



Cement-Lime Stabilization Of Oil Contaminated Clayey Soil

¹Abhimanyu k, ²Athul C Rajan, ³Muhammed Althaf P A, ⁴Akhila Vijayan

¹Student, ²Student, ³Student, ⁴Assistant Professor

¹Department of Civil Engineering, ²Department of Civil Engineering, ³Department of Civil Engineering,
⁴Department of Civil Engineering,

¹ Adi Shankara Institute of Engineering and Technology Kalady, Ernakulam, India, ² Adi Shankara Institute of Engineering and Technology Kalady, Ernakulam, India, ³ Adi Shankara Institute of Engineering and Technology Kalady, Ernakulam, India,
⁴ Adi Shankara Institute of Engineering and Technology Kalady, Ernakulam, India,

Abstract: Oil contamination of clayey soils poses a severe threat, mainly along the coasts and marinas, since it affects soil structure, rendering the soil unsuitable and unstable for construction. . Clayey soils are common substrata when large amounts of pollutants need to be absorbed; at the point when soil structures break down, they engulf moisture, accumulate pollutants to a end. Oil hydrocarbons disturb the clay's particle cohesion and create more settlement with less stability. Oil polluting the soil implies some impediment to sorptivity, which goes so far as to limit essential processes like compaction, which are necessary to build soil stability. The main focus of this research project will be to determine the extent of oil contamination in clayey soil along the Cochin marine areas responsible for changing properties related to the strength, the permeability of the soil and plasticity. The main motivation in this research activity is in having a data-driven rehabilitation of the soil so that stability is restored and supports sustainability in the building industry. This research is far from changing the usability of the soil for construction and plays its bit in environment-friendly modalities that save groundwater from contamination while protecting coastal ecosystems and communities from the vices of groundwater contamination.

Index Terms - Oil contamination, Clayey soil, Cochin marine side, Cement-Lime stabilization

I. INTRODUCTION

Oil contamination in soils brings significant challenges, especially in coastal and marine areas where clayey soils are common. When oil seeps into the ground, it fundamentally changes the soil's natural structure, making it less suitable and more unstable for construction. Key properties, like compressibility, shear strength, and permeability, are all impacted by oil pollutants, meaning the soil can shift more easily under weight and lose its strength to hold structures securely. Clayey soils are particularly vulnerable to contamination because they naturally hold moisture and tend to absorb pollutants more than other soil types. The hydrocarbons in oil disrupt the clay particles, making the soil less cohesive and more prone to settling, which affects stability. Additionally, oil can make the soil more resistant to absorbing water, complicating the natural processes needed for soil compaction and stability. This deterioration highlights the importance of assessing oil-contaminated soils, especially in sensitive marine areas, to maintain safe building practices and protect the environment.

Our project aims to thoroughly study and understand the extent of oil contamination in the clayey soil along Cochin's marine area, identifying how much these soils have been altered and proposing practical solutions to rehabilitate them. By collecting and testing soil samples, we'll examine changes in core properties like compressive strength, permeability, and plasticity to see how they are affected by oil contamination.. Our goal is to create a data-driven foundation for selecting the best remediation techniques to restore soil stability and strength in a way that's effective and sustainable. This work goes beyond just fixing soil for construction; it's about contributing to safe, environmentally-friendly practices that prevent groundwater pollution and protect both local communities and ecosystems from the damaging effects of oil contamination.

II. RELEVANCE OF STUDY

The critical need for sustainable, cost-effective solutions in managing clayey soils, which are abundant in many regions and often present challenges for infrastructure development due to their low bearing capacity and high plasticity have to be addressed. Cement-lime stabilization is a proven technique that enhances the engineering properties of clayey soils, making them suitable for foundational uses in the construction of roads, buildings, and other infrastructure. By increasing strength, reducing plasticity, and improving overall stability, cement-lime stabilization transforms marginal soils into reliable construction materials, supporting the development of resilient infrastructure. Furthermore, this method is cost-effective compared to traditional soil remediation options, such as excavation and off-site disposal. By reusing existing soil on-site, cement-lime stabilization minimizes the need for new materials, reduces transportation costs, and eliminates disposal fees, which can be substantial in large-scale projects. This economic advantage makes it an attractive choice, especially in regions where budgets are constrained.

In addition, cement-lime stabilization aligns with environmental regulations, which increasingly mandate the treatment of contaminated soils before reuse or disposal. Contaminants, such as oils and other hazardous substances, can often be immobilized through the chemical reactions involved in cement-lime stabilization, rendering the soil safer for use or environmentally compliant disposal. This compliance facilitates project approvals and ensures adherence to environmental standards, allowing for responsible soil management in construction projects. Therefore, this study not only contributes to advancing infrastructure development on challenging soil types but also promotes sustainable practices by optimizing resource use, reducing costs, and meeting regulatory requirements. By highlighting these benefits, the study underscores the relevance of cement-lime stabilization as a strategic, environmentally sound approach to soil improvement in civil engineering.

III. METHODOLOGY

The methodology for this study involves a systematic approach to assessing and rehabilitating oil-contaminated clayey soil from Cochin's marine area. It begins with an extensive literature review to understand the impact of oil on soil properties and the effectiveness of cement-lime stabilization. Soil samples are collected and subjected to initial laboratory tests, including specific gravity, consistency limits, and hydrometer analysis, to determine baseline properties. These samples are then artificially contaminated with varying oil percentages, followed by repeated tests to observe changes in strength, plasticity, and permeability. Stabilization is carried out by mixing different cement-lime ratios with the contaminated soil allowing for curing under normal and saline conditions to simulate coastal environments. Post-stabilization tests, including unconfined compressive strength (UCC), consolidation,

and consistency limits, are conducted to evaluate improvements in soil performance. Data from these tests are analyzed statistically to identify the optimal mix for restoring soil strength and stability. The findings aim to offer a sustainable remediation solution that minimizes environmental impact while preventing groundwater pollution and supporting safe land use.

MATERIALS USED

1.1 SOIL

This study has retrieved soil samples from a site located at Kaloor - Kadavanthra Road, Kochi, Kerala (Lat: 9.992386°, Long: 76.292338°). Because the site is located in a developed urban center, the soil is undergoing active development, making it perfect for analyzing the geotechnical and environmental characteristics of the soil.

1.2 CONTAMINANT

Petrol is a common contaminant in urban and industrial settings because it is widely utilized as a fuel. Its storage leaks, underground tank ruptures, and poor disposal practices only contribute to the issue. Petrol is concerning as a contaminant due to its ability to potentially change the physical chemistry or biology of the soil. It has the capacity to harm soil micro organisms, lower the soil's permeability, and change crucial geotechnical factors including compaction strength, shear strength, and load capacity. Also, the volatile organic compounds and polycyclic aromatic hydrocarbons which are present in petrol, could contaminate water resources and endanger both people's health and ecosystems. The study discusses petrol spills and the subsequent soil behavior, analyses the effects of the contaminant on the geotechnical attributes of the soil, and assesses the environmental risks that such contamination can cause.

The petrol is selected because it is one of the most extensively consumed products around the globe. It highly contributes to environmental pollution through accidental spills and leakages. The usage of this fuel in transport and industries is one of the leading causes of widespread pollution in most urban and coastal areas. Samples were collected from the Cochin marine side as that region was quite prone to contamination because of proximity to industries and marine activities. Soil specimens are artificially contaminated with petrol at varying percentages, thereby simulating a real world condition. In this study, effects of petrol contamination on the soil properties and environment are intended to be analyzed.

SITE VISIT

On 29th August 2024, a site visit was conducted at Kaloor, Kochi. During the visit, clayey soil was collected from a depth of 25 meters for analysis. The purpose of this activity was to investigate the soil's characteristics and properties at that depth, potentially aiding in geotechnical or construction-related evaluations.



Figure 1 : Site visit conducted on Kaloor

?? SAMPLE PREPARATION

Petrol was used for engaging the samples and determining the effects on the specific characteristics of the soil. The soil samples utilized were prepared by taking 1.160 kg of soil and adding a certain amount of petrol which was equal to 5%, 10%, and 15% of the sample's weight. These were blended with the soils and its contaminants to a maximum possible range and mixed for a relatively longer duration. This is done in order to try and replicate actual contamination of soil which occurs in the real world. Once those mixtures were ready, the samples were allowed to sit for seven days. In this phase petrol works to change the chemical and physical properties of the soil, and the goal of this procedure is to imitate the long-term impact of contamination on the soils behavior. Being an extremely fueling, hydrocarbon challenging petrol is accepted to change vital soil attributes like permeability, compaction, shear strength, fuel. This method aids in understanding the consequences of petroleum contamination and devising strategies to counter the issue.

?? EXPERIMENTAL TESTING

The geotechnical properties of clay soils affected by oil spillage was the focus of an investigative study through laboratory testing. Determining the changes in soil consistency including its liquid limit, plastic limit, and plasticity index: factors crucial in assessing the soil's plasticity and workability was done through the Atterberg limits test. These results determined the extent to which oil contamination altered the soil's water retention capability and its various states (liquid, plastic, semi-solid). The specific gravity test was one of the preliminary tests done in order to determine the extent of oil contamination on soil particle density.

The unconfined compression test (UCS) is performed in order to measure the oil contamination effects on soil shear strength of the contaminated soil. It was possible to determine oil contamination factors existing in the soil by looking at the weakness of soil. The consolidation tests were conducted to analyse the settlement and consolidation properties. These tests uniquely integrated all aspects necessary to fully describe the physical strength, and deformation characteristics of oil contaminated clayey soil, which is vital when devising engineering strategies, forecasting the behavior of soils in contaminated contexts, and planning for remediation.

IV. RESULTS AND DISCUSSION

4.1 Specific Gravity Test

The result shows the effect of oil contamination on the specific gravity of 7-day cured soil samples. The results indicate that specific gravity decreases from 2.35 for raw, uncontaminated soil to 1.987 at 5% oil contamination and further to 1.88 at 10% contamination. At 15% contamination, the specific gravity increases to 2.22.

Table 1 Effect of oil contamination on Specific gravity

Oil contamination (%)	Specific Gravity (G)
0	2.35
5	1.987
10	1.88
15	2.22

4.2 Atterberg Limits

The result shows the influence of oil contamination on the Atterberg limits of soil samples. The results indicate that the liquid limit increases significantly with oil contamination, peaking at 68.0% for a 15% contamination level, before declining at higher contamination levels. In contrast, the plastic limit shows a decreasing trend with increasing contamination up to 15%, reaching a minimum of 16.50%, and then rises slightly. These variations suggest a complex interaction between oil and soil particles, potentially altering the soil's consistency and plasticity.

Oil displaces water in the soil pores and coats the clay particles, reducing their ability to adsorb water and weakening the electrostatic and hydrogen bonding that contribute to plasticity. This coating effect also alters inter-particle forces and makes the soil behave more like silt or sand, which naturally have lower plastic limits. Additionally, oil reduces the ionic activity in the pore water, further diminishing the soil's plastic behavior. As a result, the plastic limit decreases, reflecting changes in the soil's consistency and workability. The liquid limits increase with a light slope till 15 % oil contamination and decreases as contamination reaches 20%. We can also see an increase in plastic index till 15% contamination and then a decrease as it moves to 20% contamination. The increase in cohesion of contaminated clay must have been caused by the increase in bonding by oil particles. Hence, additional water would be required to cause a change in consistency level for a thick layer of contaminated clay.

Table 2 Effect of oil contamination on Atterberg Limits

Oil contamination (%)	Liquid Limit (%)	Plastic limit (%)	Plastic index
0	45.2	29.3	15.9
5	54	25.26	28.74
10	56	17.6	38.4
15	68	16.5	51.5
20	55	27.2	27.8

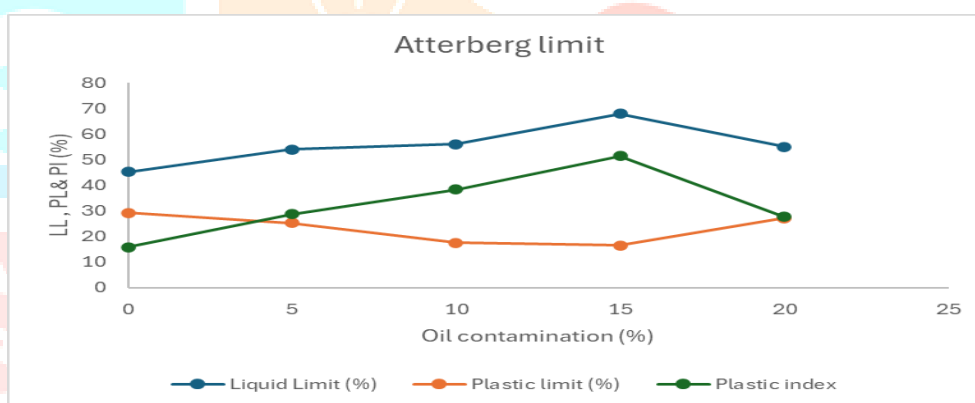


Figure 2: Effect of oil contamination on Atterberg Limits

4.3 Unconfined Compression test

The result shows the influence of oil contamination on the Unconfined Compressive Strength (UCS) of soil samples cured for 7 days. The UCS values exhibit variability depending on the percentage of oil contamination. For uncontaminated soil, the UCS value is 2.540 KN/m². As oil contamination increases to 5% and 10%, the UCS values decrease to 1.820 KN/m² and 1.760 KN/m², respectively. Interestingly, at 15% oil contamination, the UCS increases to 2.336 KN/m², and a significant rise to 3.800 KN/m² is observed at 20% contamination. The unconfined compressive strength decreases as the oil content rises. This might be because of the coating, which lessens the friction between the soil particles and weakens their binding, decreasing strength, or it could be because of the pore pressure. Additionally, analysis reveals that strength increases when it reaches 15%. From 15% to 20% oil contamination we can observe an abnormal increase in strength. It might be caused by variations in the morphological properties of the soil.

Table 3 Effect of oil contamination on UCS values

Oil contamination(%)	UCS value	UCS value
0	2.54	2.54
5	1.82	1.82
10	1.76	1.76
15	2.33	2.33
20	3.8	3.8

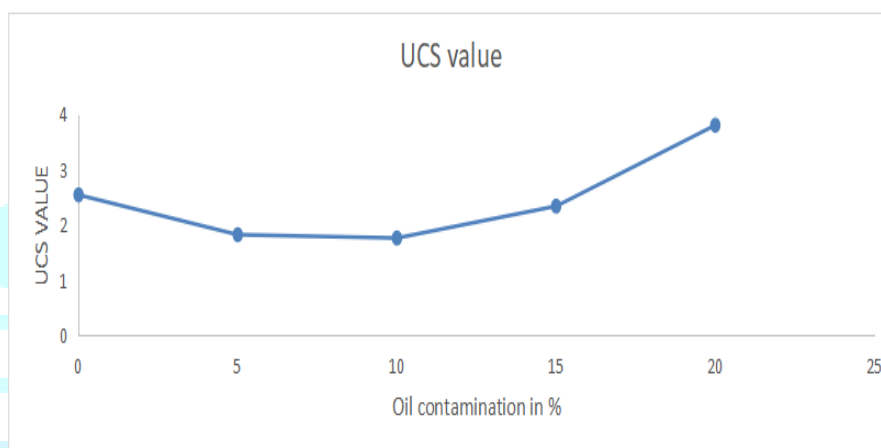


Figure 3: Effect of oil contamination on UCS values

4.4 Consolidation

Table 4 Effect of oil contamination on Consolidation

Oil contamination(%)	Coefficient of Consolidation(Cv)
0	0.936
5	1.834
10	2.082
15	3.662
20	2.152

In uncontaminated soil, C_v is $0.936 \text{ m}^2/\text{s}$, representing a standard consolidation rate. As oil contamination increases to 5% and 10%, C_v rises to $1.834 \text{ m}^2/\text{s}$ and $2.082 \text{ m}^2/\text{s}$, respectively. This increase is attributed to the lubricating effect of oil, which reduces friction between particles and allows faster water movement through the soil matrix. The highest C_v value of $3.662 \text{ m}^2/\text{s}$ is observed at 15% contamination, indicating optimal lubrication and particle rearrangement. However, beyond this point, C_v decreases to $2.152 \text{ m}^2/\text{s}$ at 20%, suggesting that oil-induced pore clogging and particle binding reduce permeability and slow down

consolidation. This non-linear behavior reflects the dual impact of oil contamination: initially promoting faster consolidation due to lubrication and later impeding it due to pore clogging.

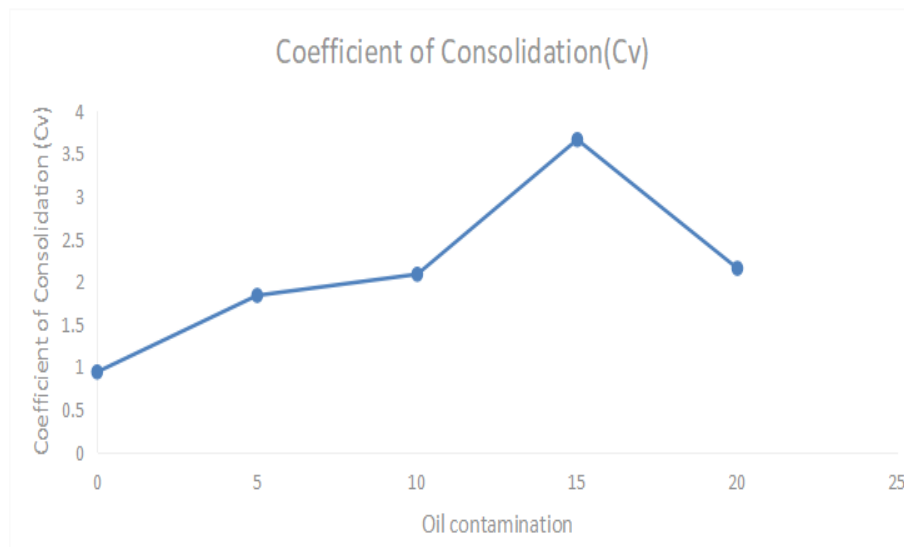


Figure 4: Effect of oil contamination on Consolidation

4.5 INFERENCE

While moderate contamination levels (up to 10%) show a predictable decline in UCS, plastic limit, and specific gravity, along with an increase in the liquid limit, higher contamination levels (15% and above) exhibit unexpected morphological changes. These changes include particle agglomeration, densification, and altered pore structures, leading to enhanced UCS and specific gravity but reduced permeability and consolidation rates.

The results suggest that 10% oil contamination represents the optimum threshold where soil properties remain relatively stable, and the adverse effects on strength, consistency, and consolidation are minimal. In contrast, 15% oil contamination is considered unstable, as it introduces significant morphological changes that lead to unpredictable settlement patterns and compromised structural performance. Such instability poses challenges for foundation design, slope stability, and other geotechnical applications where soil reliability is critical.

Selecting 10% oil contamination as the threshold ensures a balance between performance and predictability, making it ideal for further stabilization and lab analysis.

V CEMENT-LIME STABILIZATION OF OIL CONTAMINATED CLAYEY SOIL

5.1 Cement & Lime

The stabilization of oil-contaminated clayey soil using Ordinary Portland Cement (OPC) and ordinary lime is an effective method for improving geotechnical properties by leveraging hydration, pozzolanic reactions, and particle encapsulation. Oil contamination weakens soil structure by reducing interparticle bonding, friction, and pore pressure dynamics. OPC provides immediate strength through the formation of calcium silicate hydrate (C-S-H) and calcium aluminate hydrate (C-A-H) compounds, which bind soil particles, reduce void spaces, and improve load-bearing capacity while encapsulating oil particles. Lime reduces plasticity by causing cation exchange and flocculation, improving workability and facilitating long-term

strength gain through pozzolanic reactions in an alkaline environment. This combination accelerates consolidation, reduces settlement potential, and mitigates swelling behavior by transforming the clay into a stable, aggregated structure. Additionally, OPC and lime are economical and locally available, making this approach a practical, sustainable, and reliable solution for stabilizing oil-contaminated clayey soils.

5.2 Sample Preparation

We use cement-lime in 2:1 ratio at varying dosages of 5%, 10%, 15%, and 20% is an effective technique for improving the geotechnical properties of 10% oil-contaminated clayey soil. Oil contamination weakens soil strength by coating clay particles, reducing friction, and increasing pore pressure, which deteriorates the overall load-bearing capacity and consolidation behavior. Stabilization with Ordinary Portland Cement (OPC) and ordinary lime offers a combined effect where cement hydration provides immediate strength gain, and lime-induced pozzolanic reactions enhance long-term durability by forming cementitious compounds like calcium silicate hydrate (C-S-H) and calcium aluminate hydrate (C-A-H). The pre-weighed cement-lime mixture is gradually added to the 10% oil-contaminated soil. Thorough mixing is done to achieve uniform distribution of the stabilizer throughout the soil matrix. Mixing is continued until the blend shows consistent color and texture, indicating proper homogeneity. The samples are sealed in plastic wraps to prevent moisture loss during the curing period. Applying the stabilizer in increments of 5%, 10%, 15%, and 20% by dry weight of the soil under air-tight conditions and curing for 7 days ensures optimal hydration without moisture loss.

VI RESULT & DISCUSSION

6.1 Specific Gravity

Initially, the specific gravity of untreated soil is 2.23, indicating the natural density of the soil particles. With the addition of 5% cement-lime, the specific gravity slightly increases to 2.25, suggesting the initial binding effect of cement and lime with soil particles. This is due to the gradual filling of voids and the partial replacement of lighter oil-coated particles with denser cementitious material. As the stabilization content increases to 10%, the specific gravity rises to 2.3, reflecting enhanced densification and better particle packing. The pozzolanic reaction between lime and the clay minerals, coupled with the hydration of Ordinary Portland Cement (OPC), forms cementitious compounds like calcium silicate hydrate (C-S-H) and calcium aluminate hydrate (C-A-H), which significantly improve soil density. At 15% cement-lime, the specific gravity reaches 2.38, indicating a substantial improvement in particle density. The significant increase can be attributed to the filling of micro and macro voids by the cementitious compounds and the coating of oil-contaminated particles with lime, which mitigates the impact of oil-induced bonding reduction. The steady upward trend suggests that cement-lime stabilization effectively enhances the compactness and structural integrity of oil-contaminated clayey soils.

Table 5 Effect of Cement-Lime stabilization on Specific gravity

Cement lime (%)	Specific Gravity (G)
5	2.23
10	2.25
15	2.3
20	2.38

6.2 Atterberg Limits

At 5% cement-lime, the liquid limit is 82%, indicating high water retention capacity, while the plastic limit is 40.4%, resulting in a plasticity index of 41.6%. The high PI reflects high clay content with substantial plasticity. The initial cement-lime addition partially flocculates the clay particles, reducing their plasticity but not significantly altering the water absorption capability. With an increase to 10% cement-lime, the liquid limit drops to 62%, and the plastic limit becomes 37.37%, reducing the plasticity index to 24.63%. The decline in LL and PI suggests that cementation reactions form a stronger soil structure, reducing the water absorption capacity. At 15% cement-lime, the liquid limit further decreases to 58%, the plastic limit stabilizes at 36%, and the plasticity index drops to 22%. The reduction reflects improved particle aggregation and the formation of cementitious compounds, limiting the soil's capacity to retain water. Finally, at 20% cement-lime, the liquid limit is 52%, the plastic limit is 35.6%, and the plasticity index reduces to 16.4%. This substantial reduction shows a shift from plastic to semi-plastic behavior. Cement-lime interactions form stronger bonds, filling voids, and reducing the double-layer thickness around clay particles, leading to decreased plasticity and better soil stability. The consistent decline in Atterberg limits indicates that cement-lime stabilization effectively reduces the water sensitivity and plastic nature of oil-contaminated clayey soil, improving its engineering properties.

Table 6 Effect of Cement-Lime stabilization on Atterberg Limits

Cement lime(%)	Liquid Limit (%)	Plastic limit (%)	Plastic index
5	82	40.4	41.6
10	62	37.37	24.63
15	58	36	22
20	52	35.6	16.4

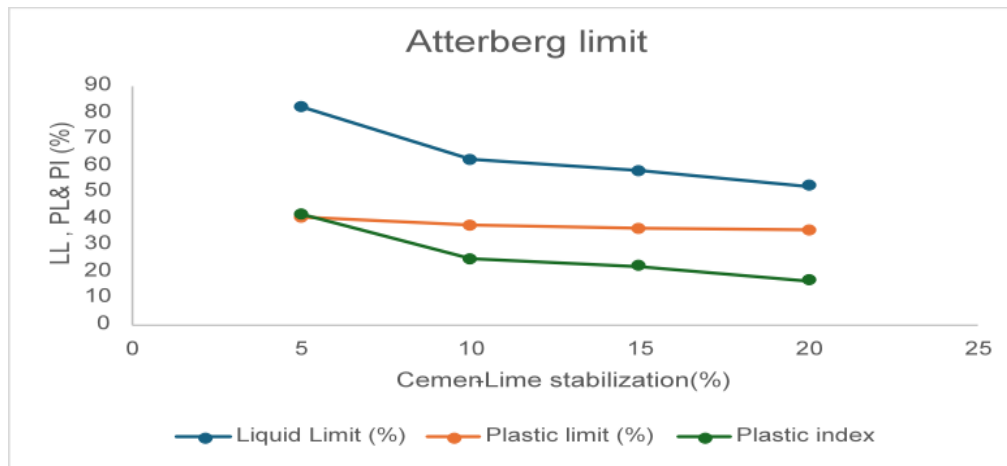


Figure 6: Effect of Cement-Lime stabilization on Atterberg Limits

6.3 Unconfined Compression test

The Unconfined Compression Strength (UCS) Test results demonstrate the progressive improvement in the strength of oil-contaminated clayey soil with increasing cement-lime stabilization. At 5% cement-lime, the UCS value is 4.72 KN/m², indicating the initial formation of cementitious bonds through flocculation of clay particles. This modest improvement signifies the early stages of stabilization where the binding agents begin to fill the voids and enhance the soil structure. As the cement-lime content increases to 10%, the UCS value rises to 5 KN/m², reflecting further development of calcium silicate hydrates (CSH) and calcium aluminate hydrates (CAH), which contribute to stronger inter-particle bonding. A slight increase to 5.07 KN/m² at 15% cement-lime* suggests a gradual stabilization where the reaction products have sufficiently coated the clay particles, although the rate of strength gain starts to plateau. The most significant improvement is observed at 20% cement-lime, where the UCS value reaches 7.04 KN/m², indicating optimal stabilization. At this stage, the void spaces are effectively filled, and the soil matrix becomes denser and more cohesive, enhancing its ability to resist deformation. . Additionally, cement-lime stabilization mitigates the adverse effects of oil contamination by counteracting the lubricating effect of oil on soil particles, thus improving shear strength. Overall, the trend in UCS values confirms that increasing the cement-lime content significantly improves the load-bearing capacity of contaminated clayey soil, with 20% cement-lime offering the most effective stabilization.

Table 7 Effect of Cement-Lime stabilization on UCS values

Cement lime(%)UCS value54.72105155.07207.04Figure 7: Effect of Cement-Lime stabilization on UCS values	UCS value54.72105155.07207.04Figure 7: Effect of Cement-Lime stabilization on UCS values
54.72105155.07207.04Figure 7: Effect of Cement-Lime stabilization on UCS values	4.72105155.07207.04Figure 7: Effect of Cement-Lime stabilization on UCS values
105155.07207.04Figure 7: Effect of Cement-Lime stabilization on UCS values	5 155.07 207.04 Figure 7: Effect of Cement-Lime stabilization on UCS values
15 5.07 20 7.04 Figure 7: Effect of Cement-Lime stabilization on UCS values	5.07 20 7.04 Figure 7: Effect of Cement-Lime stabilization on UCS values
207.04Figure 7: Effect of Cement-Lime stabilization on UCS values	7.04Figure 7: Effect of Cement-Lime stabilization on UCS values

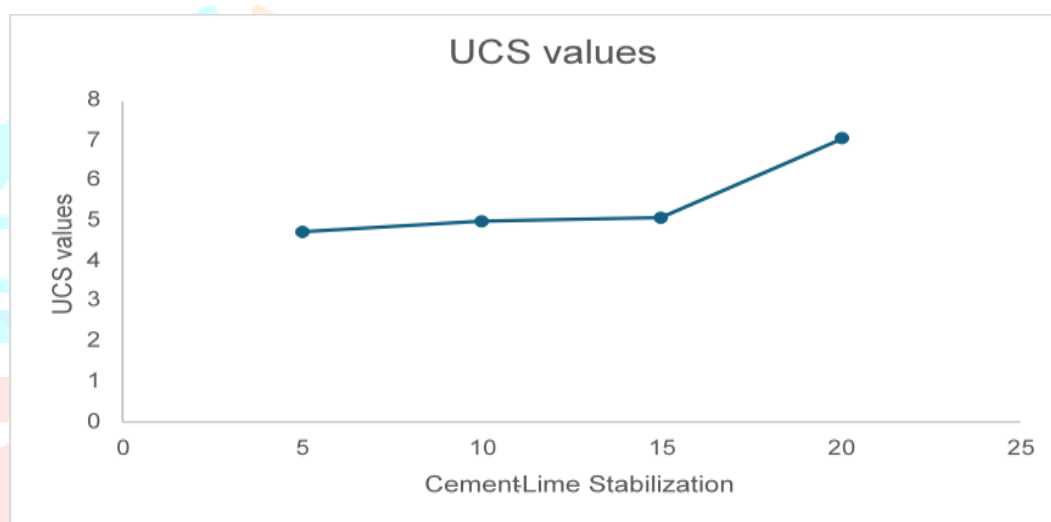


Figure 7: Effect of Cement-Lime stabilization on UCS values

6.4 Consolidation

The Consolidation Test results reveal a clear decreasing trend in the Coefficient of Consolidation (C_v) with increasing cement-lime stabilization in oil-contaminated clayey soil. At 5% cement-lime, the C_v value is relatively high at 4.95 m^2/s , indicating faster dissipation of excess pore water pressure and higher permeability. This is because, at lower stabilization levels, the cement-lime content is insufficient to significantly alter the soil's microstructure, leaving larger void spaces for water movement. As the cement-lime content increases to 10%, the C_v value decreases to 3.1 m^2/s , reflecting the formation of initial cementitious compounds such as calcium silicate hydrates (CSH) and *calcium aluminate hydrates (CAH), which start to reduce void ratio and permeability. Further stabilization at 15% shows a notable reduction in C_v to 1.8 m^2/s , indicating denser soil structure due to enhanced flocculation and agglomeration of clay particles. The increased particle bonding reduces pore sizes, slowing water movement through the soil matrix. At 20% cement-lime, the C_v value drops significantly to 0.648 m^2/s , marking the most substantial reduction in permeability. This is attributed to the near-complete filling of void spaces and a highly cohesive soil matrix, leaving minimal pathways for water flow. Additionally, the stabilizing agents counteract the

lubricating effect of oil on clay particles, further improving the soil's structure and reducing compressibility. The overall decreasing trend in C_v demonstrates how cement-lime stabilization enhances the soil's load-bearing capacity by reducing compressibility and permeability. As a result, water expulsion becomes slower, indicating a stiffer and more stable soil structure that is less prone to settlement under load.

Cement lime(%)	Coefficient of Consolidation(C_v)	
5%	4.95	10%3.115%1.820%0.648
10%	3.115	
15%	1.820	
20%	0.648	

Table 8 Effect of Cement-Lime stabilization on Consolidation

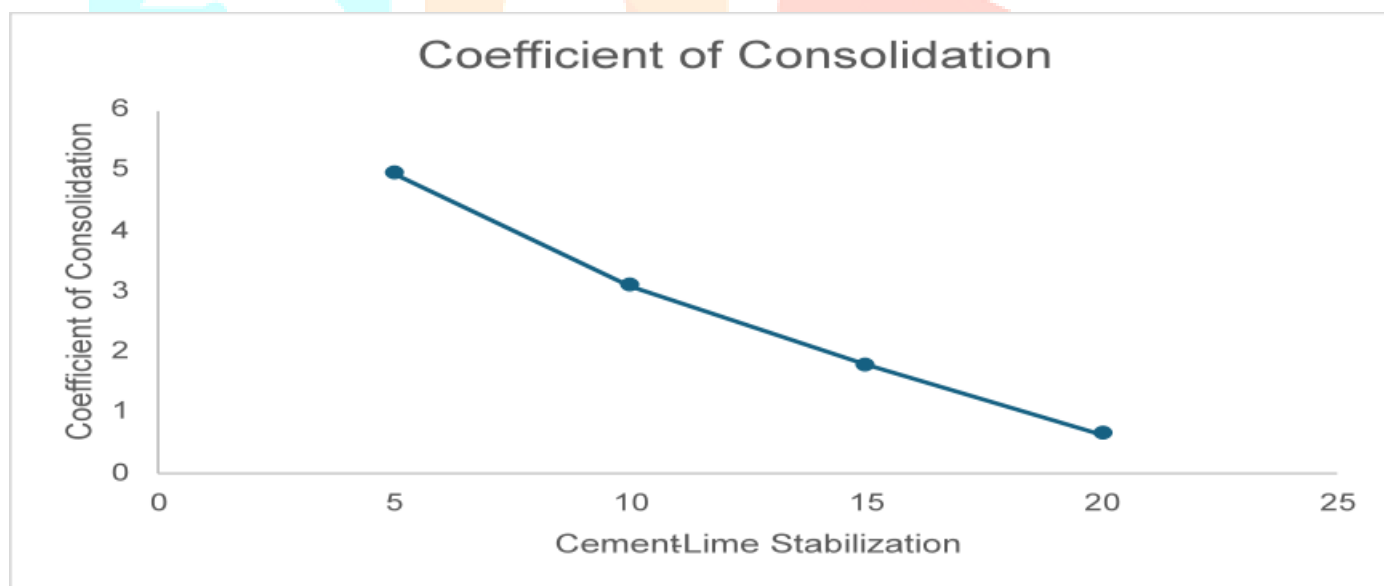


Figure 8: Effect of Cement-Lime stabilization on Consolidation

VII CONCLUSION

Cement-lime stabilization has proven to be an effective method for improving the properties of oil-contaminated clayey soil. The addition of cement and lime significantly reduces the liquid limit, plastic limit, and plasticity index, indicating a marked decrease in soil plasticity. This reduction enhances soil stability and workability, making it more suitable for construction purposes.

An increase in specific gravity with higher cement-lime content reflects improved particle packing and densification, contributing to better mechanical integrity. The rise in Unconfined Compressive Strength (UCS) values further demonstrates enhanced load-bearing capacity, which is critical for structural stability. Additionally, the coefficient of consolidation decreases with the inclusion of cement-lime, implying reduced compressibility and improved settlement characteristics. Lower compressibility minimizes long-term deformations, ensuring durability and longevity in construction applications.

Overall, cement-lime stabilization effectively mitigates the adverse effects of oil contamination by enhancing strength, reducing plasticity, and minimizing compressibility. These improvements make it a sustainable and reliable solution for construction projects, particularly in environmentally sensitive areas where soil quality is compromised. Through Cement-lime stabilization the environmental, structural and geotechnical adverse effects caused by oil contamination in marine clay can be prevented.

VIII ACKNOWLEDGMENT

We would like to express our sincere gratitude to Adi Shankara Institute of Engineering and Technology for providing the resources and facilities necessary for conducting this study. We are deeply thankful to the the Civil Department for their constant support, guidance, and encouragement throughout the duration of this project. Their expertise and thoughtful advice have been invaluable to the successful completion of this work.

REFERENCES

- (1) Effects of crude oil contamination on the index properties, strength and permeability of lateritic clay Akinwumi I. I., Diwa D Obianigwe N 2014
- (2) Isaac I. Akinwumi, Daniel Diwa, Colin A. Booth, Peter Mills Cement stabilisation of crude-oil-contaminated soil 2013
- (3) Jackie M Aislabie, Megan R Balks, Julia M Foght & Emma J Waterhouse Hydrocarbon Spills on Antarctic Soils: Effects and Management 2014
- (4) James L. Eades, d Ralph E. Grim Reaction of Hydrated Lime With Pure Clay Minerals in Soil Stabilization 2012
- (5) Lime stabilisation for earthworks: A UK perspective Paul Beetham, Tom Dijkstra Neil Dixon, John Bateman 2013
- (6) Mashalah Khomehchiyan , Amir Hossein Charkhabi , Majid Tajik Effects of crude oil contamination on geotechnical properties of clayey and sandy soils 2006
- (7) Mohamed Khemissa , Abdelkrim Mahamedi Cement and lime mixture stabilization of an expansive overconsolidated clay 2014
- (8) Mohammad Kermani & Taghi Ebadi The Effect of Oil Contamination on the Geotechnical Properties of Fine-Grained Soils 2012
- (9) Ochebo J., Ibrahim M., Joseph V Effect of Oil Contamination on Lime and Cement Stabilized Laterite Soil 2013
- (10) Opeyemi E. Oluwatuyi a, Oluwapelumi O. Ojuri b , Arman Khoshghalb Cement-lime stabilization of crude oil contaminated kaolin clay 2019
- (11) Rajab M. Abousnina, Allan Manalo, Weena Lokuge, Jim Shiau Oil contaminated sand: An emerging and sustainable construction material 2011
- (12) Stabilisation of desert sands using cement and cement dust M. Y. Al-Aghbari, Y. A. Mohamedzein, R. Taha 2015
- (13) Stabilization of Lateritic Soils Using Steel Slag Jaja Godfrey Waribo Tom, Tamunoemi Alu Long John 2011
- (14) The Compressibility Behavior of Oil Contaminated Soils Ijimdiya, T.S.a and Igboro, T. 2012
- (15) WANG Ying, FENG Jiang, LIN Qianxin, LYU Xianguo , WANG Xiaoyu Effects of Crude Oil Contamination on Soil Physical and Chemical Properties in Wetland of China 2013