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Use of recycled concrete aggregates from precast block for the production of new building blocks: An industrial scale study

Zengfeng ZHAO[a,*], Luc COURARD[a], Sylvie GROSLAMBERT[b], Thomas JEHIN[c], Angélique LÉONARD[b], Jianzhuang XIAO[d]

[a] Building Materials, Urban and Environmental Engineering, University of Liège, Belgium
[b] Department of Chemical Engineering, PEPs, University of Liège, Liège, Belgium
[c] Prefer Company, Flemalle, Belgium
[d] Department of Building Engineering, Tongji University, Shanghai, China

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ABSTRACT

Large amounts of construction and demolition (C&D) waste are generated annually and will increase in the future. Until now, only a small fraction of concrete by-products is re-used as recycled concrete aggregates (RCA) for the manufacture of concrete. In this paper, the feasibility of using RCA obtained from old precast concrete block was investigated for the industrial scale production of new blocks. Concrete building blocks with different substitution rates (0%, 30% and 100%) of natural aggregates (NA) by the same volume fraction of RCA were manufactured in a factory and the mechanical properties and durability of concrete blocks were monitored. The results show that incorporating RCA slightly decreases the compressive strength and impairs the durability of concrete blocks. However, the compressive strength of concrete blocks made with 100% RCA could reach 11.1 MPa after 28 days, which is within the requirement in Belgian codes for this type of block. The concrete blocks produced with 30% and 100% of RCA reached the strength, capillary water absorption, drying shrinkage and freeze-thaw resistance requirements for concrete blocks specified by Belgian codes. A cradle-to-gate life cycle assessment (LCA) was performed on both "classical" blocks with only NA and with substitution of NA by RCA. When considering the additional use of RCA from a nearby C&D waste recycling centre, the substitution of 30% or 100% of NA by RCA led to a reduction in the land use category, in addition to supporting the implementation of the circular economy.

1. Introduction

Very large quantities of construction and demolition (C&D) waste are produced every year around the world. The European Union (EU) produces 820 million tonnes of C&D waste (Gálvez-Martos et al., 2018), which is one of the heaviest and most voluminous waste streams generated in the EU (approximately 25% - 30% of all wastes). The composition of C&D waste is heterogeneous and may consist of numerous materials, including concrete, bricks, gypsum, wood, glass, metals, plastic and excavated soil. The main constituent of C&D waste is concrete (varies from 32% to 75% depending on the origin), ceramics and masonry (Batayneh et al., 2007; Bianchini et al., 2005; Sani et al., 2005; Xiao et al., 2012). On the other hand, more than 2.7 billion tonnes of aggregates are produced every year in the EU according to European Aggregates Association (UEPG, 2017). Therefore, it is very important to recycle C&D waste and substitute natural aggregates in order to protect the environment and save natural resources. EU Waste Framework Directive (2008/98/EC) has provided a framework for moving towards a European recycling society with a high level of resource efficiency. In particular, Article 11.2 stipulates that "Member States shall take the necessary measures designed to achieve that by 2020 a minimum of 70% (by weight) of non-hazardous C&D waste excluding naturally occurring material defined in category 17 05 04 in the list of waste shall be prepared for re-use, recycled and other material recovery (including backfilling operations using waste to substitute other materials)" (European Commission, 2008).

Up to now, most of recycled C&D waste has been used as a base or sub-base material in road construction ("down cycling"), engineering fill or landfill engineering (Barbudo et al., 2012; Poon and Chan, 2006a), while only a small proportion is re-used as recycled aggregates in the concrete industry (high-value application) (Courard et al., 2010; Delvoie et al., 2018; Huang et al., 2002; Xiao

* Corresponding author.
E-mail address: zengfeng.zhao@uliege.be (Z. ZHAO).

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