Improvement of Fine-Grained Soils of Khorramshahr Arvand free Zone with Lime and Steel Slag for using at Earth Works

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Abstract

The soil of the Arvand free zone in the north of Khorramshahr is fine cohesive and cannot be used in earth works. On the other hand, suitable materials for this purpose (coarse-grained soils) are located at the farther distances which a considerable cost requires. In this regard, it is trying to improve the soil with lime and furnace steel slag. This study is focused on improvement of the fine-grained soil by adding various contents of lime and furnace steel slag. For this purpose, after sampling and performance of compaction tests, different amounts of slag (10, 20 and 30% by weight of dry soil) and lime (2, 4 and 6% by weight of dry soil) were added to the soil and after curing for 28 days, the effect of additives on the physical and mechanical properties of soil was investigated by using several tests such as Atterberg limits, compaction, uniaxial compressive strength (UCS) and CBR as soaked and unsoaked. Based on USCS classification the study soil is CL, its plasticity index is about 25% and sulphate ion content is more than 0.5%. Experimental results show that by adding slag and lime at different contents to soil, mechanical properties of soil improve dramatically, so plastic index of soil decreased and UCS and CBR has been increased. Also, the maximum dry unit weight of soil increases and the optimum moisture content decreases. The test results also indicate that the effect of lime on soil is higher than slag and the effect of slag for less than 35% is not considerable, however the test result of unsoaked CBR show that the bearing of soil increase in the more than slag content 20% is significant. According to the previous studies, due to the relatively high sulphate ion content in the soil, the use of lime alone is inappropriate and the slag can only physically improve soil conditions but also chemically prevent the formation of large volume minerals (like Ettringite) by the reaction of lime with soil sulphate ion.

Keywords: Arvand free zone, Soil improvement, Lime, Furnace steel slag, CBR.

Extended Abstract

Introduction

The fine-grained soils have various problems like low compressive and shear strength, instability, expansive nature, volumetric shrinkage, cracking due to desiccation and high settlement under loading. These problems restrict the engineers to use these kind of soils for earth works or built structures on them. Lime is frequently used to improve the fine-grained soils, but the abnormal plasticity and swell potential occurs in the soil improved with lime due to existence of sulphate. Recently, some other materials such as steel furnace slag has been considered to be an economically and environmentally reliable solution. Previous studies show that slag can neutralize the effect of sulphate, and create further increase in the strength and load-bearing capacity of the soil. The swelling potential and cohesion of soil particles reduce and the CBR and compressive strength of the soil increase by adding the slag.

In the Arvand Free Zone in the north of Khorramshahr city, several large projects are under construction. The soils of the area are generally fine-grained and are not proper for using in road subgrade or subbase, foundation and other construction projects. The coarse aggregate resources are located at the far distance from this area and subsequently using of them for the civil projects is so costly. On the other hand, the soil of the site has a relatively high sulphate that cannot be improved with lime. However, large amounts of steel slag are daily producing in Khuzestan steel plant processes that are dumped in open areas. For these reasons, using slag with lime in this place can be a good solution. Therefore, the aim of this study is to improve the soil of Arvand Free Zone with lime and slag so that it can be used in earth works.

Material and methods

In this study, soil sampling was performed from Jahanara Arvand Steel Complex site. Then, the experiments were performed in two phases. In the first phase, physical and mechanical tests were performed to identify the basic characteristics of the soil. In the second phase, the soil was mixed with 2, 4 and 6% of lime and 10, 20 and 30% of fine-grained slag and

treated for 28 days. By performing Atterberg limits, compaction, UCS and CBR, soil strength after improvement were investigated.

To examine the effect of lime and slag on the Atterberg limits of soil, the mixed samples were kept in a plastic bag for 28 days for curing and then tested. Each experiment was performed twice. The compaction test was performed by standard method on the soil mixture with 10, 20 and 30% slag. For UCS tests, the samples were molded in a split steel mold of 50 mm diameter and 100 mm height and compressed to the desired compaction. After 28 days curing, the samples were tested by UCS apparatus.

The CBR test was performed under optimum water content and saturation conditions on improved samples with different amounts of lime and slag. When the soil mixture contained the lime as an additive, the CBR test was performed after curing for 28 days. In other cases, according to the standard, the unsaturated samples were tested immediately after sample preparation and the saturated samples were tested after 4 days of saturation. It is worth mentioning that all samples were made and tested with maximum density as achieved by Proctor compaction test (ASTM D698).

Results and discussion

The soil contains more than 95% of fine-grained material and its plasticity index (PI) is about 18%. This soil is classified as CL according to USCS and the A7 according to AASHTO. Based on the compaction test, the optimum moisture content of this soil is 19.2% and the maximum dry density is 17.0 kN/m^3. The soil sulphate of soil content is between 0.5 and more than 4%.

The results revealed that the Atterberg limits decrease with increasing slag and lime contents. The results of compaction tests indicated that with increasing the slag contents, the dry density increases and the optimum moisture content decreases. The results obtained from the uniaxial test showed that the uniaxial strength of the soil increases with increasing the lime contents (Figure 1). CBR percentage increases with increasing the lime and slag contents, which is mostly due to the presence of lime in the soil. It was observed that the effect of slag in reducing swelling is not

significant, in contrast, the lime has a considerable effect on the swell percent reduction, such that the swell percent decreases from 2% to lower than 0.5% by increasing the lime content.

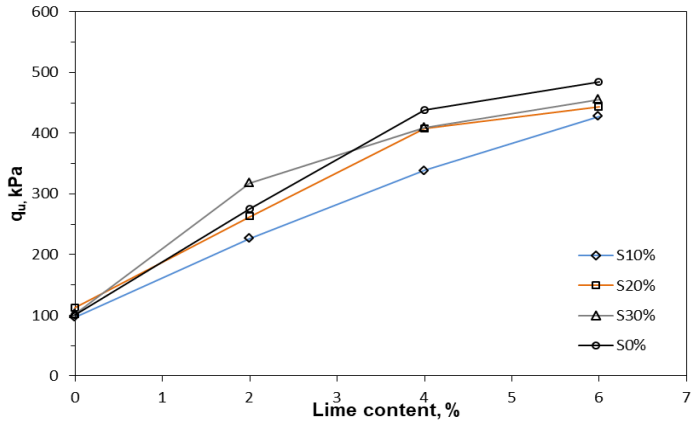

Figure 1. Effect of different amounts of lime on the UCS

Conclusion

1. The experimental results are shown that with increasing the lime and slag contents, the soil plasticity index decreases, although the effect of lime is more significant in this process.
2. Compaction tests showed that with increasing the amount of slag, the optimum water content decreases and maximum dry density increases.
3. In the absence of lime, no significant effect was observed in the UCS value of the soil after adding the steel slag up to 30%. But, with increasing lime, the UCS value increases dramatically.
4. The results of the CBR tests indicated that slag alone, even at 30% content, cannot significantly increase the CBR value of the saturated soil. But, with the addition of lime, the soil bearing capacity increases significantly.

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