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Study on Libyan Silt Property and Suggestions on Its Application in Subgrade Construction

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Abstract. The basic physical and mechanical properties of Libyan soil are analyzed through some experiments, including direct shear test, grading analysis test and compression test. According to the test results, the soil is named as low liquid limit silt featured by weak strength, high compressibility and permeability, which directly influences sub-grade stability, durability and pavement's usability. In order to solve these problems, measures are discussed from two aspects, namely, soil improvement and construction method. The strength of the soil is apparently increased by the cement and lime adding, and the compressibility is decreased at the same time. And the rising height of capillary water reducing and protection forms for silt soil slope are also proved to be effective in the subgrade construction.

Preface

In recent years, more and more international projects have been undertaken in China, especially such ones like infrastructure project in the Sahara Desert areas. However, the soil in those areas is quite different from that in China. Close attentions were paid to the distinctive soil in Sahara Desert areas by some scholars like Li Zhenshan[1], Fan Hongwei[2] and Zhao Chongke[3]. Though lots of new discoveries have been found, further in-depth projects are still to be explored, for instance, the geologic origin and complex structural composition of unfavorable geology road discovered in desert highway construction, the huge disparities of soil property, the foundation treatment process, the roadbed construction technique and the aeolian sand reformed measures.

This paper mainly focuses on the representative soil in Libya, specific soil improvement scheme and construction measurement of handling methods aiming at its poor property in subgrade engineering using.

Physical Property of Soil

1.1 Particle Size Analysis

The soil sample is tested according to *Standard for Soil Test Method*, GB/T50123-1999[4], and the results of particle size analysis are shown in figure one.

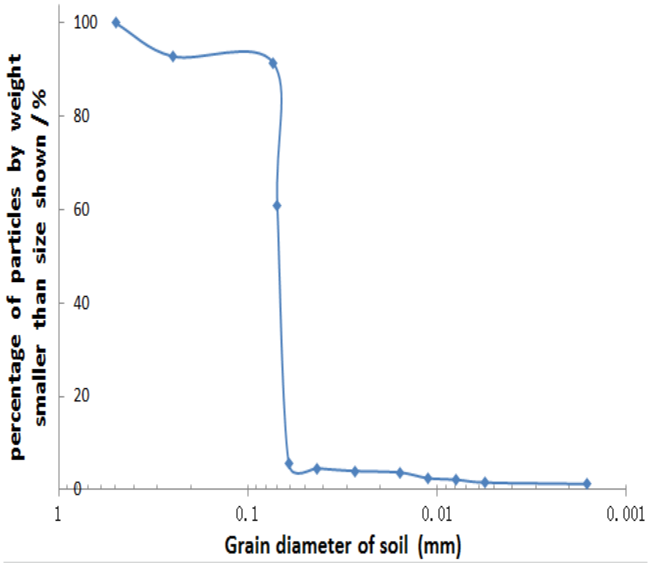


Fig1 Grading Curve

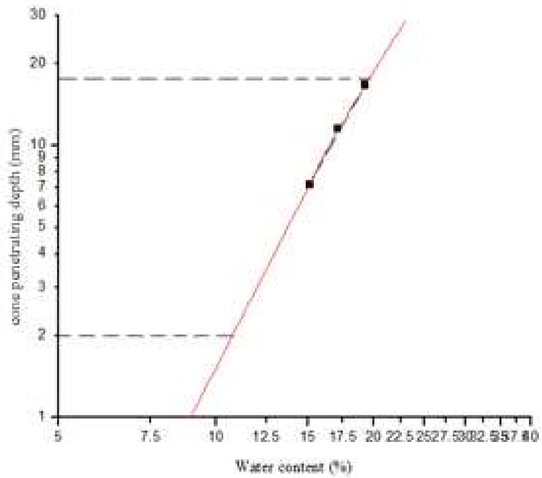


Fig2 Circular Cone's Sinking Depth and Water Ratio

The results indicate that the soil with Cu of 1.116 and Cc of 1.0076 has weak gradation and would not be compacted in subgrade engineering. Further research found that the specific gravity is 2.64, which is lower than that of the common slit (with specific gravity around 2.70) of China because of the high quartz content in the soil.

1.2 Water Ratio Limit

Test method: place air-dried sample 200g 0.5mm representative soil sample on a rubber plate, then use pure water to make soil sample into an even paste, stir the prepared sample and put it into test sample cup, conduct test of marginal water ratio with Even meter, repeat step three, four and five to test the sinking depth and corresponding water ratio of the second point and the third point samples respectively. The result is shown in Figure Two.

According to the test result, the soil can be named as low liquid limit slit, since the soil's plastic limit is 10.9%, liquid limit is 19.8% and plasticity index IP is 8.9.

Mechanical Property of Soil

2.1 Strength Characteristics

Two different degrees of compaction 0.95 and 0.85 are prepared according to the sub-grade soil standard. The direct shear test is conducted after samples are infiltrated overnight. Test results can be achieved in Table Three.

The optimal water ratio of the soil is around 18%, for at this value the largest shear strength and its particles can be achieved. At the same time, for each water ratio, with the degree of compaction increasing from 0.85 to 0.95, an increase of the cohesion force and internal friction angle can also be seen.

2. 2 Compression Characteristic

The void ratio variation of each sample at the degrees of compaction of 0.85 and 0.95 is shown in Chart Four. Then, the coefficient of compressibility and modulus of compression is achieved.

Table 3 Direct Shear Test Result of Compaction

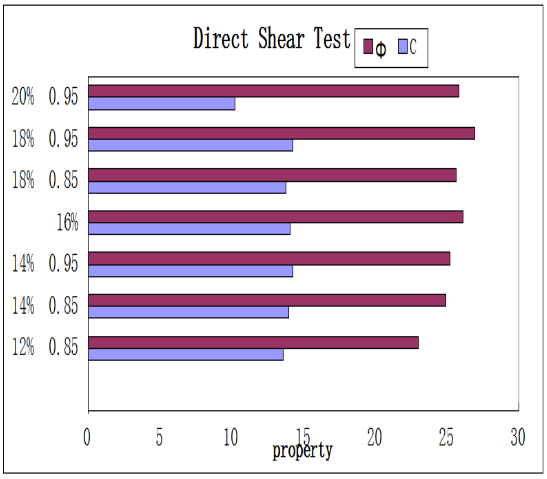
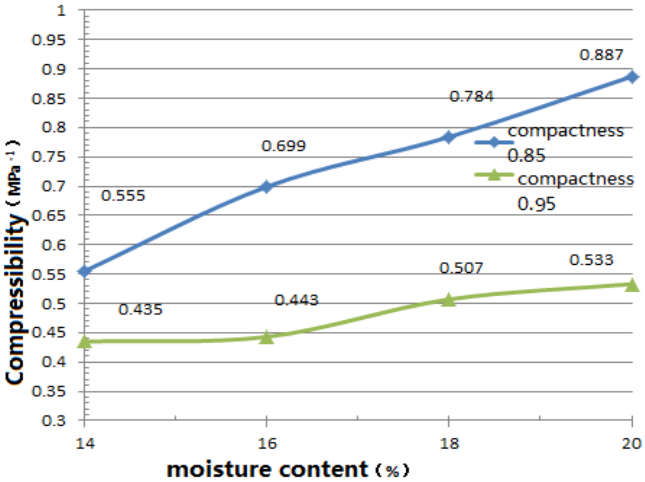


Chart 4 Water Ratio and compressibility Under Two Degree



Under same degree of compaction, with the increase of water ratio, the soil's coefficient of compressibility increases and Modulus of Compression decreases. And water ratio and degree of compaction are important parameters that influence sub-grade fill strength.

Properties Analysis of the Reformed Libyan Soil

Due to the serious defects of its particle size distribution, it is hard to be compacted and to meet subgrade requirements. After compaction, a relatively large volume ratio of air appears in the soil, which applies the access to the water entering, makes the soil easier to be humidified and be out of shape. Meanwhile, when used as sub-grade filling, frost heaving is easy to happen when water is absorbed by embankment because of rain and the underground water.

Sub-grade bed's strength, stability, durability and pavement's usability may be easily influenced. As silty soil's capillary water rises fast and high, the sub-grade bed will gradually lose stability with the increase of water.

With the increase of degree of compaction, the inner space becomes smaller and particles are closer to each other, which leads to the increase of cohesion force. Furthermore, based on the judge conditions of soil's compressibility, this slit still belongs to high compressible soil that is not suitable to be applied to engineering project, such as sub-grade filling.

Hence, to deal with engineering project, two aspects should be considered: first, improve the properties of soil; second, control specific construction methods. Relevant experiments of reformed soil are as follows.

3.1. Properties of Improved Silt

Lime and cement of different blending ratios are added to the sample of 18% water ratio and 0.95 degree of compaction.

3.1.1 Strength Index Analysis

The results of the improved sample after consolidation direct shear test in the same manner with the prime soil sample are shown in Figure Eight and Figure Nine after data collocation (Zero point value is the experimental value of the prime soil sample not added to improvers):

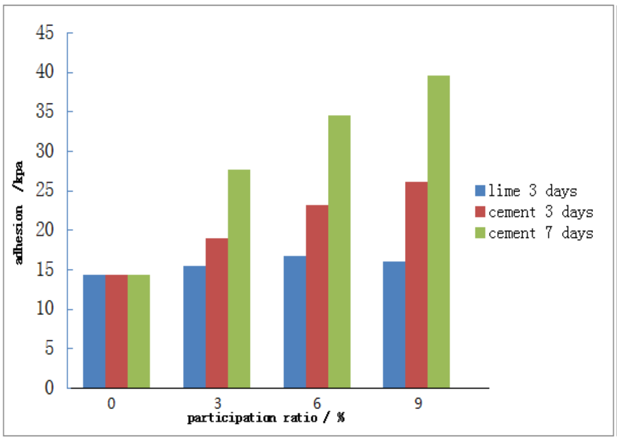


Fig 8 Cohesion Curve of blending Ratio Samples

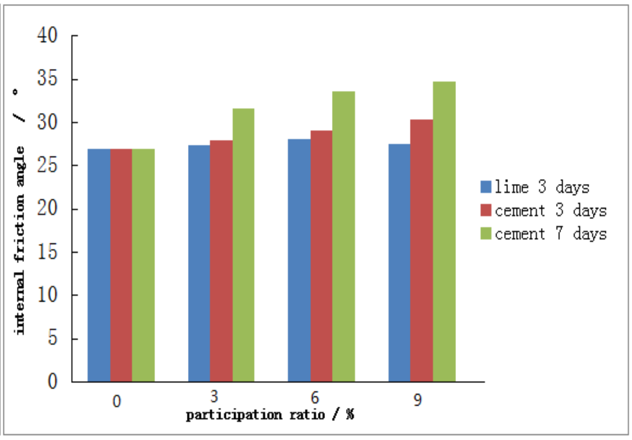


Fig 9 Friction Angle Curve of Blending Ratio Samples

The shear strength of the sample is improved when either the lime or cement increases. For cement samples, with increasing blending ratio, both cohesion and internal friction angle of the sample increase and reach to the maximum value. At the blending ratio of 9% after seven days' conservation, the cohesion increases to 39.6 from the 14.27 of prime soil. Taking into account the economic issues, the blended cement ratio should be controlled at around 6% -7%.

When the blending ratio is less than 6%, both the cohesion and internal friction angle are increased with the blending ratio, and when the blending ratio increases from 6% to 9 %, both indicators have declined, indicating that the incorporation of lime and shear strength are proportional only within a certain range. The blending ratio should not exceed 6%.

3.1.2 Compression Test on Improved Soil

Relation between compression and improved soil is shown in Figure 10.

With the incorporation of 9% lime or 9% cement, the compressibility of the soil is decreased, and the compression coefficients decrease from 0.507 to 0.396 and 0.500 respectively. As it is defined according to the compression of the soil: for 100-200kpa compression coefficient a, $a < 0.10$ indicates compressibility, $0.1 \leq a < 0.5$ medium compressibility, and $a \geq 0.5$ high compressibility.

After being improved by lime and cement, Libya silt soil is transferred from the original high compression into the medium compressible soil, which plays a significant role in engineering applications. Also, lime soil is harder to be compressed than the cement soil is, although the compressibility of both has been greatly reduced than that of prime soil.

3.2. Study on the Control of Capillary Water

3.2.1 Influence Factors of Capillary Water

Height of capillary rise will be influenced by many factors.

1) Granularity of soil[5]: The finer the soil grain is, the higher the capillary water will rise. The result can be seen from Figure 11. Generally, the grain size of Libya silty soil is below 0.075mm. The content is up to 98%. On balance, the capillary action among soil grains strengthens.

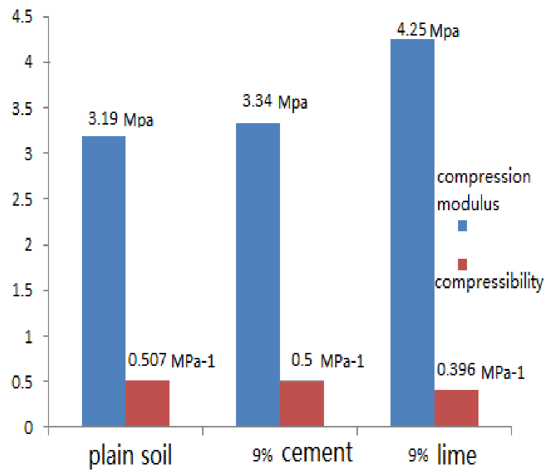


Fig.10 Compression and compression modulus of improved soil

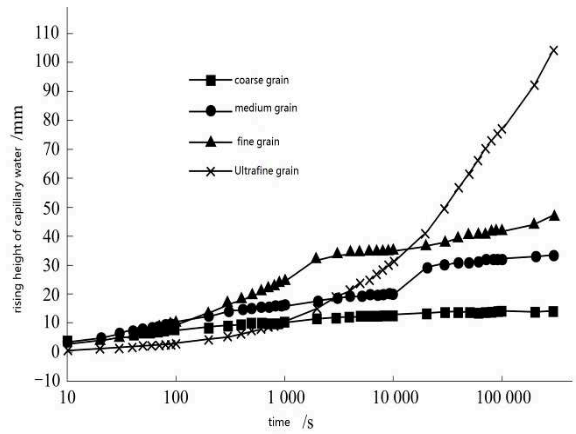


Fig.11

2) Gradation: Gradation of soil grain and the uniformity coefficient of grain size jointly determine the size of space. The more widely the grains are distributed, the smaller the space will be and the higher the capillary water will rise.
3) Groundwater table : As for the coastal region of Libya, groundwater table is relatively low. The average groundwater level is only about 1.5m, indicating that water has great influence on the silty soil roadbed there.

3.2.2 Proposals on Engineering Disposal

The main factors influencing capillary action of Libya silty soil are external experiments. So some proposals on engineering disposal are put forward after considering the range of strong capillary action and road engineering disease from two aspects, namely, soil property improvement and water separation.

3.2.2.1 Soil Property Improvement[6]

(1) Replacement of soil: Proper soil should be chosen to fill roadbed, such as sandy soil. Sandy soil has the advantages of good water stability and high strength.

(2) Piling: In order to enhance the soil property, evenly spaced pile holes can be made on the foundation bed. Then materials, such as lime, cement and rubble and so on, can be put into the holes.

(3) Stabilized soil: Pozzolanic reaction, produce crystal structure and generate gel structure that can improve water stability, intensity, cohesion and internal friction angle of soil can be caused after the foundation soil is mixed with modified materials, such as lime.

3.2.2.2 Water Separation

(1)Increasing the height of roadbed

(2) Methods to improve pavement structure: 1) Paving the sand bed; 2) Paving limestone soil; 3) Paving slag limestone soil.

(3) Reinforcing the processing of surface water and ground water of roadbed: 1) Improving the roadbed drainage.2) Lowering underground water: a. Building tubular sewer; b. Building blind drain.

3.3. Study on Silty Soil Roadbed Slope Protective Engineering[7]

Silt soil subgrade slope is easy to be damaged. Therefore, it is of great importance to protect slope in combination with surrounding environment and construction conditions of the silt soil subgrade. Some reasonable silty soil subgrade slope protection measures are as follows.

(1) Berm: High strength surrounding clay with the width of 1 m is paved outside the surrounding silty soil roadbed slope, thus the whole slope and foundation are all closed up and give full play to the shear strength of soil. The berm is to widen transverse distance of the slope bottom and slow average

slope of the slope, but a wide range of building slope protection can increase the quantities. Therefore, according to the actual situation, the width of the silty soil subgrade slope berm can hover from l m ~ 2 m.

(2) Vegetation protection[8]: According to the characteristics of the soil and climate, trees and flowers are planted to increase stability of embankment slope and then the rain splashing and roadbed slope washing are prevented so as to restore the original state of nature, which, according with the surrounding ecological environment, contributes to environmental protection significantly.

(3) Masonry protection: It mainly uses rock block, boulder strip and solid concrete precast block. This method has strong anti-scouring capability, but the cost is high, and it is not beautiful and has pollution to the environment. Therefore, attention should be paid to the coordination of overall beauty and surrounding environment when using it.

(4) Comprehensive protection[9]: The combination of vegetation protection and masonry protection is crucial. This kind of protection is more suitable for silt soil subgrade with aesthetics and anti-scouring ability. Although the surrounding soil is suitable for plant growth, it fails to have the anti-scouring ability. Therefore, with masonry protection as the skeleton, to adopt plant protection in interspace is the best way.

Conclusion

(1) The soil named sandy low liquid limit silt, with large amount of particle size from 0.06 mm to 0.075 mm and the properties of weak strength, high compressibility and permeability, cannot be directly used in subgrade engineering.

(2) After being improved by cement, shear strength of the soil is enhanced significantly and the mixing ratio between 6% and 7% is the optimum adding content due to the economic consideration. Its compression performance is improved considerably by the lime adding. Shear strength begins to decline at mixing ratio of lime from 6% to 9%. And cement improves the shear strength of the soil more apparently than lime does, and lime improves the compression performance more distinctly than cement does.

(3). Reducing the rising height of capillary water leads to the reduction in the water ratio of roadbed, the raise in the unconfined compressive strength of subgrade soil and thereafter the improvement in the stability of roadbed.

(4) Several suitable protection forms for silt soil subgrade slope are identified, which can be used for subgrade slope protection during the construction and utility period of highway.

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References

[1] Li Zhenshan, Study on the Concrete Aggregates Manufactured with Desert Sand.
[2] Fan Hongwei, Cause Analysis for Shahalamao Tunnel Collapse.
[3] Zhao Chongke, Application of Horizontal Jet Grouting Reinforcement Technique in Shahalamao Railway Tunnel.
[4] China, Standard for Soil Test Method, GB/T50123-1999.
[5] HANG Ping, WU Hao, YIN Hongjian, WANG Haikun, LI Baogang, Effect of Particle Size Distribution on Capillary Water Upward Movement.
[6] CHEN Rong-jie, Design and Construction of Widening, Reconstruction and Reinforcement of High Slope Road.
[7] WANG Sihai, Research on Washout of Silt Soil Roadbed Slope of Expressway.
[8] LI Zhigang, QIAN Guochao, CHEN Yunhe, WU Guanghuai, Test Study on Design for Synthetical Protection and Beautification of Expressway.
[9] CHEN Rong-jie, Design and Construction of Widening, Reconstruction and Reinforcement of High Slope Road.