Settlements of Soils By Sodium Silicate

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Abstract- *Soil is the basic foundation for any civil engineering structures. It is required to bear the loads without failure. In some places, soil may be weak which cannot resist the oncoming loads. In such cases soil stabilization is needed. Soil stabilization cannot explain as the alteration of soil properties by chemical or physical means in order to enhance the engineering quality of the soil. This report deals with the complete analysis of the improvement of soil properties and its stabilization using the sodium silicate.*

Various lab tests are conducted like liquid limit, plastic limit, standard proctor test etc.., and field tests like core cutter and sand replacement methods etc.., on soils to decide the properties and stiffness of them. The constructional activities in some particular areas often demand deep foundations because of poor engineering properties and the related problems arising from weak soil at shallow depths. The very low bearing capacity of the foundation bed causes shear failure and excessive settlements. Further, the high-water table and limited depth of the top sandy layer in these areas restrict the depth of foundation thereby further reducing the safe bearing capacity. This report discusses grouting as one of the possible solutions to the foundation problems by improving the properties of soil at shallow depths by using sodium silicate.

Since 1945, various researchers have reported on the effectiveness of sodium silicate has a stabilizing admixture. Sometimes the silicate was used alone and some times in the combination with various other chemicals. Sodium silicate has to improve building materials more than a century. This study presents characterization of sodium silicate prepared from kankra kaolin.

Keywords- Sodium silicate, settlements, foundation, bearing capacity.

I. INTRODUCTION

1.1. General

The construction of structures on weak ground often requires the soil to be improved in order to ensure the safety and the stability of surrounding buildings. Soil is one of the most important engineering materials. Determination of soil conditions is the most important first phase of work for every type of civil engineering facility. The knowledge of soil is necessary for the designing of foundation, pavement, underground structures, embankments, earth retaining structures, dams etc. As a result, various parameters like bearing capacity, stress distribution in the soil beneath the loading area, the probable settlement of the foundation, effect of ground water and effect of vibrations etc are needed for the design of foundation.

The selection of the most suitable method depends on a variety of factors, such as: soil conditions, required degree of the compaction, type of structures to be supported, maximum depth of compaction, as well as site-specific considerations such as sensitivity of adjacent structures or installations, available time for completion of the project, competence of the contractor, availability of equipment's and materials etc. Soil compaction can offer effective solutions for many foundation problems, and is especially useful for reducing total settlements in sands.

However, efficient use of soil compaction methods requires that the geotechnical engineer understands all factors that influence the compaction process. The poor-quality soils, especially their low bearing capacity, make it necessary to improve their properties by stabilization. The compaction of soils is intrinsically dependent upon the vertical effective stress, the type and gradation of soil, etc.

The settlement of saturated cohesive soil consists of the sum of three components:

- Immediate settlement occurring as the load is applied.
- Consolidation settlement occurring gradually as excess pore pressures generated by loads are dissipated.
- Secondary compression essentially controlled by the composition and structure of the soil skeleton.

The settlement of coarse-grained granular soils subjected to foundation loads occurs primarily from the compression of the soil skeleton due to rearrangement of particles. The permeability of coarse-grained soil is large enough to justify the assumption of immediate excess pore pressure dissipation upon application of load. Settlement of coarse-grained soil can also be induced by vibratory ground motion due to earthquakes, blasting or machinery, or by soaking and submergence.

1.2. Literature Review

Button (1953)[1]

He analyzed the bearing capacity of a strip footing resting on two layers of clay. He assumed that the cohesive soils in both layers are consolidated approximately to the same degree. In order to determine the ultimate bearing capacity of the foundation, he assumed that the failure surface at the ultimate load is cylindrical, where the curve lies at the edge of the footing. The bearing capacity factor used depends on the upper soil layer and on the ratio of the cohesions of the lower/upper clay layers.

Reddy and Srinivasan (1967)[2]

They extended the work of Button to include the effect of the non-homogeneity and anisotropy of soil with respect to the shear strength. The basic assumptions involved in determining the ultimate bearing capacity are: the failure surface is cylindrical, the coefficient of anisotropy is the same at all points in the foundation medium, the soil in each layer is either homogeneous with respect to the shear strength or the shear strength in each layer varies linearly with depth. In both papers, the assumption of cylindrical potential failure surface led to values of Nc is 7% higher than the values obtained by the Prandtl solution in the case of homogeneous subsoil. In the case of an-isotropic and non-homogeneous subsoil, the values are even higher and the error increases with increasing non-homogeneity of the two layers.

Brown and Meyerhof (1969)[3]

They investigated foundations resting on a stiff clay layer overlying a soft clay layer deposit, and the case of a soft layer overlying a stiff layer. They assumed that the footing fails by punching through the top layer for the first case, and with full development of the bearing capacity of the lower layer in the second case.

They also conducted a series of tests on footings in homogeneous clay. They observed that the pattern of failure beneath a footing is a function of the physical mode of rupture of the clay, which is strongly dependent on the structure of the clay. The failure mechanism of the structure of the clay is not adequately defined by conventional Mohr-coulomb concepts of cohesion and friction.

Meyerhof and Hanna (1978)[4]

They considered the case of footings resting in a strong layer overlying weak deposit and a weak layer overlying strong deposit. The analyses of different soil failure were compared with the results of model tests on circular and strip footings on layered sand and clay. They developed theories to predict the bearing capacity of layered soils under vertical load and inclined loading conditions.

This paper is a development of the previous theory (Meyerhof 1974), taking into consideration all possible cases of two different layers of subsoil, and also including the effect of inclined and eccentric loading on the ultimate bearing capacity of strip, rectangular, and circular footings. This theory and the failure mechanism considered are approximations of the real failure mechanism, which depends on many factors.

Meyerhof (1974)[5]

He investigated the case of sand layer overlying clay: dense sand on soft clay and loose sand on stiff clay. The analyses of different modes of failure were compared with the results of model test results on circular and strip footings and field data. .

Theory and test results showed that the influence of the sand layer thickness beneath the footing depends mainly on the bearing capacity ratio of the clay to the sand, the friction angle (ϕ) of the sand, the shape and depth of the foundation. This paper is limited to vertically loaded footings, and does not include eccentric or inclined loads, it is also limited to sand over clay, and has no solution for clay over sand. In the case of dense sand on soft clay, the theory considers simultaneous failure of the sand layer by punching, and general shear failure in the clay layer, which is not always the case.

Hanna and Meyerhof (1979)[6]

They extended their previous theory of the ultimate bearing capacity of two-layer soils to the case of three-layer soils. The analysis compared well with the results of model tests of strip and circular footings on a three-layer soil. Only one case was considered in this paper, that for footings subjected to vertical loads and resting on subsoil consisting of two strong layers overlying a weak deposit.

1.3. Aim

To stabilize the soil by adding sodium silicate to achieve high and effective properties of the soils.

1.4. Scope of Study

To focused on the quality and improvement of settlement of soils by sodium silicate.

II. MATERIALS AND METHODS

2.1. Materials Collection Data

In this study Black cotton soil (IS sieve 4.75mm passed), Red soil (IS sieve 4.75mm passed), and Sodium silicate (Na_2siO_3) powder commercially available in market were used for the Settlement of Soils and for entire tests.

Materials	Quantity	Location
Black Cotton soil	20kg	Dhullapally
Red Soil	20kg	Dhullapally
Sodium silicate	1kg	Bal Nagar

- The Black cotton soil and Red soils were obtained from Dhullapally, Hyderabad, Telangana.
- Sodium silicate can change the property to raise the normal properties of soil in effective manner. To obtain the maximum dry density of soils to settleable.

Fig 2.1. (a) Black cotton soil

Fig 2.1. (b) Red soil

Fig 2.1. (c) Sodium silicate (Na_2siO_3) powder.

2.2. Study objects

- To study the properties of Red soil and Black cotton soil.
- To stabilize soils with sodium silicate.
- Improving settlements of soils.
- Different types of laboratory tests on soils.

2.3. Methodology

Take a representative oven-dried sample, approximately 3 kg in the given pan. Thoroughly mix the sample with sufficient water to dampen it with approximate water content of 4-6 %. Add 10% of sodium silicate powder to the samples. Weigh the proctor mould without base plate and collar. Fix the collar and base plate. Place the soil in the Proctor mould and compact it in 3 layers giving 25 blows per layer with the 2.5 kg rammer falling through. The blows shall be distributed uniformly over the surface of each layer. Remove the collar; trim the compacted soil even with the top of mould using a straight edge and weigh. Divide the weight of the compacted specimen by volume and record the result as the bulk density. Remove the sample from mould and slice vertically through and obtain a small sample for water content. Add water in sufficient amounts to increase the moisture content of the soil sample by one or two percentage points and repeat the above procedure for each increment of water added. Continue this series of determination until there is either a decrease or no change in the wet unit weight

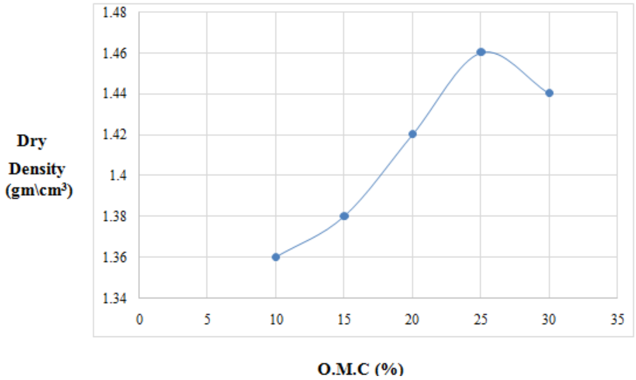
III. RESULTS AND DISCUSSIONS

3.1. Standard Proctor Test Results

Black Cotton soil

Results:

i) Max Dry density for Black Cotton soil is 1.46gm/cm^3.
ii) Optimum Moisture Content for Black cotton soil is 27%.

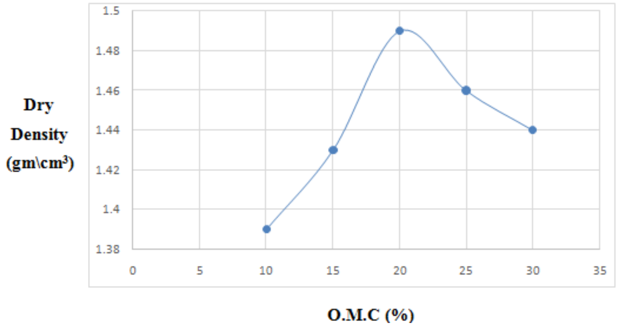


Graph: 3.1. Black cotton soil

Red soil

Results:

i) Max Dry density for Red soil is 1.49gm/cm^3.
ii) Optimum Moisture Content for Red soil is 26%.



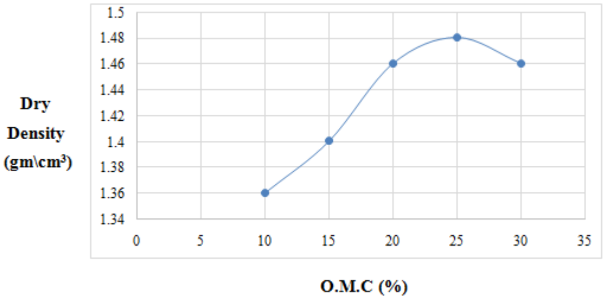
Graph: 3.1. Red soil

3.2. Standard Proctor Test Results (Addition of Sodium Silicate)

Black Cotton soil

Results:

i) Max Dry density for Black Cotton soil is 1.48gm/cm^3.
ii) Optimum Moisture Content for Black cotton soil is 23%.

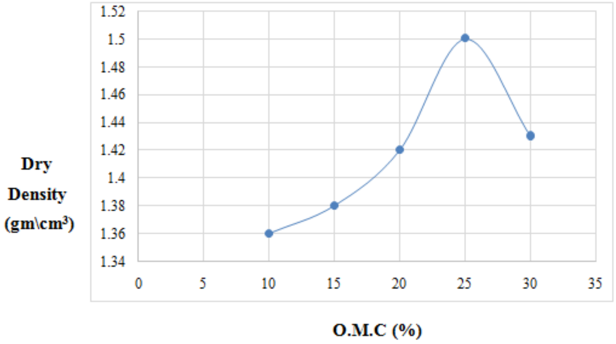


Graph: 3.2. Black cotton soil

Red soil

Results:

i) Max Dry density for Red soil is 1.50gm/cm^3.
ii) Optimum Moisture Content for Red soil is 21%.

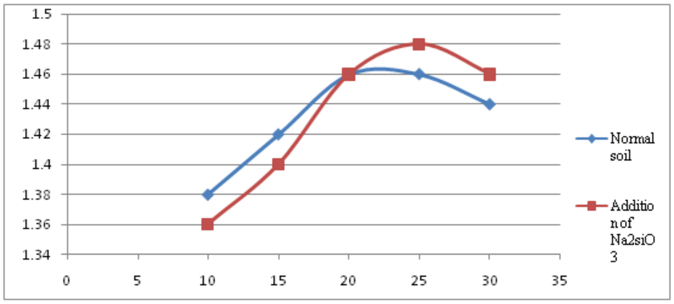


Graph: 3.2. Red soil

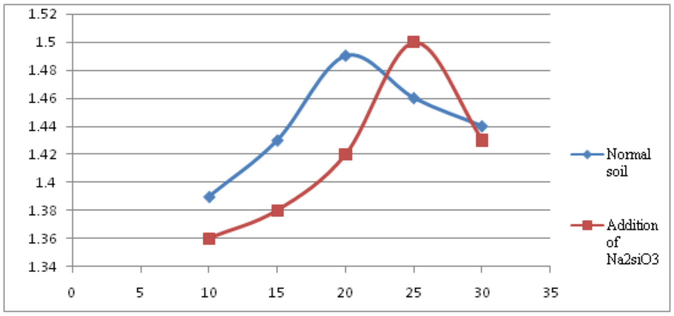
3.3 Comparison of soils:

Table-3.3 Comparison of Soils:

Standard Proctor Test	Black Cotton soil		Red soil	
	Max dry density(gm/cm³)	OMC (%)	Max dry density(gm/cm³)	OMC (%)
Normal soil	1.46	27	1.49	26
Addition of sodium silicate	1.48	23	1.50	21



Graph 3.3: Black cotton soil



Graph 3.3: Red soil

IV. CONCLUSION AND REFERENCES

4.1. Conclusion

Based on this experimental investigation made on Black cotton soil and Red soil was concluded as

- Sodium silicate is used as an excellent soil stabilizing material for active soils which undergo through frequent expansion and shrinkage.
- The reaction is very quick and stabilizes the soil within few hours.
- Sodium silicate acts immediately and improves various properties of soil such as resistance to shrinkage during moist conditions and subsequent increase in the compression resistance with the increase in time.

Hence, there is overall gain in strength parameters of soil due to addition of sodium silicate.

REFERENCES

[1] "Lectures of Foundation Engineering." CE 552, KFUPM, Saudi Arabia. Dr. Sahel Abduljauwad. 2016.
[2] Button, S. J. (1953), the Bearing Capacity of Footing on Two-Layer Cohesive Subsoil. Proceedings of the 3rd International Conference on Soil Mechanics and Foundation Engineering, vol. 1, pp. 332-335.
[3] Reddy, A. S. & Srinivasan R. J. (1967), Bearing Capacity of Footings on Layered Clays. Journal of the Soil Mechanics and Foundations Division, ASCE, Vol. 96, No. SM9, pp. 1951-1965.
[4] Brown, J. D. & Meyerhof, G. G. (1969), Experimental Study of Bearing Capacity in Layered Clays. Proceedings of the 7th International Conference on Soil Mechanics and Foundation Engineering, Mexico, vol. 2, pp. 45-51.
[5] Meyerhof, G. G. (1974), Ultimate Bearing Capacity of Footings on Sand Layer Overlying Clay. Canadian Geotechnical Journal, vol. 11, pp. 223-229.
[6] Meyerhof, G. G. & Hanna, A. M. (1978), Ultimate Bearing Capacity of Foundations on Layered Soils under Inclined Load. Canadian Geotechnical Journal, vol. 15, n. 4, pp. 565-572.