

Modification of consolidation parameters of marl soils using geopolymerization mechanism (case study: Tabriz marl)

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Abstract

The process of forming cemented alumino-silicate bonds in the presence of an alkali activator is referred to geopolymerization. In this study, the application of this method has been evaluated to modify the consolidation coefficients of Tabriz marl. For this purpose, zeolite and metaclay were used separately as the sources of alumina-silicate and sodium hydroxide solution as an alkali activator. The effect of marl type, weight percentage of zeolite and metaclay, alkali activator concentration and curing time has been examined on consolidation behavior of improved samples. The results indicate very appropriate effect of geopolymerization on consolidation characteristics of marl and the optimal composition for the samples has been obtained. In the optimal samples of zeolite geopolymer with yellow or green marl (15% zeolite and 12 M alkaline solution), the coefficients of C_c and C_s are improved by about 70% to 80% and this reduction is less in the optimal samples of metaclay geopolymer. By comparing all of results, it can be concluded that zeolite is more suitable source of alumina-silicate for the purpose of this research, and on the other hand, the amount of modification of consolidation coefficients of yellow marl geopolymer samples is more than similar samples containing green marl.

Keywords: *Tabriz Marl, geopolymerization, zeolite, metaclay, consolidation test*

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Extended Abstract:

1. Introduction

Marl or marl clay is a general term for carbonated soils in which the amount of carbonate varies from 20 to 55% (Elert et al., 2017). According to the standard classification methods, marls are generally classified as clays or silts. Clay soils are considered to be one of the most important types of problematic soils. Marly soils are not excluded from this problem. Stabilization is the most common technique to improve the mechanical characteristics of problematic soils, and in clays, the use of lime to modify its weaknesses has been very common for many years (Al- Mukhtar et al., 2012, Obuzor et al., 2012). In some clay soils that do not contain sufficient amounts of Si and Al to carry out the pozzolanic reaction, these ions must be added to the medium through a stabilizing agent. One of the most common materials is Portland cement (the most common stabilizer after lime). In the current situation, it is accepted in the world that new binders are needed to replace Portland cement (OPC) to improve environmental performance and durability. One type of these newly proposed binders are alkali activated binders, which studies indicate the fact that this new binder probably has a great potential to become an alternative to Portland cement (Pacheco-Torgal et al., 2008). In 1978, a French researcher named Davidovits made and patented the bonds obtained from the alkaline activation of metakaolin and named this type of bonds "geopolymer" (Davidovits, 1978). Until now, the geopolymerization method has been used to improve clay soils, and generally fly ash or metakaolin has been used as a source of silica alumina. In the current research, it has been tried to use resources available in nature such as zeolite and the problematic soil itself in heat-treated form (meta clay) as an additive. According to the explanations provided, if appropriate results are obtained, the geopolymerization method can be used as a new method to improve the consolidation behavior of marl soils.

2. Materials and methods

The base soil (yellow and green marl) studied in the recent paper was prepared from a depth of 1-2 meters in Nasr region, located in the northeast of Tabriz city. The natural zeolite and metaclay used in the recent research were obtained from the Amirabad zeolite mine and from the calcination process of carbonate clay respectively. On the other hand, sodium hydroxide has been chosen as a base activator because it is cheaper and also has a higher efficiency in separating silica and alumina monomers (Zhang et al., 2013). In this research, several consolidation tests according to ASTM standard D2435-04 have been planned and carried out to investigate the effect of factors such as type and percentage of alumina silicate materials, concentration of alkaline activator and curing time on yellow and green marl samples. To prepare geopolymer samples, the yellow and green marl soils passed through sieve No. 40 (each separately) were mixed with an additive containing alumina silica (zeolite or metaclay) in dry state with desired weight percentages for 5 minutes and then the alkali activator (L) with a specific molarity in optimum moisture content is added to the materials.

3. Tests results

The obtained results indicated that using the geopolymerization technique has very acceptable results in improving the consolidation characteristics of marl soils.

In all yellow marl geopolymer samples, for all concentrations of alkaline solution, by increasing the weight percentage of zeolite up to 15%, the compression and swelling coefficients of the samples decreased and the amount of zeolite 15% can be introduced as the optimal percentage. Also, curing time has a positive role in improving the consolidation characteristics of geopolymer samples and both C_c and C_s coefficients have decreased due to curing.

Similar to the yellow marl zeolite geopolymer samples, in the modified green marl samples, 15% zeolite and 12 M alkaline solution concentration were obtained as the optimal values. According to the obtained results, the reduction of compression and swelling coefficients in both types of green and yellow marl zeolite geopolymer samples in the optimal combination is between 70 and 80%. The results of tests on metaclay geopolymer samples indicate that the effect of increasing the percentage of metaclay on the improvement of consolidation coefficients is low compared to zeolite. In meta clay geopolymer samples with yellow and green marl, 15% weight value was obtained as the optimal amount of metaclay. But in yellow and green metaclay geopolymer samples and for all percentages of metaclay, the alkaline activator concentration value of 4 M and 12 M were obtained as optimal values respectively.

4. Conclusion

In this research, geopolymerization method was used to stabilize two types of yellow and green marl of Tabriz, and the effect of the type and weight percentage of additive containing alumina silica (zeolite or metatarsal), the concentration of alkaline solution and the curing time in modifying the compressibility coefficients (C_c) and The swelling (C_s) of the samples has been evaluated. Based on results, the following conclusions could be drawn:

The process of geopolymerization in yellow and green marls was tested as a satisfactory technique and with the application of this method, the soil consolidation coefficients have been significantly improved.

In all weight percentages of zeolite or metaclay and for all alkaline solution concentrations, the amount of modification of consolidation coefficients of yellow marl geopolymer samples is better than green marl geopolymer samples.

Consolidation coefficients of zeolite geopolymer samples (in both types of yellow and green marl) are lower compared to metaclay geopolymer samples, and this indicates the better performance of zeolite compared to metaclay in this study.

By referring to all the results of the tests and since the aluminosilicate sources (zeolite and metaclay) and alkaline activator used in this research are easily available or can be prepared easily and at a very low price, therefore, the geopolymerization modification method can be used as an economically, technically and functionally, the appropriate option for the modification of problematic marly soils should be proposed for surface layers (by mixing) and in deep layers (by jet grouting).

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