STABILIZATION OF SOFT SOIL SUBGRADE LAYERS BY USING LIME-MICRO SILICA FUME MIXTURE

Hassnen Mosa Jafer Hayder Abbas Obaid Ahmed Hassan Hadi
Coll.of Engineering / Univ. Of Babylon

ABSTRACT :

The engineering properties of soft soil subgrade layer my need to be improved to make such as soil good for construction by using stabilization method. Pavement subgrade stabilization relied on treatment with lime, cement, silica fume, and micro silica fume. The main objective of this research is to investigate the effect of lime-micro silica fume mixture on the soft soil properties. A series of laboratory tests have been implemented to the soft soil samples with (0,3,6,9,12)% lime and(0,6,12,18)% micro silica fume. The results indicate improvement on the soft soil engineering properties. The liquid limit values decrease from53% to 33% with L-MSF 12-0%, plastic limit values increase from 27% to 41% with L-MSF 9-18%, and plasticity index values decrease from 26% to 1.21% with L-MSF 9-6%. The max dry density values decrease from 1.62gm/cm3 to 1.32 gm/cm3 with L-MSF 9-18%, and optimum moisture content increase from 22% to 28.66% with L-MSF 12-0%.The CBR values increase from 3% to 13.5 % with L-MSF 6-18%. This research results conclude that lime and micro silica fume can be used to stabilized soft soil subgrade and improve soil properties to make such soil suitable for engineering projects.

تثبيت طبقات الترب الناعمة باستخدام مزيج ألنوره المطفأة وغبار ألسليكا فائقة النعومة

احمد حسن هادي حيدر عباس عبيد حسنين موسى جعفر

الخلاصة:

يهدف هذا البحث إلى دراسة تأثير إضافة مزيج ألنوره وغبار السليكا فائقة النعومة على خواص الهندسية للترب الناعمة. حيت تم أجراء سلسلة من الفحوصات ألمختبريه على نماذج من التربة الناعمة تضمنت إضافة مادتي ألنوره المطفأة بنسب (0,3,6,9,12)% وغبار السليكا فائقة النعومة وبنسب (0,6,12,18) % من وزن التربة الجاف. وبينت النتائج لهذه الفحوصات انخفاض قيم حد السيولة من 53% للتربة الطبيعية إلى 33% للتربة ألمثبته عند إضافة مزيج ألنوره- غبار السليكا بنسبة(12-0)%، وارتفعت قيم حد أللدونة من 27% إلى 40.96% عند إضافة مزيج ألنوره- غبار السليكا بنسبة(9-18)%. أما قيم مؤشر أللدونة فانخفضت من 26% إلى 1.21% عند إضافة مزيج ألنوره-غبار ألسليكا بنسبة(9-6)%. كما بينت النتائج نقصانا في قيم الكثافة الجافة العظمى من1.62غم/سم^3 إلى 1.32غم/سم^{3}عند نسبة ألنوره-غبار السليكا (9-18)%و ازدادت نسبة الماء المثلى من 22% إلى 28% عند نسبة ألنوره-غبار سليكا (12-0)%. أما فيما يخص قيم نسبة التحمل الكالفورني (CBR) فارتفعت قيمه من 3% إلى 13.5% عند استخدام مزيج النورة- غبار السليكا بنسبة(6-12)%. ومن خلال هذا البحث والنتائج

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أعلاه نستنتج من أمكانية استخدام مادتي ألنوره المطفأة وغبار السليكا فائقة النعومة كمزيج لتثبيت التربة الناعمة وتحسين خواصها الهندسية مما يجعلها مناسبة للمشاريع الهندسية

1-INTRODUCTION :

Civil engineering projects located in areas with soft soil is one of the most common problems in many parts of the world. The old usual method to soft soil stabilization is to remove the soft soil and replace it with stronger materials. The high cost of this method has driven the researchers to look for alternative methods and one of these methods is the process of the soil stabilization (2008, Khelifa,et.al.).Soil stabilization is the technique introduced many years ago with main purpose to render the soil capable of meeting the requirements of the specific engineering projects (2005, Kolias,et.al.).In addition, when the soils at site are poor or when they have undesirable property making them unsuitable for use in a geotechnical projects, they may have to be stabilized (1996 ،Bowles, et.al.). Stabilization of pavement subgrade soil has traditionally relied on treatment with lime, cement, and special additives such as Pozzolanic materials. Pozzolanic materials such as fly ash, silica fume, micro silica fume, and rice husk ash, which are regarded as wastes may be used for soil improvement as indicated in recent research (2006 ،Abd El-Aziz, et.al.),(1999، Muntohar) , and(1975،Yoder, et.al.).

The use of lime for stabilization of subgrade layers was developed in south states of USA indecade1930, in which the clayey subgrade layer was stabilized by using lime (2010 ،Khabiri). Lime stabilization enhance engineering properties in soil, including improved strength, improved resistance to fracture, fatigue and permanent deformation resistance, improved resilient properties, reduce swelling, and resistance to the damaging effect of moisture(1999،Little).Also lime stabilization effects include: reduction on soil plasticity, increase in optimum moisture content, decrease in maximum dry density, improvement in compaction of soil, reduction of the soil capacity to swell and shrink, and improvement in the CBR value of the soil(2006 ،National lime association).

In another hand Pozzolanic materials also used for soil stabilization. Micro silica fume is one of these materials. Micro silica fume is an industrial waste produced from the smelting process of silicon metal and forrsilicon alloy production. It contain high amount of extremely fine and amphrous size particles. Micro silica fume has been used in civil engineering works as a binder material in a combination with cement materials or individual for soil stabilization and given great results (2009 ،A.Seco, et.al.)and(199 ، 6Taylor, et.al.).Micro silica fume improves compressive strength, bond strength, abrasion resistance, and reduce permeability, and its available in two conditions: dry and wet.

2-Materail Properties

2-1 Soil

The soil samples used in this research was brought from AL-Midhatia which is agriculture area located about 30Km to the south of Hilla city. The obtained samples located at depth of (1m) from the natural ground surface. The soil samples were put in

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plastic bags labelled and transported to soil mechanics laboratory in the Engineering College at University of Babylon. The physical characterization of the soil is presented in Table1, and the particle size distribution curve of the soil is shown in figure1.

Table-1 Physical properties of soil

Properties		Value
Atterberg limits	Liquid limit, L.L, (%)	53
	Plastic limit, P.L, (%)	27
	Plasticity Index, P.I, (%)	26
Grain size analysis	%Sand(0.075-4.75)mm	1.1
	%silt(0.005-0,075)mm	46.5
	%clay(<0,005)mm	52.4
Compaction test	Max. dry density, gm/cm^3	1.62
	Optimum moisture content	22%
Specific gravity		2.65

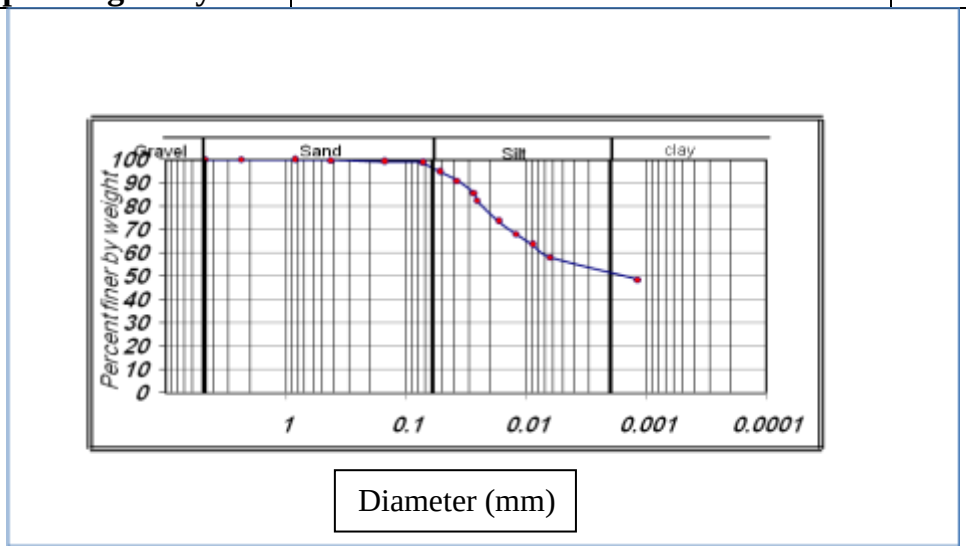

Figure-1 Particle size distribution curve

2-2 Lime

The lime used in this research is hydrated lime Ca $(OH)_2$ was brought from Karbala-lime factory. The lime to be used may be either hydrated or quicklime, although most stabilization is done using hydrated lime. The reason is that quicklime is highly caustic dangerous to use. The chemical composition of hydrated lime use in this research is shown in Table2.

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Table-2 Chemical composition of hydrated lime

Properties	Value%
Activity	78.31
$Ca(OH)_2$	91.23
CO_2	2.21
SO_3	0.27
Mg+CaO	69.4
SiO_2	2.78
MgO	0.35
Al_2O_3	0.00
Fe_2O_3	0.20

2-3 Micro silica fume

Micro silica fume used in this research is sold in powder form as shown in figure 2, with relative density equal to 2.25, and with surface area equal to (20000 m^2/Kg). The chemical composition of this material which is applicable to the ACI committee 226 requirements (1987 ،ACI committee 226) is given by the manufacture and shown in Table 3.

Figure-2 Micro silica fume

Table-3 Chemical composition of Micro silica fume

Composition	Value%
SiO_2	98.87
Al_2O_3	0.01
Na_2O	0.00
K_2O	0.08
MgO	0.01
CaO	0.23

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2-4 Water

Water used for mixing or curing shall be reasonably cleaned and free from oil, salt, acid, alkali, sugar, vegetable, or other substances injurious to the finished product. Water known to be of potable quality may be used without testing.

3-Expermental Work

3-1Soil Index Test

The soil index test was carried out at the soil mechanic laboratory of Babylon University, College of Engineering, Civil department. The water content of the selected soil was determined in accordance with ASTM D-2261(1986 ،ASTMD2216), the specific gravity of the soil was determined according to the ASTM D-854(1986 ،ASTM D854), and the grain size analysis was determined by the sieve analysis and hydrometer according to ASTM D-422(1986 ،ASTM D422). The Atterberg limits (liquid limit, plastic limit, and plastic index) for the natural and stabilized soil samples were determined according to the ASTM D-4318(1986 ،ASTM D4318). The maximum dry density and the optimum moisture content for natural and stabilized soil samples were determined in accordance with ASTM D-698(1986 ،ASTM D698).

3-2 Fabrication of Soil-lime- Micro silica fume Mixtures

The first step in the fabrication of soil-lime micro silica fume mixture is to dry the soil sample by put these samples in oven for (24) at temperature of 105C^{o}. The samples will be taken from the oven and allowed to coal at the room temperature. The amounts of lime were select to be(0.3,6,9,12)%, and for micro silica fume(0,6,12,18)% to the weight of the dry soil.

3-3 The California Bearing Ratio (CBR) Test

The California Bearing Ratio (CBR) test is simple strength test that compares the bearing capacity of a material with that of a well-graded crushed stone. The CBR value of soft soil used in this research was 3 %.(1986 ،ASTM D).

4-Analysis of the Results and Discussions

4-1 Effects of the Lime-Micro Silica Fume on the Consistency Limits

The effects of lime-micro silica fume on the consistency limits are shown in the figures 3, 4, and 5. The liquid limit values are decreased, while the plastic limit values are increased. The liquid limit value decreased from 53% to33% and plastic limit value increased from 27% to41% when the L-MSF percents are 12-0%, and 9-18% respectively. In the other hand the plasticity index values decreased from 26% to 1.21% when the L-MSF percent was9-6%.The reason of these changes on the values of L.L, P.L, and P.I due to flocculation process and pozzolanic reaction occur when lime, water, soil, and micro silica fume react to form various cementing compounds. Flocculation and agglomeration produce a change in the texture of soft clay soils, clay particles tend to

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clump together to form larger particles, these reaction tend to decrease the liquid limits , increase the plastic limits, and decrease plasticity index **(1999،Das)**.

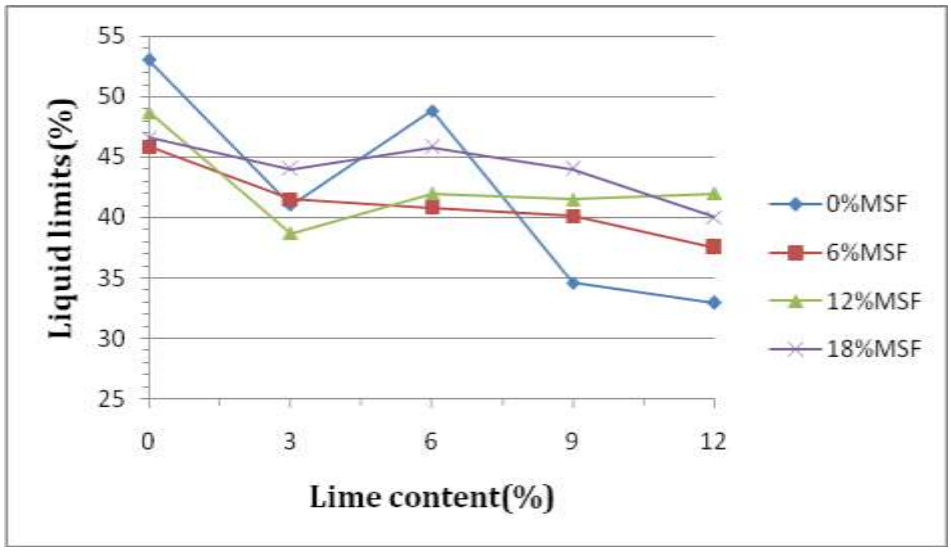

Figure- 3 Effects of L-MSF on the liquid limits values

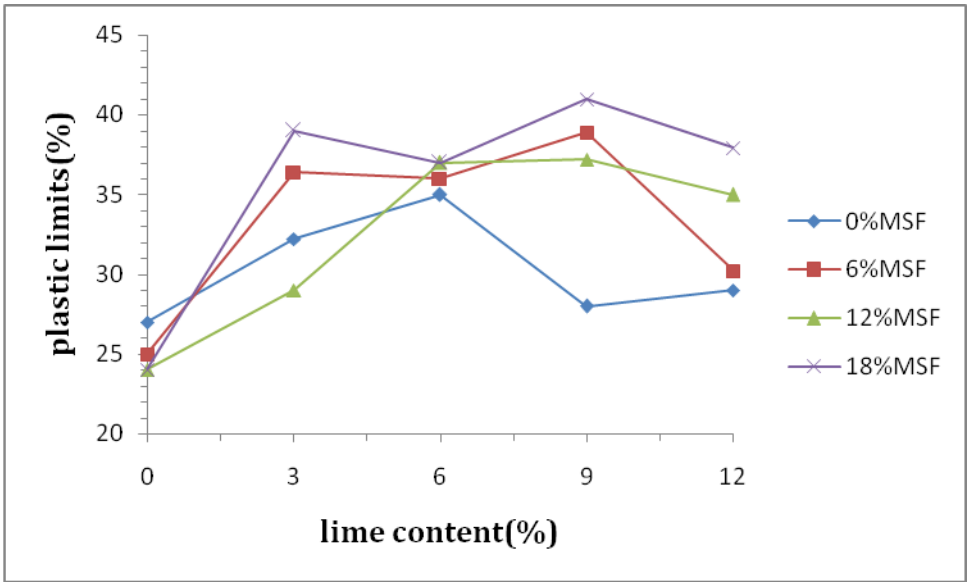

Figure-4 Effects of L-MSF on the plastic limits

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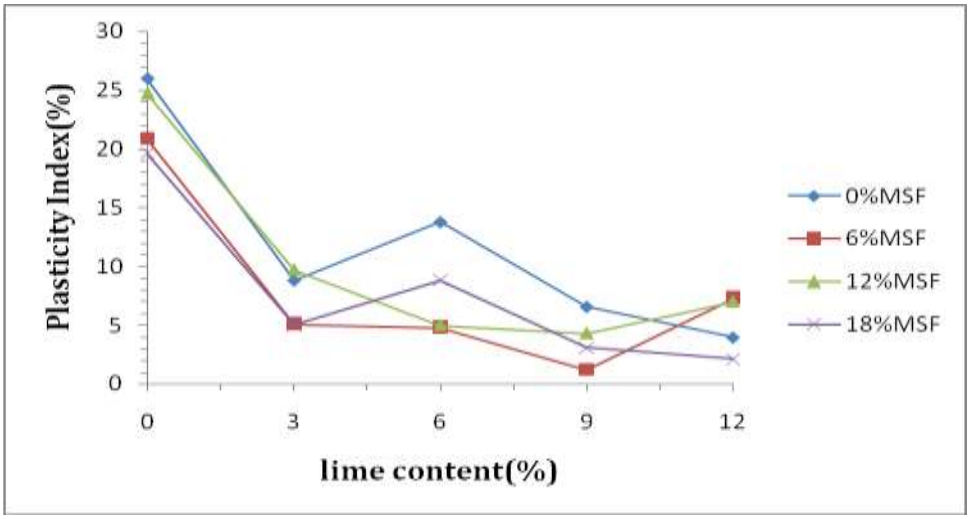

Figure-5 Effects of L-MSF on the plasticity limits

4-2 Effects of the Lime-Micro Silica Fume on the Compaction Parameters

The effects of lime-micro silica fume on the compaction parameters (MDD, OMC) are shown in figure6 and 7. The MDD values are decreased from 1.62gm/cm^3 to 1.32 gm/cm^3 with L-MSF percent 9-18%, and OMC values are increased from 22% to 28.66% when the L-MSF percent are 12-0%. The reason of MMD decreasing that compaction energy is less than natural state, because of the micro silica fume change the particle size distribution and surface area and the addition of higher amount of micro silica fume with low density which will fills the voids of the composite samples.(4). The OMC increase with addition of L-MSF due to change in surface area of soil mixture. Also the flocculation and agglomeration produce change in the texture of clay soil, clay particles tend to clump together to form larger particles, these reaction tend to decrease MDD and increase OMC (2006، National lime association).

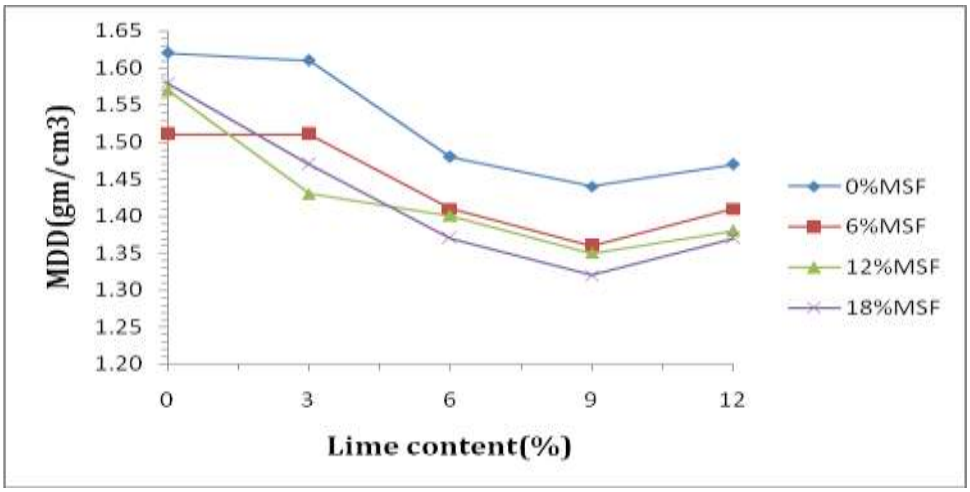

Figure-6 Effects of L-MSF on the MDD values

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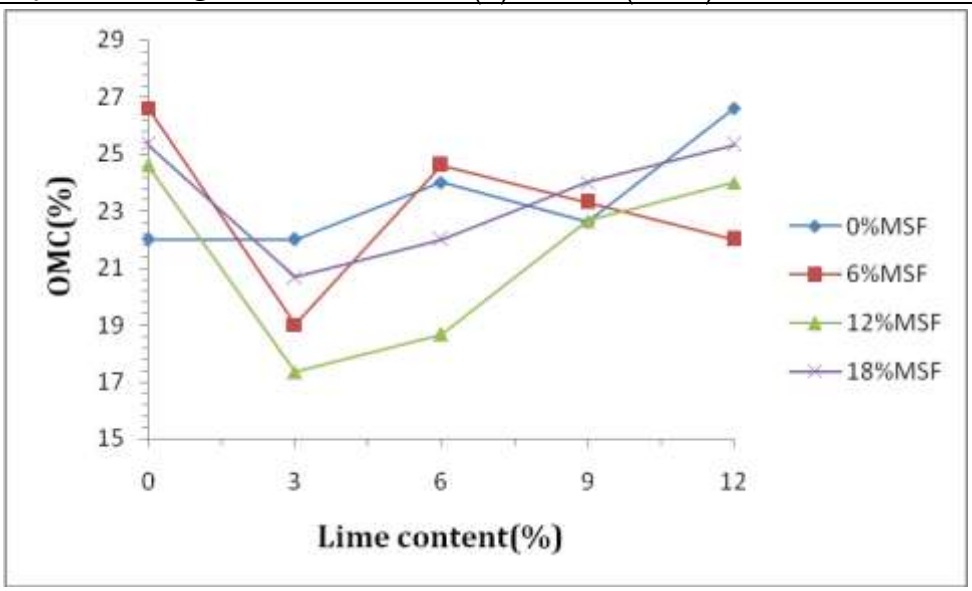

Figure-7 Effects of L-MSF on the OMC values

4-3 Effects of the Lime-Micro Silica Fume on the CBR Values

Figure 8 show the effects of L-MSF on the CBR values of the soil. The CBR values are increased from 3% to 13.5% with L-MSF percent equal to 6-18%. This increase will improve the strength and deformation properties of the soil.

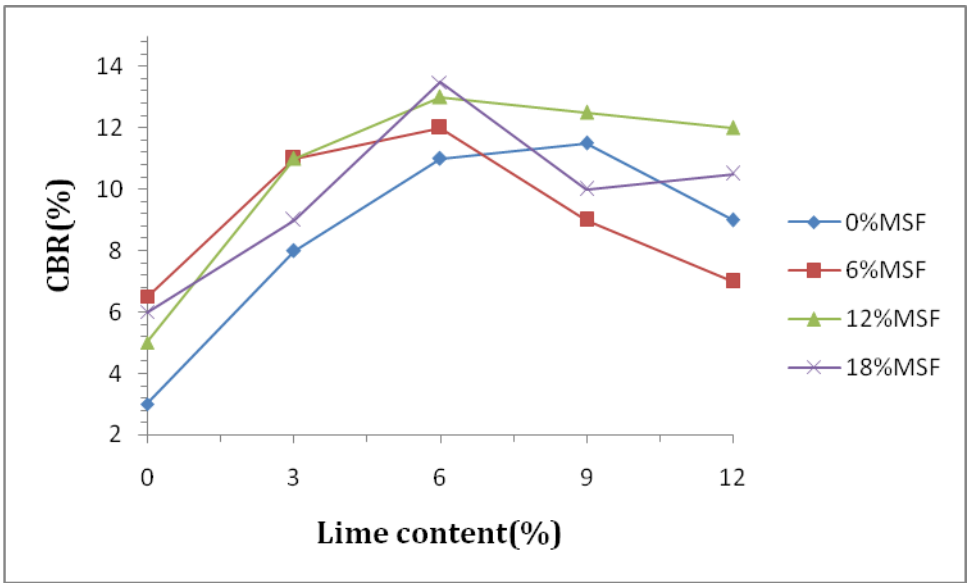

Figure-8 Effects of L-MSF on the CBR values

5-Conclusions

The following conclusions are derived from this study:

1. The lime-micro silica fume decreased the liquid limit to 33% for 12% lime, and 0% micro silica fume.

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2. The lime-micro silica fume increased the plastic limit to 41% for 9% lime, and 18% micro silica fume.
3. The lime-micro silica fume decreased the plasticity index to 1.21% for 9% lime, and 6% micro silica fume.
4. The max dry density decreased to 1.32gm/cm^3 with 9% lime, and 18% micro silica fume.
5. The optimum moisture content increased to 28.66% with 12% lime, and 0% micro silica fume.
6. The California Bearing Ratio (CBR) values increased to13.5% with 6% lime, and 18% micro silica fume.
7. With this study and the above points its conclude that lime and micro silica fume can be used to stabilized soft soil subgrade layers and improve soil properties to make such as soils suitable for engineering projects.

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