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Investigating the Influence of the Combination of Cement Kiln Dust and Fly Ash on Compaction and Strength Characteristics of High-Plasticity Clays

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ABSTRACT

An experimental study was conducted to determine the effect of cement kiln dust (CKD) and fly ash (FA) on compaction and strength characteristics of the high-plasticity clay obtained from a forest road in North of Iran. Accordingly, the soil was mixed with 15% CKD by dry weight the soil, and a partial replacement of the CKD with 10, 20, and 30% FA was applied to produce mixtures. The unconfined compressive strength tests were performed on specimens after a curing time 7 and 28 days. Also, the microstructures of untreated and treated specimens were examined using a scanning electron microscope (SEM). It was found that incorporation of CKD and FA leads to a decrease in the volume of pores in the soil matrix, which is due to the formation of calcium silicate hydrates and calcium aluminate hydrates gels. These cementitious compounds in the mixtures were presumed to be the significant factor contributing to strength improvements.

Keywords: Soil stabilization, Cement kiln dust, Fly ash, Compressive strength, High-plasticity clay

1. INTRODUCTION

High-plasticity clays occur in many parts of the world and cause extensive damage to the structures and pavements resting on them due to their low bearing capacity [1, 2]. There are various techniques used for the improvement of the soil based on the construction activity and type of soil. Soil stabilization is a very common process for almost all construction projects, which is classified into two categories, i.e. mechanical stabilization and chemical stabilization [3]. Mechanical stabilization can be achieved through the physical process by changing the grading of the soil by either induced vibration or compaction or by adding fibrous and non-biodegradable reinforcement [4]. Chemical stabilization is associated with the modification of soil properties by the addition of chemically active materials, which can change the surface molecular properties of the soil particles and, in some cases, cement the particles together [3, 5]. Portland cement is a comprehensive chemical stabilizer widely used in ground improvement projects. However, cement stabilization is nowadays not desirable because of environmental issues associated with the CO2 emissions from the production of Portland cement, energy demand, resource conservation consideration, and economic impact due to the high cost of Portland cement production [6]. Accordingly, in recent years, a great effort has been done to develop alternative agents or non-conventional additives, especially those that are more effective and less costly, for a sustainable soil stabilization process [7-11]. Cement kiln dust (CKD) is a by-product of Portland cement manufacturing, which is composed of micron-sized particles collected from electrostatic precipitators during the production of cement clinker [12]. The presence of free-lime (CaO), the high alkali content, and the large fineness of CKD make it as a potential candidate to improve the engineering properties of different soils [13-15]. In addition, Ghavami et al. (2020) indicated that stabilized soil with 15% CKD as an environment-friendly method reduced 96% energy consumption and the equivalent CO2 emission, and 60% of the cost rather than treatment the soil with 9% of Portland cement [16]. Fly ash