INNOVATIVE APPROACH TO PRODUCE SOIL-BASED BUILDING PRODUCTS

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Degree of Doctor of Philosophy in Civil Engineering

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Declaration of Candidate and Supervisor

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Name of the supervisor: A.A.D.A.J. Perera

Signature of the supervisor: Date:

Abstract

Innovative Approach to Produce Soil-Based Building Products

Keywords: Reduced Clay & Silt, Soil Washing, Soil Blocks, Roof Tiles, Burnt-Bricks

Soil as a building material has been used in different forms which include mud, adobe, rammed earth and bricks. Also, Compressed Stabilized Earth Blocks (CSEBs), a form of soil blocks with different additives, including cement, fly ash, and lime, have been investigated by many researchers for their advantageous properties. A literature review established that compressive strength significantly depends on the clay and silt (finer) content and 25% finer content produces the optimum results. However, investigators have not considered the amounts of other large particles. Furthermore, most of the researchers have adopted the method of adding different materials to soil in order to reduce the finer content in the soil. This study focused on an innovative approach to reduce finer content by washing and to utilize finer part of soil for different soil-based products simultaneously. Washing of soil is introduced as a method to reduce the finer content and soil with reduced finer content was investigated for production of compressed stabilized earth blocks. Further, the water re-cycling and its optimization for the washing process too was investigated. The separated finer content together with fly ash was investigated for the production of other soil-based productions namely roof tiles and burnt-bricks.

This study also investigated the use of theories of particle packing optimization which changed the soil grading while enhancing the properties of CSEBs. It established the changing of soil particles in different ranges to fit the soil grading to an optimization curve. Moreover, the use of fly ash as a finer replacement to the washed soil produced significant improvements in CSEB properties made with washed soil compared to that of CSEB made with un-washed soil. Laboratory testing clearly showed that the use of washed soil with 5%-10% finer content improved the compressive strength of the CSEB by 50% with different percentages of cement stabilization. In addition, significant improvements in dry densities and water absorption ratios of blocks were also observed with this particle size distribution modification. Industrial scaled soil blocks made with the selected optimum finer content of 7.5% and 7% cement stabilization verified that the blocks properties meet the requirements given in the standards SLS 1382 and SLS 855.

The soil washing process reduced the finer content in the soil producing a considerable amount of finer that could be used to produce building materials like roof tiles and burnt bricks. This extracted finer alone was difficult to be used, however adding fly ash gave significant enhancements to properties of roof tiles and burnt bricks. In fact, the study showed that 25% addition of fly ash to the extracted finer was more desirable. Roof tiles made with extracted finer and 25% of fly ash reported that the breaking strength, water absorption and permeability of tiles meet the requirements given in SLS 2. Burnt bricks made with extracted finer and 25% of fly ash also reported that the compressive strength, water absorption, and efflorescence meet the requirements given in SLS 39. Moreover, the properties of wire-cut bricks made with extracted finer and 25% fly ash also satisfied the requirements in SLS 39. The process optimization established that up to 60% water can be re-cycled. Cost analysis for the building materials considered in this study showed that the unit price of each product was significantly low compared to the current market price. Therefore, further research could be done to streamline all the processes and products considered in this study.

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