IOSR Journal of Applied Geology and Geophysics (IOSR-JAGG)
e-ISSN: 2321–0990, p-ISSN: 2321–0982. Volume 14, Issue 1 Ser. 1 (Jan – Feb 2026), PP 34-37
www.iosrjournals.org

Investigation Of The Impact Of Common Salt On Lime-Stabilised Lateritic Soil

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Abstract
This study investigated the effect of common salt on lime-stabilised soils with a view to assessing the impact of common salt on the soil-stabilising potential of lime. To achieve the aim of the study, soil samples were collected from two identified locations. Preliminary and geotechnical tests (particle size analysis, specific gravity, Atterberg's limit, compaction, unsoaked California bearing ratio (CBR) and unconfined compression strength (UCS)) were conducted on the soil samples, following standard procedure. Thereafter, the soils were treated with a constant 8 % proportion of lime and 3 %, 6 % and 9 % proportion of common salt. Each percentage of additive was by weight of the dry soil. The proportions were thoroughly mixed and cured for 48 hours, after which the unsoaked CBR and UCS of the treated soils were determined, using standard procedure. Results showed that the soils are well laterised, possess intermediate plasticity, and minima plastic clayey characteristics. The CBR values also showed that one of the samples is suitable for subgrade filling, while the other sample is a suitable sub base material for road construction. Results of UCS tests showed that the soils may be adequate for shallow foundation support with minima stabilisation requirements. Results of CBR tests on the lime-stabilised soils showed continuous increase in CBR values with the addition of proportions of common salt. That is, the addition of common salt did not adversely affect the stabilising effect of lime on the soil samples, rather, it improved the properties of the soils. It was also observed that, with the addition of common salt to the lime-stabilised soils, the optimum values of common salt were 3 % (first sample) and 6 % (second sample). The study concluded that addition of common salt to lime-stabilised soils led to improvement in the engineering properties of the soils.
Keywords: *common salt, lateritic soil, lime, soil compaction, soil stabilisation,*

Date of Submission: 29-01-2026 Date of Acceptance: 09-02-2026

I. Introduction

The construction of highways, airfields, earth dams, embankments, erosion control, etc., has made considerable use of soil stabilization, with the aid of industrial products such as lime, cement , etc and agricultural wastes such as bagasse ash, groundnut shell ash, wood ash, etc (Ajala *et al*, 2020; Daramola *et al*, 2021; Adunoye *et al*, 2022; Adunoye *et al*, 2023; Adunoye *et al*, 2024).

Lime stabilisation is a widely used technique for improving the strength and durability of soil. The addition of lime to soil leads to cation exchange, flocculation, and pozzolanic reactions, which collectively improve soil properties. Studies have shown that lime treatment can increase soil strength, reduce plasticity and compressibility, and improve durability and fatigue strength (Al-Gharbawi *et al*, 2023; Ayoola *et al*, 2024).

Common salt (sodium chloride) has been explored as a potential additive for soil stabilisation. Studies on the influence of salt-lime, phosphogypsum-lime and polypropylene fiber-lime stabilisation on soil strength have found that the best performance in terms of strength increase and reduction in plasticity was achieved by adding varying proportions (percentages) of the additives in the soil (Gharbawi *et al*, 2023; Al-Gharbawi *et al*, 2023).

This study investigated the specific impact of common salt on the stabilising property of lime on selected lateritic soils.

II. Materials And Methods

Materials and equipment

The materials used for this study include laterite soil samples (collected from identified locations), lime and common salt (purchased from open market).

The equipment and apparatus used for laboratory analysis include those for the determination of moisture content, specific gravity, Atterberg;s limits. Other equipment used are: compaction apparatus, compression machine, and California bearing ratio (CBR) machine. All equipment were available in the Geotechnical

Engineering Laboratory (subsequently referred to as the Laboratory) of the Department of Civil Engineering, Obafemi Awolowo University, (OAU), Ile-Ife.

Soil sampling and preparation

The soil samples used were collected from two different borrow pits- one at Kopek Opa, Atakumosa West Local Government, and the other at New Market in OAU campus, Ile-Ife. Both locations are in Osun state, Nigeria. About 25 kg of each sample was collected using a hand auger. Disturbed samples were collected in water-proof sacks, properly sealed labelled and immediately transported to the Laboratory. At the Laboratory, representative samples were taken for the determination of natural moisture content, after which the remaining samples were air-dried for subsequent laboratory analysis.

Geotechnical evaluation of soils in their natural state

The following preliminary and geotechnical tests were conducted on the soils in their natural state, using standard procedure as outlined in BS 1377 (1990): natural moisture content, specific gravity, particle size analysis, Atterberg's limits, compaction, unsoaked California bearing ratio (CBR), and unconfined compression test (UCS).

Geotechnical evaluation of lime-stabilised soils treated with common salt

The dry soil samples were treated with 8 % (by weight of dry soil) of lime, and the resultant mixture was thoroughly mixed. In an attempt to study the effect of common salt on lime-stabilised soils, salt was added to the dry lime-stabilised soils in proportions of 3 %, 6 %, and 9 % by weight of dry treated soils. The treated samples were thoroughly mixed and subjected to unsoaked CBR and UCS tests in the laboratory, using standard procedure as outlined in BS 1377 (1990). The treated soils were allowed to cure for 48 hours before carrying out the tests.

III. Results And Discussion

Results of preliminary and geotechnical tests on soils in their natural state

The results of preliminary and geotechnical tests on soil samples in their natural state are presented in Table 1.

Notably, the soil sample from OAU-New market has a higher natural moisture content compared to the sample from KOPEK- Opa. This difference can be attributed to the soil's void ratio; as higher void ratios generally lead to higher moisture content. Weather conditions (rainy or dry season) and water table at the point of sample collection are additional factors that influence the natural moisture content of soil samples. Iit is widely acknowledged that lower moisture content is indicative of better soil quality (Jackson and Ravindra, 2002).

According to Lamber and Whiteman (1969), most lateritic soils typically fall within the specific gravity range of 2.65 – 2.85. The values of the specific gravity of the soil samples (Table 1) suggest a high degree of laterisation in the soil samples. The results of Atterberg's limits tests indicate that both soil samples possess intermediate plasticity.

Table 1: Results of preliminary and geotechnical tests on natural soil samples

Properties	OAU-New Market)	KOPEK-OPA
Natural moisture content (%)	19.04	16.80
Specific gravity	2.730	2.60
Liquid limit (%)	64.04	38.44
Plastic limit (%)	47.55	26.87
Plasticity index (%)	16.49	13.67
Percentage passing sieve No. 200 (Fines)	0.07	0.08
Percentage passing sieve No. 40	25.91	31.04
AASHTO classification	A-2-7	A-2-7
Optimum moisture content (%)	25.26	20.84
Maximum dry density (kg/m^3)	1.74	1.86
California bearing ratio (%)	20.02	30.90
Unconfined compressive strength (N/m^2)	2.80	3.00

Based on the results of the index properties tests, the classification of the soil samples using American Association of State Highway and Transportation Officials {AASHTO) classification system showed that the two samples fall within A-2-7 group. This signifies that the soil samples are suitable materials for subgrade in road construction.

The values of optimum moisture content (OMC) and maximum dry density (MDD) (Table 1) obtained from compaction tests on the soil samples indicate that both samples possess minima plastic clayey characteristics (Das, 2006). The CBR values of the natural soils (Table 1) also indicate that the sample from OAU New Market is suitable for subgrade filling, while the sample from KOPEK Opa is a suitable sub base material for road construction. It can also be inferred from the results that the soils exhibit sandy-clayey characteristics (Das, 2006).

The unconfined compressive strength (UCS) test is used to assess the shear strength of cohesive soils, particularly clays, without lateral confinement. According to Das and Sobhan (2018), soils with UCS values between 25 kPa and 50 kPa are classified as soft, while those above 200 kPa are considered stiff. Therefore, the results of UCS tests on the tested natural soils (Table 1) indicate that both samples could be described as having medium to stiff clay consistency. Also, the soils could be said to be relatively competent clay, suitable for moderate load-bearing applications. These values also reflect good cohesion and strength development, potentially influenced by factors such as soil mineralogy, moisture content, and structure (Head, 2006). For engineering purposes, the UCS results imply that the soil may be adequate for subgrade or shallow foundation support with minimal stabilisation requirements.

Effect of common salt on lime-treated soil samples

Figures 1 and 2 show the variations in the values of CBR and UCS with varying proportions of common salt. Figure 1 shows that addition of common salt to the lime-stabilised soils increased the CBR of the soil samples. This shows that the load bearing capacity of the soil increased with the addition of common salt to the lime-stabilised soils. This shows that the addition of common salt does not adversely affect the stabilising effect of lime on the soil samples; rather, it improves the property of the soils.

Figure 2 shows that, with the addition of common salt to the lime-stabilised soils, the UCS increased up to certain optimum values. For Sample 'OAU New Market', the optimum value of common salt was 3 %; while for Sample 'KOPEK Opa', the optimum value of common salt was 6 %.

The mechanisms of lime stabilisation involve cation exchange, flocculation, and pozzolanic reactions. These reactions lead to the formation of cementitious compounds, which improve the soil's strength and durability. The high pH environment created by lime treatment also contributes to the stabilisation of soil particles [1].

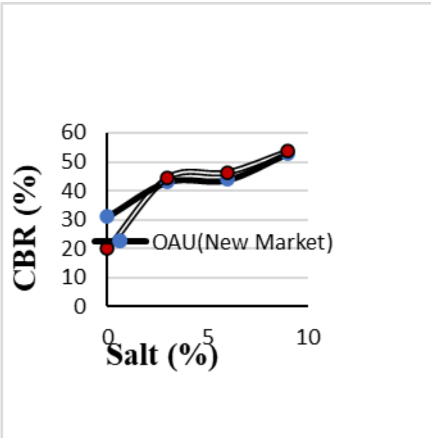

Figure 1: Variation of CBR with lime-stabilised soils treated with common salt

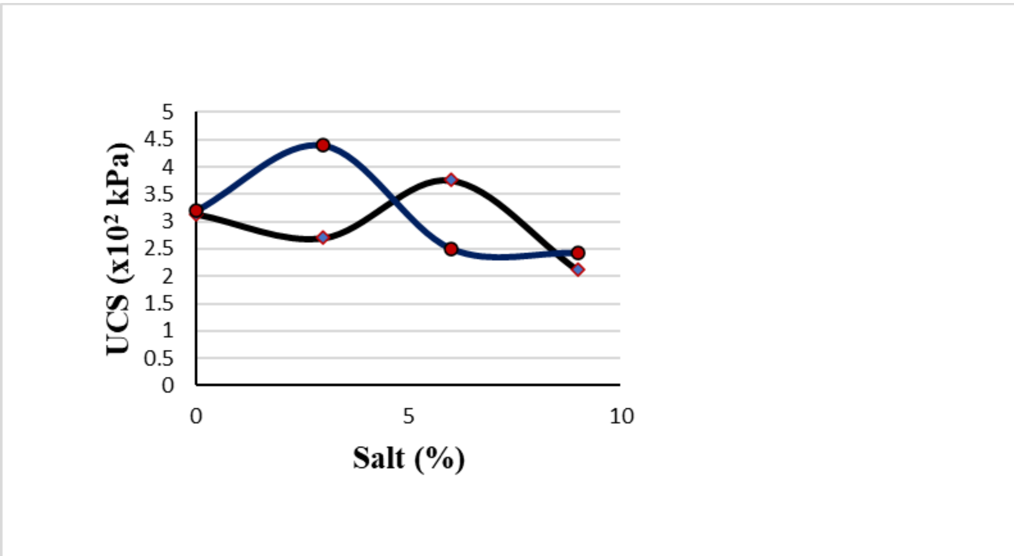

Figure 2: Variation of UCS with lime-stabilised soils treated with common salt

Common salt (sodium chloride) doesn't significantly affect the pozzolanic properties of lime because it doesn't react with the lime (calcium hydroxide) in a way that would hinder the pozzolanic reaction.

Pozzolanic reactions involve the reaction of silica-rich materials (like silica fume) with calcium hydroxide (lime) to form calcium silicate hydrate gel, which is a key component of cementitious materials.It could be deduced that common salt (NaCl) doesn't participate in this reaction and doesn't significantly interfere with the pozzolanic reaction between lime and silica-rich materials. Therefore, common salt does not adversely affect the pozzolanic properties of lime.

IV. Conclusion

Effect of common salt on lime-stabilised soils has been studied. The tested soil samples, in their natural state were found to belong to A-2-7 category, according to AASHTO classification. They were also found to be stiff, in terms of strength, and are suitable as subgrade and subbase materials for road construction works. Having established from previous studies that stabilisation of soil with lime leads to improved soil strength, it was observed that addition of common salt to the lime-stabilised soils further increased the engineering qualities of the soils. the CBR increased with increase in common salt content, while the UCS also increased with increase in common salt content but attained optimum values at 3 % and 6 % common salt content, respectively. Common salt did not reduce the stabilising potential of lime on the tested soil samples.

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