

Stabilization of Clayey Soil Using Pine Needles and Calcium Chloride

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ABSTRACT: Soil stabilization is a broad subject especially when it comes to clayey soil it is more significant. It aims at developing the strength of soil and escalating its confrontation to softening by means of bonding the particles of soil jointly. The main objective of the paper was to study about stabilization of clayey soil using Pine needles and calcium chloride. Index properties of parent soil, compaction characteristics and CBR of both parent soil and soil treated with pine needles and calcium chloride were found out. All the tests were conducted by following the Indian standards guidelines. It was concluded that Combination of both calcium chloride and Pine needles in soil improves Both MDD and CBR value at certain percentages, hence this type of soil which is reinforced with these materials can be used for various purposes as various limitations like low strength, Water content in soil swelling properties etc have been encountered.

KEYWORDS: Clayey soil, Stabilization, Pine needles, Calcium Chloride, Dry density, CBR, OMC

I. INTRODUCTION

Disintegration of physical and chemical agents leads to the formation of soil. It is formed when rocks, minerals like granite marble sandstone, organic matter both animated and in animated, water and air combine with each other. Soil is by and large falsified due to weathering action of wind, rain, snow, sun which lead to the disintegration of rocks. Humus also leads to the soil formation on combining with rock. Reactions mixed up in chemical process are corrosion, hydration, carbonation and oozing by natural acids and water. Nature of soil can be identified by combination of humus and the size of the grains of rock. The grains may be very small and even, clay is the best example or they may be larger, like grains of sand or may be gravel. Soil is considered to be the important part of environment because it is the place where plants and animals survive and grow. Beside this maximum of rainwater also makes its passage through soil and hence purity of water is maintained by soil. As far as civil engineering is concerned soil is the earliest and used building material. It is also the material which has been used at great numbers. Soil has been classified on numerous bases. The main being residual soil, transported soil, organic soils and volcanic soils. However type of soil can also vary with climate. Mainly for engineering structures residual soil is used further classified as black cotton soil and laterite soil. Clayey soils have been selected for the study. In India they are mostly used for the growth of cottons and are found in northern India brownish in color. These soils are expensive. They shrink quickly under the action of applied loads. Optimum moisture content of these soils is very high. These soils are vastly perceptive to dampness alterations, when pressure is applied on sub grade objects. Sub grade and its objectionable distinctiveness needed to be tailored by use of an appropriate stabilization method. Different methods have been used for improving the stability of soil and its engineering properties. Main aim of stabilization is to increase the stability and strength of soil and then use it for construction of roads and highway pavements in an economical and effective manner. Soil Stabilization is done physically, mechanically or chemically. In Physical stabilization, soil is stabilized electrically, thermally and by action of freeze and thaw vibrating the soil mass. The particular method chosen for a given soil depends upon its formation and types.

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Soil stabilization is a broad subject especially when it comes to clayey soil it is more significant. It aims at developing the strength of soil and escalating its confrontation to softening by means of bonding the particles of soil jointly or making soil water (Sherwood, 1993). Lately, a large amount of laboratory experimental studies have been carried out, wherein soil is mixed with artificial and natural fibers. Besides soil, concrete has also been extensively reinforced with different waste fibers like lathe scrap (Qureshi et.al, 2016). Soils have been mixed with fibers like hair, bamboo Coconut (coir), fiber Sisal, Palm fiber, Jute, Flax, and Pine etc. Soil Stabilization can also be done by adding lime, cement, calcium chloride, sodium chloride etc. Sometimes combination of both fibers and chemicals has been used. Fiber reinforced soil aided with some chemical performs as a multiple material in which fibers of comparatively high tensile strength are rooted in soil mass. Shear stresses in the soil activate tensile confrontation in the fibers, which in turn imparts better potency to the soil. Largely, use of haphazard isolated elastic fibers impersonate the performance of plant roots and add to the solidity of soil mass by addition of strength to the near-surface soils in which the effective stress is low. Whereas chemical like calcium carbide increases the strength of soil to a great extent. In this way, laboratory and some in situ pilot test results have led to heartening results demonstrating the possible application of fibers for the reinforcement of soil offering a simulated mutation of the property of plants. The results of using chemical and fibers both have also been very heartening. (Setty and Rao 1987) says that the strength of lateritic soil increases to a great extent on addition of fibers besides increasing the other properties of soil. The method of reinforcement is to be used for various projects in soil engineering from retaining walls to earthen banks and sub grade stabilization beneath footings and pavements. (Gray and Maher 1990) found that haphazardly circulated fibers increases the final strength and inflexibility of sands. The sand-fiber combination was found to have curved linear or bilinear failure envelopes, with the fracture taking place at a critical incarceration stress. (Bauer et.al 1991) found that the strength of soil which was reinforced with flexible, semi rigid and rigid metallic fibers and found that shear resistance of soil was increased to a great extent. The peak and residual strengths were increased by 100 and 300% in both the cases. Under the influence of the tractive resistance, the tensile strength of the higher rooted soil has been enhanced by 5.7 kPa when reinforced with fibers of metals (Zhou et al 1998). The addition of 51 mm lengthy monofilament polypropylene fibers by taking a fiber content of 1% (by dry weight) on sand have found to increase its overall strength (Santoni and Webster, 2001). Fiber presence increased the strength of the raw fly ash specimens and changed their brittle behavior into ductile behavior (Kaniraj et al 2003). The method of inclusion of isolated synthetic fibers in soil and mixing of a prearranged quantity of fiber provides interlocking like configuration results in mechanical reinforcement of the soil mass at scrupulous water content (Barbu et.al 2004). Soil Stabilized using lime, cement, mixture of lime and cement, Sarooj (artificial pozzolan) and heat action showed that the swelling was zero by adding 6 % lime so was the case about swelling pressure beside this the strength increases (Al-Rawaset.al 2005). The use of lime presents better results when contrast with the additional stabilizers in soil. (Chen and Wang, 2006) studied different types of additional admixtures were used with cement to stabilize a soft soil with a high natural content and found that by adding extra admixtures characteristics of cement-stabilized soils were improved. Use of human hair fiber in soil have exposed that the strength drastically increases with the addition of HHF and also prevents the sample from fracture (Butt et.al, 2016). By using lime cement and other stabilizers the strength of soil have increased

The main aim of the paper is to study the Effect of Use of pine needles and Calcium chloride stabilization on strength behavior of clayey soil by determining the index properties of clayey soil and comparing the CBR and compaction characteristics of clayey soil treated with pine needles alone, calcium chloride alone and one treated with mixture of both pine needle and calcium chloride with parent clayey soil. Hence determining how effective of pine needles and calcium chloride's mixture could be in clayey soil. Combination of the soil with stabilizer is done to modify the chemical and physical properties such as inflexibility, compressibility, permeability, workability, lower the ground water level and get rid of fragile soil

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II. MATERIALS

(i). Soil

A clayey soil is a fine-grained natural material that combines one or more clay minerals with traces of metal oxides and organic matter. Mostly soil in Jammu and Kashmir is clayey especially in sambha from where Basantar River flows (Aslam & Raina, 2016). The soil samples were collected from Mendhar about 50 km away from Poonch. Samples for soils were created in the college of Engineering & Technology BGSB University Rajouri (J&K) geotechnical engineering lab. The various preliminary tests for the index properties and strength properties were done in the lab using Indian standard. Sieve analysis was carried out for all the samples

Table 1 Properties of soil

S.No.	Soil property	Soil sample
1	Colour of soil	Greyish Brown
2	Nature of soil	Clay type
3	Natural moisture content (w %)	12.80
4	Specific gravity G	2.62
5	Uniformity coefficient Cu	3.98
6	Coefficient of curvature Cc	2.00
7	Liquid limit (%)	56.59
8	Plastic limit (%)	32.65

(ii). Pine needles

Large amount of fibers and wastes which are dumped in improper way in Rajouri and Poonch town and hence these materials are easily available (Raina and Alam, 2014; Shawl et.al 2015; Raina and Anjum; 2015; Aslam et.al, 2015). As far as development regarding civil engineering structures there are various bridges and aqueducts which benefits irrigation (Raina et.al; 2016). Naturally available Pine needles were collected from local forest of Gambhir Muglan located on Rajouri Poonch border Rajouri, J&K. Pine needles were separated and fibers were cut in length of 12 mm to 16mm. The properties of pine needles are given in table 2.

Table 2: Properties of pine needles

S.No.	Material Properties	Values
1.	Fiber Length	12 mm to 16 mm
2.	Diameter	0.5 mm to 1.1 mm
3.	Colour when dry	Brown
4.	No. of fibers per g	200
5.	Holocellulose content	67.29%
6.	Pentosan	11.57%

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Figure 1: Pine Needle Fibers

(iii) Calcium Chloride:

Calcium Chloride is concerned it is hygroscopic in nature and reduces water content in soil by Also by causing colloidal reaction. It is an organic compound with chemical formula as $\text{CaCl}_2 (\text{H}_2\text{O})_x$, where $x = 0, 1, 2, 4,$ and 6 . All of these salts are a highly soluble in water. They are mainly used for deicing and dust control. It also increases the maximum dry density of soil. Use of Calcium Chloride in clayey soil makes it brawny and less stretchy by changing mineral structure of clay, thus reducing expansion on addition of calcium chloride. The calcium chloride is also easily available and was collected from the chemistry lab in the university.

Table 3: Physical Properties of Calcium Chloride

S. No.	Chemical formula	CaCl_2
1	Molar mass	110.98 $\text{g}\cdot\text{mol}^{-1}$
2	Appearance	White powder, hygroscopic
3	Odour	Odourless
4	Density	2.15 g/cm^3 (anhydrous)
		2.24 g/cm^3 (monohydrate)
		1.85 g/cm^3 (dihydrate)
		1.83 g/cm^3 (tetrahydrate)
		1.71 g/cm^3 (hexahydrate)

III. METHODOLOGY

(i). Compaction characteristics

Compaction characteristics like dry density and optimum moisture content were determined by Compaction proctor test for parent soil and soil having varied values of 0% to 1.8% (multiples of 0.6) of pine needles by weight of the total quantity soil taken and calcium chloride as 0 to 3% by multiple of 3 by weight of the total quantity soil taken by following IS: 2720 (Part 8) 1980.

(ii) CBR

It was determined by California Bearing Ratio test. This test was done for parent soil and soil reinforced with of 0% to 1.8% (multiples of 0.6) of pine needles by weight of the total quantity soil taken and calcium chloride as 0 to 3% by multiple of 3 by weight of the total quantity soil taken.

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IV. EXPERIMENTAL RESULTS

(i) VARIATION OF OMC AND MDD WITH PINE NEEDLES REINFORCEMENT IN CLAYEY SOIL

It is seen that with addition of pines the dry density decreases and OMC increases, thus to overcome the problem it was decided to add 3 % of calcium chloride by weight of dry soil to the soil sample which contains 0% pines and also to the sample which contains 0.6 % and 1.2% pines. It is observed that with pine needle treatments compaction curve gets flattened, thereby ensuring that a given percentage of the prescribed density can be achieved over a much wider range of moisture contents, so that relaxed moisture control specifications are possible. It was found that that with addition of pine needles in the parent soil, the dry density decreases and OMC increases. The dry density of parent soil was 1.96 mg/cc, when 0.6 % pines were added it reduces to 1.84 mg/cc, on increasing the percentage of pines from 0.6 % to 1.2% dry density decreases from 1.84 mg/cc to 1.76 mg/cc. At last when percentage of pines was 1.8% by weight in soil dry density was 1.59 mg/cc as shown in Fig. 2. As far as OMC is concerned, it was increasing with increasing in quantity of pines in soil, for 0 % pines OMC was 13 %, for 0.6 % pines OMC was 16.25. At 1.2 % pines in soil OMC was found to be 16.75 % and at 1.8 % pines, OMC was 17.56 % as shown in Fig. 3.

The decline in dry density as a result of addition of pines in soil mass may have resulted due arrangement of flock with rise in percentage of pines, connecting clay particles and pine needles thus increasing size of pore voids, which result in superior water holding capacity of soil mass. The decrease in MDD values may also have been as a result of increase in fiber-fiber interaction. The fiber may not be completely associated with soil matrix and poor diffusion of fiber in the soil matrix may trim down interfacial strength.

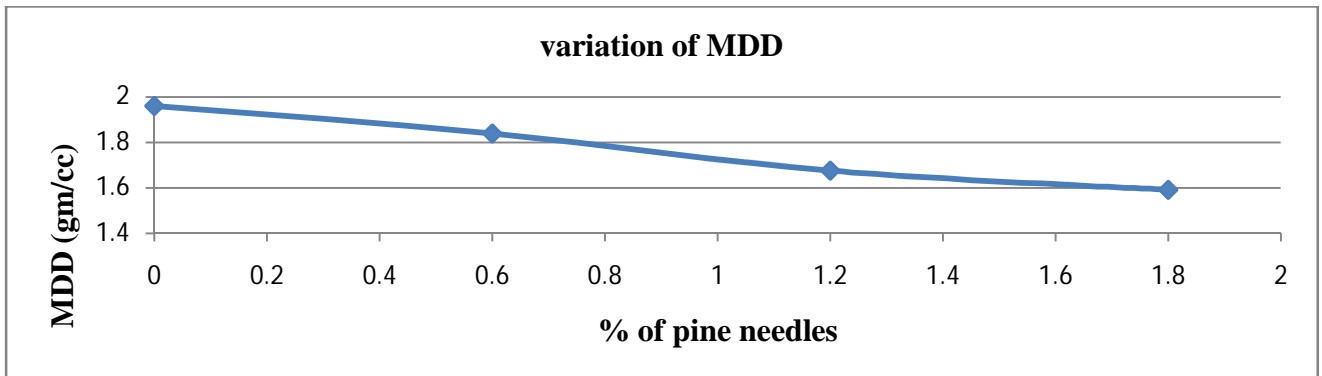
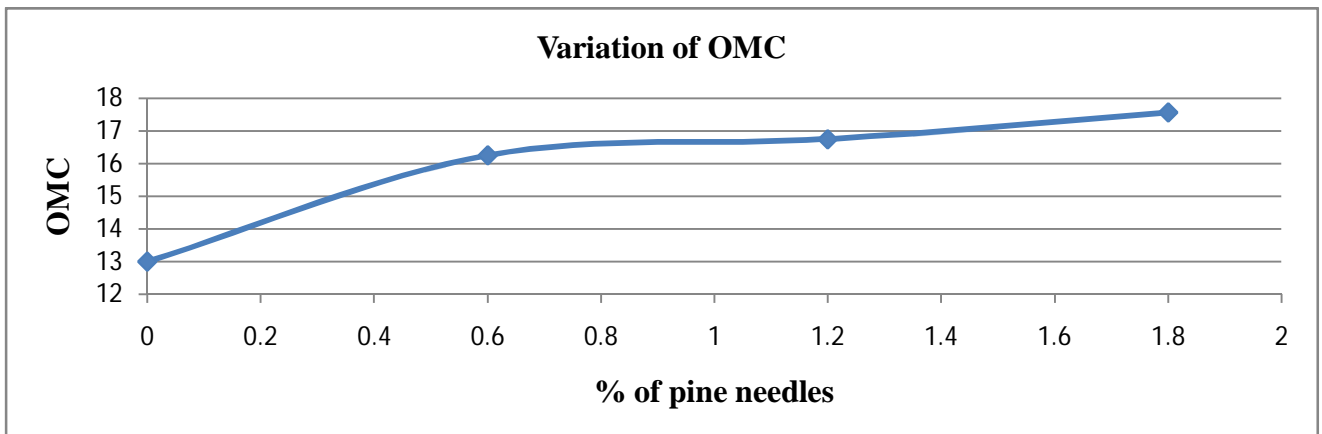


Fig 2: Variation of MDD with % of Pines in soil



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(ii) Variation of OMC and MDD with Pine Needles reinforcement Calcium Chloride both in soil

After the compaction test it was found that optimum percentage for soil to remain stable in relevance to all its compaction properties like dry density, void ratio, OMC. The optimum percentage of both pine and calcium chloride was found to be 0.6% and 3 % respectively. At 0% pine needles and 3 % Calcium Chloride clayey soil, maximum dry density was equal to 1.89 gm/cc and optimum Moisture Content was 7%, by adding 0.6 % pines to this sample maximum dry density increases to 2.13 mg/cc as shown in Fig. 4 and OMC reduces to 5.65% as shown in Fig. 4.17. Since calcium chloride exceedingly soluble and can be dissolved easily so it can be easily washed away by rain and may need more than one treatment in a single season to sustain its efficiency. Also by adding calcium chloride alone soil remains brittle. The amount of calcium chloride required to improve various soil properties is higher thus making it an expensive material. It was used alongside pine needles to impart ductility to soil and increase dry density as most of other materials reduces the density hence it was preferred over others despite being expensive. Combination of both at 0.6 % pines and 3 % calcium chloride by weight have been found to be optimum percentage for this untreated soil sample for improving soil properties. No tests were carried out on 1.2 % pines and 3 % calcium chloride and 1.8 % pines and 3 % calcium chloride as it is understood from the fact that the dry density from here on will increase in such a way that void ratio will come out to be negative which obviously is not required as we only needed the optimum amount of calcium chloride and pine needles.

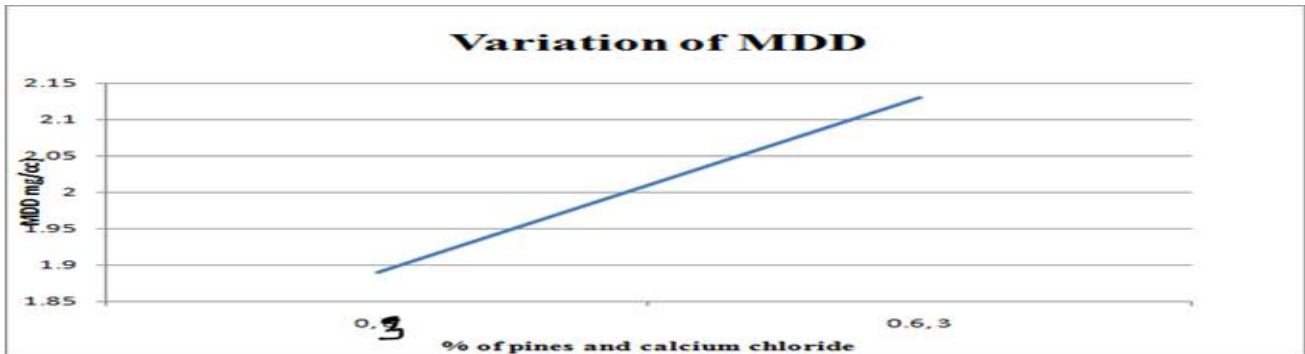


Figure 4: Variation of MDD with % of Pines and Calcium Chloride

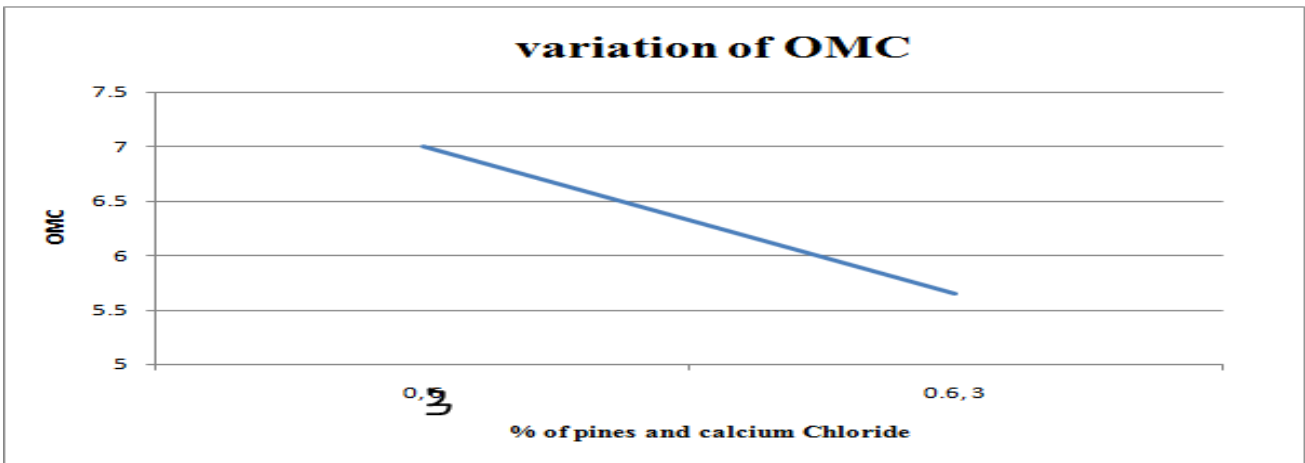


Figure 5: Variation of OMC with % of Pines and Calcium Chloride

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(iii) Variation of CBR with Reinforcement of Pine needle and calcium chloride in soil

On adding pines to the clayey soil it was found that CBR value increases a little bit but not to a great extent from 6.60 % for unreinforced soil to 7.79% and 9.09 % respectively by adding 0.6 % pines and 1.2 % pines respectively. However at 1.8 % pines addition, CBR decreases from 9.09 % to 7.89 % clearly indicating that as far as CBR is concerned optimum percentage of pines is 1.2 % by weight of soil after that CBR decreases as shown in Fig. 6. Since little amount of increase in CBR was found by adding pine needles it was decided to add 3 % of calcium chloride by weight of dry soil to optimum percentage of 1.2 % and check the how much CBR value can improve by its addition. No experiments were conducted on other percentages, as there was no need to do so because by conducting experiment on other percentages the CBR value would obviously have been lesser. So CBR test on 3% calcium carbide added and 1.2 % Pines was done. It was noted that significant increase in CBR value of Soil takes place that is to 13.52 % from 9.09% at 1.2 % pines from 6.60 % for parent soil.

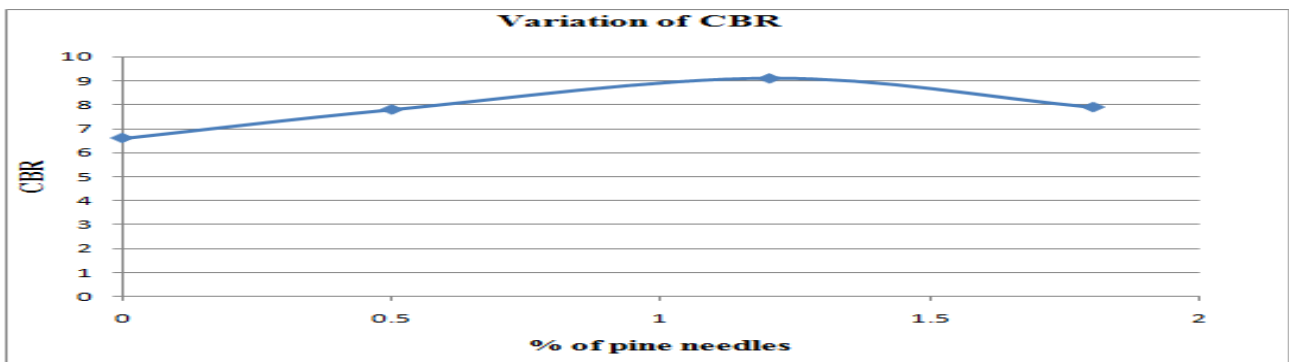


Figure 4.5: Variation of CBR with percentage of Pine needles

V. CONCLUSION

On the basis of analysis and interpretation of results obtained from the experimental investigations carried out in the present research work following conclusion are drawn.

1. It was found that that with addition of pine needles in the parent soil, the dry density decreases and OMC increases. When pines were added dry density reduces, on increasing the percentage of pines from 0% to 1.8 % dry density decreases from 1.96g/cc to 1.59 g/cc respectively .As far as OMC was concerned, it was increasing with increasing in quantity of pines in soil that is from 13% to 17.56 %. This increase in OMC and MDD was mainly due to flocculation among clay particles and pine needles, thus as a result of rise in percentage of pines, size of pore voids also increases, which result in better water holding capacity of soil mass and as a result the moisture content increases.
2. To overcome the above mentioned difficulty calcium Chloride was added to soil in addition to Pine needles. It was found that optimum percentage for soil remains stable in relevance to all its compaction properties like dry density, void ratio, OMC.
3. The optimum percentage of both pine and calcium chloride at which soil acquires best results was found to be 0.6% and 3 % respectively.
4. By addition of pines to the clayey soil it was found that CBR value increases a little bit but not to a great extent.
5. The optimum percentage at which soil acquires maximum CBR was 1.2 % by weight of soil after that CBR decreases. So to increase CBR value Calcium Chloride was added and was noted that significant increase in CBR value of Soil takes place.

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From above Discussion it can be concluded that Combination of both calcium chloride and Pine needles in soil improves Both MDD and CBR value at certain percentages, hence this type of soil which is reinforced with these materials can be used for various purposes as various limitations like low strength, Water content in soil swelling properties etc have been encountered.

REFERENCES

1. Sherwood, P. (1993). Soil stabilization with cement and lime. State of the Art Review. London: Transport Research Laboratory, HMSO.
2. Qureshi, Z. N., Raina, Y. M., & Ruffaie, S. M. A. (2016) Strength Characteristics Analysis of Concrete Reinforced With Lathe Machine Scrap. International Journal of Engineering Research and General Science, 4(4), 210-217.
3. Gray, D. H. & Ohashi, H. (1983). Mechanics of fiber reinforcement in sand. Journal of Geotechnical Engineering, 109(3), 335-353.
4. Setty, K.R.N.S., & Rao, S.V.G. (1987, December). Characteristics of fiber reinforced lateritic soils. In Proceedings of the Indian Geotechnical Conference, Bangalore, India (Vol. 1, pp. 329-333).
5. Bauer, G. E., Fatani, M. N., & Al-Joulani, N. (1991). Reinforcing soil with aligned and randomly oriented metallic fibers.
6. Santoni, R. L., & Webster, S. L. (2001). Airfields and roads construction using fiber stabilization of sands. Journal of transportation engineering, 127(2), 96-104.
7. Kaniraj, S. R., & Gayathri, V. (2003). Geotechnical behavior of fly ash mixed with randomly oriented fiber inclusions. Geotextiles and Geomembranes, 21(3), 123-149.
8. Barbu, B., McManis, K., & Nataraj, M. (2004). Study of silts moisture susceptibility using the tube suction test. In Transportation Research Board 2004 Annual Meeting, CD-ROM Publication, Transportation Research Board, National Research Council, Washington DC.
9. Al-Rawas, A. A., Hago, A. W., & Al-Sarmi, H. (2005). Effect of lime, cement and Sarooj (artificial pozzolan) on the swelling potential of an expansive soil from Oman. Building and Environment, 40(5), 681-687.
10. Chen, H., & Wang, Q. (2006). The behaviour of organic matter in the process of soft soil stabilization using cement. Bulletin of Engineering Geology and the Environment, 65(4), 445-448.
11. Butt W.A.Mir, B. A., & Jha, J. N. (2016). Strength Behavior of Clayey Soil Reinforced with Human Hair as a Natural Fibre. Geotechnical and Geological Engineering, 34(1), 411-417.
12. Aslam, Z., Raina, Y. M., & Mohiuddin, I (2015) Study of Physico Chemical Parameters of Basantar River and Impact of Industrial Waste on Groundwater Quality in Vicinity of Dumping Site in Samba Town, Jammu & Kashmir, India, International journal of Engineering research and Technology , 5(3), pp 327-332
13. Raina, Y.M. & Alam, P. (2014): Wastewater Treatment and Management in Rural areas - A Case Study of Rajouri District, Jammu and Kashmir, India, International Journal of Development Research, 4 (11), 2266-2269
14. Shawl, Z. Z., Raina, Y. M., & Mir, S. (2015). Design of Sewerage System in Hilly Areas and Various Challenges: A Case Study on Design of Sewerage System in Baba Ghulam Shah Badshah University, Rajouri, Jammu & Kashmir, India. International Journal of Innovative Research in Science & Engineering, 3(3), 116-125.
15. Raina, Y. M., & Anjum, F. (2015). Analysis and Effect of Plastic and Biomedical waste on Rajouri Town, Jammu and Kashmir, India. International Journal of Innovative Research in Science Engineering and Technology, 4(6), 3904-3909.
16. Aslam, Z., Raina, Y. M., & Mohiuddin, I (2015). Characterization of Wastewater in Rajouri Town, Jammu And Kashmir, India, International journal of Engineering research and applications , 5(10), pp 69-79
17. Raina, Y. M., Ahmed, S., Shawl, Z. Z., & Ahmed, A. Hydraulic design of an Aqueduct and its necessity in Rajouri town in Jammu and Kashmir. International Journal of Research in Engineering And Technology, 5(06), 213-216.