International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 08 | Aug 2020 www.irjet.net p-ISSN: 2395-0072

The California Bearing Ratio Value for Clayey Soil Subgrade Stabilized using Nano Silica-Human Hair Fibre Mixture

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Abstract -*Weak soil subgrade possesses risk for the pavement construction due to its low shear strength and high swelling and shrinkage characteristics. To enhance the strength of subgrade soil, stabilization is the most suitable method. In this study Nano silica (sio_2) which particles are less than 100mm and human hair fibre which is a non-biodegradable solid waste material used as stabilizer to enhance the strength of clayey soil. The soil sample were treated with various percentage of Nano silica(i.e. 1%,2%,3%,4% by weight of soil) separately and then the optimum soil-Nano silica mixture were treated with various percentage of human hair fibre (i.e. 0.5%,1%,1.5%,2% by weight of soil). In order to find consistency limit, optimum moisture content(OMC,), maximum dry density(MDD) and CBR strength, the Atterberg's limit test, standard proctor test ,California bearing ratio test were carried out respectively . In comparison with Nano silica and combination of Nano silica and Human hair fibre, the combination provides better improvement considering the properties of soil. The best results are obtained when 3% of Nano silica and 1.5% of human hair fibres were mixed with soil.*

Key Words: Clayey soil, Nano Silica, Human Hair Fibre, CBR, Subgrade, SiO_2.

1. INTRODUCTION

The pavement performance relies upon the characteristics of subgrade and sub base. So the subgrade has to be strong enough to hold up the weight of the overlaying pavement layers and also wheel load's weight coming over it. In light of enlarging the usage of recourse and increase in population, the soil with relevant properties for construction of pavement are not accessible. This circumstances forces the engineers to complete the work on weak soil. Therefore, it is required to enhance the nearby soils properties ought to be suitably considerable. Stabilization is one of the best methods for enhancing the strength properties of clayey soil using various types of additives and fibres. The main motive here is to increase the strength of clayey soil and to reduce the cost of construction using locally available materials.

One of the new imaginative fields as of late acquainted with soil is Nano technology. Nano technology is the mechanism that manages the molecule which is in Nano metric scale. In the behaviour of soil exhibiting different properties, this technology plays a critical role, which is recently added in soil stabilization. The strength properties of soil influenced by the utilization of Nano particles (in order to 10^{-9})and soil becomes more reactive due to its larger specific area.

Lately, in geotechnical engineering soil stabilization by using waste material has been taken from an ecological prospective. Human hair fibre is one of the natural non bio-degradable solid waste materials found in most part of the country which create many environmental problems. For improvement of the strength and CBR value of clayey soil subgrade, human hair fibre can be used as a reinforcing agent. HHF is economical and decreases the disposal issue. In this study we used Nano Silica and HHF combinedly for strength improvement of weak soil subgrade.

2. LITERATURE REVIEW

Seyed et al. (2013)[1]investigated the impact of Nanomaterial to stabilize a weak soil. They were conducted fifty CBR tests. The results show a little effect of lime in the soil improvement. The consiquences of Nano-silica on the stabilization of the soil-lime mix was studied. The results showed that the CBR strength of the soil lime mixture increased more rapidly with adding Nano-material. The optimum mixture design was found to be 5% lime and 3% Nano-silica.

Iranpour and Haddad (2016)[2] investigated the impact of four types of nano-materials (nano-clay, nano-copper, nano-alumina, and nanosilicanano-silica) on the collapsible soil treatment. They argued that using an appropriate percentage of nano particles could improve soil specifications.

Dr. Sunil Pusadkar1(2017)[3] et al. performed a study on Nano-silica on geotechnical properties of black cotton soil especially Atterberg's limit, compaction characteristics, unconfined compressive strength, CBR value and swelling pressure. To reach the maximum increase in strength parameters, the optimum Nano-silica content occurs at 0.6 % based on obtained results.

S. Ghavami (2018) [4] et al. Performed a study on silica fume and Nano silica on geotechnical properties of kaolinite soil. He found that, the results of soaked California bearing ratio test after 7 days of curing demonstrated that 15% of silica

fume and 3% Nano-silica increased the California bearing ratio values about two times more than the raw soil.

Rohin Kaushik (2014) [5] Have done the research on "Innovation technique of improving the CBR value of soil using Hair fiber", and observed that there was an increase in the bearing capacity of the soil and hence decrease in the undesirable settlement of structures. The stability of slopes and CBR value got increased on addition of large percentage of HHF.

Wajid Ali Butt, B.R. Mir, J.N. Jha (2016) [6] conducted research on strength behavior of clay soil with human hair fiber of varying percentages (0.5, 1, 1.5, 2, and 2.5%). It was found that for 0% HHF the CBR value was 4.75% and was increased to 7.75% after addition of 2% of HHF.

S. Mary Rebekah Sharmila, K. Shankar Narayanan (2017)[7] carried out the experimental study on effect of HHF on atterberg limit, compaction characterstics and strength properties of clayey soil. The strength of the soil sample increased up to 1.2% for soil sample and then it decreased. This paper shows that the usage of Human hair fiber gives high strength for clay.

Renju R pillai and Ayothiraman Ramanathan[8] used fiber content on Kaolinite clay with addition of 2.0% fibers by weight and found the unconfined compressive strength increases up to 2 times that of unreinforced soil.

3. EXPERIMENTAL AND TEST METHODS

3.1. Material

3.1.1 Soil

For this experimental study, soil is collected from one field of IGIT Sarang, Dhenkanal in the Odisha state. As per IS code 1498-1970, the soil is classified as intermediate compressible clay (CI) and moderate expansive in nature.

Table -1: Geotechnical properties of virgin soil.

Properties		value
Specific gravity		2.7
Grain size analysis	Silt (%)	35.53
	Clay (%)	44.016
Maximum Dry Density(gm/cc)		1.71
Optimum Moisture Content(OMC)		16.48
Differential Free Swell (%)		30
Liquid Limit (%)		46.81
Plastic Limit (%)		18.55
Shrinkage Limit (%)		28.26
Plasticity Index (%)		28.26
Soil classification		CI

3.1.2 Nano Silica

Nano silica is the Nano particles of silicon dioxide (SiO_2). It is collected from one company of Hyderabad (Srishakti minerals) as shown below in figure.

Figure -1: Nano Silica powder

CERTIFICATE OF ANALYSIS

NANO SILICA

TEST ITEM	STANDARD REQUIREMENTS	TEST RESULTS
SPECIFIC SURFACE AREA (M2/G)	200 ± 20	202
PH VALUE	3.7 – 4.5	4. 12
LOSS ON DRYING @ 105 DEG.C (5)	≤ 1. 5	0. 47
LOSS ON IGNITION @ 1000 DEG.C (%)	≤ 2.0	0.66
SIEVE RESIDUE (5)	≤ 0. 04	0. 02
TAMPED DENSITY g/L	40 – 60	44
SiO2 CONTENT (%)	≥ 99. 8	99. 88
CARBON CONTENT (%)	≤ 0. 15	0. 06
CHLORIDE CONTENT (%)	≤ 0. 0202	0. 009
Al2O3	≤ 0. 03	0. 005
TiO2	≤ 0. 02	0. 004
Fe2O3	≤ 0. 003	0. 001
SPECIFIC GRAVITY	2. 2 – 2. 4 (GENERALISED)	
PARTICLA SIZE	17 NANO	

Figure -2: properties of Nano Silica

3.1.3 Human Hair Fibre

Human hair is collected from the local market of Angul district. The size of collected hair is about 2 to 40 mm. It is a waste material. Hair collected from market is shown below in figure.

Figure -3: Human hair fiber

3.2 Sample preparation

All samples are prepared by mixing of oven dried soil with different percentage of materials such as Nano silica and then soil with optimum value of Nano silica followed by different percentage of human hair fibre before conducting the laboratory tests.

- The soil taken from oven which is passing through 4.75 mm IS sieve used for testing.
- Nano silica and human hair fibre were added to the soil by percentage varying as 1%, 2%, 3%, 4% and .5%, 1%, 1.5%, 2% by weight of soil respectively.
- First soil is mixed with Nano silica separately, and then with its optimum value, human hair fibre is mixed by percentage varying at 3% Nano silica.
- Then samples are ready for laboratory tests.

3.3 Test methods

After the sample preparation, the tests were conducted in the laboratory to determine the effectiveness of the admixture and fibre in clay. For the following test the Indian standard codes were used as reference.

- Specific gravity test-IS:2720(part 3/SEC-I)-1980
- Grain size analysis-IS:2720(part 4)- 1985
- Atterberg limits –IS:2720(part 5)- 1985
- Free swell index test –IS:2720(part 40) -1977
- Standard proctor test –IS:2720(part 7) -1980
- CBR tests-IS:2720(part 16)-1987

4. RESULTS AND DISCUSSION

4.1 Effect on compaction characteristics

The relation between dry density and moisture content of soil and various percent of Nano silica were determined by light compaction test as per IS:2720(PART VII) 1974. Effects of Nano silica on the compaction behaviour of clayey soil are shown in chart-1 & chart-2 respectively. The result shows that the MDD decreases with increase in Nano silica up to 2% then it increases with addition of 3% Nano-silica, it again decreases with addition of 4% Nano silica and with increase in the percentages of Nano Silica the OMC also increases. Specific surface area of Nano-Silica is more so that it keeps more moisture.

Effects of optimum Nano silica mixture with various percentage of human hair fibre on the compaction behaviour of clayey soil are shown in chart-3 and chart-4 respectively. The result shows that MDD decreased with increase in 0.5% of HHF and it increased further addition of 1% and 1.5% of HHF and again decreased with the addition of 2%HHF. The OMC increases with increase in percentage of HHF up to 1% and it decreases with addition of 1.5% HHF and then increases with addition of 2% HHF.

Table -2: Compaction test results of soil and different percentage of Nano silica & HHF.

Mixture	OMC (%)	MDD(gm/cc)
Virgin soil	16.4	1.72
1% NS	21.22	1.55
2% NS	21.68	1.56
3% NS	22.02	1.61
4% NS	23.39	1.52
Soil+3%NS+ 0.5%HHF	20.85	1.42
Soil+3%NS+ 1 %HHF	20.53	1.58
Soil+3%NS+ 1.5 %HHF	19.85	1.59
Soil+3%NS+ 2 %HHF	20.21	1.58

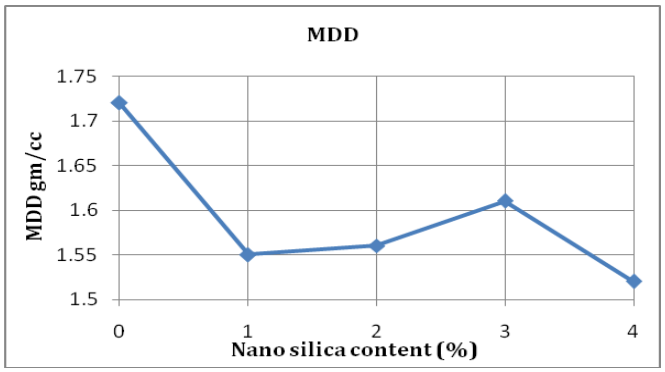

Chart-1: Variation graph of MDD values for soil stabilized with different percentage of Nano Silica.

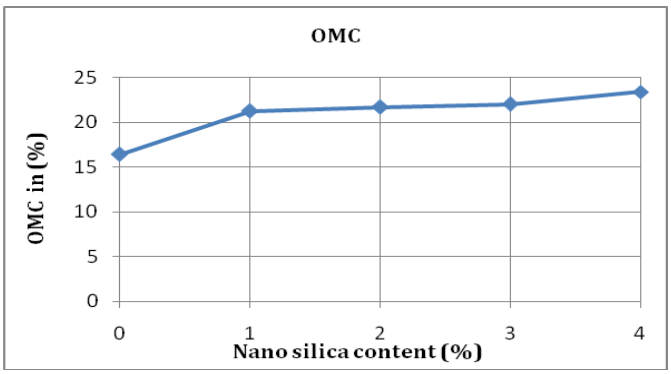

Chart-2: Variation graph of OMC values for soil stabilized with different percentage of Nano Silica.

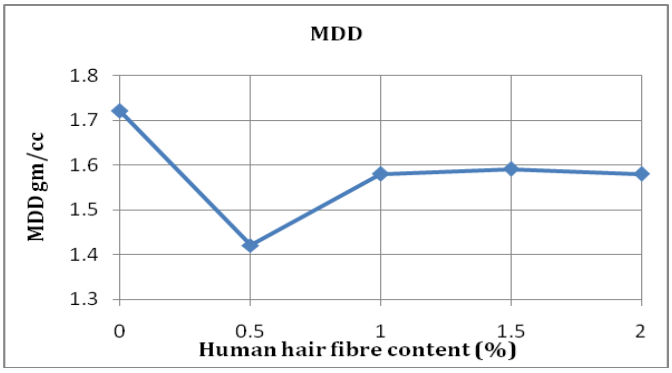

Chart-3: Variation graph of MDD values for different percentage of HHF in optimum soil nano silica mix.

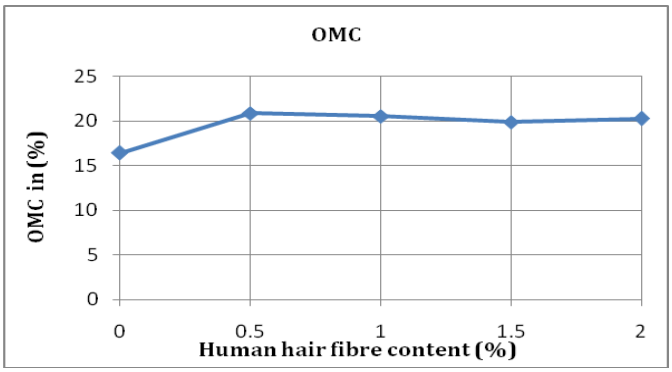

Chart-4: Variation graph of OMC values for different percentage of HHF in optimum soil Nano silica mix.

4.2 Effect on CBR value

The CBR test is used commonly to determine the subgrade strength of pavement. Here this test was conducted for unsoaked condition as per IS: 2720, 1987 Code. The tests were conducted at the remoulded samples compacted with OMC. Chart- 5 shows, load penetration curve of the soil with various percentages of nano silica and increased loads for soil nano silica mixture. By taking a constant percentage of nano silica i.e 3% different percentages of human hair fibre were added. Chart-6 shows that the load penetration curve increases with increase in percentage of human hair fibre up to 1.5% then it reduced. Chart-7 shows that the CBR value increases with increase in percentage of nano silica and also it increases with percentage of human hair fibre up to 1.5% with optimum soil nano silica mixture, then it reduced after reaching optimum fibre content. The CBR value increased due to the improved interfacial fascination between soil particle and fibre. But the fibre-fibre interaction which occurs after reaching the optimum fibre content is the reason for reduction in CBR value.

Table -3: CBR values of soil and different percentage of Nano silica & HHF.

Mixture	CBR value(%)
Virgin soil	5.09
1% NS	7.88
2% NS	8.58
3% NS	9.68
4% NS	9.78
Soil+3%NS+ 0.5%HHF	10.03
Soil+3%NS+ 1 %HHF	11.48
Soil+3%NS+ 1.5 %HHF	12.82
Soil+3%NS+ 2 %HHF	12.02

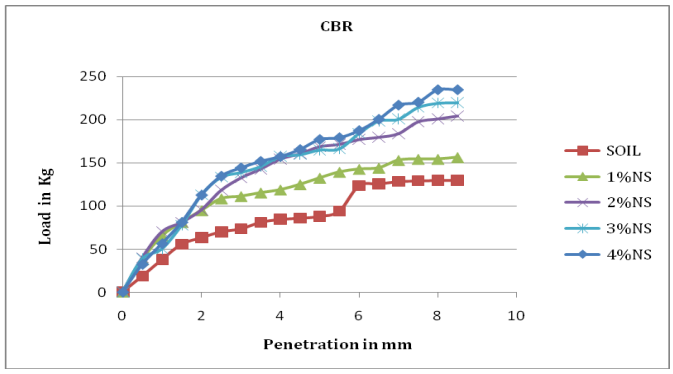

Chart-5: Variation graph of load penetration curve for soil stabilized with different percentage of Nano Silica.

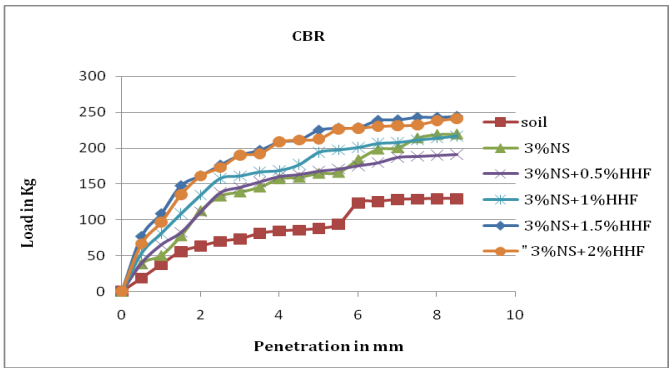

Chart-6: Variation graph of load penetration curve for different percentage of HHF in optimum soil Nano silica mix.

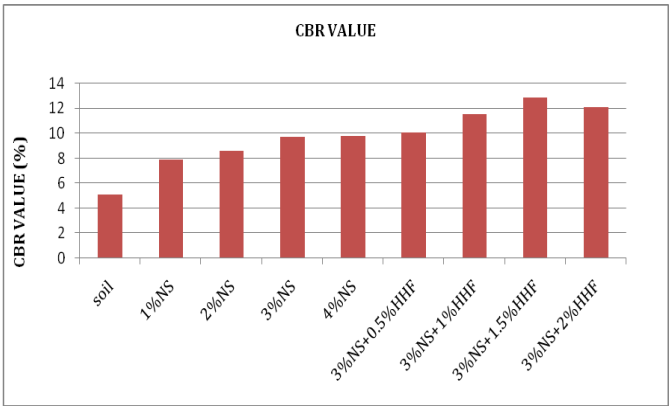

Chart-7: Variation graph of CBR values of clayey soil stabilize with different percentage of Nano silica and human hair fibre.

5. CONCLUSIONS

An extensive laboratory testing program was carried out to investigate the influence of using various proportions of Nano silica and Human hair fibre on the characteristics of clayey soil. The entire important tests related to soils have been conducted and the variation of engineering properties with percentages of Nano-silica and Nano-silica with Human hair fibre is reported. The conclusions are summarised as follows:

- The OMC increases with the increase in percentage of the Nano silica in the mixture, whereas the MDD decreases with increase in percentage of Nano silica the highest value of MDD observed at 3%NS by weight.
- The OMC decreased and MDD increased at addition of 1.5% HHF with optimum soil-NS mixture.
- The CBR value of optimum soil-NS mixture increases 90.174% as compared to virgin soil.
- The value of soil-3%NS-1.5%HHF mix increased by 151.86% as compared to virgin soil.

Hence, it is concluded that the clayey soil has been improved by stabilizing with 3% Nano silica with 1.5% HHF. Such improvement may be due to more specific surface area of Nano silica and fibre in human hair. Hence it would be an ideal solution for quality roads with having tremendous cost saving features.

REFERENCES

[1] Seyedi Gelsefidi Seyed Alireza, Mirkazemi Seyed Mohammad and Baziar Mohammad Hasan (2013), "Application of Nanomaterial to Stabilize a Weak Soil", Seventh International Conference on Case Histories in Geotechnical Engineering, Missouri University of Science and Technology, Paper No. 6.10a.

[2] B.J.E.G. Iranpour, The influence of nanomaterials on collapsible soil treatment, 205 (2016) 40-53.

[3] Dr. Sunil Pusadkar, Snehal Bakhade, Dr. Anant Dhatrak(2017)"Effect of Nano-Silica on Performance of Black Cotton Soil".International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES) Volume 3, Issue 06, June-2017

[4] S. Ghavami , B. Farahani , H. Jahanbakhsh , F. Moghadas Nejad "Effects of Silica Fume and Nano-silica on the Engineering Properties of Kaolinite Clay".AUT Journal of Civil Engineering AUT J. Civil Eng., 2(2) (2018) 135-142 .

[5] RohinKaushik(2014):Have done the research on 'Innovation technique of improving the CBR value of soil using Hair fiber'

[6] W. A. Butt, B. A. Mir, J. N. Jha "Strength Behaviour of Clayey soil Reinforced with Human Hair as a natural fiber". Geotech Geol Eng (2016) 34:411-417

[7] K. S. Narayanan et al. "Stabilization of Clay with Human Hair Fiber International Journal of Civil Engineering and Technology".8(4), 2017, pp. 662-667 .

[8] Renju et al. Third International Conference on Construction in Developing Countries (ICCIDC–III) "Advancing Civil, Architectural and Construction Engineering & Management" July 4-6, 2012 Bangkok, Thailand.

[9] Dr.B.C. Punmia, Ashok Kumar Jain and Arun kumar jain. "Soil mechanics and foundations". book

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