Development of an Innovative Insulation Fire Resistant Façade from the Construction and Demolition Waste

DEFEAT

INTEGRATED/0918/0052

DELIVERABLE D3.3

RECYCLED CONCRETE AGGREGATES

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DELIVERABLE INFORMATION

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INTERNAL REVIEWER	Prof. Michael Petrou
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This report is submitted upon the fulfillment of Deliverable D3.3 of research project DEFEAT: Development of an Innovative Insulation Fire Resistant Façade from the Construction and Demolition Waste (INTEGRATED/0918/0052).

The current report includes the description of the recycled aggregate treatment methodology, the reuse suggestions and their justifications.

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Internal Peer Reviewer: Professor Michael Petrou

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1. Introduction

In order to maximize the benefit from the separation and recycling process, concrete rubbles were collected and subjected to treatment for the partial removal of the adhered mortar. Specifically, the recycled concrete aggregates (RCA) were added in a modified concrete truck mixer for various time intervals (optimum duration was determined based on the results). During this process, water was added in order to remove and wash out smaller particles, dust and the weaker adhering mortar. This method, which resembles a prolonged Los Angeles test, decreased significantly the adhered mortar, and discarded the weaker or fractured aggregates, keeping only the stronger and sounder ones. The treated aggregates will be used for the production of new concrete mixtures. In order to remove the adhered mortar on Recycled Concrete Aggregates (RCA), the mechanical treatment method proposed by (Dimitriou et al., 2018) has been adopted.

Figure 1. Addition of Recycled Concrete Aggregates (RCA) in concrete truck mixer for treatment.

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2. Separation and Treatment Methodology

The mechanical treatment was initially performed in a 100L inclined mixer to evaluate the effect of the aggregate's collision on each other (Figure 2). The aggregates were rotated in the mixer for up to five hours with one-hour time interval, to determine their circularity and mass loss variation. The aggregates were added in a 1/1 ratio with water to enhance the adhered mortar removal. The circularity of the aggregates was determined using high-resolution images in a digital form and a mathematical procedure using Image J software (National Institutes of Health, 2021).

Figure 2. Treatment of Recycled Concrete Aggregates (RCA) in 100L concrete mixer for treatment.

The process followed to determine the circularity of each aggregate consisted of initially calculating the area and the perimeter of each aggregate using Image J and then using the following equation:

$$\text{Circularity} = (4 \times \pi \times A)/P^2 \qquad \text{(Savva et al., 2021)}$$

where:

A is the area of the aggregate (mm^2)

P is the perimeter of the aggregate (mm)

Circularity values are ranging from 0.0 to 1.0 with 1.0 corresponding to a perfect circle. As the value approaches 0.0 is an indication of an increasingly elongated shape.

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Samples of recycled concrete aggregates (RCA) having a mass of 3 kg were initially collected and placed on a black felt (a small portion at a time) along with a measuring tape and photographed. The obtained images were edited to remove the background. Following editing, the image was analysed using ImageJ software. Initially, the scale was set and the image was converted into a 32-bit image. The threshold was adjusted and the image was analysed for the determination of circularity. The overall circularity of each sample was taken as the average of the circularities of all the analysed aggregate particles.

Figure 3. Treated Recycled Concrete Aggregates (RCA) after 1 hour (top) and after 5 hours (bottom).

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3. Results and Discussion

Changes in mass loss and circularity for both 4/10 mm and 8/20 mm RCA and Natural Aggregates (NA) along with the effect of the presence of adhered mortar on the changes in circularity are shown in Table 1 and **Error! Reference source not found.**. Up to the 3rd hour of treatment, the 4/10 mm aggregates suffered a steady mass loss rate of approximately 2% for each hour of treatment - a trend which was also apparent on the circularity readings at an almost linear rate. For the 8/20 mm, however, mass loss was more intense within the first 3 hours compared to 4/10 mm. Thereafter, mass loss was still occurring at comparable lower rates in both cases. However, circularity variations were not as significant, apart from the case of 8/20 mm RCA where a sharp increase to almost 21% occurred on the 5th hour of treatment.

The results suggest that the optimal duration in terms of cost and performance efficiency would be 3 hours. Although a noticeable effect was observed on 8/20 mm RCA treated up to 5 hours, the additional power consumption needed for this task renders the mechanical treatment of aggregates for such a long period as an economically unviable option. From this perspective, for large-scale experiments, it was decided that RCA should receive a 3-hour treatment. The results presented in Table 1 showed a higher circularity difference from RCA to treated aggregates after 3 hours, which is attributed to the larger mass of aggregates (1.5 tons) added in the concrete mixer drum **Error! Reference source not found.**.

Table 1. Changes in geometry and mass of RCA subjected up to small-scale and large-scale treatment.

	RCA 4/10mm								
	Circularity recordings (Small scale)			**Mass loss recordings (kg)**			**Circularity recordings (Large scale)**		
	Before treatment	**After treatment**	**% Variation**	**Before treatment**	**After treatment**	**% Variation**	**Before treatment**	**After treatment**	**% Variation**
RCA 4/10mm	0.6523	0.7637	14.58	2.951	2.534	14.15	0.6605	0.7938	16.8
RCA 8/20mm	0.6492	0.7623	14.84	2.98	2.472	17.04	0.6516	0.7864	17.2

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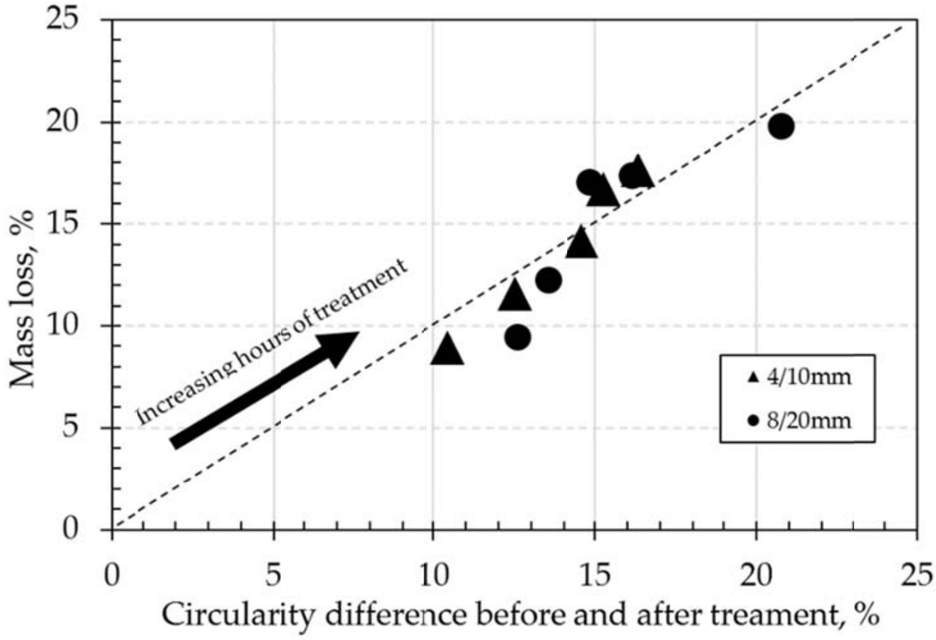

Figure 4. Changes is mass loss and circularity for 10mm RCA subjected to small scale treatment for up to 5 hours.

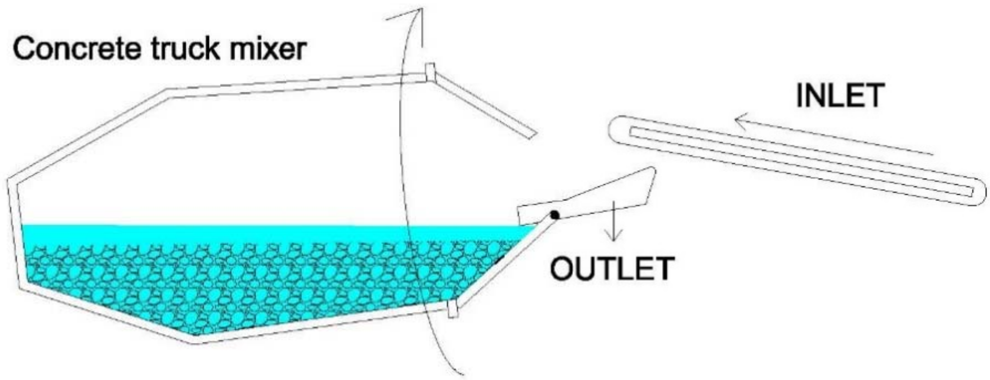

Figure 5. Modified concrete mixer for RCA treatment (Dimitriou et al., 2018)

The conclusion was that a three-hour treatment period was enough to remove the majority of the adhered mortar, without jeopardizing other aggregate properties such as the initial shape and size fraction. The proposed method is low-cost and simple, since the electricity required to rotate the drum motor is the only source of energy employed and the treatment method requires the addition of aggregates and water within the concrete mixer drum and their rotation for the predefined amount of time. After the treatment method investigation, experimental evaluations were conducted on the treated RCAs sieve analysis and water absorption.

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4. Recycled Aggregates Reuse

It is suggested that the RCA reuse should be handled using the normal weight aggregates concrete sieve analysis as a reference. The replication of the reference sieve analysis using treated and field aggregates may slightly vary the mixture design quantities, however, the aggregate packing and the cement paste content are expected to remain similar.

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