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Review

Performance of cementitious renderings and masonry mortars containing recycled aggregates from construction and demolition wastes

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HIGHLIGHTS

- Systematic literature review and meta-analysis on recycled aggregate mortars (RAM).
- Rendering mortars with RA generally present similar performance to control mortars.
- Masonry mortars with RA normally have greater bond strength than regular mortars.
- High potential for cement content reduction of mortars containing very fine RA.
- Fine RA is a technically feasible and cost-effective alternative to natural sand.

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ABSTRACT

This paper presents a systematic literature review of 114 publications published over a period of 39 years from 1977 to 2015, alongside a meta-analysis of collated data sourced from publications concerning the effect of incorporating recycled aggregates, from treated construction and demolition wastes, on the performance of cementitious renderings and masonry mortars. Several of the most relevant properties were evaluated regarding the mortars' fresh state and their mechanical, physical and durability-related performance. The results suggest that an increasing content of recycled aggregates may reduce the performance of some of the masonry mortars, which can nonetheless be easily compensated, but most recycled aggregates mortars for rendering applications have shown comparable performance to that of conventional mortars and complied with the requirements of the European Standardization.

Contents

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Acronyms

ASTM	American Society for Testing and Materials
CDW	construction and demolition wastes
CP	ceramic powder
EN	European Normalization
ITZ	interfacial transition zone
LCL	lower confidence limit
MRA	mixed recycled aggregate
NA	natural aggregates
NAM	natural aggregate mortar
RA	recycled aggregates
RAM	recycled aggregate mortar
RCA	recycled concrete aggregate
RMA	recycled masonry aggregate
SCM	supplementary cementitious materials
UCL	upper confidence limit

1. Introduction

The consumption of natural resources and energy has been increasing proportionally to the World's population growth and subsequent development of economic sectors. As a result, the rising consumption of already scarce resources is causing a great impact on the environment, often irreversible. According to the Eurostat [1], the total amount of waste generated in the EU, in 2012, was over 2.5 billion tonnes, 34% of which resulting from construction and demolition activities. Since most countries have no specific treatment plan for these materials, they are sent to landfill instead of being reused and recycled in new construction.

The use of recycled aggregates (RA) from treated construction and demolition wastes (CDW) as replacement of natural aggregates (NA) in the production of new construction products has been considered one of the most efficient methods to add value to these materials, frequently regarded as worthless. Indeed, as an alternative to depositing them in landfills, the use of RA creates new market opportunities, which are also favourable to the environment.

According to some recommendations and specifications concerning RA [2–18], there are three main types of materials resulting from CDW, which, after undergoing proper beneficiation processes in certified recycling plants, are suitable for the production of cementitious products; these are recycled concrete aggregates (RCA), recycled masonry aggregates (RMA) and mixed recycled aggregates (MRA). Although it is usual to find other materials in RA, in lesser amounts, such as asphalt, plastic, wood, rubber and glass, these are considered as contaminants and have strict limits to their content, owing to their negative impact on the mechanical and durability-related performance of concrete [19]. However, despite some of the shortcomings of concrete containing coarse fractions of crushed glass [20,21], when using its finer fraction in the production of mortars, results consistently show enhanced performance [22–24]. This indicates a high potential of reusing the finer fractions of other materials also present in CDW in the production of mortars.

According to EN 998-1 and -2 [25,26], mortars for masonry construction can be classified in two main categories: rendering mortars and masonry (bedding) mortars, respectively. The former are normally applied in external or internal renderings on walls, ceilings, columns and partitions. The latter are mortars used to lay and bind construction units (e.g. ceramic bricks or concrete blocks). Although these standards cover the use of binders other than those of the EN 197 [27], this study only covers the influence of using fine RA on the properties of cementitious mortars.

These mortars must be produced using aggregates in conformity with the requirements of EN 13139 [28]. In its most recent version, the properties of aggregates and filler aggregates obtained by processing natural, manufactured or recycled materials and mixtures of these aggregates are specified. Besides scoping the use of aggregates with oven dried particle density over

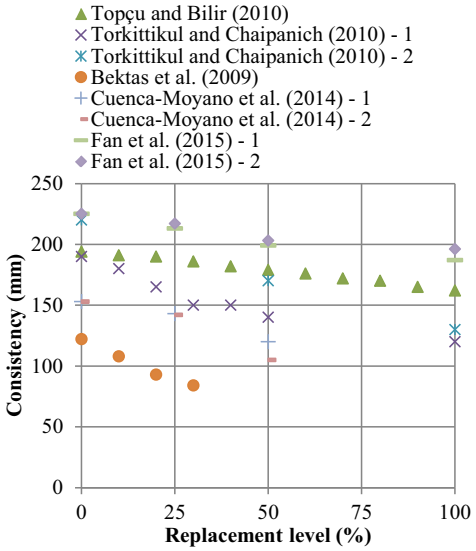

Fig. 1. Consistency of RAM with increasing fine RA content.