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Review

An overview of study on recycled aggregate concrete in China (1996–2011)

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ABSTRACT

A series of investigations on the mechanical property, durability, and the structural performance of recycled aggregate concrete (RAC) have been carried out in the past 15 years (1996–2011) in China. The achievements of researches on recycled concrete are relatively sufficient to review and share with investigators from other countries. Some research progress of micro- and meso-structure of RAC is introduced in the first part of this paper. The second part of this paper is devoted to the mechanical properties of RAC material: strength, elastic modulus, Poisson's ratio, stress–strain curve. The third part of the paper gives research on durability of RAC: carbonization, chloride penetration, shrinkage and creep. The last part presents a review on the structural performance of RAC elements and structures: beams, columns, slabs, beam–column joints, shear walls as well as frames made with RAC. Results of all researches reveal that with proper design and construction, it is safe and feasible to apply RAC as a structural material in civil engineering. Moreover, in this paper, the relevant research results of RAC obtained in China and from other countries are compared and discussed. This review provides helpful directions to those who are already engaged in this research, and points out areas which are needed to promote safe and economic use of RAC.

Contents

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1. Introduction

The difficulties of disposing of the concrete rubble and demolition waste together with a developing scarcity of virgin aggregate have prompted an urge to recycle waste concrete as natural aggregate in fresh concrete. China is a large resource consumer with shortage of resources and extensive management, and its economic growth is increasingly constrained by resources and the environment. According to statistics, China's consumption of cement is 820 million tons and accounts for 55% of the world. It is estimated that approximately 200 million tons of waste concrete are currently produced annually in the mainland of China [1]. Moreover, some natural disasters such as *Wenchuan* earthquake (2008), *Yushu* earthquake (2010) and *Yunnan* earthquake (2011) in China have resulted in a great quantity of waste concrete. So it can be foreseen that demolition contractors will be encouraged to reuse and recycle the waste concrete in China.

On behalf of RILEM Technical Committee 37-DRC, Nixon prepared a state-of-the-art report on recycled concrete as an aggregate for concrete, covering the period 1945–1977 [2]. A second state-of-the-art report on recycled aggregate and RAC was prepared by Hansen, covering developments between 1978 and 1985 [3]. And the third state-of-the-art report was an updated version of the second state-of-the-art report including developments in the period 1985–1989 [4]. In 2002, ACI Committee 555 reported information on evaluating and processing waste concrete for production of aggregates suitable for reuses in concrete constructions [5]. In recent years from 1996 to 2011, many Chinese investigators have engaged in the studying of RAC and nearly all aspects of mechanical property and structural performance have been covered. And up to today, two national symposiums on recycled concrete and two international conferences on waste concrete recycling and management have been held in China. To summarize all of those achievements, this paper is not only written primarily as a state-of-the-art report on the recycled concrete in China but also to provide the basis for the further study on recycled concrete.

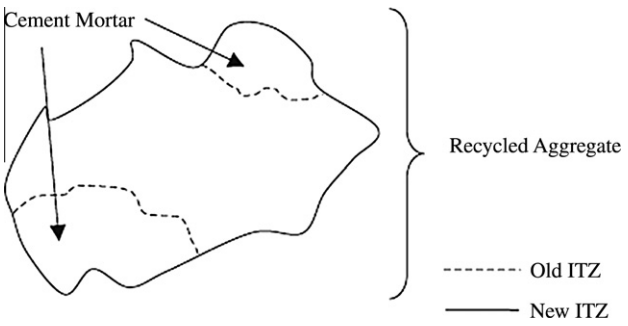

Fig. 1. Meso-structure of RAC prepared with RCA [9].

2. Micro- and meso-structure of RAC

Du et al. [6] reported that the micro-hardness of recycled coarse aggregate (RCA) was much higher than that of the interfacial transition zones (ITZs) in the RAC, and the micro-hardness of the interface between the RCA and the new mortar matrix was the lowest. Poon et al. [7] investigated the effect of microstructure of ITZ on the compressive strength of RAC. Their scanning electron microscopy (SEM) observations revealed that the aggregate–cement matrix interfacial zone of RAC consisted mainly of loose and porous hydrates whereas the aggregate–cement matrix interfacial zone of conventional concrete consisted mainly of dense hydrates. Tam et al. [8] found that the microstructure of RAC was much more complicated than that of the conventional concrete. RAC possessed two ITZs, one is between the RCA and new mortar matrix, and the other is between the RCA and the old mortar attached (old ITZ). The old mortar of the RCA formed the weak link in RAC, which was composed of many porosity and cracks. The structure of RAC is schematically shown in Fig. 1. Under the observation of SEM, many voids and cracks were found between the RCA and mortar matrix (Fig. 2).

Similar results were obtained by researchers from other countries. Etxeberria et al. [9] found that the adhered old mortar on