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Instability improvement of the subgrade soils by lime addition at Borg El-Arab, Alexandria, Egypt

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ABSTRACT

Subgrade soils can affect the stability of any construction elsewhere, instability problems were found at Borg El-Arab, Alexandria, Egypt. This paper investigates geoengineering properties of lime treated subgrade soils at Borg El-Arab. Basic laboratory tests, such as water content, wet and dry density, grain size, specific gravity and Atterberg limits, were performed for twenty-five samples. Moisture-density (compaction); California Bearing Ratio (CBR) and Unconfined Compression Strength (UCS) were conducted on treated and natural soils. The measured geotechnical parameters of the treated soil shows that 6% lime is good enough to stabilize the subgrade soils. It was found that by adding lime, samples shifted to coarser side, Atterberg limits values of the treated soil samples decreased and this will improve the soil to be more stable. On the other hand, Subgrade soils improved as a result of the bonding fine particles, cemented together to form larger size and reduce the plastiCity index which increase soils strength. The environmental scanning electron microscope (ESEM) is point to the presence of innovative aggregated cement materials which reduce the porosity and increase the strength as a long-term curing. Consequently, the mixture of soil with the lime has acceptable mechanical characteristics where, it composed of a high strength base or sub-base materials and this mixture considered as subgrade soil for stabilizations and mitigation the instability problems that found at Borg Al-Arab, Egypt.

1. Introduction

Borg El-Arab City is located at the northern coastal plain about 45 km south-west Alexandria City; 7 km from the Mediterranean coast (Fig. 1). Borg El-Arab City have two parts at different elevations, the first part of Borg El-Arab City was constructed between elongated ridges (foreshore and inland ridges) in the depression area. These depressions are distinguished into near-shore depressions, which are near sea level or slightly below. In these depressions, there is a thick layer of alluvial deposits which need to vital treatment. The extension of Borg El-Arab City was constructed along the third ridge which composed of a very thin layer of alluvial deposits. In the area of the depressions, cultivated lands are common in the first part near to the power lines cables pillar, in which irrigation and sewage can affect the stability of the constructions at Borg El-Arab, Alexandria, Egypt (Abdel-Hafez et al., 2006; Alhussein et al., 2014).

In addition joints and cracks conduct water down to the beds, on its way down at the side of, salt there are minerals with high damage potentials like gypsum and clay minerals with swelling potentials lead to exerting pressure on the neighboring strata or on the man-made structures (Wüst and Mclane, 2000; Kramarenko et al., 2016). The concrete base of the power lines is constructed in alluvial deposits, which composed of salt and intercalations of sand, silt, and clays. Further civil manufacture has been constructed on clayey soils, which are prone to breakdown if not suitably (El-Shinawi and Naymushina, 2015). The high cost of removal these unsuitable soils method has ambitious researchers to work for other methods, and one of these methods is the process of soil stabilization. In contrast, the geophysical methods application can improve the consistency of soil and the study cost (Attwa and El Shinawi, 2014). Lime-addition is an effective alternative for improving subgrade soils properties and extensively used in civil engineering projects (Al Rawas and Goosen, 2006). More studies have been approved for treatment subgrade soils by lime (Thompson, 1964; Croft, 1967; Sabry, 1977; Castle and Arulanandan, 1979; Lees et al., 1982; Gay and Schad, 2000; Vorobieff and Murphy, 2003; Lin et al., 2007; Chen, 2009; Harichane et al., 2011). Subgrade soils can be improved by lime treatment as a result of cation

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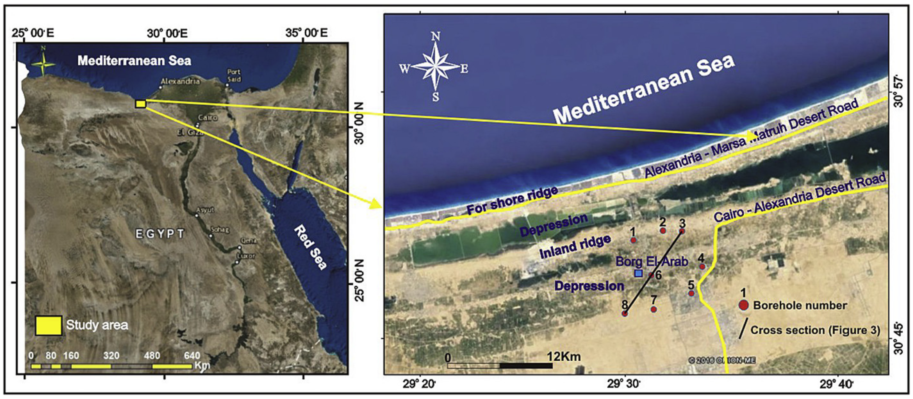

Fig. 1. Location map of the interested area at Borg El-Arab.

exchange and attraction which causes connection of fine-grained with each other, this process is called flocculation. The lime-fines reactions depend on the mineralogical composition, moisture content, the curing time and the temperature. The objective of this research is study the instability problems which related to the construction of different engineering purposes and investigate the effects of Lime-addition as an effective alternative for improving soil properties at Borg El-Arab, Egypt. Finally, the results were existed, discussed and compared with natural soil.

2. Geologic setting

In Borg El-Arab City, Alexandria, Egypt, the foundation soils are composed of subgrade alluvial deposits with low bearing capacity and high compressibility. This City is proposed to include a lot of vital constructions. The coastal plain is affected by several elongate ridges, which form gentle sweeping running sub-parallel to the present. These ridges have an average elevation of 10 m and in some places may rise to 50 m. These ridges represent ancient shorelines of Mediterranean Sea in Pleistocene time. The coastal ridges are missing or deformed at several localities along the coast due to the effect of local structures and erosion (El-Fiky, 1996). The areas between the elongated ridges represent depressions (Fig. 2). The depressions surface is almost flat to gently sloping towards depressions center. The elevation depressions range between 30 m to about the mean sea level (Gemail et al., 2004). The subsurface area stratigraphy is mainly composed of Quaternary deposits. The surface layer of the area is formed from alluvial deposits, which contain sand, silt and clay intercalations. The oolitic limestone of Middle Miocene is underlying the alluvial deposits (Fig. 2). The Moghra Formation of Lower Miocene is underlying the oolitic limestone, which composed of shaly sand, calcareous, gypsiferous and cherty (Bayoumi and Sayed, 1973). Alluvial deposits all over the area are consisting mainly of loamy soil associated with lacustrine deposits with a thickness which may exceed 8 m. These soils are underlain, especially in the west, by an evaporate series of alternating gypsum and marly beds. The overburden deposits were formed mainly by the continued disintegration of the rocks forming both the table land and the ridges by the action of streams and rains. This loam has been deposited in geologically recent times and is still going on nowadays by the heavy rainfall during winter season.

3. Materials and methods

In the current work, twenty five samples were collected from eight boreholes at shallow depths (10 m) from the ground surface (Fig. 1). Soil profile along three drilled boreholes passing through the central part of the area shows three main types of soils (Fig. 3). They were loam, calc, sand and silt 0–2 m and mainly poorly graded sands with silts and clays (clayey sands) with little or no gravels near the surfaces with average 8 m thickness. This layer was underlined by oolitic limestone, which composed of shaly sand, calcareous, gypsiferous and some cherts. Basic laboratory

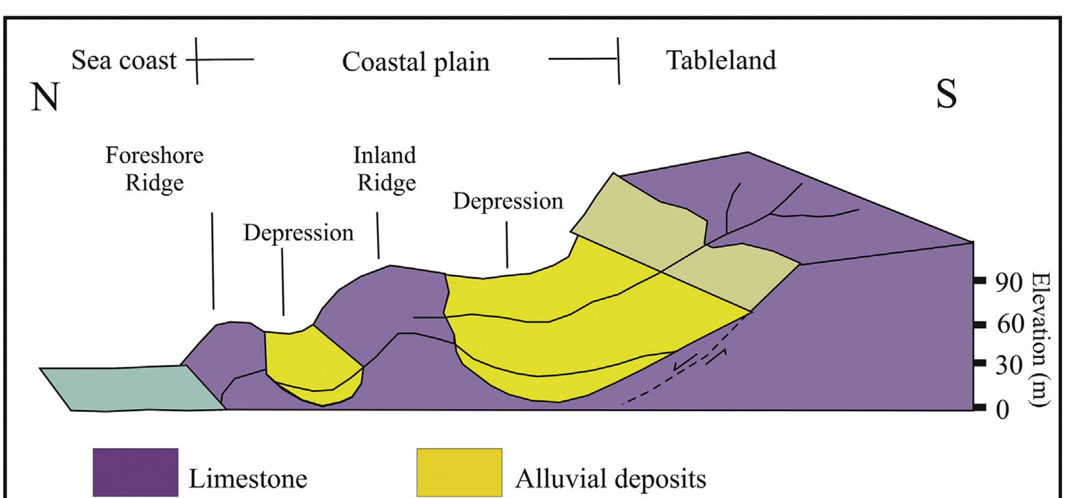

Fig. 2. Generalized block diagram shows the most geomorphologic features in the study area (modified after Gemail et al., 2004).