ALKALI-AGGREGATE REACTION IN RECYCLED CONCRETE WITH AGGREGATES QUALIFIED AS REACTIVES BY THE ASTM C 1260 METHOD

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Abstract

The durability of concrete with recycled aggregates should conform to the intended useful life of the structures. Although there have been sufficient experiences on these concretes resistant behavior, their durability has not yet been studied in the depth it requires.

Many of its problems are associated with the original components of concrete demolition, the age of the demolished structure, the change in the type of structure and the new concrete cement content.

In this research paper, two recycled concretes used as fine aggregate (characteristic of the constructions from Entre Ríos) are studied. The aggregates are of basaltic origin and boulder from the Uruguay River.

The ASTM C 1260 method was used to show the remaining reaction potential of recycled aggregates, given some considerations that should not be neglected to ensure the durability of concretes made with this type of aggregates.

Keywords: concrete, alkali-silica reaction, recycled, durability.

INTRODUCTION

Nowadays, the pressure in the building sector is increasing significantly to encourage the recycling of waste, both derived from its own activities as well as from other sectors. The most outstanding advantage of this recycling process is that it carries a simultaneous solution to the issues caused by the large amount of waste sent to landfill without exploitation, as well as the production of a new raw material which help to reduce the extraction of primary natural resources.

In the recycling of construction materials, the recycled aggregates are the main component, derived from the large volumes of waste from construction and demolition, all of which could be eliminated by reusing them. In some countries, the annual waste generation is one ton per inhabitant, from which 80% is disposed in landfills. The average rate for European recycling reaches 40 percent. In Argentina, despite the experience gained to the present, there is no specific legal framework for this type of aggregate. There have only been some individual initiatives and specific experiences aiming at promoting the use of recycled aggregates.

Recycled aggregate still generates distrust and needs a more extensive control to guarantee its compliance in the various applications where it is used. In order to obtain a suitable recycled aggregate, it is necessary to process the waste properly and make an extensive control of the input materials entering the concrete manufacturing plant. Moreover, it is essential to develop adequate processing techniques to ensure high quality material.

Concrete is a heterogeneous material that uses aggregates of different origins and characteristics in its composition and it is also subject to influence from the environment where the construction work is located. Prior to the application, it is necessary to evaluate the origin of the demolished concrete in order to prevent premature deterioration problems caused by its composition, state and health [1, 2].

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All the concepts mentioned above should be taken into account when dealing with recycled materials so as not to neglect the importance of the concrete durability. In other words, to preserve in time the initial properties for which it was designed and, by doing so, ensure its useful lifetime [3, 4]. Deterioration leads to the need of investment on reparation before it was expected, having to replace the construction partially or entirely, therefore lowering the credit attributed to the recycling of construction materials such as concrete.

The exploitation of natural aggregates deposits has changed the landscapes causing depression in many areas and generating serious problems of environmental impact. Consequently, recycled aggregates have become a valid alternative for the concrete production, considering that their characteristics mostly comply with the standard aggregates and the specified resistance. The specified properties are different from the natural aggregate extracted from a river or quarry, so some of these properties may need control. Besides, their origin involves a greater variety in the production, i.e. to add the recycled production to the natural aggregate [5].

The elaboration of aggregates from recycled concrete is quite simple since the machinery is similar to the one used for natural aggregate production and can attain regular concrete. Recycled concrete has greater absorption and dust, making it necessary to apply certain recommendations. For example, washing previously and using it in saturated surface dry state to minimize absorption problems of this material in dosage [6, 7].

Concrete structures can suffer different pathologies like ASR, alkali-silica reaction. This pathology is concerned with the use of deleterious aggregates that react with the alkalis contained in portland cement concrete in the presence of humidity, causing technical and economic disadvantages in the constructions where it is used, putting in danger human lives or causing major repair expenses.

The recycled concrete affected by ASR or having in their composition potentially reactive aggregates can develop the reaction in new concretes, this being due to the remaining reactivity in the first case or the change in the conditions of the mixtures, caused either by the higher alkali content or by the exposure of structures to humid environments [8].

In this paper, we seek to analyze the behavior of recycled aggregates by assessing their likelihood of developing ASR. We will make use of the ASTM C 1260 method to answer if the aggregates obtained by crushing portland cement concrete can be used or not without the previous application of methodologies to prevent or minimize this reaction.

2. MATERIALS AND METHODS

2.1 Materials

To elaborate the mixes analyzed in this study, fine aggregates were used, obtained from crushed concrete with coarse aggregate either from basalt or from boulder. All of these being potentially reactive materials to ASR which had been part of concrete used in structures at height (buildings) (Table 1).

The aggregate obtained in the crushing has a rough texture and rounded particles (hammer crusher). Analyzing the physical properties that recycled concrete aggregates have in reference to the natural aggregates, clast composition stands out since it is partially original rock and partially mortar. This causes a noticeable difference in water absorption, which, at times, highly surpasses the corresponding value for the natural coarse aggregate. The explanation for this phenomenon is that these clasts are composed of stony particles with mortar adhered to the surface as well as mortar particles alone at this crushing level. Mortar properties in fresh status were maintained in a small environment, its workability in particular. Then, the crushing material was considered as a natural aggregate.

2.2 Methods for assessment and analysis

The methodology used to analyze the possibilities of ASR development corresponds to the accelerated method ASTM C -1260 standard.

3 RESULTS

The expansion development by ASR of these recycled concrete has been represented in graphs, following the ASTM C 1260 methodology (Figures 1, 2 and 3), (Table 2).

The slopes of the curves are the characteristics obtained with natural aggregates.

In the photographs taken after the trial, cracks in test bars can be observed with the naked eye, as well as the rosette-like gels from alkali- silica reaction that can be seen by using the electron microscopy (Figures 4, 5).

4 DISCUSSION

The photos make it clear that these recycled materials show alkali- silica reaction under the accelerated method of ASTM C-1260.

The expansion values obtained in the case of crushed basalt (B1) are similar to the lowest values measured in the basalts of the region (Expansion values 0.3 to 0.7 in the region to ASTM C 1260). This would indicate that the clays that contaminate the basalts have been hydrated, mostly, in the recycled concrete, and that we would now be only measuring the remainings from the alkali- silica reaction [9].

In the case of boulder (CR1 and CR2), the values measured correspond to the highest measured values in boulders (Expansion values 0.03 to 0.13 in the region to ASTM C 1260).In this case, the crushed boulder from the recycled concrete (largest exposed surface within the concrete) would add to the remaining expansion.

It should be taken into consideration that, in both cases, new alkalis volumes are incorporated in the mixtures produced with recycled concrete aggregates within the cement.

5 CONCLUSIONS

In the presence of potentially reactive aggregates in original concrete, the recycled concrete can develop ASR, taking into account that the amount of highly soluble alkali is renewed as provided by the new cement content. It is necessary to know the remaining deleterious potential from recycled concrete or the aggregates it contains, prior to its use in new concrete.

In the case of the crushed concretes studied in this research, it should be noted that they were taken from vertical concrete structures (high buildings) where they generally lack the humidity required to develop the alkali-silica reaction.

Taking into account all of the above mentioned, we can assert that when crushed concretes are used as concrete aggregates they should be considered as new aggregates and studied as such.

In the case of ARS, it is recommendable to start by examining the change of destination of the material with respect to the presence of constant humidity (from aerial structures to pavements). This is essential since these materials are generally recycled into pavements due to the fact that a high percentage of them can be recycled, making it very convenient.

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TABLE 1: Origin features of recycled concrete.

<table>
<tr><td>Recycled Concrete</td><td>Fine</td><td>Coarse</td><td rowspan="4">FINE:
Fine aggregates are siliceous, being quartz the principal mineral, with minor amounts of opal and chalcedony. Together, the polymorphs of silica (quartz, chalcedony and opal) comprise between 85% and 95 % of the samples. The rest is composed of lithic clasts of basalt and sandstone, and minor amounts of feldspar, magnetite and other opaque minerals.

COARSE:
Basalt, given the observed characteristics, can be classified as a tholeiitic, hypo-crystalline Basalt, but with a very low proportion of altered volcanic glass (less than 5-7%). The total alteration of glass and the partial of clay minerals micro phenocrysts (possibly smectite and/or illite) suggest the presence of an argillic alteration of mild type.
The Boulders (gravel), although predominantly siliceous, show a marked difference in their mineralogical composition. Opal (20-40%) and chalcedony (15-25%) are the major fraction in respect to quartz and sandstone lithic clasts that are located in proportions higher than 10%.</td></tr>
<tr><td>B1</td><td>Silica Sand</td><td>Basalt</td></tr>
<tr><td>CR1</td><td>Silica Sand</td><td>Boulder 1</td></tr>
<tr><td>CR2</td><td>Silica Sand</td><td>Boulder 2</td></tr>
</table>

TABLE 2: Results.

Mix	Fine	Coarse	Expansion ASTM C-1260 (%)	
			in 16 days	in 28 days
B1	Silica Sand	Basalt	0.251	0.333
CR1	Silica Sand	Boulder 1	0.136	0.198
CR2	Silica Sand	Boulder 2	0.129	0.205

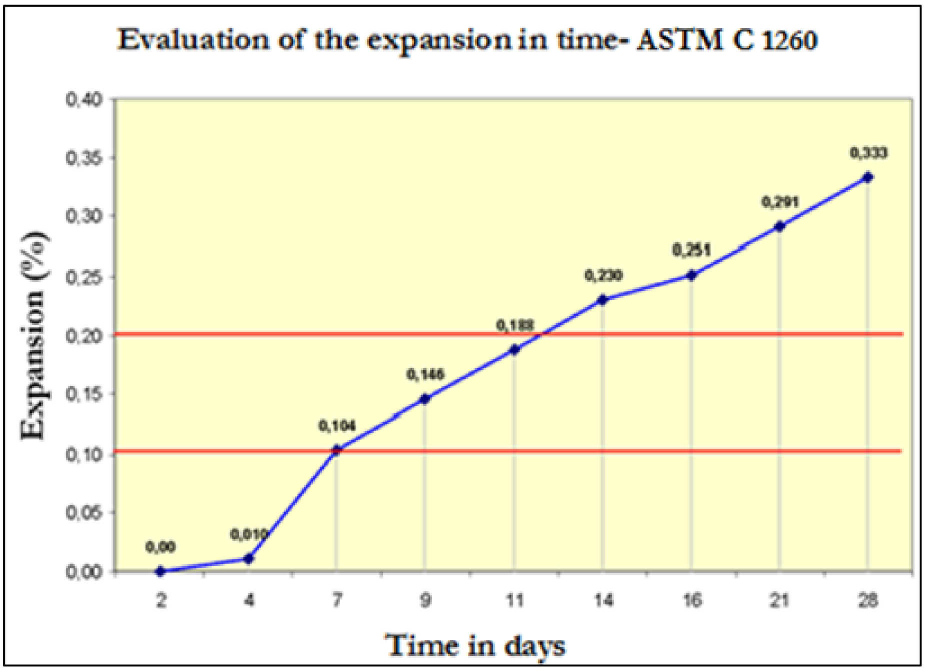

FIGURE 1: Recycled B1-ASTM C-1260.

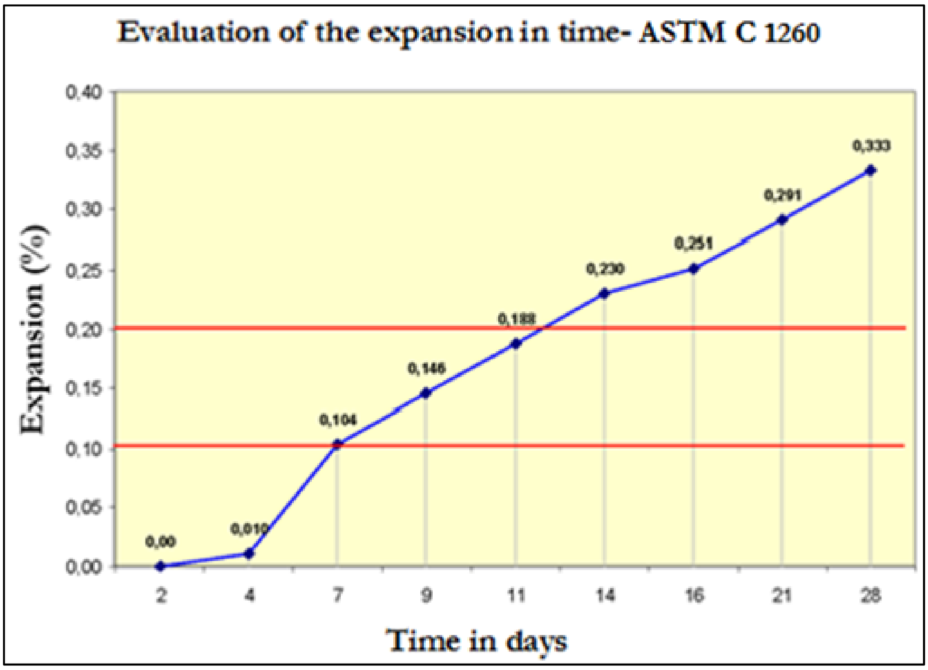

FIGURE 2: Reclycled CR1-ASTM C-1260.

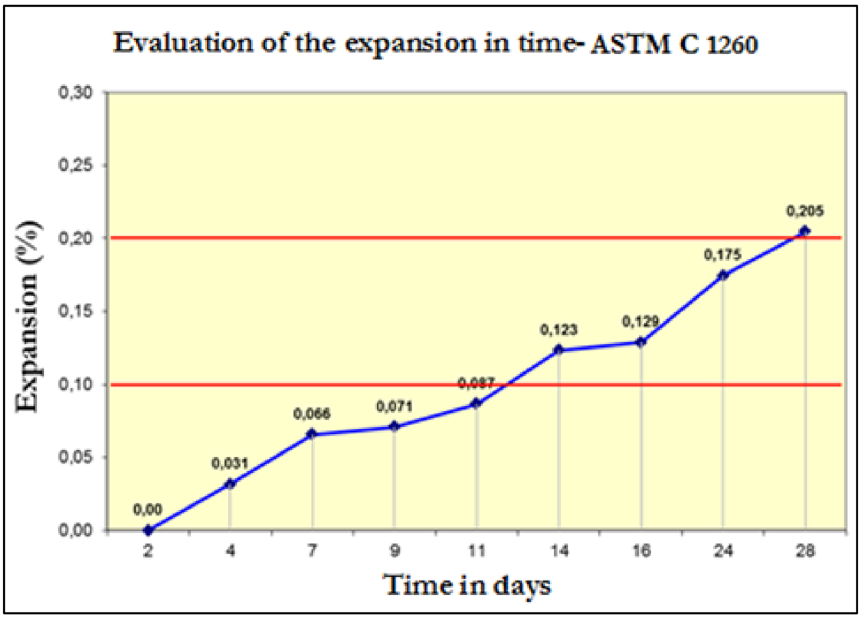

FIGURE 3: Recycled CR2-ASTM C-1260.

FIGURE 4: Cracking in mortar bar.

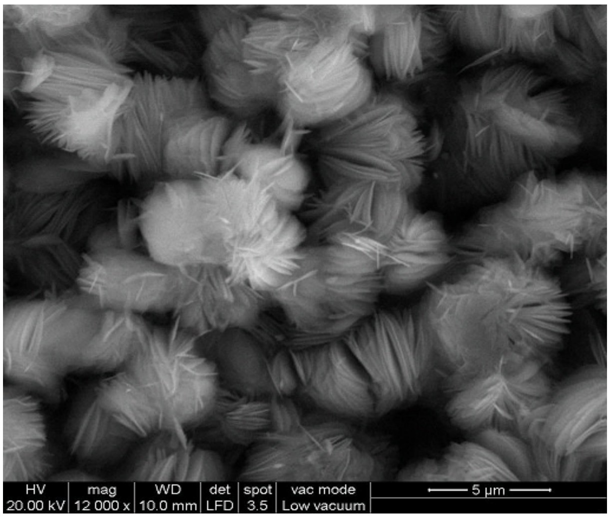

FIGURE 5: Rosette-like gels SEM (M B1).