International Journal of Innovative Research in Engineering and Management (IJIREM)
ISSN (Online): 2350-0557, Volume-11, Issue-3, June 2024
https://doi.org/10.55524/ijirem.2024.11.3.13
Article ID IJIRD-133z9, Pages 82-85
www.ijirem.org

Improvement of Subgrade Using Lime

Abid Khurshid Malik[1], and Er. Rabinder Singh[2]

[1] M. Tech Scholar, Department of Civil Engineering, RIMT University, Mandi Gobindgarh, Punjab, India
[2] Assistant Professor, Department of Civil Engineering, RIMT University, Mandi Gobindgarh, Punjab, India

Correspondence should be addressed to Abid Khurshid Malik; Abidmalik846@gmail.com

Received: 22 May 2024 Revised: 5 June 2024 Accepted: 20 June 2024

ABSTRACT- Karewa soils are extensively spread in the state of Jammu and Kashmir and they've been used as subgrade of pavement layers. Karewa soils are generally muddy soils and are characterized as low bearing capacity materials for flexible pavement layers. When similar soils can not be replaced, its subgrade performance should be increased by several revision ways. In the place where ground water table is high, the strength of subgrade is negatively affected by humidity infiltration to subgrade and base due to capillary action. The purpose of this design is to estimate the use of low contents of lime in the revision of Karewa soil properties. The main goal of this research is to find the ideal lime dosage for stabilising the readily available karewa soil in the area. The research includes analyses of basic characteristics of soil. Moreover tests are done to find the extent of modification by analyzing the impact of adding different amounts of lime to estimate the extent of revision on MDD, OMC and CBR of the soil. The experimental examinations shown that there's a tremendous increase in the CBR value of the soil treated with lime, therefore leading to dropped consistence conditions of the sub-base and base courses.

KEYWORDS- Atterberg Limits, Compaction, Soaked, CBR Test, Lime

I. INTRODUCTION

Pavement subgrades must be stable during construction and perform throughout the design life of the pavement. Frequently, the subgrade is the weakest member of the pavement structure and is one of the most important factors influencing pavement performance. The subgrade during construction must be sufficiently stable to prevent rutting and shoving. The subgrade must also provide a stable platform to construct the various pavement layers effectively and efficiently. First, the subgrade must serve as a "working platform." Secondly, it must have sufficient strength so that large permanent deformations do not accumulate over time and affect the performance of the pavement. Many pavements in Kashmir, and in other states, have been, and are continuing to be, constructed on soil sub grades of poor or marginal engineering properties. Typically, the pavement sub grades consist of fine-grained soils, such as clay or silty clay, of low-bearing strengths. This has lead to premature failures of the pavements and failures during construction and operation [1]. Occasionally, pavement failures during construction have been reported and have required expensive remedial solutions. Although pavements of sufficient thicknesses may be designed for low bearing sub grades, the question that arises is whether pavements can be constructed as designed. The question posed above should perhaps, be viewed in another perspective [2]. What are the cost and consequences if subgrade improvements are not made? Many pavements have failed during construction over the past several years requiring additional cost to repair. Also, many pavements have failed prematurely, or before their design lives have expired because of weak sub grades. Although exact figures cannot be assigned to this problem, the costs are believed to be substantial.

II. OBJECTIVE

The main objectives of this study are as follows:

- To explore the possibility of using lime as a subgrade stabilizing agent.
- To study the effect of lime on proctor's density and OMC of Karewa soil.
- To study the effect of lime on consistency limits of clayey soil.
- To study the changes in CBR of soil by the addition of lime.
- To explore the benefit and cost analysis of using lime as a subgrade stabilizer thereby leading to decreased thickness of the subsequent layers.

III. LITERATURE REVIEW

Majumder et al. [3] conducted a study to investigate the use of hydrated lime to meet the CBR criterion set by the Ministry of Road Transport and Highways, Government of India. BC soil collected from various sites in the Maharashtra region was tested for suitability as a subgrade material. The soil was found to be unsuitable due to its low CBR value and high plasticity. To improve its properties, lime was added, and the strength and deformation criteria of the subgrade material for flexible pavement were examined. Dhar et al. [4] studied the potential of lime to improve the strength and bearing capacity of subgrade soil. They evaluated the effects of soil type, varying lime percentages (3%, 5%, 7%, and 9%), and curing durations (0, 7, 14, and 28 days) on the engineering properties of the soil. This evaluation involved a series of laboratory tests, including linear shrinkage, unconfined compressive strength (UCS), split-tensile strength (STS), and California bearing ratio (CBR) tests.

Insha Kouser et al. [5] revealed a significant increase in the CBR value of soil treated with lime, resulting in reduced thickness requirements for sub-base and base courses. The addition of crumb rubber powder to the soil notably enhanced its shear parameters and increased soil permeability.

Tahmeena et al. [6] investigated two waste materials, Red Mud and Hydrated Lime, in various proportions. Hydrated Lime (HL) was mixed with natural soil samples at concentrations of 0%, 2%, 4%, 6%, 8%, and 10% by weight. The optimum proportion of Hydrated Lime was determined to be 6% based on Unconfined Compressive Strength (UCS) values. When 6% HL was added to the natural soil, the UCS value increased from 89.5 KN/m² to 120.6 KN/m².

Mir, J.A. [7] provides crucial insights into the characteristics and causes of the Late Permian mass extinction. Additionally, the jointed nature of the Panjal volcanics and the uplift associated with Himalayan tectonics have created the distinctive relief responsible for the formation of waterfalls.

Portelinha, F.H. et al. [8] assess the use of low lime and cement contents in modifying the properties of lateritic soil, focusing on the behavior of mixtures from the beginning of construction to the final product. They evaluated workability, chemical properties, mechanical behavior, and mineralogical composition. Mechanistic analyses were also conducted to assess fatigue failures in asphalt layers within roadway structural layers.

IV. EXPERIMENTAL WORKS AND METHODOLOGY

- The project was executed wholly and solely in Road Research and Material Testing Laboratory located in the campus of Kashmir Government Polytechnic College, Gogji- Bagh, Srinagar.
- The Karewa soil for the project is taken from NH-1A near Lethpora in the vicinity of an irrigation canal. Visual examination leads to the primary classification of the soil sample, which is taken at a depth of 2 metres below the natural ground surface. Karewa soil known for saffron cultivation.

A. Sample Preparation and Experimental Program

To investigate the impact of lime on the Karewa Soil, a number of tests and analyses are conducted, including the Atterberg limits test, the California Bearing Ratio test, the maximum dry density test, and the optimal moisture content test. Based on these studies, the ideal amount of lime needed to stabilise the Karewa soil was identified. The project's experimental work will be completed in two stages. Basic testing on a sample of plain soil will be conducted in the initial phase in accordance with applicable codal requirements[9]. The tests will be repeated in the second phase with varying amounts of lime added, and any variations from the first phase will be meticulously noted. Initially, mechanical liquid limit devices are used to perform liquid limit tests In contrast, the plastic limit is determined using the thread rolling method in accordance with IS:2720(V)-1985. The Standard Proctor Test, according to IS: 2720(VII)-1980, was used to assess the ideal moisture content and dry density of soils. By dry weight of soil, 3%, 5%, 7%, and 9% of lime are added to the soil during the second phase. These soil samples that had been treated with lime had their geotechnical characteristics assessed and contrasted with those of the unstabilized soil.

B. Determination of Atterberg Limits

The Atterberg limit test's goal is to gather fundamental index data about the soil that will be used to calculate its strength and settling characteristics. A fundamental gauge of a fine-grained soil's necessary water content is the Atterberg limit., like its shrinkage limit, plastic limit and liquid limit. These tests are primarily used on clayey or loose soils since these are the soils that expand and shrink because of wet content [10]. Clays and silt react with water and so change sizes and have varied shear strengths. so these tests are wide utilized in the preliminary stages of designing and pavement to make sure that the soil can have the right quantity of shear strength and not an excessive amount of change in volume because it expands and shrinks with completely different moisture content.

- ***Liquid Limit***

The water content at which soil transitions from a liquid state to a plastic state is known as the liquid limit. At the liquid limit, the clay is practically sort of a liquid, however possesses a small shearing strength. The shearing strength at that stage is that the smallest value that may be measured within the laboratory. The liquid limit of soil depends upon the clay mineral available. The stronger the surface charge and the thinner the particle the greater are going to be the amount of adsorbed water and, therefore, the higher will be the liquid limit (see the table 1).

Table 1: Liquid Limit of Simple Soil

LIQUID LIMIT OF SIMPLE SOIL As per IS 2720(PART-5)				
TYPE OF MATERIAL	KAREWA SOIL			
SOURCE	PAMPORE KAREWAS			
PROPOSED USE	ROAD SUBGRADE			
OBSERVATION	**DETERMINATION**			
Number of blows (N)	34	28	17	22
Mass of empty container (M1) (g)	21.07	19.62	23.10	22.31
Mass of container + wet soil (M2) (g)	40.74	40.69	49.41	44.16
Mass of container + dry soil (M3) (g)	36.54	36.05	43.54	39.17
Mass of water = (M2 - M3) (g)	4.20	4.64	5.87	4.99
Mass of dry soil = (M3 - M1) (g)	15.47	16.43	20.44	16.86
Water Content (%) =(M2-M3) / (M3-M1)	26.68	28.24	28.71	29.59
RESULTS				
LIQUID LIMIT (%) = 28.30				

V. RESULT AND DISCUSSIONS

Liquid limit and Plastic limit tests were carried out to classify the Karewa soil while the Standard Proctor Test and California Bearing Ratio test were carried out to assess the effects of lime on the Karewa soil.

A. Atterberg Limits

- ***Liquid Limit***

Influence of lime on liquid limit of Karewa soils is determined as shown in figure 1. Simple Karewa soil's liquid limit increased from 28.30 to 31.10 after 3% of dry lime was applied. After then, the liquid limit decreased as the lime concentration was gradually raised to 7%. This reduction takes place as lime is added to the Karewa soil; as Ca+ ions are released into the pore fluid and electrolyte concentration rises as a result, the thickness of the diffuse double layer is decreased by cat ion exchange (replacement of soil's monovalent ions with lime's divalent ions Ca2+ held around soil particle), which lowers the liquid limit. The liquid limit starts to rise once more as the lime concentration continues to rise.

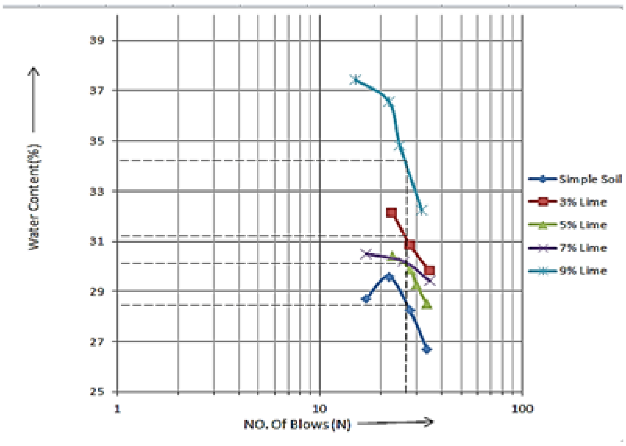

Figure 1: Liquid Limit Curves

- ***Plastic Limit***

Plastic limit is a measure of cohesion of soil particles against cracking and also it's the water content of soil when it approaches a certain shear resistance. With the adding of lime, the thickness of diffuse double layer decreases which makes increase charge concentration and there by viscosity of the pore fluid. It results in interparticle shear resistance, resulting in an increased plastic limit. Figure 2 shows variation in plastic limit with completely different lime content for Karewa soils. it's It's observed that plastic limit will increase with lime content. More 3-dimensional lime content has an impact on plastic limit. Additionally, it was shown that the plastic limit doesn't deviate significantly above 5% lime concentration.

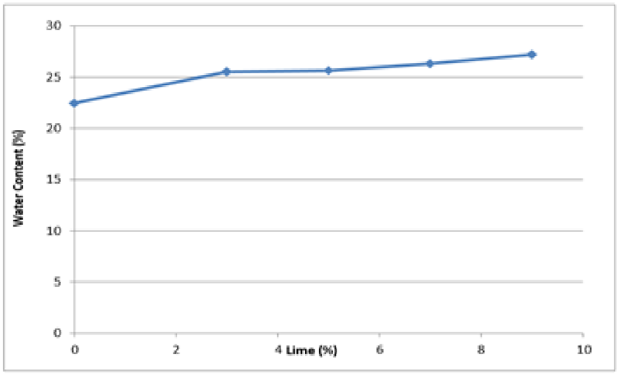

Figure 2: Plastic Limit Curves

- **IS Classification of Fine Grained Soil by Plasticity Index Curves**

On the basis of the experimental work done with regards to the liquid limit and plastic limit of Karewa soil, It was discovered that the plasticity index was 6.05 at a liquid limit of 28.30. This result implies that the soil falls in the CL-ML category (see the below table 2 and figure 3).

Table 2: IS Classification of Soil

Low Plasticity	WL<35%
Intermediate Plasticity	35% < WL <50%
High Plasticity	WL > 50%

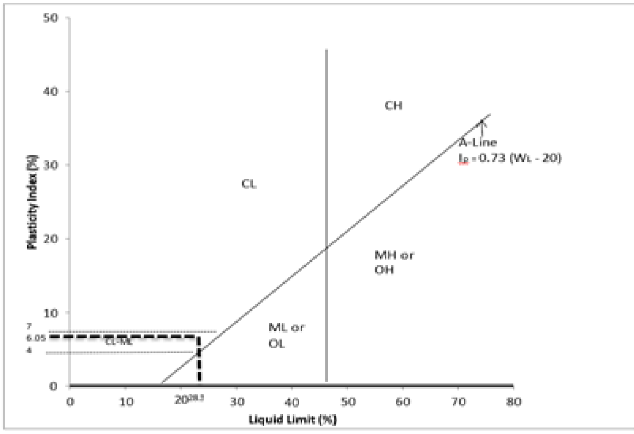

Figure 3: Plasticity Curve

- ***Results***

The plasticity index of the Karewa soil was found to be 6.05 at liquid limit 28.3 %. Therefore the soil falls under the category CL-ML soil.

B. Effect of Lime on Compaction Characteristics

When lime is added, dry density increases by up to 7% lime content. In figure 4 shows that as the concentration of lime is increased from 0% to 7%, the dry density rises from 1.74g/ml to 1.82g/ml. After more lime was added, the dry density slightly dropped to 1.80g/ml. The clay particles get flocculated and agglomerated when lime is applied in excess of 7%, increasing the pore space with the soil matrix or increasing the void ratio. This decreases the maximum dry density (MDD) because the flocculated structure counteracts the compactive effort.

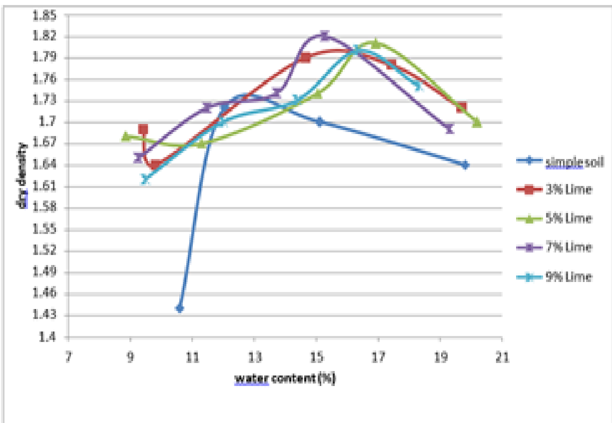

Figure 4: Standard Proctor Test Curves

C. Soaked CBR Test

The test samples are soaked for 4 days and tested in the same manner as that of unsoaked samples. The CBR value of the Karewa soil gradually rises as the lime level increases from 0% to 7%, according to experimental studies done for soil samples with varied lime contents. The CBR value increases significantly up to a 7% lime addition, beyond which the effect is less pronounced or remains constant. As a result, 7% lime content is considered ideal and shouldn't be exceeded(see the below figure 5).

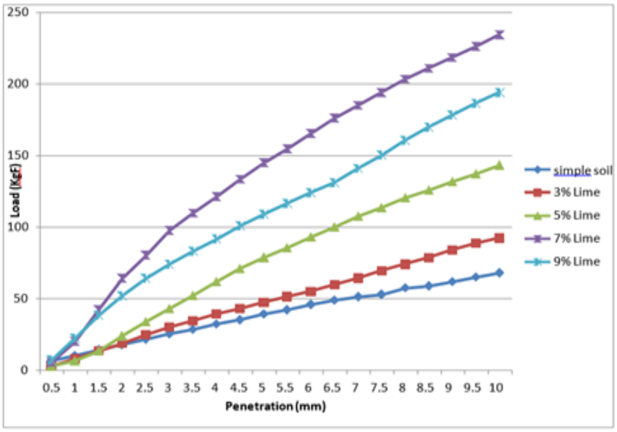

Figure 5: CBR Curves

VI. CONCLUSION

Numerous soil engineering properties can be enhanced by the addition of lime. The kind of soil and lime concentration determine a number of features for this soil-lime combination. After a number of experiments on karewa soils were conducted on this subject by varying specific parameters, the following conclusions were achieved. The liquid limit of karewa soil decreases as the amount of lime concentration increases. This outcome is attained by the double layer's thickness decreasing as the pore fluid's electrolyte content rises.

- As the charge concentration of pore water grows, the viscosity increases, and the Karewa soil offers great resistance against inter-particle movement, the plastic limit of the soil increases with higher lime concentrations.
- The results of the liquid limit and plastic limit tests in conjunction with the plasticity index Curves show that the Karewa soil has a CL-ML character.
- At low lime content, the compaction characteristics of Karewa soils change dramatically. The maximum dry density rises as the lime content does.
- The CBR test is used to assess the soils' resistance or strength to penetration. The value of CBR of Karewa soil rises from 1.88 to 7.03 as the concentration of lime is increased from 0% to 7.
- Following the testing of the Karewa soil used in this study, the tabulated data and accompanying plots reveal one point of inflexion known as the optimum lime concentration, which is established as 7% lime content to dry weight of the soil. The subgrade's cbr value increases from 1.88 to 7.03 as the lime concentration is gradually increased from 0% to 7%.
- Subgrade permits a subsequent reduction in the base and sub-base courses, even by up to 50%.

VII. FUTURE WORK

- Numerous compounds, including alkalis, chlorides, and sulphides, have unstudied impacts on soil, including drying and wetting, freezing and thawing, and responsiveness.
- It is also possible to determine additional geotechnical characteristics, such as those related to shear strength, compressive strength, hydraulic conductivity, and consolidation.
- The response of lime treated Karewa soils under repeated loading can be evaluated.
- The impact of lime on the interplay between permeability, specific surface area (SSA), and cat ion exchange capacity (CEC).
- The impact of additional additives like cement, silica fume, fly ash, etc. on all geotechnical characteristics of Karewa soils.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest between them and with any third party

REFERENCES

1) B.L. Gupta and Amit Gupta, Roads, Railways, Bridges, Harbor and Dock Engineering, 2014.
2) K.R. Arora, Soil Mechanics and Foundation Engineering, 2011.
3) M. Majumder and S. Venkatraman, "Utilization of the Lime as Subgrade Stabilizer in the Pavement Construction," Arab J Sci Eng, vol. 47, pp. 4929–4942, 2022. [Online]. Available: https://doi.org/10.1007/s13369-021-06291-4.
4) S. Dhar and M. Hussain, "The strength and microstructural behavior of lime stabilized subgrade soil in road construction," International Journal of Geotechnical Engineering, vol. 15, no. 4, pp. 471–483, 2019. [Online]. Available: https://doi.org/10.1080/19386362.2019.1598623.
5) I. Kouser and R. Singh, "Soil Stabilization using Crumb Rubber Powder and Lime," International Journal of Innovative Research in Engineering & Management (IJIREM), vol. 9, no. 3, pp. 93-95, 2022.
6) Tahmeena and Ashish Kumar, "Stabilization of Black Cotton Soil Using Red Mud and Hydrated Lime," International Journal of Innovative Research in Computer Science and Technology (IJIRCST), vol. 10, no. 3, pp. 251-255, 2022.
7) J.A. Mir, I.M. Bhat, K.O. Murtaza, et al., "Geological Heritage of the Kashmir Valley, North-Western Himalaya, India," Geoheritage, vol. 15, p. 26, 2023. [Online]. Available: https://doi.org/10.1007/s12371-023-00791-3.
8) F.H. Portelinha, D.C. Lima, M.P. Fontes, and C.A. Carvalho, "Modification of a lateritic soil with lime and cement: an economical alternative for flexible pavement layers," Soils and Rocks, São Paulo, vol. 35, no. 1, pp. 51-63, 2012.
9) T.W. Kennedy, R. Smith, R.J. Holmgreen Jr, and M. Tahmoressi, "An Evaluation of Lime And Cement Stabilization," Transportation Research Record, 1987.
10) G. Bell and J.M. Coulthard, "Stabilization of clay soils with lime," Engineering Geology, 1990.