# CEMENT AND FLY-ASH CHEMICAL STABILIZATION OF EXPANSIVE CLAY SOILS

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## Introduction

The ever increasing need for spreading urban development in areas with unstable soil formations has made relevant the technique of stabilizing weak soils by mixing them with various percentages of stabilizing agents, such as cement and fly-ash in the form of powder or slurry. Cement was first used in a construction project in South Carolina, USA, in 1935 [1]. In Albania, however, this technique has found very limited application. This study dwells into the effects of using cement and fly-ash for the purpose of reducing swelling and improving the overall geotechnical parameters of an expansive clayey soil of marine Pliocene deposits along the western coast of the Albanian shoreline. The ability to expand in volume during the rainy season of the clayey soil has caused repeating slope failures and road heaves. Studies [2, 3] have shown that the application of less than 14% of cement and fly-ash as binders could yield significant results in improving soil parameters via the reaction of calcium oxides, silica and alumina – in the presence of water – by forming chemical compounds of the type $3CaO$- $2SiO_2$-$4H_2O$ (CSH). A series of laboratory tests were performed in order to obtain the characteristics of the clayey soil and to assess the effects of binder content and curing time of soil-cement and soil-cement-fly-ash samples on the swelling and geotechnical properties of the soil such as unconfined compressive strength.

## Samples and methods

The soil samples were collected in the Durres region of Albania and were classified as CH according to the Unified Soil Classification System (USCS), as shown in (Fig. 1).

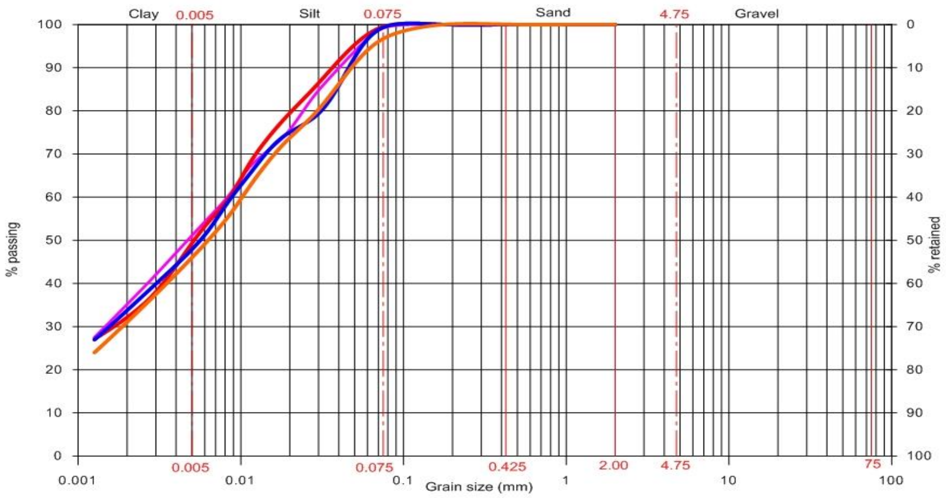


***Figure 1.*** *Grain size distribution of clayey soil.*

***Table 1.*** *Chemical composition of clay, cement and fly-ash according to XRF method.*

| | CaO | $SiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | MgO | $SO_3$ | $K_2O$ | $Na_2O$ | LOI |
|---|---|---|---|---|---|---|---|---|---|
| **Symbol** | C | S | A | F | M | S’ | K | N | - |
| **Clay soil** | 10.56% | 46.93% | 12.26% | 7.01% | 5.60% | 0.51% | 2.40% | 1.51% | 12.43 |
| **Cement** | 61.69% | 14.68% | 3.87% | 2.44% | 1.74% | 2.54% | 0.46% | 0.18% | - |
| **Fly-ash** | 3.65% | 46.90% | 11.71% | 12.05% | 8.11% | 0.71% | 1.99% | 0.61% | 13.11 |

The physical properties of the clay were determined, alongside the mineral composition of the soil as well as the main oxides present in it, as shown in (Tab. 1). The primary clay mineral influencing the expansive behavior of the soil is Illite. The appropriate percentages of cement and fly-ash were determined according to the pH-method [4] to be 3% cement 3.5-8% C-FA, whereas the curing time periods used were 7 and 28 days. A total of 12 cycles of wetting and drying of the samples were conducted according to ASTM D559-03 to examine the effect of the changing seasons on the soil. The Proctor test was also conducted to determine the change in characteristics of the compaction curve and in the values of optimum moisture content and maximum dry density. Furthermore, the swelling test was performed with a series of four different stress levels (0.25, 1, 2 and 4kg/cm$^2$) on an oedometer instrument. The results determined the percentage swelling of each specimen as well as the swelling pressure in relation to the C and C-FA content and the curing period. Moreover, a number of unconfined compressive strength tests were performed on the treated and untreated-compacted samples.

## Results

The results obtained showed that the treatment of the clayey soil with cement and cement-fly-ash yielded positive results concerning the swelling potential of soil, decreasing from 300kPa for the untreated-compacted soil to 50kPa for 3% cement cured for 7 days and 25kPa for 3.5C-8FA cured for 28 days. The wetting-drying tests showed an increase in durability of the treated-compacted samples that increased with the curing period. The unconfined compressive strength increased significantly for the treated samples. The compaction curve changed in shape from a belled-shape curve into a less concave shape. The optimum moisture increased whereas the maximum dry density decreased, as shown in (Fig. 2).

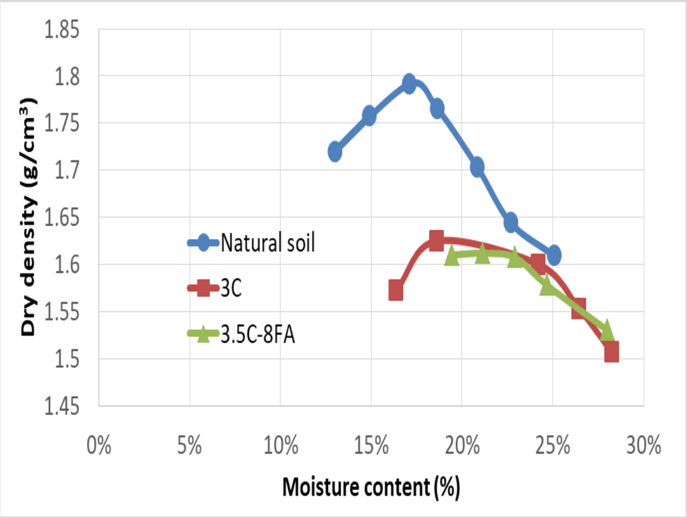


***Figure 2.*** *Change in shape of the compaction curve.*

## Conclusions

- The treatment of clayey soil with cement and cement-fly-ash binding agents significantly decreases the swelling potential of the soil.
- The treated soil showed that it is more immune to the changing seasonal rainfalls.
- The unconfined compressive strength parameters increase in relation to curing period for the treated samples.
- The change in the compaction curve also indicates that the soil after treatment is less prone to changing its volume with a fluctuation of moisture content.

## References

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