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Improvement in Bearing Capacity of a Soft Soil by Addition of Fly Ash

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Abstract
Soft soils are not suitable for use in runway and highway construction due to their undesirable characteristics such as poor grading, low strength, and excessive plasticity, tendency to shrink or swell. By stabilizing such soils with appropriate agents, their engineering properties can be improved. One of the stabilizing agents is Class C fly ash. The paper aimed to study the bearing capacity improvement of a soft soil (from Elmadağ area) by using Class C fly ash (from Soma Thermal Power Plant). In the experimental study, index properties of soft soil and fly ash stabilized samples are determined. Then modified Proctor compaction, soaked California Bearing Ratio, and Unconfined Compressive Strength characteristics of the samples are investigated. During the study, the stabilized soil samples are prepared at different fly ash contents, i.e., 0%, 3%, 5%, 7%, and 10%. The samples are subjected to soaked California Bearing Ratio tests after 0, 7, and 28 days of curing. In addition to California Bearing Ratio tests, Unconfined Compressive Strength tests with 0, 7, and 28 days of curing are performed. In order to observe microstructures of samples, Scanning Electron Microscope-Energy Dispersive X-ray analysis are performed. The results of the study show that bearing capacity of Elmadağ soft soil can be improved substantially and swell can be reduced significantly by using Class C fly ash.

Keywords: California bearing ratio, unconfined compressive strength, stabilization, soft soil, fly ash

1 Introduction

Construction of highways and runways over soft soils is one of the most common civil engineering problems in many parts of the world since soft soils generally show low strength and high compressibility. Subgrades having California Bearing Ratio (CBR) values smaller than 8 and Unconfined Compressive Strength (UCS) values smaller than 48 kPa are considered as soft soil and need to be stabilized especially in pavement applications (Das, 1997). The general and conventional approach to construct highway or runway on soft soils is to remove the soft soil and then replace it with a stronger material such as crushed rock. The high cost of replacement makes administrations to

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evaluate alternative methods of construction on soft soils and new stabilization techniques. One method is to use fly ash as a stabilizing agent (Şenol, Edil, Bin-Shafique, Acosta, & Benson, 2006).

Fly ash is a finely graded residue resulting from the combustion of pulverized coal in a coal-fired boiler and transported by flue gases especially in electricity generating thermal power plants. Particles are generally in the form of spheres of silicon, aluminum and iron oxides. Particle size ranges from 0.01 μm to 100 μm (Chang, Lund, Page, & Warneke, 1977).

Utilization of fly ash has led to international standards, specifications and practices for classification and usage. According to ASTM C618, "Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete" classification, fly ashes are classified as either Class F or Class C. Class F fly ash has pozzolanic properties whereas Class C fly ash has both pozzolanic and cementitious properties.

Class C fly ash is also referred to as high calcium fly ash because it typically contains more than 10 percent CaO. The high CaO content mainly contributes to self-cementing property in the presence of water.

Hydration of fly ash is defined as formation of cementitious material by the reaction of CaO with the pozzolans (SiO_2, Al_2O_3, Fe_2O_3) in the presence of water. The hydrated calcium silicate gel or calcium aluminate gel cementitious material can bind inert material together (Transportation Research Board, 1987).

2 Materials and Methods

This study aimed to use self-cementing Class C fly ash in various proportions for the bearing capacity improvement of a soft soil. Soft soil samples were obtained from Elmadağ Province nearby Ankara-Samsun State Highway in KM: 48+500. Laboratory tests were performed on Elmadağ soft soil and the results are tabulated in Table 1.

Test	Characteristic	Unit	Result
Sieve Analysis	Sand	%	34.1
	Fines	%	65.9
Atterberg Limits	Liquid limit (LL)	%	27
	Plastic limit (PL)	%	19
	Plasticity index (PI)	%	8
Soil Classification	USCS group symbol	-	CL
Specific Gravity	G_s	-	2.77
Modified Proctor Compaction	Optimum moisture content (OMC) (w_{opt})	%	7.63
	Maximum dry density (MDD) (γ_{dmax})	g/cm^3	2.188
CBR (Unstabilized)	CBR (Sample 1 - 2)	%	3.0 - 2.9
	Swell (Sample 1 - 2)	%	5.0 - 5.1

Table 1: Laboratory test results of Elmadağ soft soil

Stabilizing agent namely self-cementing Class C fly ash was obtained from Soma Thermal Power Plant (lignite-fired). Soma is located approximately 87 km north of Manisa, Turkey. Its specific gravity is 2.23 and it is light gray in color. The chemical composition is tabulated in Table 2.