International Journal of Science and Research (IJSR)
ISSN: 2319-7064
SJIF (2022): 7.942

A Review on Stabilization of Kuttanad Clay with Nano Silica

Hiba Noushad

M-Tech Scholar, Civil Engineering

Rajadhani Institute of Engineering and Technology, Thiruvananthapuram, Kerala, India

hibanoushad96[at]gmail.com

Abstract: ***Soil stabilisation with nano additives is one of the decade most popular trends. The purpose of this study is to see how adding nano-silica to Kuttanad clay affects its geotechnical qualities. Initial properties of kuttanad clay are determined. When different percentages of nano material were added to soil, variations in Atterberg limits, MDD, UCS, and CBR strength properties were investigated. Maximum dry density (MDD) and optimum moisture content (OMC) for Kuttanad clay are to be determined from compaction tests. Uncon fined compressive strength is used to calculate strength parameters for clayey soil. Due to an increase in the plastic limit and a decrease in the liquid limit, increasing the nano silica to soil ratios resulted in a reduction in the plasticity index. As the percentage of Nano silica increases, the quality of the product improves.***

Keywords: Kuttanad clay; Nano silica; Compressive strength; Maximum dry density; Soil stabilization

1.Introduction

Nanosilica has come to be used widely as a composite material in geotechnical engineering in recent years and is known for its excellent properties of small particle size, porous and large surface area. Only a few studies on the use of nanomaterials and silica-based materials to improve clay soil have been published. In this research, nano silica was chosen to improve the characteristics of Kuttanad clay. Therefore, the main objective of this research is to stabilize the Kuttanad clay soil with nano-silica in order to improve the properties of Kuttanad clay. Atterberg limit, specific gravity, compaction test strength, and CBR tests were undertaken as part of the research. The appropriate dosage of admixtures to be applied to the clay soil was determined by a series of unconfined compressive (UC) strength tests conducted in the laboratory.

2.Materials Used

A. Cohesive soil

Cohesive soils are fine grained soils and are those whose particles aggregate or clump together. Significant plasticity and Cohesion characteristics are found in clay because the clay particles are so small and numerous. This provides maximum surface area for cohesive bonding activity to take place.

B. Nano silica

Among the nano-materials, nano-silica is the most widely used by the researchers. Nano-silica improves the soil strength and stiffness due to its high pozzolanic activity, tiny size, void-filling effect and high specific surface area (SSA). Sample preparation incorporating nano-silica is done by adding nano-silica to the soil and then the mixed material is prepared using a mechanical mixer. Water is added gradually based on the optimum moisture content of each mixture. The mixing is continued for about 20 min to attain uniformity.

3.Literature Review on Nano Silica

Noor et al. (2021) presented a study and discussed about the Variation of Consistency Limits and Compaction Characteristics of Clayey Soil with Nanomaterials. In this study, experimental tests were conducted to investigate the effect of using conventional materials and nanomaterials on the physical properties (consistency limits and compaction characteristics) of soft soil. The results showed a significant improvement in maximum dry density and plasticity index and the improvement depends on the type of nanomaterials. The maximum dry density has increased as the content of nanomaterials has increased until this value of maximum dry density reduces the strength of the soil to the optimum percentage. This research was conducted to study the effect of the addition of four materials on the physical properties of the soft soil. The increase in the dry density is occurs with the increase of the nanomaterial content (nano fly-ash, and nano-silica fume) until reaching the optimum contents (3%), while dry density decrease in the case of continuing increase in the ordinary additives.

Mehdi et al. (2021) investigated the use of an alternative pozzolanic mix of nano-additives (i.e., nano-silica and nano-alumina) and cement to reduce the usage of cement for achieving competent soil stabilization outcomes. A series of unconfined compressive strength (UCS), direct shear, and durability tests were conducted on marl specimens cured for 1, 7, and 28 days stabilized with nano-additives (0.1~1.5%), 3% cement, and combined 3% cement and nano-additives. The UCS and shear strength of stabilized marl increased with nano-additives up to a threshold nano-additive content of 1% which was further intensified with curing time. Nano-additive treated cemented marl specimens showed long durability under the water, while the cemented marl decomposed early. The

microfabric inspection of stabilized marl specimens showed significant growth of calcium silicate hydrate (CSH) products within the micro fabric of nano-silica treated marl with reduced pore-spaces within aggregated particles. The results confirmed that nano-additives can replace cement partially to achieve multi-fold improvement in the strength characteristics of the marl.

Rusel Zahraw et al. (2021) conducted a study on leachate composition of lead and cadmium ions from solidified mortar mixed with Nano silica. This paper discussed the effects of Nano silica on leaching contamination from solidifying samples and compressive strength.

The results obtained from this study indicate that the use of cement-based 15 % OPC by weight and 5% Nano silica as replacement of cement mixtures in the solidification process can be very suitable for the treatment of contaminated wastes, sites, and landfills even when the initial concentration of heavy metal ions is relatively high (1500 mg/kg). The results of compressive strength were analysed to study the effect of heavy metal ions type and concentration, binder to media composition ratio, and the Nano silica percentage as replacement of OPC. Using Nano silica in solidification gives both pozzolanic activity and the ability to reduce the mobilize of heavy metals.

Sajad Shahsavani et al. (2021) done a study on the Effects of freeze-thaw cycles on the characteristics of the expansive soils treated by nanosilica and Electric Arc Furnace (EAF) slag. The impacts of nanosilica and the Electric Arc Furnace (EAF) slag on the improvement of the swelling potential, volume changes, and Unconfined Compressive Strength (UCS) of the expansive clay samples were experimentally investigated in this study. In addition, the durability of the stabilizers against adverse effects of consecutive freeze-thaw cycles was also assessed using macro and micro tests. The results confirmed the strong potential use of the mixture of the EAF slag and nanosilica in reducing the negative effects of freeze-thaw cycles on the soil characteristics Reza et al. (2020) studied the utilization of Nanosilica and Hydrated Lime to Improve the Unconfined Compressive Strength (UCS) of Gas Oil Contaminated Clay. In present research, using lime as a traditional additive and nanosilica is considered for treating of gas oil contaminated clay. The polluted specimens were prepared by mixing the soil with gas oil in amounts of 0, 3, 6 and 9% by dry weight. The contaminant increased liquid limit (LL) and plastic limit (PL), and reduced maximum dry density (MDD) and optimum moisture content (OMC) of the soil. Unconfined compressive strength (UCS) of the soil showed an initial increase in 3% of contamination and then a decrease for the heavily contaminated samples (i.e., gas oil content greater than 3%). After adding 0, 1, 2 and 3 weight percent of lime and nano silica, both independently and together; LL, PL, OMC and UCS of the samples increased and MDD of the treated soils decreased. Meeravali Karumanchi et al. (2020) done a study on Improvement of consistency limits, specific gravities, and permeability characteristics of soft soil with nanomaterial: Nanoclay. In the present study, aimed to be improved the plasticity index, specific gravity, compaction, shear strength (Unconfined Compressive Strength-UCS), and permeability characteristics by adding nanomaterial: Nanoclay.

Stabilization of soil with Nanoclay proven excellent results and improved all geotechnical properties such as index and engineering properties. Determine the optimum dosage of the Nanoclay effect on the soil and responses on specific gravity, index, and engineering properties of soil. At the optimum dosage of Nanoclay proved maximum escaped all voids and filled with Nanoclay particles. The stabilization is useful for all embankments related to civil, geotechnical, transported, and slope stability.

Pourya Kargar et al. (2020) done a study on Collapse Remediation of Illinois Loess Using Electrokinetics Technique by Nanosilica and Salt. Increase in the moisture content directly affects the geotechnical behavior of all types of soil. This study shows how the electrokinetics technique, as an innovative in situ solution that changes the physiochemical properties of soil, can contribute to the improvement of Illinois loess collapsibility. According to the results of standard collapse potential measurements, the efficiency of this method at three different maximum vertical stresses were evaluated. It was observed that the electrokinetics technique is able to significantly decrease the collapse potential of Illinois loess. However, the extent of improvement was not equal for different stabilizer agents at different maximum vertical pressures.

Ghasabkolaei et al. (2016) investigated the use of nanosilica to improve geotechnical characteristics of cement treated clayey soil from the coastal area of the eastern Caspian Sea in the Golestan province, Iran. Atterberg limits, unconfined compressive strength, and California bearing ratio (CBR) tests were performed to investigate the soil plastic and strength parameters. The addition of nanosilica enhanced the strength parameters of the clayey soil. This study presented the effect of nanosilica on the geotechnical properties of clayey soils that were treated with cement. The results of the Atterberg limit, unconfined compressive strength, and CBR tests were also investigated. The results shows that the plasticity index decreases with addition of cement to the clayey soil. Moreover, addition of nano silica to the cement-treated clay slightly increases the plasticity index. Mechanical properties, such as unconfined compressive strength, elasticity modulus, and CBR, were considerably enhanced. Saman et al. (2016) conducted a study to explore the impact of nanosilica on the microstructure properties and mechanical characteristics of cemented sand. Cement agent included Portland cement II. Cement content was 6% by weight of the sandy soil. Nanosilica was added in percentages of 0, 4, 8 and 12% by weight of cement. Cylindrical specimens were prepared with relative density of 80% and optimum water content and cured for 7, 28 and 90 days. Unconfined compression test (for all curing times) and compaction test are also performed in the present study. The results shows that adding optimal percentages of nanosilica to cement stabilized sand enhances its mechanical and microstructure properties. This research evaluated the impacts of nanosilica particles

on the mechanical characteristics and microstuctural properties of cement treated sandy soil.

Muhammed Ali et al. (2015) investigated the effect of nano silica on swelling, compaction and strength properties of clayey soil stabilized with lime. In this study, the effects of adding nano-silica and lime with different percentages on clay are investigated. Results show that slight addition of nano-silica to clay mixed with lime results in a significant improvement in plastic properties, compaction, strength and swelling of the modified soil. The effects of curing time were also evaluated in this study and results showed that adding nano-silica causes strength of soil mixed with lime to increase more rapidly in a shorter time. Due to small size of nano-silica, the addition of these nanoparticles will increase samples' reactivity even at an early age, subsequently compressive strength is increased.

Mohd Raihan Taha et al. (2012) done an experimental study performed on four types of soils mixed with three types of nano-material of different percentages. The expansion and shrinkage tests were conducted to investigate the effect of three type of nano-materials (nano-clay, nano alumina, and nano-copper) additive on repressing strains in compacted residual soil mixed with different ratios of bentonite (S1 = 0 % bentonite, S2 = 5 % bentonite, S3 = 10 % bentonite, and S4 = 20 % bentonite). The soil specimens were compacted under the condition of maximum dry unit weight and optimum water content (wopt) using standard compaction test. The physical and mechanical results of the treated samples were determined. The untreated soil values were used as control points for comparison purposes.

It was found that with the addition of optimum percentage of nano-material, both the swell strain and shrinkage strain reduced. The results show that nano-material decreases the development of desiccation cracks on the surface of compacted samples without decrease in the hydraulic conductivity.

4.Conclusion

Based on the literature review of Stabilization of Kuttanad clay with Nano silica, the following conclusions were drawn.

- The study deals the geotechnical properties of clayey soil amended with nano silica or Nano additives in different proportions.
- The results of Atterberg limits experiments indicate that with addition of each percentage of Nano silica, the liquid limit decreases and plastic limit increases. Thereby plasticity index decreases.
- The UCS increases with increase in the percentage of Nano additives.
- The addition of nano-silica particles to the parent clay resulted in a drop in maximum dry density and an increase in optimal moisture content as the nano-silica concentration increased. The unconfined compressive strength of clayey soil rose dramatically as the proportion of stabiliser was increased. Based on the findings, it can be inferred that nano-silica has the potential to alter the engineering qualities of soil to a degree. When nano-silica is added to clay, the failure strain of the specimens is reduced when compared to Kuttanad clay that has not been treated.

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