging to the groups of montmorillonite, illite etc. Identification of expansive clays ability and methods of its investigations were described by previous experts caused by soil swelling in building industry are comparable to losses caused by environment. Usability of the joining pile on the expansive soils gives an important advantage**.** Joining piles provides a new idea of piling. It is a combined foundation including the base made in the soil, and the post elements (a bundle of piles or micropiles) joining the base with the girt. In the case of swelling soils, capacity of the system of piles or micropiles bundle is making a base joining them to make up the role of the anchoring pile. There are many reasons for which the received results should be compared with the results of research conducted in the other countries as it makes possible to know the geological properties of several kinds of soils. The study conducted will be compared with other experts on the properties of many swelling soils and soft rocks. Considering mainly on their origin and mineralogy. In the rock media and particularly in their weatherings e.g. in marl eluwium, swelling brings about continuous changes in fissures or in spaces between larger rock fragments, exerting an influence on the strength of a medium, and also leads to the continuous variations of the medium which is debris under extreme humidity conditions and which in proper, changes in moisture content, preceded by the periods of drought, becomes similar to cohesive soil. The phenomena of swelling and shrinkage may bring them to the external states. These concepts are some of the challenges in clay reaction with other minerals like nickel that will definitely cause some challenges in construction of structures and ground water explorations.

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