Quest Journals
Journal of Architecture and Civil Engineering
Volume 7 ~ Issue 11 (2022) pp: 51-54
ISSN(Online) : 2321-8193
www.questjournals.org

Research Paper

A Review on Selfhealing of Soil under Freeze and Thaw Conditions

K.V.Bhavya Sree[1], K.Manoj[2], K. Krupa Percy[3], K.Maniraj[4]
[1234]UG Student,GMR Institute of Technology, Rajam, 532127, India

ABSTRACT: *Freeze-thaw cycle is the freezing and thawing of water inside of the soil associated with the winter months it is also known as frost shattering, Freeze and thawing is the weathering process which has a great impact in changing the engineering properties of soil. In cold regions freeze thaw durability is important for geotechnical infrastructure, many of them undergo freeze thaw cycles annually, many of them experience extensive repeated cycling deterioration due to freeze thaw cycles results unpredictably in civil infrastructures. freeze and thaw must be taken into consideration, it has impact on behaviors in stability and analysis of deformation for slope and cuts in cold region with soil layer experiencing freeze-thaw cycle. The strength of soil decreases with increase in moisture when the soil is exposed to freezing and thawing which leads to formation of cracks. Studies show that an increase in the number of freeze-thaw cycles decreases the unconfined compressive strength, the engineering properties of soils such as permeability, water content, stress strain behaviour, failure strength, elastic modulus, cohesion, and friction angle. To overcome these effects, several self- healing materials like Metakaolin, nano $SiO_{2,}$ LAMBSON microcapsules, LUVOMAG MgO pellets, Solid Microcapsules, Super absorbent polymer, silica fume, Magnesium pellets, silt clay, sodium hydroxide, sodium silicate, sodium lignosulfonate and other materials are used to improve the self-healing capacity of soil.*
KEYWORDS: *self healing, freeze and thaw*

Received 01 Nov., 2022; Revised 09 Nov., 2022; Accepted 12 Nov., 2022

I. INTRODUCTION

It has been acknowledged that freeze-thaw cycling is a weathering process which change the structure and has influence on the engineering properties of soil. In cold climate when soil is exposed to weather, the freeze-thaw cycle takes place which leads results the change in strength, volume, compressibility and bearing capacity of soil, to overcome these effect we came to a conclusion to use add mixtures in the soil which improv e the important properties of soil to withstand the number of freeze-thaw cycles. Lime and other materials is commonly used as a soil stabilizer because it is soil which subjected to freeze and thaw conditions both physical and mechanical properties are tested it has more impact especially on density and hydraulic permeability .freeze-thaw has a dual influence on soil density that is loose soil tend to become Densified and dense soil become looser after freeze-thaw cycles. By adding the add mixture to soil the calcium-silicate reaction takes place there is an increase in the alkalinity of the pore water due to the presence of sodium and potassium hydroxide ,which depresses the freezing point below that normally encountered materials are used as add mixtures since these materials are having inbuilt ability to heal the soil when soil is exposed to number of freeze-thaw cycles . when soil is exposed to freeze-thaw cycle here we test the engineering properties of soil sample by addition of add mixture and normal sample without any add mixture. The strength of clay soil is increased by the addition of lime ,change in plasticity and increase in unconfined compressive strength, durability.

II. .SELFHEALING MATERIALS

Silica fumes:-silica fume is an amorphous poly-morph of silica dioxide it is an by-product of silicon and Ferro silicone industry alloy production and it consist of spherical particles with an average diameter of 150mm, it is about 1% the size of cement . It is also known as mirosilica.

LUVOMAG MgO pellet:- Magnesium Chloride pellets is a premium ice melt product that provides the performance which is having least impact on surrounding area, it is highly flammable in powder form, it is mainly used for aircraft materials.

Nano-SiO_2 :- Nano -Sio_2 is a white fluffy powder it composed of highly pure silica powder, it can be prepared by the hydrolysis reaction of TEOS (Tetra ethyl orthosilicate) in ethanol using water and NH3 using solution gel method.
Lambson microcapsules:- Lambson microcapsules contains sodium silicates ,which plays major role in self-healing of soil ,it is prepared by Lambson Limited industry it consist of 41% sodium silicate, 55% of mineral oil, 4% emulsifier. These microcapsules have diameter of 200-300 µm
SAP (super absorbent polymer):- Super absorbent polymer is a group of polymer it is a copolymer of acrylamide and sodium acrylate with a particle size of 100 µm and density of 0.75 g/cm^3. It is made of synthetics polymers.
Sikaaer microcapsules: sikaaer microcapsules contains elastic acrylonitrile-polymer envelope which provide a controlled air entrainment . these microcapsules with a size range of 5–100 µm containing of 85 prefabricated air bubbles.

III. SAMPLE PREPARATION

The fine-grained soil was dried at around 105° C in an oven. Silica fume and fine-grained soil requirements were measured by a combined total dry weight of the sample, and blended in the dry condition. Then, the dry, fine-grained soil was combined with silica fume to create necessary volume of water for ideal moisture content the ideal moisture natural and stabilised fine-grained soil samples' contents were Standard Proctor tests were used to determine. Compactions of the after mixes of fine-grained soil and natural dirt with small particles cylinder samplers were pressed into the compacted soil to collect silica fume. Samples were extruded into the cylindrical samplers Unconfined compression testing used samples that were 70 mm in length and 35 mm in diameter. After Each sample was taken out of the cylinder sampler, and plastic-wrapped to stop water loss. the natural and synthetic samples tested the permeability of stabilised fine-grained soil using falling-head permeability were additionally compressed in the ideal moisture contents of the cylinder-shaped moulds. These cylindrical samples have a diameter of 100 mm. with a 200 mm length.

IV. LITERATURE REVIEW

Mingtang Chai , Hu Zhang ,Jianming Zhang , Zhilong Zhang (2017) [1] Cement additives affected the modification of warm and ice-rich frozen soils and it offered us to choose the right additives among all other additives and amount that it is needed to add to the sample. Attapulgite, metakaolin, nano-SiO_2, SF and HA were among the additions that raised the UCS of warm and frozen soils. it can be choosen one or more of these compounds to add to HA to change the freeze thaw effected region, warm, In effected samples. it is not advisable to use NaOH, Na_2SiO_3, or SL since they lower the freezing point of water and melt ice.

Chen, Jingtao (2020)[2] The water cement ratio needs to be kept at around 0.5 when cement is put to warm, ice-rich frozen soils. Attapulgite, metakaolin, or SF dosages we should take 2%–8% of the dry weight of cement in frozen soils with a water content of 30%–90% they are stabilized by 15% 1qcement, and the HA dosage should be kept at 0.49%–0.62% to attain the perfect sample with the property we are required in self healing.

Tuğba, Selim Altun, and İrem Kalıpcılar (2015) ssssssssss[3] The increasing the cement content from 0% to 5% improved the behavior of the soil from very ductile to brittle, increasing cement content to 10% resulted in very brittle behavior.The strength loss of clay specimens treated with 5% cement was 38% on the other hand the strength loss of clay specimens treated with 10% cement was 24%. Specimens subjected to 5 freeze–thaw cycles showed 42% and 37% strength loss for clay.

Selim Altun,Alper Sezer ,Alper Erol(2009)[4] Two sets of tests were conducted to know how the freezing and thawing processes affected the mechanical behaviour of silty soils. Both natural and blended soils in the first group displayed brittle behaviour with increased compressive strengths after freez-thaw cycles. The results shows the water content decreased after curing. The natural soil specimen in the second group had the lowest strength value after several cycles of freezing and thawing others has lost strength .Number of freeze-thaw cycles there is more cracks were observed here It is observed stabilisation with fly ash and cement significantly improves compressive strength. It also improves the bearing capacity.

Reza Jolous Jamshidi ; Craig B. Lake ; and Christopher L. Barnes(2022)[5]The physical performance of silty sand that has been treated with cement was examined. There are 14 different test sets conducted As pre the results of hydraulic conductivity and unconfined compressive strength tests, it includes differences in the hydraulic conductivity results in the decrease in magnitude and strength loss of up to 95% based on the remaining UCS values. . According to the results of hydraulic conductivity and unconfined compressive strength tests the soil sample we have prepared experience a change depending on the freeze-thaw cycle after 4 and 12 freeze-thaw cycles changes in the specimens like hydraulic conductivity and compressive strength were tested based on the results it is notes that more damage typically occurred in the sample after the 12^{th} number of the freeze-thaw cycle.

Ekrem Kalkan(2009)[6]The impact of silica fume on the freezing process was determined in this study. investigations on the thawing of fine-grained soils the resulting conclusions are as In all of the stabilised fine-grained soil samples the silica fume increases the plastic limits decreases the liquid limits and plasticity index. The addition of silica fume results in an increase in unconfined compressive strength and a decrease in permeability .The fine-grained soil's freezing and thawing resilience is increased by adding silica fume. Silica fume boosts the freezing and thawing of the stabilized samples when compared to that of natural fine-grained soil samples even while the unconfined compressive strength decreases and permeability increases with an increase in the number of freezing and thawing cycles.

Wang, Q., Liu, F., Zhong, X., Gao, Z., Liang, S., & Liang, Y(2021)[7] The soil strain weakens and the damping ratio rises after one freeze-thaw cycle of the saturated remoulded loess. Four freeze-thaw cycles later, the soil strain becomes more powerful. The dynamic shear modulus reaches its highest and the damping ratio reaches its minimum after seven freeze-thaw cycles. After numerous freeze-thaw cycles, saturated remoulded loess exhibits improved dynamic performance.It is clear that freeze-thaw cycles had an impact on the structure of saturated remoulded loess. Increased freeze-thaw cycles result in a decrease in large and medium particles.

Richard d. walker and cetin karabulut(1965)[8] When lime concentration was increased up to 10%, strength loss during freezing and thawing was reduced. The first five cycles of freezing and thawing resulted in a loss of strength for every soil-lime combination. The effects of freezing and thawing on unconfined compressive strength Compared to silt-lime combinations, the amount of clay is substantially higher. Disintegration in lime-stabilized soils occurred in the closed systems used in this study. due to the hydraulic pressures produced by the freezing and thawing process, Unfrozen water is moving through the pores as a result of freezing-induced water expansion.

Nitin Tiwari(2020)[9]it was studied during the freezing-thawing cycle different curative techniques, such as GC, MC, and SC, and their effects over periods of 7, 14, and 28 days have been taken into consideration. The clay minerals and cations adsorbed for the charged balance caused swelling-shrinkage in expansive soil due to their layered structure. Infrastructure damages result from expansive soil's increased nonrecurrent swelling-shrinking tendency.The SF can be used as an alternative to BC soil stabilisation because it has properties that are comparable to those of cement. The BC soil's SF content resulted in the formation of hydrated gels called CSH and/or CASH, which fill the cavity and matrix of well stabilised dirt. The UCS and STS values increase significantly while using the SC and MC curing procedures. From the results of the F-T test, PP fiber has a greater level of durability and can be utilized to prevent brittle shear failure in chemically stabilized soil.

Wang Miao(2018)[10] The concept of a correction coefficient is proposed for freezing-thawing cycles, The static strength and cohesion decrease exponentially as the number of freezing-thawing cycles increases, but the internal friction angle increases exponentially. When compared to the initial static strength before freezing-thawing cycles, the soil sample static strength decreases by about 30%, 15%, and 5% at confining pressure, Finally as the confining pressure rises the influence of the confining pressure on the freezing-thawing cycles decreases. The internal friction angle increases by about 20% after the first freezing-thawing cycle. as the number of freezing-thawing cycles increases, so does the internal friction angle, eventually reaching a balanced value that is about 40% greater than the internal friction angle before the freezing-thawing cycles.

S. Siva Gowri Prasad, P.V.V. Satyanarayana (2018) [11] The best solution for increasing the load carrying capacity of the soil is to use silica-manganese slag as stone column material. This increase is approximately 9% when compared to quarry stone aggregates due to the increased stiffness of the column material and may also be due to increased friction between the slag aggregates. Because of frictional mobilisation in the geotextile discs, lateral reinforced geotextile discs increased the load carrying capacity of the stone columns. This friction mobilisation resists the bulging of the stone column and transfers the loads to the bottom of the column, increasing the load carrying capacity. The stone column's load carrying capacity is proportional to the distance between the reinforced discs.

S.Siva Gowri Prasad, P.V.V.Satyanarayana (2019) [12] Silica-manganese slag is a potential alternative for improvement of soft soil as it has a better load-carrying capacities than conventional stone columns (about 9%) because of the superior properties of the slag over the stone chips. The load-carrying capacity of the stone column was increased by introducing the encasement, due to mobilization of the hoop stresses which resist bulging. These hoop stresses help to transfer the load to the bottom of the stone column, and thus the bearing capacity increases. The load-carrying capacity also increased by increasing the encasement length of the column. Bulging was reduced by providing reinforcement to the columns. The maximum bulging occurred at the center of the column for both the plain and fully-reinforced columns. For the other reinforcement lengths, bulging was found just below the encasement depth.

V. CONCLUSION

In all of the stabilised fine-grained soil samples, the silica fume reduces the liquid limits and plasticity index while increasing the plastic limits. Due to this, the types of soil in composite samples with the silica fume change in the character of compaction parameters, high silica fume levels shift from high plastic to low plastic. The optimal moisture content is raised and the maximum dry unit weight is decreased when silica fume is added. The addition of silica fume to the fine-grained soil improves the freezing and thawing endurance while increasing the unconfined compressive strength and lowering permeability. It is noticed that silica fume increases the freezing and thawing even while the unconfined compressive strength drops and permeability increases with an increase in the number of freezing and thawing cycles. The resilience of the fine-grained soil during freezing and thawing is increased by adding silica fume. Silica fume boosts the freezing and thawing bearing capacity of the stabilized samples when compared to natural fine-grained soil samples, even while the unconfined compressive strength declines and permeability increases with an increase in the number of freezing and thawing cycles. To improve the freezing and thawing durability of fine-grained soils, silica fume waste material modification may be a practical and creative solution. These results show that stabilised fine-grained soil exhibits stronger freezing and thawing resistance to changes in strength and hydraulic conductivity than natural fine-grained soils, all other things being equal

REFERENCES

[1]. Effect of cement additives on unconfined compressive strength of warm and ice-rich frozen soil (Mingtang , Chai , Hu Zhang , Jianming Zhang , Zhilong Zhang)
[2]. Development and performance of self-healing and self-immune soil-cement systems subjected to freeze-thaw cycles (Chen, Jingtao)
[3]. Assessment of strength development and freeze–thaw performance of cement treated clays at different water contents (Skylar, Tuğba, Selim Altun, and İrem Kalıpcılar)
[4]. The effects of additives and curing conditions on the mechanical behavior of a silty soil(Selim Altun, Alper Sezer ,Alper Erol)
[5]. Examining Freeze/Thaw Cycling and Its Impact on the Hydraulic Performance of Cement-Treated Silty Sand (Reza Jolous Jamshidi1; Craig B. Lake2; and Christopher L. Barnes)
[6]. Effect of silica fume on the geotechnical properties of fine grained soils exposed to freeze and thaw (Ekrem Kalkan)
[7]. Effect of Freezing and Thawing on Unconfined Compressive Strength of Lime-Stabilized Soils (Wang, Q., Liu, F., Zhong, X., Gao, Z., Liang, S., & Liang, Y)
[8]. Effect of Freezing and Thawing on Unconfined Compressive Strength of Lime-Stabilized Soils (Richard D. Walker And Cetin Karabulut)
[9]. Effect of Curing on Micro-Physical Performance of Polypropylene Fiber Reinforced and Silica Fume stabilized Expansive Soil Under Freezing Thawing Cycles (Nitin Tiwari)
[10]. Shear strength of frozen clay under freezing-thawing cycles using triaxial tests (Wang Miao)
[11]. Performance of Encased Silica-Manganese Slag Stone Columns in Soft Marine Clay (S.Siva Gowri Prasad ,P.V.V.Satyanarayana)
[12]. Improvement of Soft Marine Clay with Laterally Reinforced Silica-Manganese Slag Stone Column (S.Siva Gowri Prasad ,P.V.V.Satyanarayana)