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# Impact of Lime on Compaction Characteristics of Jamshoro Shale

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ABSTRACT

*The most complex problem for any civil engineering work is when the structure which is laying on the soil is weak. Jamshoro shale is an example of such problematic soil, which gets expanded as soon as it is exposed to moisture and shrinks back once it dries. Such phenomenon is very critical for the structures and road networks built on shale forming settlements and cracks. Such kinds of soil must be stabilized by chemical or mechanical techniques to make them strong enough to carry the loads and resist settlements and cracking. The stabilization of the ground by utilizing or adding any chemical agent is a sustainable approach; it strengthens the soil properties without replacing or wasting the soil present. In this research, the treatment of lime with shale is been performed to observe the modification of the geotechnical characteristics of the soil. The different proportions of Hydrated Lime 0%, 7%, 8%, and 9% were mixed by the dry weight of soil to investigate the effect of lime on the compaction and plasticity characteristics of the shale. Various tests such as the modified proctor test, liquid limit test, and plastic limit test performed in the laboratory. From the results, it was observed that the properties of Jamshoro shale such as plasticity index, optimum moisture content, and maximum dry density were improved. The plasticity index of shale dropped to 2% from 24%. That suggests lime can be used as an economical and eco-friendly stabilizing agent.*

*Keywords: Soil stabilization; lime; compaction; expansive soil; plasticity*

## INTRODUCTION

All of the structures are being built on different soils at varying depths. Soils are used to support the foundations of various civil engineering structures. Furthermore, in highways the soil is utilized in the sub-grades. The geotechnical characteristics of soil influence the stability of structures; soil-bearing capacity is a measure of whether the existing soil can sustain the load coming over it. This bearing capacity of a soil depends on the nature of the soil. ASTM (2000).

Any structure or roadway needs a good foundation to ensure the best construction and durability. Therefore, the soil on which the building is resting, or the soil being used in the sub-grade of road embankments must have enough strength so the structure's serviceability should be assured. The weak grounds cause damage to the structures, and settlement occurs, which then leads to cracks and swelling of structural components; such soil is considered problematic soil (B.M Das1985). The structures built on this soil lead to the failures of buildings and distresses to the pavements, i.e., Roads.

The failure of structures is risky as far as human lives are concerned. Indeed, this kind of problematic soil should be improved, modified, stabilized, or replaced to make a stable foundation for the structures. However, the engineering approach is to consider the economy of the project. The soil replacement can sometimes be uneconomical due to high transportation charges; therefore, this technique is not preferable. The other ground improvement technique that is most widely used is the stabilization of soil (Habiba Afrin 2017).

A complex hurdle in civil engineering projects is when the soil found beneath is expansive. Expansive soil tends to swell when it interacts with the water, and it shrinks back when the moisture content is reduced. Due to this expansion and contraction behavior, the soil will deform, and settlements will occur. Therefore, the soil cannot be used directly for major construction works, i.e., Buildings and Roads.

Due to excessive settlements, cracks have appeared in the buildings built on this soil. The swelling has also been identified in some structures due to soil expansion (MUET 2006). While the subgrade of road works is also shale, the rutting occurred to the pavements. These problems have been identified for the existing structures on this soil.

FIGURE 1. Cracks developed in MUET boys hostel due to excessive settlement

The damages to structures are due to the low bearing capacity of the soil. Therefore, this research is conducted to stabilize the soil by adding lime with various percentages (7%, 8%, and 9%) and analyzing the impact of lime on the properties of Jamshoro shale.

## AIM AND OBJECTIVES OF THE STUDY

This research aims to enhance soil properties by utilizing readily available material lime. The study is being conducted to investigate the effect of adding various different percentages of lime on the compaction characteristics of the Jamshoro soil.

The soil is treated with Lime to study the variations in properties of the soil. The main objectives of this study are as follows.

1. To examine the effect of lime on the maximum dry density of Jamshoro shale.

2. To examine the effect of lime on the optimum moisture content of Jamshoro shale.

3. To examine the effect of lime on the plasticity characteristics of Jamshoro shale.

FIGURE 2. Rutting occurred in M-9 motorway due to weak subgrade soil

## LITERATURE REVIEW

In a research study by Ashok Kumar et al. (2017) on Jamshoro shale, where various percentages of lime (i.e., 0%, 1%, 2%, 4%, 6%, 8%, 10%, and 12% by dry weight of soil) were added into soil. It was concluded that by adding lime up to 12%, the maximum dry density (MDD) was decreased from 1.70 g/cc to 1.59 g/cc, and the optimum moisture (OMC) content was increased from 18.22% to 22.24% for the addition of 12% of lime content. It was ended that lime used in the soil will require more compaction effort.

Ashfaque A. Pathan et al. (2017) carried out a study on Jamshoro soil by adopting a microbial-induced calcite precipitation method for modification of soil properties. The bacterium used in this research was Sporosarcina pasteurii (Bacillus pasteurii) added to the nutrient solution at different percentages (1%, 2%, and 3%). Different amounts of the bacteria—50ml, 100ml, and 150ml—were introduced then left for curing for 7 days. The bacterium mixed with the soil causes cementation among the soil particles and therefore enhances their properties. The results conclude that at 1% (50ml) addition of bacterium increased the maximum dry density value to 2.12 g/cc from 1.94 g/cc while optimum moisture content was reduced to 5.5% from 9.45%. At 2% and 3% bacterium addition, the MDD value was decreased to 2.1 g/cc and 2.08 g/cc respectively. It was concluded that the best results for the dry density are obtained at 1% of bacterium addition.

Another research was carried out on Nigerian lateritic soil by Emmanuel Sunday Ajayi (2012) by using lime content of 0%, 2.5%, 5%, and 7.5% concentrations respectively. Five specimens were prepared for each concentration of lime content and tests were performed according to British standards. The results of five specimens showed that at the natural condition the maximum dry densities ranged from 1.59 g/cc to 1.89 g/cc and their optimum moisture contents ranged from 3.72% to 13.94%. With the addition of lime, it was observed that at 2.5% addition of lime the MDD was decreasing, and OMC was increasing for all five specimens. Similarly, further addition of lime that is 5% and 7.5% showed depletion in MDD and an enhancement in the OMC values.

Mohammad Imran Hossain et al. (2013) carried a research work to improve the plasticity index of swelling clay by adding 2%, 4%, 6%, and 8% lime content. The results showed that at 2% and 4% addition of lime reduced the liquid limit and plastic limit values which ultimately decreased the plasticity index which was 31.1% and reduced to 5.32%. Further addition of lime that is 6% and 8% increased the plasticity index which was 5.87% and 10.36% respectively for the given percentages of lime. So the minimum value of the plasticity index was obtained at a 4% addition of lime.

## RESEARCH METHODOLOGY

### MATERIALS USED

The subsequent section interacts with the different materials utilized in this research to inquire about the use of chemical agent on the aspects of soil's physical and geotechnical behavior.

Materials to be used,

1. Jamshoro Soil
2. Hydrated Lime

### LABORATORY TESTING

The soil collected from the pit is preserved from the moisture content. The index properties of the soil are determined using the AASHTO and ASTM

Table 3.1 shows the index properties of soil

| Physical Properties | Values |
|---|---|
| Natural Moisture Content | 9.13% |
| Liquid Limit | 57% |
| Plastic Limit | 33% |
| Plasticity Index | 24% |
| Group | A-7-5 |
| Free Swell Index | 40% |
| Fine-Grained (-#200) | 95% |

standards under codes D-1140 for gradation, D-4318 for atterberg limits, and D-4643 for determining moisture content. ASTM (2000).

### PROPORTIONS OF THE MIX

The soil sample is then treated with lime by mixing different percentages of lime (i.e., 0%, 7%, 8%, and 9%). The proportions of lime are based on the dry weight of the soil passed through the No.4 sieve (4.74mm dia). Hydrated lime used is passed from the No.40 sieve (0.425 mm dia). After mixing of soil and lime following tests were performed in the geotechnical laboratory of the Civil Engineering Department of Mehran University of Engineering & Technology.

### ATTERBERG LIMITS

Clayey soils behave differently at different moisture contents which can be represented by the empirical methods known as Atterberg limits. Atterberg limit relates to the different moisture contents at which soil consistency changes from one state to another. Consistency indicates the firmness of soil. Consistency is directly correlated with soil stability as it is resistant to deformation or rupture. Atterberg limit comprises the accompanying fundamental values of moisture content. ASTM (2000).

### MODIFIED PROCTOR TEST

Modified Proctor Test is conducted to come up with the compaction of various soils and the characteristics of the soil with an adjustment of water content; furthermore, the relation among Dry Density and Moisture Content. For the modified Proctor test, a rammer weighing 10 pounds (4.5 kilograms) and an 18-inch fall are used to crush the dirt into the mold in five layers (45 cm). The modified proctor exam is governed by AASHTO T180-90 and ASTM D1557-91 standards. ASTM (2012).

## RESULTS & DISCUSSION

Effect of Lime on Plasticity Characteristics of Jamshoro shale:

Figure 3 illustrates the effect of 0%, 7%, 8%, and 9% of lime on the liquid limit of shale. The liquid was found to be 57%, 66%, 58.7%, and 56.6% at the respective proportions.

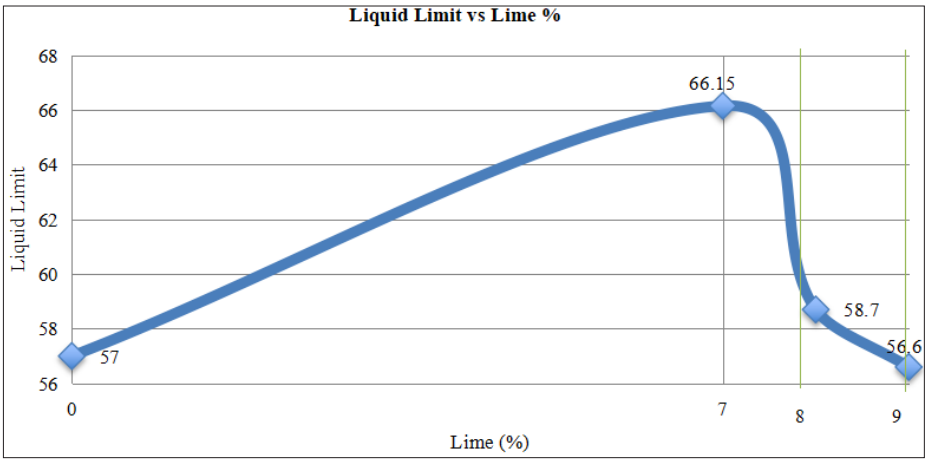


FIGURE 3. Impact of Lime on Liquid Limit of Jamshoro shale

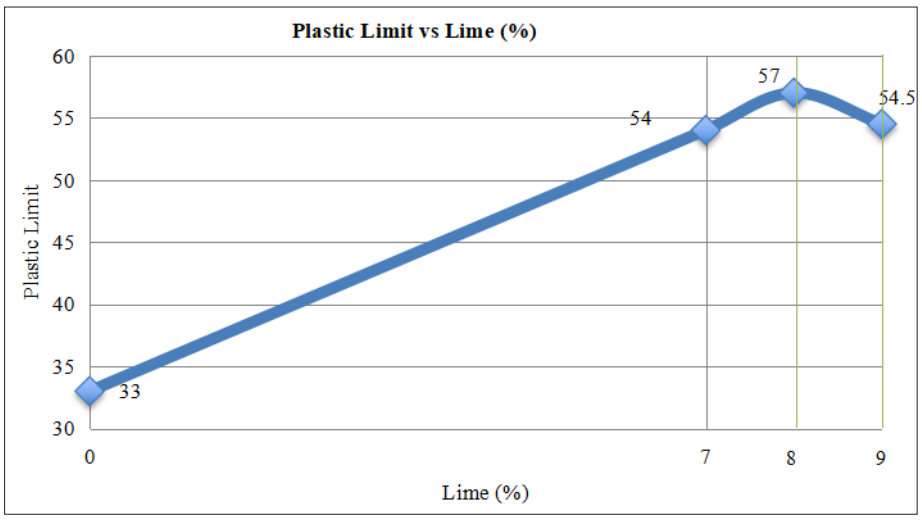


FIGURE 4. Impact of Lime on Plasticity limit of Jamshoro shale

The plasticity limit of jamshoro shale was obtained at 33%, 54%, 57%, and 54.5% with the addition of 0%, 7%, 8%, and 9% of lime. Figure 4 shows the variation in the effect of lime on the plasticity limit.

Figure 5 shows the impact of lime on the plasticity index of the jamshoro shale which decreased up to 8% and then rises a bit at 9% lime. At 0%, 7%, 8%, and 9%, the PI of jamshoro shale was obtained 24%, 12%, 2%, and 3% respectively.

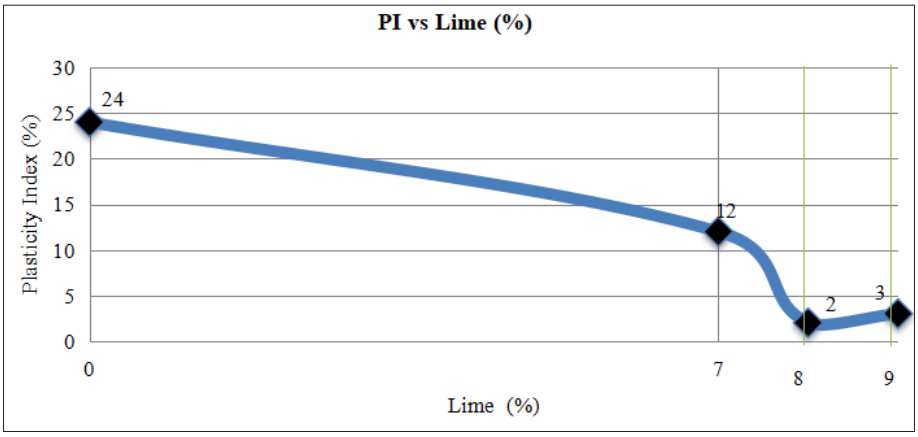


FIGURE 5. Impact of lime on the Plasticity Index of Jamshoro shale

## EFFECT OF LIME ON COMPACTION CHARACTERISTICS OF JAMSHORO SHALE

Figures 6 and 7 illustrates the impact of lime concentration on the maximum dry density (MDD) and optimum moisture content (OMC) of the jamshoro shale respectively. The MDD of soil was decreasing with the lime addition. It was obtained 1.71g/cc, 1.55g/cc, 1.54g/cc, and 1.54g/cc at 0%, 7%, 8%, and 9% lime addition respectively.

The OMC of the jamshoro shale was increasing with the inclusion of lime amount. At the addition of 0%, 7%, 8%, and 9% of lime the OMC was obtained 18%, 21.7%, 22%, and 22.7% respectively.

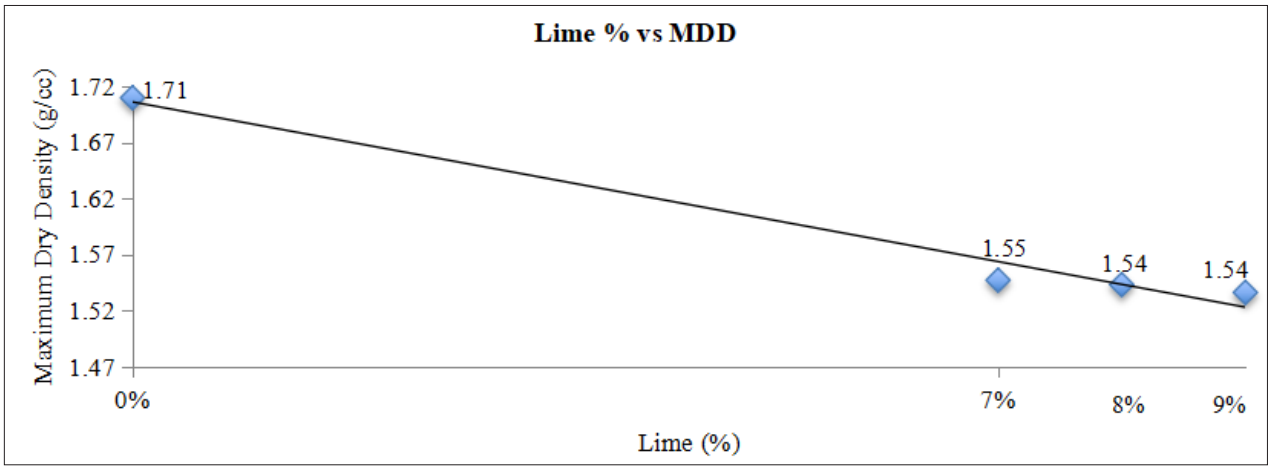


FIGURE 6. Impact of lime on Maximum Dry Density (MDD) of Jamshoro shale

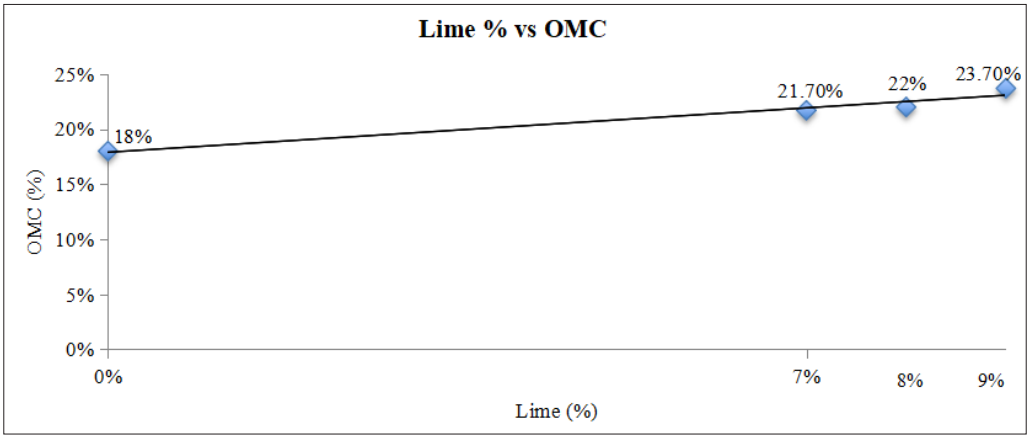


FIGURE 7. Impact of lime on Optimum Moisture Content (OMC) of Jamshoro shale

## CONCLUSION

In the research, lime-treated soil was used to improve the properties of shale. Various tests were performed in the geotechnical laboratory. The results of the experimental work conclude that,

Considering the atterberg limits of shale. At different proportions of lime, the values of liquid limit and plastic limit kept increasing. But, up to a certain point afterwards the values showed decline. As we can observe, the liquid limit increased to 66% first and then dropped to 58.7% and 56.6% at 8% and 9% lime proportion respectively. Similarly, plastic limit was increased up to 57% at 8% lime addition. Further addition of lime reduced the plastic limit to 54.5%.

The plasticity index was dropping by the addition of lime quantity in the shale from 24% at 0% lime to 2% at 8% lime. Although, the further addition increased the plasticity index.

Optimum moisture content of naturally present soil was 18%. The addition of lime percentages continuously showed a considerable increment in the value of OMC to 21.70% at 7% lime addition, 22% at 8% lime addition, and 23.70% at 9% lime addition in the soil. The results of modified proctor test showed that the maximum dry density of soil was abruptly changed with the addition of various percentages (7, 8, and 9%) of lime. The maximum dry density MDD was reduced to 1.55g/cc from 1.71g/cc at 7%. The value further reduced to 1.54g/cc at 8% lime addition and remained steady afterwards.

The use of lime for the treatment and stabilization of soil suggests that it may be used for the ground improvement of shale. It is recommended that the plasticity characteristics of the shale are enhanced at 8% of lime addition. However, the OMC kept increasing and MDD was decreasing suggesting that it will require extra effort for the compaction. Lime being cheaply available can be an economical way to strengthen the weak soil beneath the structures and make them durable.

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