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The use of sugarcane bagasse ash and lime to improve the durability and mechanical properties of compacted soil blocks

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ABSTRACT

This study analyzes the use of lime and sugar cane bagasse ash (SCBA) as chemical stabilizers in compacted soil blocks. The blocks were tested for flexure and compression in a dry and a saturated state. The tests were performed at 7, 14 and 28 days of age in order to evaluate the effects of the addition of lime and SCBA on the mechanical properties of the compacted soil blocks. The results indicate that blocks manufactured with 10% of lime in combination with 10% of SCBA showed better performance than those containing only lime. Nevertheless, the addition of lime improved the strength of the blocks when compared with blocks fabricated with plain soil. According to SEM and DRX analyses, considerable improvement of the matrix was observed due to the formation of strong phases, such as CSH and CAH for the mixtures with additives. It was also concluded that the combination of SCBA and lime as a replacement for cement in the stabilization of compacted soil blocks seems to be a promising alternative when considering issues of energy consumption and pollution.

1. Introduction

The compacted soil block emerged as an improved version of adobe which allowed soil to be reconsidered as a valuable building material, since innovations in the manufacturing and compacting processes improved the mechanical properties of the material [1]. Despite these advances in the field, further studies are needed in order to improve the durability and mechanical properties of compacted soil blocks.

Many additives such as cement, lime, asphalt emulsions, bituminous materials, and natural and industrial byproducts have been tested to improve the mechanical properties and to enhance the durability of the compacted blocks [2–7].

Portland cement has been by far the most used material for soil stabilization [2,6,7]; however, as a consequence of the high energy consumption necessary for its manufacture and the consequent environmental damage caused by the release of high quantities of greenhouse gases during its production, the cement industry has been pointed out as one of the major contributors of anthropogenic CO_2 emissions with about 5% globally [8,9]. In view of the above mentioned, several research activities have been directed towards partial or total substitution of Portland cement by pozzolanic binders, e.g. lime, fly ash, and natural pozzolans among others.

For instance, previous studies have found the use of 4–10% lime increased the mechanical strength of soil while significantly reducing water absorption [10,11]. Three types of chemical reactions have been identifying to occur in the soil: when lime is added, when ion exchange occurs, and when the pozzolanic reaction and carbonation of lime occur [10,12].

Regarding the use of fly ash, a study of the formation of the hydraulic products during the curing of clay, which contained fly ash with high calcium content as a stabilizing agent, shows that a significant amount of tobermorite is formed leading to a denser and more stable structure of the clay samples. The free CaO of fly ash reacts with the clay constituents (SiO_2 and aluminum silicates) leading to the formation of tobermorites and calcium aluminum silicate hydrates as well. The mechanical properties such as compressive and flexural strengths are considerably enhanced [13].

When the availability of fly ash is limited, the use of other waste materials is necessary, for example, the physical and mechanical properties of a sandy soil mixture with rice husk ash (RHA) and lime cured during 28 days, has been reported. Compressive strength of the mixture containing the RHA was several times higher than the control, whereas, wetting and drying testing results showed improvement with the use of RHA. XRD results confirmed the

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