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Cation exchange in montmorillonitic soil as a low cost measure to improve its shear strength

Sarkar Sudipta

[1] Geotechnical Laboratory, Eastern Region, Geological Survey of India, Salt Lake, Kolkata 700 091, India;
e-mail: sudiptaashish@yahoo.co.in

Clays in general and clay minerals in particular are an integral part of soil, which influence the bearing capacity of the soil mainly in terms of the shear strength. Soils containing montmorillonitic clays are found to be significantly adverse. To avoid the collapse of civil engineering structures, the best option is to avoid the with such clays, but this may not always be possible. Under these compelling circumstances it is necessary to enhance the shear strength of the soil at a particular location with a cost as low as possible.

To achieve these objectives, viz., (i) enhancement of the shear strength of the soil, (ii) avoiding the existing expensive, cumbersome, and inexact methods for improvement of geotechnical properties of soils, (iii) use of the optimum quantity of the resource, and (iv) restricting the cost of such improvements to the bare minimum, a soil sample containing considerable montmorillonitic clay was collected from a weathered amphibolite dyke from the Bara Ara area (86°51'E, 22°37'47"N) in West Bengal, India. The air-dried soil samples were subjected to a combined process of wet-sieving and sedimentation using the standard procedures [1,2] for obtaining the grain size distribution. Clay mineralogy of the samples was studied by X-ray diffractometry following standard procedures [3]. XRD-patterns of the soils reveal that the clay fraction of the soil is dominantly composed of smectite (Ca-montmorillonite) with a few interlayered vermiculite layers. Non-clay minerals present include gibbsite, feldspar and quartz.

In the study, dry montmorillonitic soil samples were soaked separately in different chloride solutions of various concentrations (0.5, 1, and 2N) of different cations viz. Na^+, K^+, Mg^{2+} & Ca^{2+} and cured for different periods (7, 15, and 21 days) in order to achieve completed cation exchange reactions within the montmorillonite [4]. The exchangeable cations (Ca^{+2}, Mg^{+2}, Na^+ and K^+) of the soils were then determined by analysing the Ammonium acetate (NH_4OAC) extract and distilled water (pore water) extract [5] of the clays at pH 7 in an Inductively Coupled Plasma-Emission Spectrometer (ICP-ES) - ARL 3410 system. The difference between these two results registers the quantity of exchangeable cations, and helps in determining the optimum amount of salt required.

Unconfined compression tests [6] with untreated and each salt solution treated soil sample were done to estimate the changes in the shear strengths between the untreated and each treated soil, if any. Cationic treatment of montmorillonite under varying experimental conditions changes the initial existing cationic condition in the clays of untreated soils at the micro-level affecting the geotechnical parameters significantly at the macro-level. Close scrutiny of the cation exchange as well as geotechnical data on untreated and cation treated montmorillonitic soil reveals that although 1N $CaCl_2$ and 1N KCl treatments produce similar improvement in the geotechnical properties, the 1N $CaCl_2$ treatment is more effective than the KCl treatment in raising the shear strength (by 31.52 to 35.87% for curing periods between 7 and 21 days) and lowering the swelling index [7] after 21 days of curing.

References:

[1] Carver RE (1971) *Procedures in Sedimentary Petrology*: Wiley-Interscience, New York, 653p

[2] Folk RL (1974) *Petrology of Sedimentary Rocks*: Univ. of Texas, Hemphill Pub. Co., Texas, 182p

[3] Brown G and Brindley GW (1980) In: *Cryst struc clay miner and their X-ray ident*: Miner Soc Lond, 305-360

[4] Loken T (1970) Geologiska Foreningen i Forbandlinger 92: 133-147

[5] Jackson ML (1967) *Soil chemical analysis*: Prentice Hall of India Pvt. Ltd., New Delhi, 498p

[6] Singh A (1992) *Modern geotechnical engineering*: CBS Publishers and Distributors Pvt. Ltd., Delhi, 239-241

[7] Sarkar Sudipta (2012) Abst: 34IGC, Brisbane, Australia