

Improvisation of Bearing Capacity of Soil Using Cement, Lime and Chemical

Prashika Tamang¹, Saahil Gurung², Riya Basnett³, Shravan Sharma⁴, Roshan Pandit⁵

¹Lecturer in Dept. of Civil Engineering, CCCT Polytechnic

^{1, 2, 4, 5} Diploma Student in Dept. of Civil Engineering, CCCT Polytechnic
Chisopani, P.O. Nandugaon, South Sikkim, India

Abstract –The main Purpose of our work is to stabilize soil of a particular place using different stabilizers like lime, cement, and Calcium chloride (CaCl). Among which lime is the best and economical method and gave a result which is reliable up to 97%. Soil is the basic foundation for any Civil Engineering structures like roads, buildings etc., therefore it is required to bear the loads without any failure. In some cases, soil stabilization is necessary and the main objective of the soil stabilization is to increase the bearing capacity of the soil, its resistance to weathering process and soil permeability. Usually normal soil have a less bearing capacity so they are unable to resist the load and therefore gets damaged by their physical and chemical properties like increase in moisture content and finally produces creep, shrinkage and landslide. Therefore soil stabilization techniques are necessary to ensure the good stability of soil so that it can successfully sustain the load of the superstructure especially in case of soil which is highly active.

Keywords—Permeability, Bearing Capacity, shrinkage, Stabilization, pavements, superstructure.

I. INTRODUCTION

Soil stabilization involves the use of stabilizing agents (binder materials) in weak soils to improve its geotechnical properties such as compressibility, strength, permeability and durability. The components of stabilization technology include soils and or soil minerals and stabilizing agent or binders. Soil stabilization can be explained as the alteration of the soil properties by chemical or physical means in order to enhance the Engineering quality of the soil.

Natural soil is both a complex and variable material. Yet because of its universal availability and its low cost winning it offers opportunity for skilful use as an engineering material.[1] The chief properties of a soil with which the construction engineer is concerned are;

- Volume stability.
- Strength
- Permeability
- Durability

II. STABILIZING AGENTS

These are hydraulic (primary binders) or non-hydraulic (secondary binders) materials that when in contact with water or in the presence of pozzolanic minerals reacts with water to form cementations composite materials.[2] The commonly used binders are; cement, lime and chemical (CaCl).

A. CEMENT:

Cement Stabilization increases base material strength and stiffness, which reduces deflections due to traffic load. This delays surface distress such as fatigue cracking and extends pavements structures life. Cement stabilized bases have greater moisture resistance to keep water out; this maintains higher strength for the structure. Cement reaction is not dependent on soil minerals, and the key role is its reaction with water that may be available in any soil. This can be the reason why cement is used to stabilize a wide range of soils.



Fig 1: Cement stabilization

B. LIME:

Lime provides an economical way of soil stabilization. Lime modification describes an increase in strength brought by cation exchange capacity rather than cementing effect brought by pozzolanic reaction.

Lime stabilizations technology is most widely used in geotechnical and environmental applications. Some of the applications include encapsulation of contaminants, rendering of backfill (e.g. wet cohesive soil), highway capping, slope stabilization and foundation improvement such as in use of lime pile or lime-stabilized soil columns.[3]



Fig 2: Lime stabilization

C. CHEMICAL (CaCl):

In chemical stabilization, soil is stabilized by adding different chemicals. The main advantage of chemical stabilization is that setting time and curing time can be controlled. Chemical stabilization is however generally more expensive than other types of stabilization. The application of adding of

Chemicals into soil, that results in permanent physical and chemical alterations. Physical properties like strength and bearing capacity are enhanced, while plasticity is reduced.



Fig 3: Chemical stabilization (CaCl)

III. IMPORTANCE OF SOIL STABILIZATION:

Soil stabilization plays a vital role in keeping the environment functioning, it is an important part to road construction and maintenance and is performed to eliminate the risk of environmental concerns. Soil stabilization not only protects against road maintenance and construction but also against many other things like soil erosion in many different places by increasing the strength of the soil by compounding the chemicals together to create a stronger and more cohesive soil that will not erode as easily.[4]

IV. OUR WORK:

Our work deals with stabilizing the soil using different stabilizers (lime, chemical, cement). In order to study and carry out the work we have taken the soil sample from 9th mile, East Sikkim, India. In our work we have taken varying percentage of about 2%,4%,6%,8% and 10% of every stabilizer(lime, cement and calcium chloride) used in

our work with a varying percentage of moisture content of 2%,4%,6%,8%,10% and 12% in every individual per cent of stabilizer used. The data's so obtained are calculated and the required graph is plotted. Finally the most efficient stabilizing agent is chosen and used that provides us with maximum dry density and smooth surface.

A. PROBLEM:

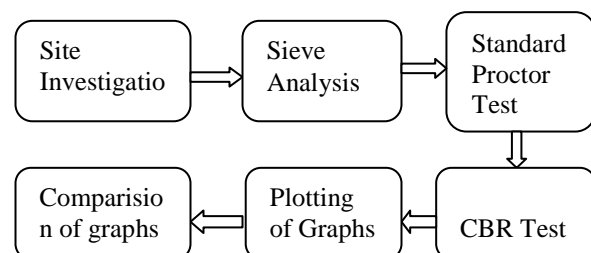
For a long time, that area has been affected by creep in our state and the local people have been facing problem while travelling through that route. The soil in that area contains maximum moisture content and therefore would get even worst during the rainy season.

B. IMPORTANCE OF STUDIED AREA:

- It is the main highway (NH10) of the state connecting our capital (Gangtok).
- For the military purpose this highway is very important as it links north east borders.
- It is the only highway for the people of north-east Sikkim to visit in and out of state.
- It connects to the only airport of Sikkim, which is still under construction.
- It is the main network, for the import and export of materials and goods for the industrial development and for the needs of Sikkimes people.

So, we have done this work to overcome the problems which we had been facing from a long time. To provide a smooth and efficient network for the people staying in an around that area and for the visitors and traveller from different parts of the world.

V. BLOCK DIAGRAM:



VI. BLOCK DESCRIPTION:

A. SITE INVESTIGATION:

We investigated the 9th mile site and brought soil sample from different spots of that particular area, and had a brief idea about that characteristic of the soil.

B. SIEVE ANALYSIS:

This test is performed to determine the percentage of different grain sizes contained in the soil sample. The mechanical or sieve analysis is performed to determine the distribution of the coarser, larger-sized particles. The hydrometer method is used to determine the distribution of the finer particles. [5]



Fig 4: Sieve particle size distribution

In our work we had prepared 2 kg of soil sample and performed the test, after which the following data were calculated and graph was prepared as shown in fig. 5 and 6.

SIEVE ANALYSIS DATA			
Sieve (mm)	Soil retained (gm.)	Percentage retained (%)	Percentage passing (%)
4.75	5.0	0.50	99.50
2.36	315.0	31.50	68.34
1.18	320.0	32.00	52.90
0.6	225.0	22.00	37.50
0.3	120.0	12.00	11.10
0.15	5.0	0.50	66.60
0.075	10.0	1.00	0.00
Pan	0.00	0.00	0.00
Total=	1000gm	100%	

Fig: 5

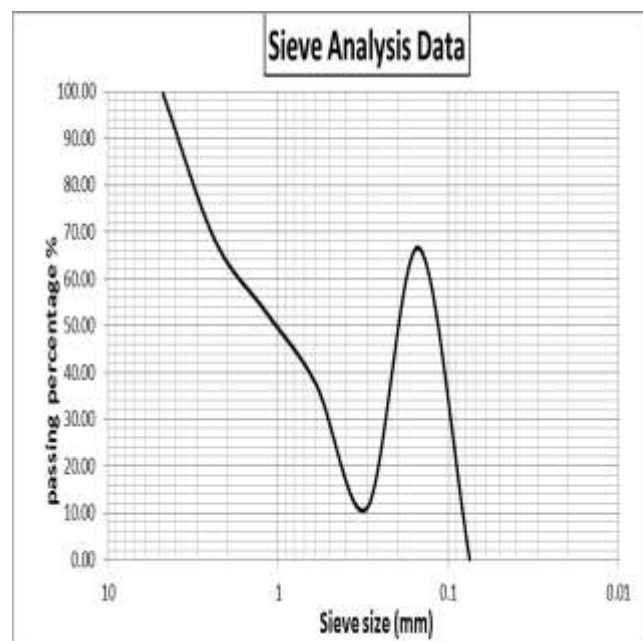


Fig: 6

According to this graph we came to know about the particle size of soil sample and thus it is classified as fine grained soil.

C. STANDARD PROCTOR TEST:

The Proctor compaction test is a laboratory method of experimentally determining the optimum moisture content at which a given soil type will become most dense and achieve its maximum dry density. These laboratory tests generally consist of compacting soil at known moisture content into a cylindrical mould of standard dimensions using a compaction effort of controlled magnitude. [6]

We took about 2kg of soil sample and usually compacted into the mould to a certain amount of equal layers, each receiving 25 no. of blows from a standard weighted of 2.5 kg at a specified height of 30cm. This process is then repeated for various moisture contents and the dry densities are determined for each. The graphical relationship of the dry density to moisture content is then plotted to establish the compaction curve. The maximum dry density is finally obtained from the peak point of the compaction curve and its corresponding moisture content, also known as the optimum moisture content.

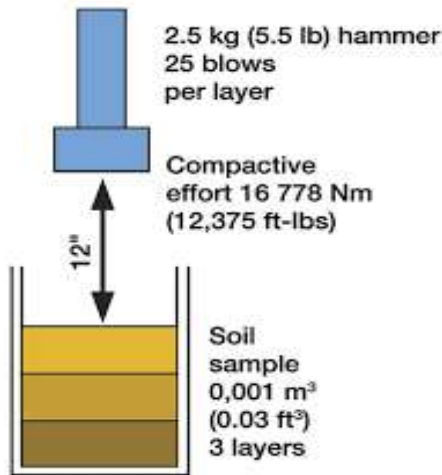


Fig: 7 Standard proctor tests.



Fig: 8 CBR Test apparatus.

After completion of the test the CBR value was found out to be:

	CBR value
Normal soil	2.2%
Using lime.	3.7%

TABLE: 2

D. CBR TEST (CALIFORNIA BEARING RATIO):

The California Bearing Ratio Test (CBR Test) is a penetration test developed by California State Highway Department (U.S.A.) for evaluating the bearing capacity of subgrade soil for design of flexible pavement. The CBR rating was developed for measuring the load-bearing capacity of soils used for building roads. The CBR can also be used for measuring the load-bearing capacity of unimproved airstrips or for soils under paved airstrips. The harder the surface, the higher the CBR rating. [7]

1) METHOD WE USED:

COMPACTION BY DYNAMIC METHOD:

For dynamic compaction, we took about 5 kg of soil sample of fine grained soil and were thoroughly mixed with water about 10% of its total weight. Then was compacted it in 3 equal layers, by a specified rammer giving 56 numbers of blows in each layer dropped from a specified height.

CBR GUIDANCE TABLE:

CBR VALUE	SUBGRADE STRENGTH	COMMENTS
3% and less	Poor	Capping is required.
3-5%	Normal	Capping considered according to road category.
5-15%	good	Capping is unnecessary except on very heavy traffic.

TABLE: 1

According to the specified table 1 the normal soil was poor in strength. Therefore, using lime stabilizer the strength was increased, thus the bearing capacity of soil is increased by 1.5%.

E. PLOTTING OF GRAPHS:

The graphs were plotted from the data, obtained from the above tests and the OMC corresponding to Maximum dry density, followed by the load bearing capacity was determined. As shown in Fig: 9.

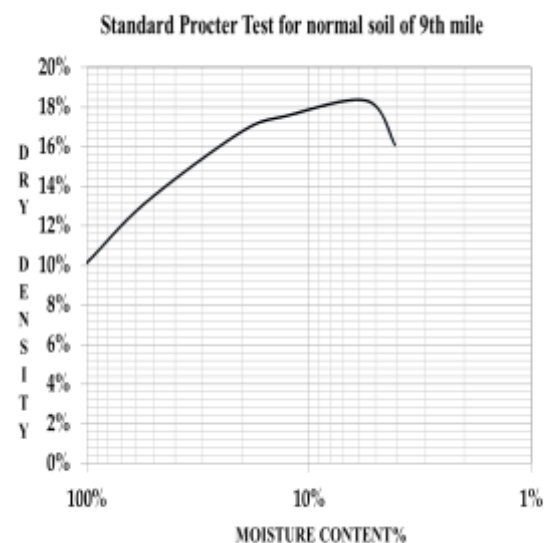


Fig: 9 Normal soil test graph.

From the above graph plotted;
 OMC = 10%
 Dry density = 18.33 KN/m³.

1. RELATION BETWEEN OPTIMUM MOISTURE CONTENT AND DRY DENSITY:

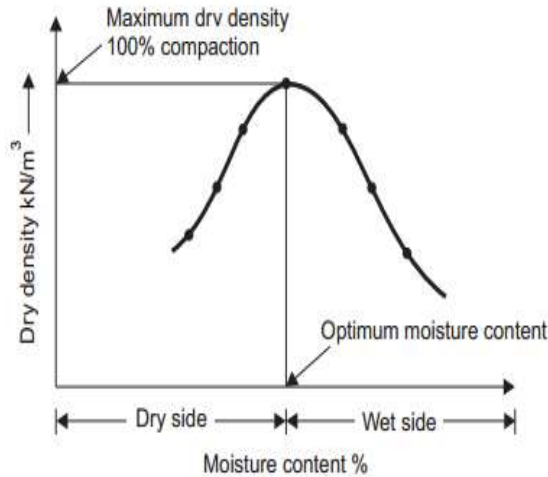


Fig.10: Water-content and dry density of soil.

When water is added to dry soil, it helps in bringing the solid particles close by coating them with thin films of water. At low water content, the soil is stiff and it is difficult to pack it together.

As the water content is increased, water starts acting as a lubricant, the particles start coming closer due to increased workability and under a given amount of compaction effort, the soil-water-air mixture starts occupying less volume, thus effecting gradual increase in dry density. As more and more water is added, a stage is reached when the air content of the soil attains a minimum volume, thus making the dry density a maximum. The water content corresponding to this maximum dry density is called the 'optimum moisture content'. Addition of water beyond the optimum reduces the dry density because the extra water starts occupying the space which the soil could have occupied. [8]

The curve with the peak shown in Fig. 6 is known as the 'moisture-content dry density curve' or the 'compaction curve'. The state at the peak is said to be that of 100% compaction at the particular compaction effort, the curve is usually of a hyperbolic form, when the points obtained from tests are smoothly joined.

The wet density and the moisture content are required in order to calculate the dry density as follows:

$$\gamma_d = \frac{\gamma}{(1+w)}$$

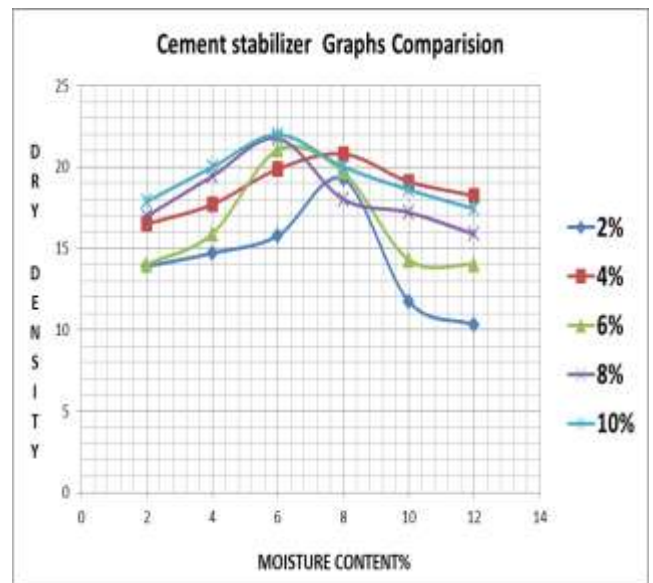
Where, γ_d = dry density of soil

γ = wet or bulk density of soil

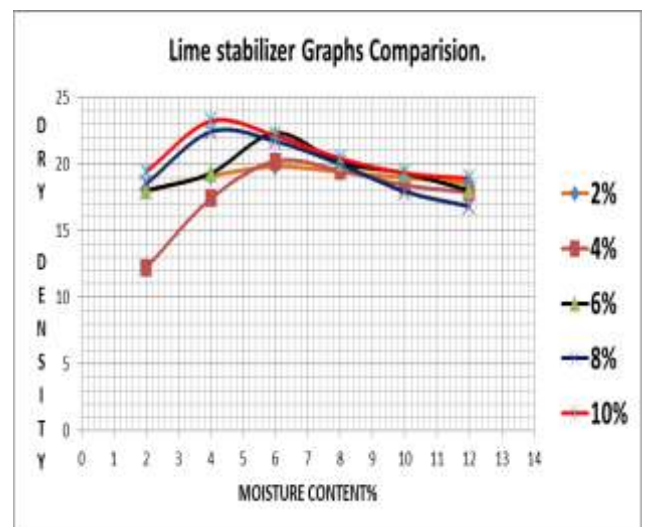
w = water content expressed as fraction.

F. COMPARISON OF GRAPHS:

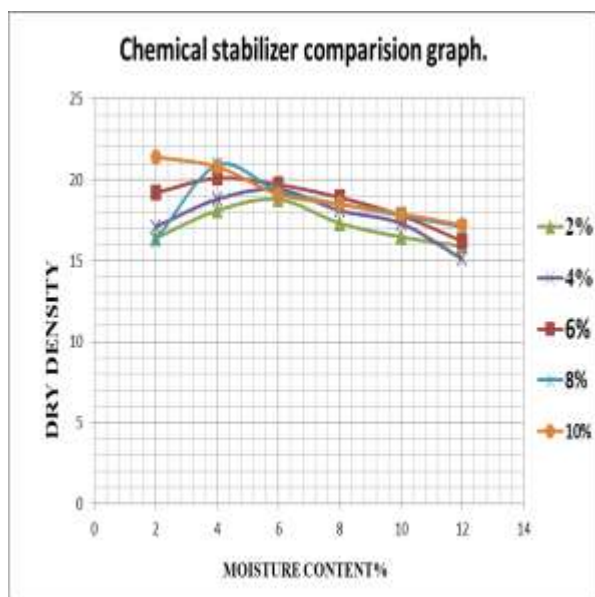
As we had performed cement, lime and chemical stabilization with varying per cent of water content i.e. 2%, 4%, 6%, 8%, 10%, 12% followed by the varying percentage of cement, lime, and chemical i.e. 2%, 4%, 6%, 8%, 10%. So, individual graph of specific per cent of the stabilizing agents with variation in the water content were plotted. Similarly, this method was followed to plot the other graphs for each per cent of the stabilizing agents. Finally, the individual graphs so obtained were compared in a single graph and was computed. As shown in fig: 10(A, B, C).



(A)



(B)



(C)

Fig: 10 (A, B, C)

VII. FUTURE SCOPE:

- We can use this stabilizing process not only for road pavement, but also for any other creep or shrinkage areas.
- Can use in those areas, whose bearing capacity, is low and in areas whose moisture content is high.
- It provides a smooth, stable and strong surface.
- It provides aesthetic beauty to the stabilized areas.

VIII. RESULTS & ANALYSIS:

- After the completion of all the tests successfully, finally we got the best result from 10% lime on 2% of OMC with maximum dry density as 23.3KN/M³, as the best stabilizer.
- Thus, the lime stabilization is reliable up to 97% as compared to other stabilizing method.
- Therefore, lime stabilization can be used in the particular area for smooth and stable surface in future.
- The bearing capacity and strength of the soil was increased by 1.5% using lime stabilizer.
- Therefore, the soil using lime can bear the normal traffic safely.

A. ECONOMIC BENEFITS OF LIME STABILISATION:

- Limitation of the need for embankment materials brought in from outside and the elimination of their transportation costs.[9]

- Reduction of transport movements in the immediate vicinity of the construction site.
- Machines can move about with far greater ease. Delays due to weather conditions are reduced, leading to improved productivity. As a result, the overall construction duration and costs can be dramatically reduced.[10]
- Structures have a longer service life (embankments, capping layers) and are cheaper to maintain.

IX. CONCLUSION:

- Lime is used as an excellent soil stabilizing materials for highly active soils which undergo through frequent expansion and shrinkage.[9]
- Lime acts immediately and improves various property of soil such as carrying capacity of soil, resistance to shrinkage during moist conditions, reduction in plasticity index, and increase in CBR value and subsequent increase in the compression resistance with the increase in time.[9]
- The reaction is very quick and stabilization of soil starts within few hours.[8]
- The graphs presented above give a clear idea about the improvement in the properties of soil after adding lime.

REFERENCES:

- [1]. Tim E. Kowalski and Dale W. starry, Jr. wirtgen "Modern soil stabilization techniques" America, Inc. 6030 Dana way Antioch, Tennessee, 37013 USA.
- [2]. Ankit Singh Negi, Mohammed Faizan, Devashish Pandey Siddharth, Rehanjot Singh. "Journal on soil stabilization using Lime" Dept. Of Civil Engineering, University of Petroleum and Energy Studies, Dehradun, India.
- [3]. Gregory Paul Makusa. "soil stabilization Methods and Materials in engineering" Practice Department of Civil, Environmental and Natural resources engineering. Division of Mining and Geotechnical Engineering. Lulea University of Technology Lulea, Sweden.
- [4]. Sherwood, P. (1993). Soil stabilization with Cement and lime. State of the Art Review. London: Transport Research Laboratory, HMSO
- [5]. Material and Tests Division, Geotechnical Section (2002): Design procedures for soil Modification or stabilization, Material and Tests Division, Geotechnical Section, Indiana.
- [6]. Mitchell J.K., (1993): Fundamentals of soil behaviour, Second Edition, University of California, Berkeley. John Wiley & Sons, Inc. 437p.
- [7]. Nalbantoglu Z. & Gucbilmez E. (2001): Improvement of calcareous expansive soils in

Semi-arid environments. *Journal of Arid and Environments*, Vol. 47, No. 4, pp. 453-463.

- [8]. Narasimha Rao S. & Rajasekaran G. (1996): Reaction products formed in lime-stabilized marine clays. *Journal of Geotechnical Engineering*, ASCE, Vol. 122, No. 5, pp. 329-336.
- [9]. National Lime Association (2004): Lime-treated Soil Construction Manual, Lime Stabilization & Lime Modification. National Lime Association, Bulletin 326, pp. 1-41.
- [10]. Mitchell J.K. (1986): Delayed failure of lime-stabilized pavement bases. *Journal of Geotechnical Engineering Division*, ASCE, Vol. 112, pp. 274-279.

South Sikkim. His main areas of interest are Auto CAD, Geo tech engineering, steel structures, and Reinforced structures.

[5]



Roshan Pandit is a final year Diploma Student, Dept. Of Civil Engineering from Centre for Computer and Communication Technology, Chisopani, South Sikkim. His main area of interest are Auto CAD, Geo tech Engineering,

Reinforced structures, tall building design.

AUTHORS:

[1]



Prashika Tamang is presently associated with the Department of Civil Engineering at Centre for Computer and Communication Technology (CCCT Govt. Polytechnic) Chisopani, South Sikkim, India as a Lecturer since

2010 & course in-charge of civil department since 2016 to till date. She is pursuing M Tech.

[2]



Saahil Gurung is a final year Diploma student, Dept. Of Civil Engineering from Centre for Computer and Communication Technology, Chisopani, South Sikkim. His main area of interest is Auto

CAD, Geo-tech engineering, steel structures, advance building construction, Reinforced structures and tall building designs.

[3]



Riya Basnett is a final year Diploma student, Dept. Of Civil Engineering from Centre for Computer and Communication Technology, Chisopani, South Sikkim. Her main areas of interests are Geo

tech engineering, steel structures, Reinforced Structures and Surveying.

[4]



Shravan kr. Sharma is a final year Diploma Student, Dept. Of Civil Engineering from Centre for Computer and Communication Technology, Chisopani,