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Effect of Lime (CaO) in Consolidation and Swelling Properties of Soil

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Abstract:

Soil is a very complex materials which includes all deposits of loose materials produced by physical and chemical weathering of solid rocks. The soil of one place is different from the soil of the other places due to variety of formation processes. Since the nature of soil varies from place to place, the properties of various physical characteristics of soil also become area specific. Therefore, adequate knowledge of properties of soil is very much essential in general as well as area specific for safe design of foundation, construction of roads, construction of airfields, construction of railway track etc. The knowledge of swelling and compressibility of soil is very important to all civil engineer and geo technical engineer as the safety of any structure largely depend on the swelling and compressibility characteristics of the soil beneath the structures. The load bearing capacity of soil can be increased by using various soil improvement techniques such as compaction, soil replacement, chemical treatment, earth reinforcement, sand piles etc. The chemical treatment by fly ash or lime is a very good and effective technique to improve the stability of soil which have been investigated by various experts all over the world. In this work also, it is attempted to study the effect of lime in consolidation and swelling properties of soil and to find the optimum level of dose of lime to be added for best performance.

Keywords: **Consolidation; Guwahati; Lime: Optimum; Swelling**

1.INTRODUCTION

At present huge civil engineering constructions are in progress all over the world. Due to speedy urbanization, growth of economic condition, advancement of technology and huge population increase particularly in developing countries around the world, a multi-dimensional constructional works are in full pace in many countries. In India also several types of constructional works like building, roads, dams, bridges, abutment etc are at accelerating paces all over the country. All such constructional works need huge amount of different materials and sites. The soil is one such item in construction which is related to materials as well as sites. In many civil engineering works, soil is required as material and almost in all civil engineering construction or any other construction it needs a site which is nothing but ground or soil. The properties of all types of soil is very much location specific. The sand or clay of all places are not equally same from physical properties point of view. But due to high demand of materials, accelerating cost and environmental pollution the usage of local soils in construction schemes is currently in the limelight. But due to poor geotechnical properties of some local soils, it is not possible to use such raw soil directly in project and in such a situation the structural engineer and geotechnical engineer are in pressure to implement the project properly and economically. To avoid such type of problem, investigations and research works are in progress to alter the properties of such weak soil by using any improvement technique and as a result so many approaches are coming out to help the engineer. One such approach or technique to enhance the geotechnical properties of soil is the addition of lime with soil. The lime has the capability to alter so many properties of soil. So, in this particular work, the attempt has been made to study the effect of lime in consolidation and swelling properties of soil.

2.LIME SOIL REACTION AND ITS EFFECT

As per the report of Singh (1989), lime can be divided chemically into two categories- quick lime and hydrated lime. Quick lime are of again two types- Calcitic(CaO) and Dolomite (CaO MgO). Hydrated lime are of three types- Calcitic [$CaO(OH)_2$], Dolomitic monohydrate [$Ca(OH)_2$ MgO] and Dolomitic dihydrate [$Ca(OH)_2$]. The calcium magnesium ratio generally determines the degree of calcitic or dolomitic. The calcitic lime has usually less than 2% MgO and dolomitic lime has MgO between 25% and 45% . Lime may also be classified on the basis of plasticity as type N (normal) or S type (special or slick).

As per Marshal and Thompson (1966), the improvement in the engineering character of lime-soil mixture was attributed to four basic reactions (a) Cation exchange (b) Flocculation and Agglomeration (c) Carbonation and (d) Pozzolanic reaction. The cation exchange capacity (CEC) is a special criteria of soil which indicate the capability of soil to attract, retain and holdexchangeable cations (K+ , Na+ , Ca2+ , Mg2+, Al3+, etc.). The soil texture, soil pH, and presence of organic matter generally influence the cation exchange capacity (CEC) of soil. The presence of high amount of organic matter and clay promotes to the higher CEC values because both have a large number of negative charges on their surface which attract and hold cations.

Due to addition of lime in fine grained soil, the clay particles are flocculated and agglomerated resulting the apparent change in texture of the clay particles making large sized aggregate. The reaction of lime with carbon-di-oxide is known as lime carbonation in which lime reacts with carbon-di-oxide to form relatively weak cementing agents, calcium and magnesium carbonate. The Marshal and Thompson (1966) revealed that the dolomite in highly alkaline environment indicates the formation of some compounds like brucite, gaylussite, calcite and buetschite. The pozzolanic reaction referred to in lime soil stabilization is a reaction soil silica and/or alumina and lime to form various types of cementing agents.As per Eades opinion the high pH causes silica to be dissolved out of the structure of the clay minerals and it combines with the Ca^{++} to form calcium silicate and this reaction remains continued as long as $Ca(OH)_2$ exists in the soil and till there is available of silica. Diamond et al established that various aluminate hydrates are also formed in lime-soil reactions and hence lime-soil reaction results partial decomposition and destruction of the clay minerals and other soil minerals by the highly alkaline environment.

3.OBJECTIVE AND METHODOLOGY

The main aim of this work is to determine the effect of various percentages of lime in consolidation and swelling properties in various type of local soil. For these four locations are chosen in and around the premier city of North East India (Guwahati) for collecting different four types of soil samples. The whole work is done as follows

(i) Collection of disturbed soil samples from selected location and lime from the open market

(ii) Preparation of soil sample for laboratory testing following Indian Standard.

(iii) Determination of different consolidation and swelling characteristics like Compression index (C_c), Coefficient of compressibility (a_v), Coefficient of volume change (m_v), Coefficient of consolidation (C_v), Coefficient of permeability (K) etc for all samples without addition of lime and with different percentage of lime.

(iv) Free swell index of all samples is determined.

(v) Interpretation of results.

The disturbed soil samples are collected from different selected locations in and around the greater Guwahati city. In collecting the soil, at each site about 10 to 50 cm thick uppermost layer of soil is removed to avoid the grass and vegetable roots with a spade and an area of about 80 cm x 80 cm is prepared for collection of soil samples. The collected soil samples are put in a gunny bag with proper marking and carried to the Civil Engineering Laboratory of Assam Engineering College, Guwahati, Assam. The soil samples are dried properly and after removing foreign matters (if any) samples are prepared for testing. The quick lime (CaO) collected from open market is broken into powdered form to pass through 425

micron sieve and mixed with soil samples in required percentage by weight. The details of locations of collection of soil samples are shown in table number 1.

Table 1

Site no	Symbol of sample	Location of site	Type of original Soil	Depth of collection of samples from existing GL (cm)
1	A	Paddy field of Village Dakhala, about 30 km west of Guwahati	CL	30
2	B	Hill behind the chemistry building of Assam Engineering College, Guwahati	CI	50
3	C	Bank of river Brahmaputra near Dakhala village, about 30 km from west of Guwahati	ML	10
4	D	Low laying area in front of P.G. hostel of Assam Engineering College, Guwahati	CH	30

Table 2 (Value of Compression Index (C_c) at different percentage of lime)

Percentage of lime	0	1	2	3	4	5	6	7
Sample A	0.18	0.178	0.195	0.21	0.29	0.261	0.182	0.17
Sample B	0.21	0.23	0.22	0.22	0.232	0.223	0.20	0.19
Sample C	0.10	0.11	0.13	0.14	0.15	0.15	0.14	0.14
Sample D	0.42	0.48	0.43	0.42	0.411	0.452	0.46	0.482

Table 3 (Value of Coefficient of Swelling Index (C_s) in cm^2/ Kg at different percentage of lime)

Percentage of lime	0	1	2	3	4	5	6	7
Sample A	0.002	0.003	0.002	0.002	0.0015	0.0016	0.006	0.003
Sample B	0.011	0.011	0.11	0.011	0.011	0.010	0.009	0.009
Sample C	0.003	0.011	0.012	0.016	0.016	0.017	0.018	0.018
Sample D	0.068	0.056	0.04	0.032	0.025	0.03	0.038	0.046

Table 4 (Value of Coefficient of Consolidation (C_v) in cm^2/ min at different percentage of lime)

Percentage of lime	0	1	2	3	4	5	6	7
Sample A	0.1	0.075	0.062	0.05	0.0375	0.04	0.042	0.051
Sample B	0.042	0.081	0.076	0.069	0.055	0.08	0.091	0.13
Sample C	0.225	0.275	0.270	0.251	0.248	0.21	0.19	0.15
Sample D	0.043	0.043	0.041	0.041	0.039	0.037	0.031	0.030

Table 5Value of Coefficient of Volume Change (m_v) in cm^2/ Kg at different percentage of lime

Percentage of lime	0	1	2	3	4	5	6	7
Sample A	0.014	0.018	0.021	0.021	0.022	0.018	0.017	0.016
Sample B	0.021	0.022	0.022	0.022	0.022	0.019	0.017	0.016
Sample C	0.01	0.009	0.0092	0.0095	0.0099	0.0098	0.0098	0.0099
Sample D	0.0276	0.035	0.0331	0.032	0.031	0.032	0.032	0.034

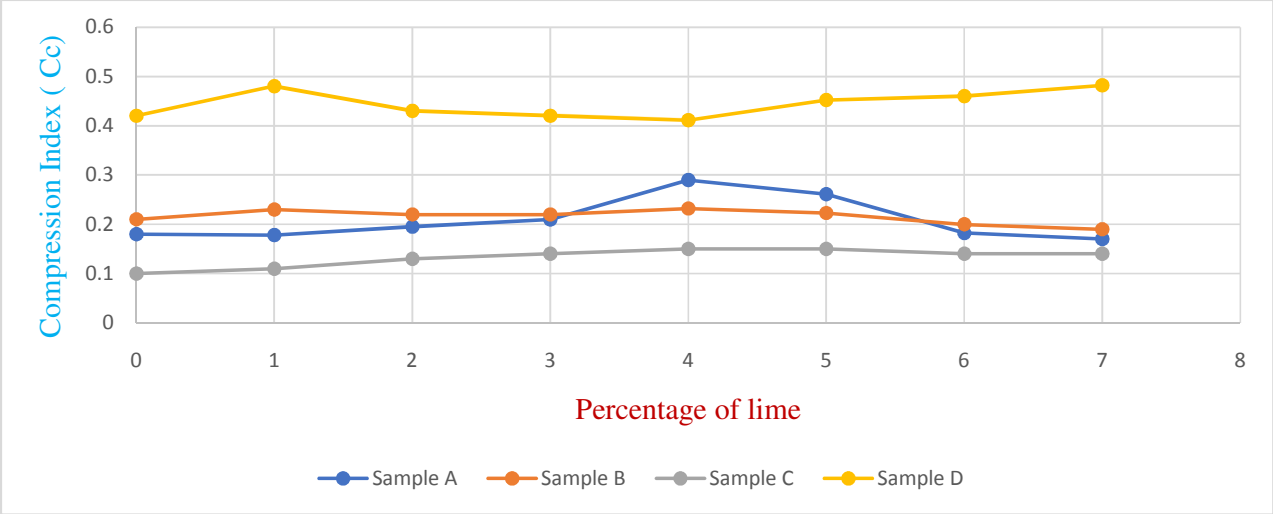

Fig 1 : Variation of Compression Index (C_c) at different percentage of lime

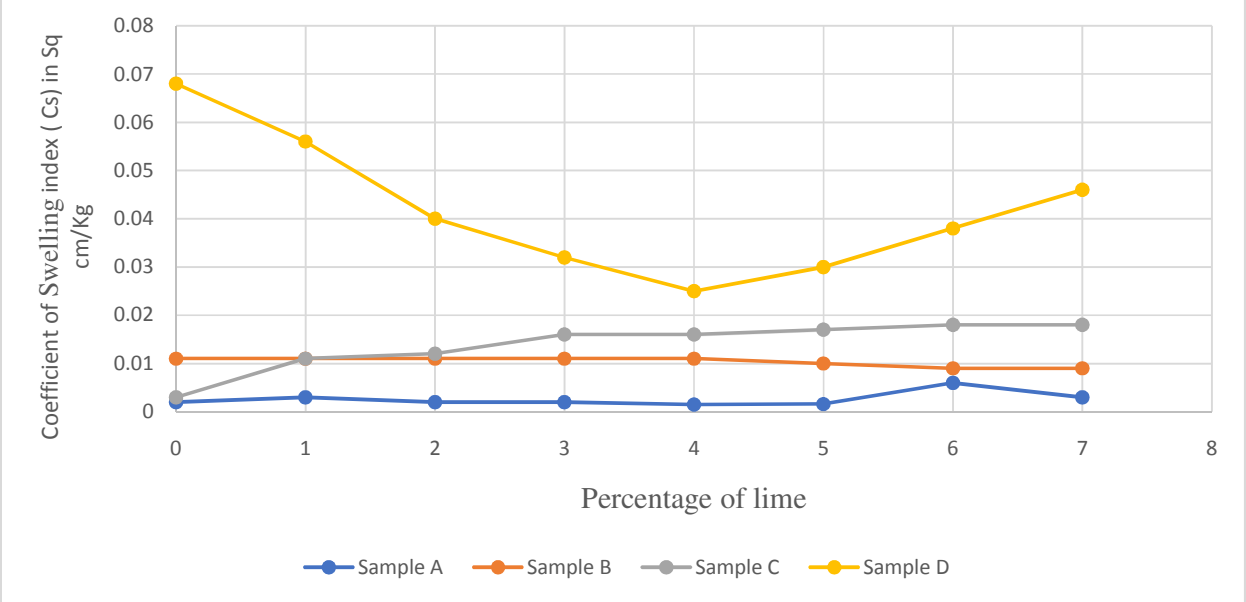

Fig 2 : Variation of Swelling Index (C_s) at different percentage of lime

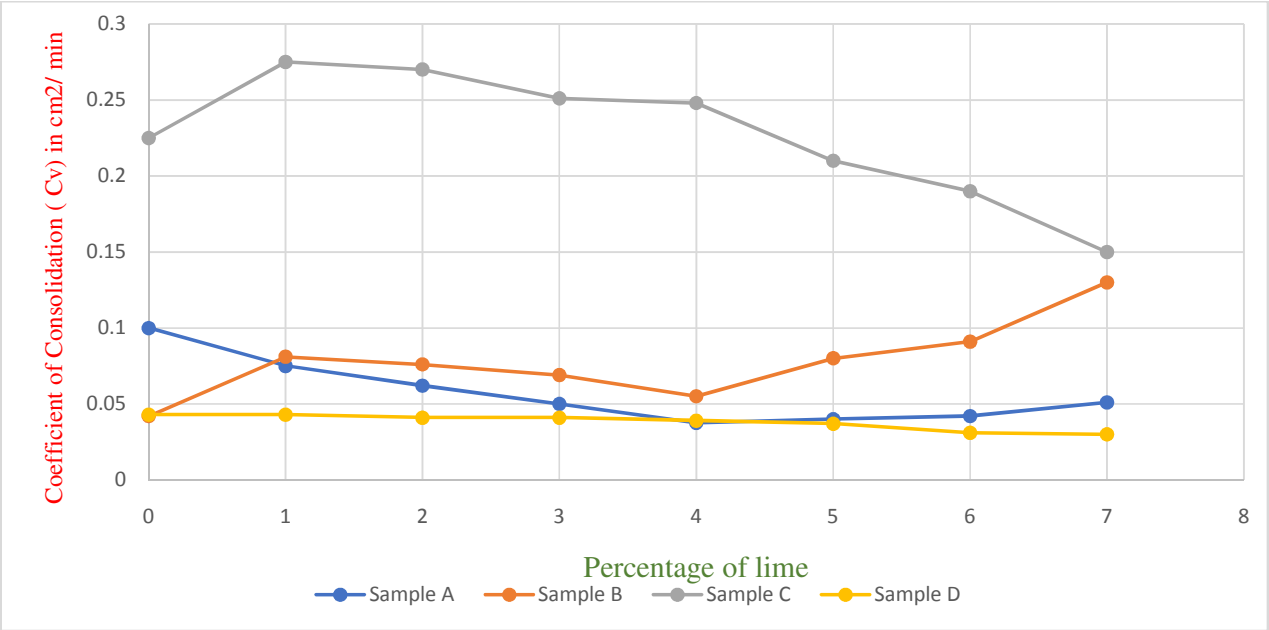

Fig 3 : Variation of Coefficient of Consolidation (C_v) at different percentage of lime

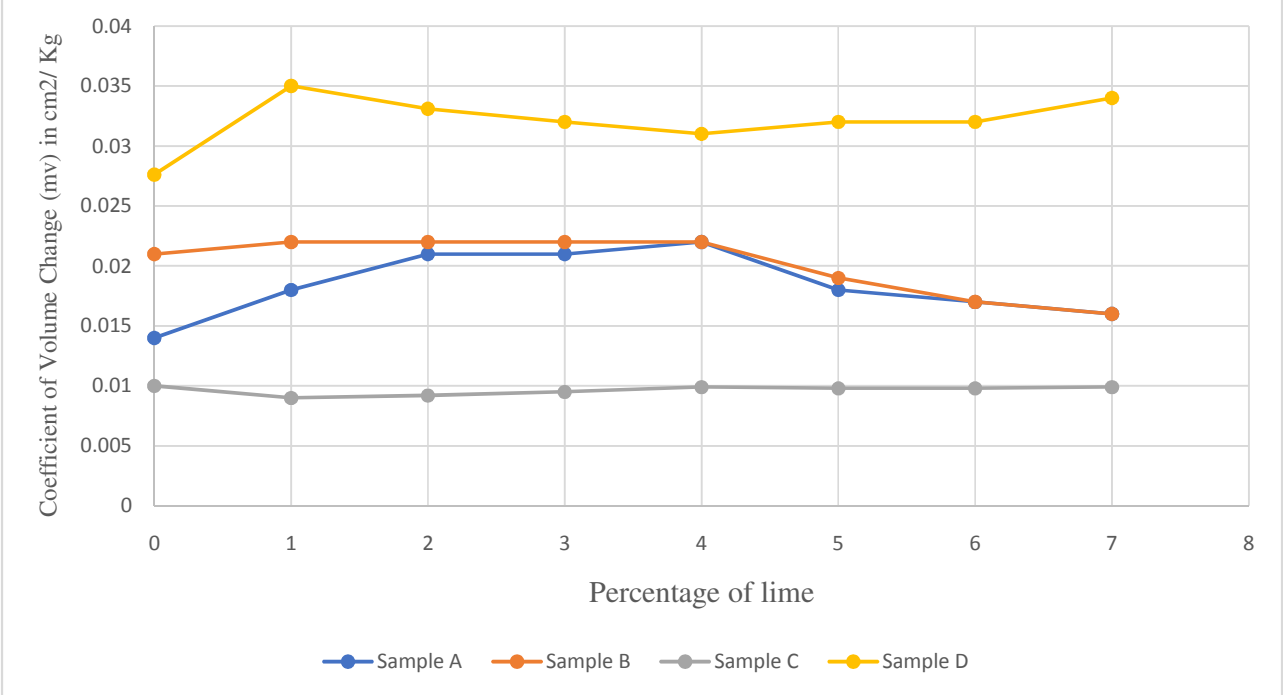

Fig 4 : Variation of Coefficient of Volume Change (m_v) at different percentage of lime

4. Test Results And Discussion

For determination of various co-efficient of compressibility characteristics, odometer test is carried out in the laboratory as per Indian Standard. The test results are tabulated in table 2 to table 5. For interpretation of consolidation test results, the pressure 4 Kg/cm^2 has been selected as this pressure range is very much common and relevant from practical point of view. The variation of different compressibility characteristics are shown in fig 1 to 4.

It has been observed from fig 1 that the value of Compression Index (C_c) for CL type soil (sample no A) remains same from 0 to 1% of lime. At 4% of lime the value of Compression Index (C_c) becomes maximum and towards 7% of lime the value decreases. In case of CI soil (sample no B), the value of Compression Index (C_c) gradually increases slightly up-to 4% of lime and then it falls with increase percentage of lime. On the other hand the ML type soil (sample no C) shows a gradual increase of Compression Index (C_c) up-to 4% of lime and then it almost remain same up-to 7% of lime. The CH type soil (sample no D) shows increase decrease trend of Compression Index (C_c) with addition of lime.

In case of Swelling Index (C_s) as shown in fig 2, it is observed that the CL type soil (sample no A), CI soil (sample no B) and CH type soil (sample no D) show almost similar trend of slightly gradual decrease up-to 4% of lime and then again it increases. But in case of ML type soil (sample no C) the Swelling Index (C_s) goes on increasing with increase percentage of lime.

The fig 3 suggest that the value of Coefficient of Consolidation (C_v) become almost minimum in case of CL type soil (sample no A), CI soil (sample no B) and CH type soil (sample no D) at 4% of lime content. In case of ML type soil (sample no C) first increase up-to 1 % of lime and then goes on decreasing.

From fig 4 it is observed that the value of Coefficient of volume change (m_v) increases gradually from 0 to 4% of lime in case of CL type soil (sample no A) and CI soil (sample no B) and beyond 4% of lime it decreases. The ML type soil (sample no C) shows no any remarkable change in Coefficient of volume change (m_v) with addition of lime. In case of CH type soil (sample no D) the Coefficient of volume change (m_v) becomes maximum at 1 % of lime and beyond that it decreases.

5. Conclusion

The lime is an affective additive to change the properties of soil. From the analysis of test results, it is clear that the addition of lime with different type of soils, the consolidation and swelling characteristics can be varied to remarkable extent. The swelling index of soil samples A, B and D become minimum at nearly 4% of lime. The pozzolanic reaction is the main factor in reducing the swelling potential of calcium saturated clay. The value of Coefficient of Consolidation (C_v) is also minimum at 4% level of lime for soil samples A, B and D. The reduction of Coefficient of Consolidation (C_v) at 4% lime may be due to pozzolanic reaction and re-orientation of soil structure at this optimum level of lime content. The increase of Coefficient of Consolidation (C_v) from 0 to 1% of lime and then decreasing for ML type soil (sample no C) is due to fact that addition of lime tends to decrease the immediate settlement of sandy soil. The Coefficient of volume change (m_v) gradually increases from 0 to 4% of lime addition in case of CL type soil (sample no A) and CI soil (sample no B) as the clayey soils tend to stabilize more at optimum level of lime. Finally it may be concluded that in most cases the value of Compression Index (C_c) is maximum at 4% of lime. The value of Swelling Index (C_s) is also minimum at nearly 4% of lime except sample no C. The value of Coefficient of Consolidation (C_v) also shows a decreasing trend and value of Coefficient of volume change (m_v) shows an increasing trend except sample no D around 4% of lime. Therefore, for best performance the optimum level of addition of lime for CL, CI and ML type soil may be taken as 4% and for CH type soil it may be in between 1 to 4%.

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