Development of cold-bonded lightweight concrete aggregates using biowaste

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Abstract

The use of lightweight concrete could overcome some of the disadvantages of normal-weight concrete. However, the fabrication of lightweight aggregates is energy intensive and considerably draws on non-renewable resources. The positive consequences from lighter weight on supporting structural components’ dimensions are frequently outrun by the increase in carbon footprint of up to 65% stemming from the lightweight aggregates. On this background, fabrication of lightweight aggregates in a low-energy cold-bonding pelletizing process, using bio-based waste and by-products, and alternative binders in combination with or instead of cement was explored. Presented results cover reflections for recipe mix design, observations made in the pelletizing and hardening process, results obtained for density, strength, thermal properties, and carbon footprint of this alternative way to produce lightweight aggregates for concrete.

Keywords: lightweight aggregates; pelletizing; biowaste; alternative binders; structural properties; thermal properties; carbon footprint.

1 Introduction

Concrete is the second most used material by mankind (after water), due to its many advantages: it has a simple recipe (basically aggregates, cement, and water), is cheaply and widely available, and is easily handled as it is pourable, possibly self-compacting, and self-hardening. Furthermore, concrete provides good acoustic insulation, fire protection and thermal storage capacity.

However, its intensive and widespread use heavily draws on non-renewable natural resources. More importantly, cement production is responsible for vast amounts of greenhouse gas emissions. In building construction, minimum dimensions of components are often dictated by execution while the concrete strength is hardly governing. And its high density may require additional material volume in supporting structures.

The use of lightweight concrete (LWC) could overcome some of these disadvantages. But the fabrication of lightweight aggregates (LWA), such as expanded glass or clay, is very energy intensive and draws on non-renewable resources, too (sand, in particular). The possible reduction of material quantity and of the associated carbon footprint, due to reduced density of LWC, is outrun by the added carbon footprint from LWA (up to 65%).

On this background, fabrication of LWA in a low-energy, cold-bonding pelletizing process from sawdust (an ample waste from timber production), calcium-rich wood ashes (an abundant waste from district heating in Switzerland), and alternative binders such as hydraulic lime and metakaolin in combination with or instead of cement is explored. This paper reports on challenges encountered and observed performances in this initial step towards an alternative way to produce LWA for concrete.