# Effective Utilization of Nano Material in Subgrade Soil for Pavements

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**ABSTRACT: In developing countries, there are several types of road failures such as potholes, cracks, base failure, wash out etc. Poor subgrades are found to be failed under repeated traffic and presence of heavy loads. Ideally the pavement subgrade should be strong enough to resist shoving, rutting excessive settlement and sufficiently stiff to reduce deflection. Nano technology can be effectively used as a preventive engineering solution in the pavement construction. This work deals with the study of effect of adding nano-silica on geotechnical properties of weak subgrade soil like Kuttanadu clay. Initial properties of clay is determined. The variation in Atterberg limits, MDD of soil, UCS and CBR strength properties of soil when adding different percentages of nano material were also studied. The optimum percentage of nano silica is found to be 10%. By adding 10% nano silica in Kuttanadu clay in its natural state, the strength is observed to be increased by 223%. As the plasticity index is reduced by 15%, the compressibility of soil is also reduced significantly. CBR value of 4% is obtained in its natural moisture content.**

## I.INTRODUCTION

The entire growth of any developing nation depends upon the quality of available transportation system. Huge amount of soil is inevitable for the preparation of pavement subgrades. But mostly the soil available is found to be very weak, highly plastic and expansive in nature so, this is not suitable for constructions in its natural condition. The pavement subgrade which refers to as the foundation soil in roads. It should be properly designed to withstand the traffic loads coming on the pavement layers. Weak subgrade soil, may cause problems for the overall durability of the pavement structure, if not treated properly which may pose a lot of constructional problems. Therefore, the soil used in pavement constructions plays a vital role in deciding the future of durable and safe road networks [1].

Due to scarcity of land, even abandoned sites with undesirable soil properties are supposed to be used for the construction of roads. It is not easy to obtain a construction site which meets the design requirements without ground improvement. Hence problematic soils are to be modified to meet the requirements before construction. Soft clays are generally modified by means of soil stabilization.[2] Now a days nano technology provides solution for many engineering issues. Different types of nano materials give scope for the ground modification during pavement construction. In this study nano silica is selected for the improvement of Kuttanadu clay during subgrade preparation. Easy availability, high pozzolanic properties and comparable cost effectiveness make nano silica attractive among various nano materials.

## II. MATERIALS AND METHODOLOGY

### *A. Materials*

i) Soil**:** The Clayey soil used in this investigation is of having high clay content. Fig 1 shows the clay sample. The soil was brought from Kuttanadu region, Alappuzha district. Soil was collected from 0.5m below ground level. Clay is seen to be black in colour and having low strength. Table1 shows the properties of Kuttanadu clay.

Figure 1: Kuttanadu Clay

Table 1. Properties Of Kuttanadu Clay

| No | Property | Value |
|---|---|---|
| 1 | Natural moisture content | 71.4% |
| 2 | Field density | 1.501g/cc |
| 3 | Specific gravity of the soil | 2.41 |
| 4 | Maximum dry density | 0.998g/cc |
| 5 | Liquid limit | 151% |
| 6 | Plastic limit | 46.1% |
| 7 | Shrinkage limit | 36.6% |
| 8 | Plasticity index | 104.9% |
| 9 | Flow index | 66.24% |

ii) Nano Silica**:** Nano silica is very active super-pozzolanic additive, also known as silicon dioxide nanoparticles or silica nano particles, which appears in the form of a white powder. Nanoparticles of $SiO_2$ exhibit high pozzolanic activity due to high amount of pure amorphous $SiO_2$. The size of the Nano silica is 200-300 nm.

Figure 2: Nano Silica

*B. Methodology*

To evaluate the effect of Nano silica on the improvement of weak soil like Kuttanadu clay, a number of test are to be conducted such as, Atterberg limit tests, Unconfined Compression Strength (UCS) test, California Bearing Ratio (CBR) test etc. For this, the soil sample was mixed with nano silica in different percentages such as 1, 2, 4, 5, 8, 10 and 12% and the tests were conducted for each sample. Soil without nano silica was also tested.

i. *Moulding and curing of specimens:* To perform the CBR tests, the soil and soil- nano silica compacted specimens used in the work were prepared by hand-mixing of soil and Nano-silica in natural moisture content. For each sample, the maximum dry density was determined by standard compaction test and the CBR specimens were prepared based on that density. After the preparation, the treated soil samples were kept in a covered container for 1-2days.

ii. *CBR test***:** The California bearing ratio test for the determination of subgrade strength of roads and pavements. It is a penetration test. CBR test is one of the effective and common methods in determining the strength of soil for the design of subgrade, sub base and base of roads.

iii. *UCS test:* This test is used to fine the unconfined compressive strength of a clayey soil (cohesive soil) sample. The unconfined strength test is an un consolidated undrained (UU or Q type) test where the confining pressure acts laterally are equal to atmospheric pressure ( zero).

## III. RESULTS AND DISCUSSIONS

The properties of Kuttanadu clay improved with addition of nano material in its natural moisture content. Upto the addition of 10%, the maximum dry density (MDD) of clay improved with increase of nano material. Beyond that the MDD slightly decreases.

i. *Unconfined Compressive Strength test:*

The UCS increases with increment in the percentage of Nano silica. Upto 5% addition of nano silica no significant improvement has been detected. But with 8 to 10% nano material, the unconfined compressive strength gets doubled. By adding12% nano material, the strength reduces slightly.

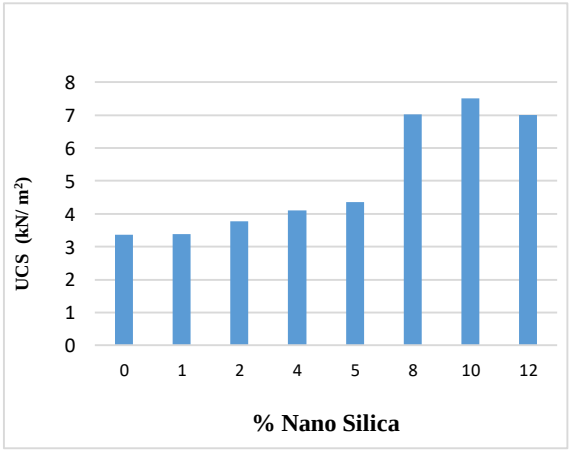


Figure 3: Unconfined Compressive Strength of soil samples

ii. *California Bearing Ratio test:* The CBR test was conducted in both soaked and unsoaked condition. Natural clay does not show any CBR value in both conditions. By adding nano silica the strength increases in unsoaked as well as in soaked condition. By adding 10% nano silica the clay exhibits a CBR value of 4% in unsoaked condition and 2.8% in soaked condition in its the natural moisture content. Figure 4 shows Unsoaked CBR strength of soil with varying nano silica percentages and Figure 5: Soaked CBR strength of soil with varying nano silica percentages.

Table2: Soaked and Unsoaked CBR values

| Sl No | % Addition of Nano Silica | CBR Value ( %) | |
|---|---|---|---|
| | | Unsoaked | Soaked |
| 1 | 0% | - | - |
| 2 | 1% | 0.87% | - |
| 3 | 2% | 1.46% | - |
| 4 | 4% | 1.87% | 1.49% |
| 5 | 8% | 3% | 1.86% |
| 6 | 10% | 4% | 2.84% |
| 7 | 12% | 3.35% | 1.86% |

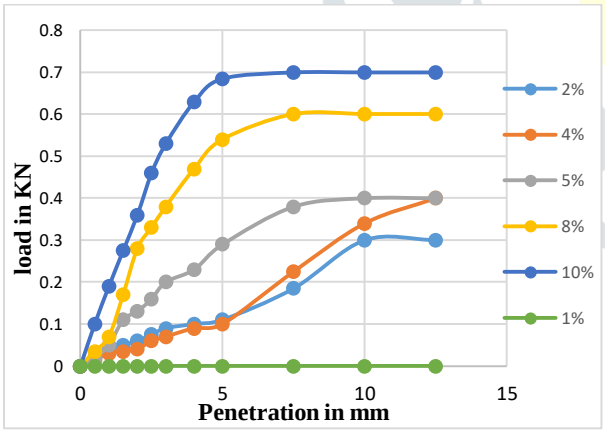


Figure 4: Unsoaked CBR strength of soil with varying nano silica percentages.

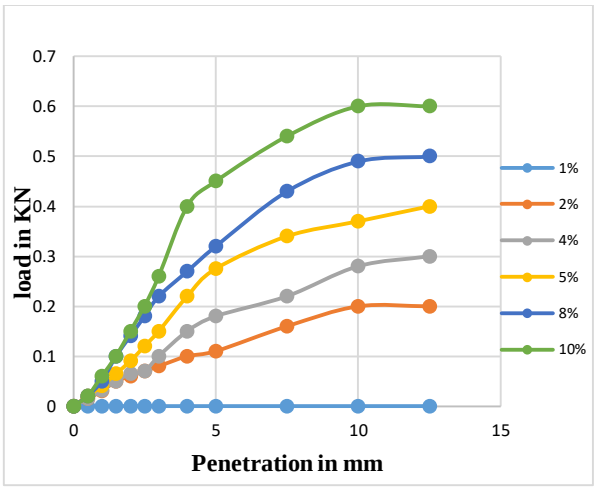


Figure 5: Soaked CBR strength of soil with varying nano silica percentages.

iii. *Plasticity Index:* The PI of soil decreases with increasing addition of nano silica. By adding 10% nano silica, the plasticity index was reduced up to 15%. It indicates a significant reduction in compressibility of soil.

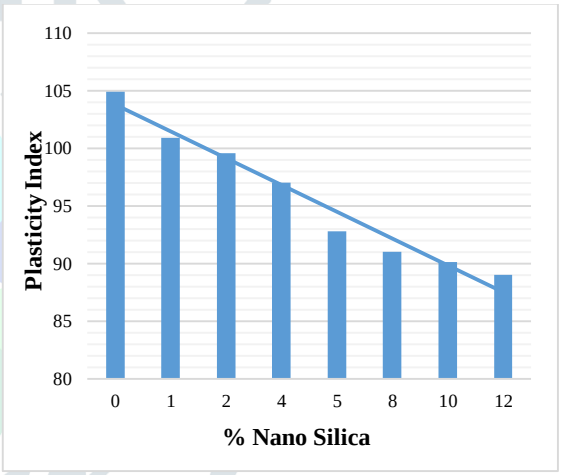


Figure 6: variation of plasticity index

## IV. CONCLUSION

In this paper, the effectiveness of adding nano silica in Kuttanadu clay as subgrade soil for pavement construction has been investigated. Results show that the increase in nano silica content will lead to the improvement in strength and geotechnical properties of clay. With increase in nano silica content, the plasticity index decreases. The optimum percentage of nano silica is found to be 10%. By adding 10% of nano silica the plasticity index decreased by 15%. The unconfined compressive strength of clay increased about 223% by addition of 10% nano material, and the soil shows significant improvement in CBR property with the addition of nano material. By adding 10% nano silica, the clay exhibits a CBR value of around 4% in unsoaked condition and 2.8% in soaked condition in its natural moisture content.

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