Evaluation of different treatment techniques in recycled aggregates for use in the production of concrete.Autores: I

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1 Summary

The results of 5 months of research in the topic Concrete produced with 100% recycled aggregates are presented. We worked with a mixed type recycled material from Madrid, Spain and the tests were carried out in the laboratory (OBP) of the University of Applied Sciences of Karlsruhe, Germany. The recycled material was characterized and separated into three fractions for use as aggregates in the production of concretes (i) fine fraction 0-4 mm (ii) intermediate fraction 4-9 mm (iii) coarse fraction of 9-16 mm. To improve the properties of the recycled aggregates, different treatments were used for each of the fractions (i) accelerated carbonation of the fine fraction, (ii) encapsulation of the intermediate fraction with steam curing, (iii) use of MSC, in this case an active mineral addition of calcined clay-limestone base, denominated by its acronym in English LC2. Established as state parameters for accelerated carbonation of the fine fraction Relative Humidity = 75%, CO2 concentration = 20% and residence time of 24 h, which resulted in an increase of 0.7% in the formation of Calcite with respect to the fine fraction without carbonation, the absorption of water decreased by 0.63% and the resistance in mortars after 28 days of curing exceeded by 0.89% the strength of the fraction without carbonation, 28 Mpa and 31 , 43 Mpa respectively. For the steam curing of the encapsulated fraction, it was worked under conditions of temperature lower than 60o and a residence time of 30 min, obtaining a decrease of 0.75% in the absorption of water with respect to the material without encapsulating. In the concretes produced with the treated aggregates, the best performance series was that which uses a combination of fine carbonated aggregate, encapsulated intermediate aggregate with steam curing and Portland cement 32.5 Mpa.

Keywords: recycled aggregates, steam curing, accelerated carbonation

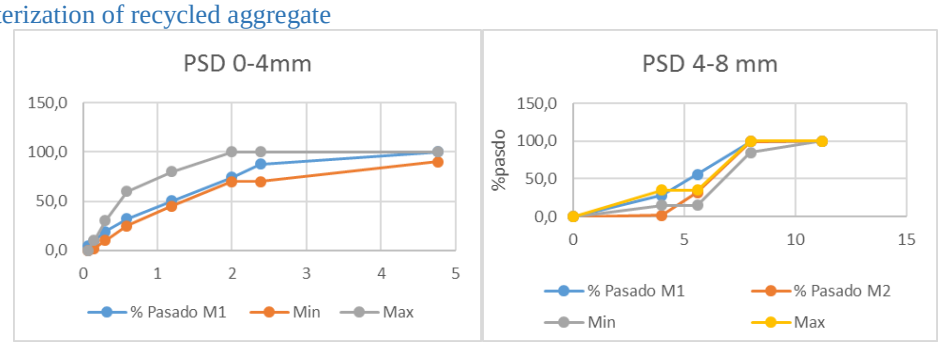
2 Introduction

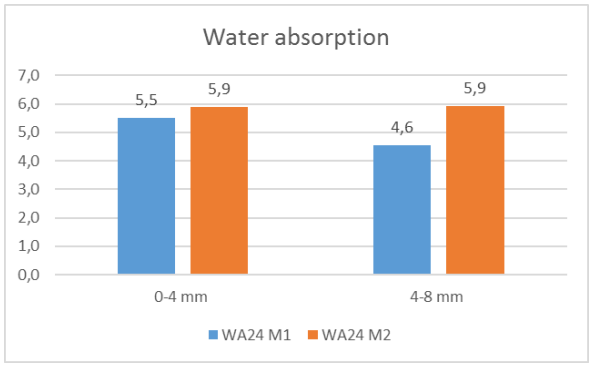
An alternative to traditional methods to improve the quality of coarse aggregate is to encapsulate the 4/8 mm RCA fraction with a layer of cement paste. The results of resistance indicate that the new technique of coating the surface of recycled aggregate with pozzolanic dust contributes significantly to better viability and greater resistance to compression and bending. The interfacial transition zone of the concrete with recycled aggregates is benefited with the new technique (2). To accelerate the curing process of the encapsulated fraction, water vapor is used, it is known that if we generate enough water vapor under ideal conditions of humidity and temperature, we would be creating favorable conditions for the cement used in the encapsulation of the fraction of the recycled aggregate is hydrated, cured and thus guarantees the curing of the encapsulated aggregates. The substitution of Portland cement for a percentage of addition in concretes produced with recycled aggregates allows to compensate the loss of strength and durability of the concretes, the substitution is effective to increase the resistance to the penetration of chloride ions in the body of the concrete. (3). Fly ash used as a mineral addition in concrete mixtures produced with recycled aggregate improves the resistance to the penetration of chloride ions, but also increases the carbonation depth of the concrete. The compressive strength decreases with the increase in the recycled aggregate content, as well as the increase in the fly ash mixture. The compressive strength of recycled aggregate concrete incorporating fly ash with standard water curing increases significantly over the years. (4). Another method to improve the properties of the recycled aggregate is based on the accelerated carbonation of the fine fraction, it was first disclosed in 1990 when Seifritz exposed a method in which a high concentration of CO2 is used in a closed chamber that would react with the silicates sprayed in order to trap the gas and allow a safe disposal of this (5). According to the literature it is recommended to use concentration values of up to 10% without notable differences in the microstructure with respect to the natural carbonation process (6) which allows accelerating the reaction on a time scale of several days to a few minutes and hours. (7), otherwise the process would take years or decades due to the low concentration of gas in the atmosphere. (8)

3 Materials and Methods

Two recycled M1 and M2 materials from a treatment plant in Madrid, Spain, both with a grain size of 020mm, were characterized. Lugo to be characterized is chosen the best properties to perform accelerated carbonation treatments and encapsulated with steam curing. After a simple characterization of the two materials, it is decided to work with the M1.

3.1 Characterization of recycled aggregate





3.2 Quickly carbonation of fine fraction of ARC recycled fine aggregate

For the carbonation of the fine ARC, different environmental conditions were used, in order to find the parameters of the carbonation process that would allow an improvement of the properties of the recycled aggregate. The environmental variables considered are listed in the following table.

Carbonation process	Temperature	Ambient
	RH	55-75%
	Concentration of Co2	10-20%
	Carbonation Time	total carbonation

Table 1: Parameters to be measured (Source: own elaboration)

For the carbonation process, a hermetic glass chamber with inlet and outlet for CO2 was used, the state parameters were controlled with the help of a weather station. The fine ARC was inside the chamber for 24 hours, the state parameters were worked in different combinations as shown in table 2. To check the carbonation state reached by the fine RCD, the one tested with phenolphthalein was used and the test was carried out. weight loss by indiction (LOI).

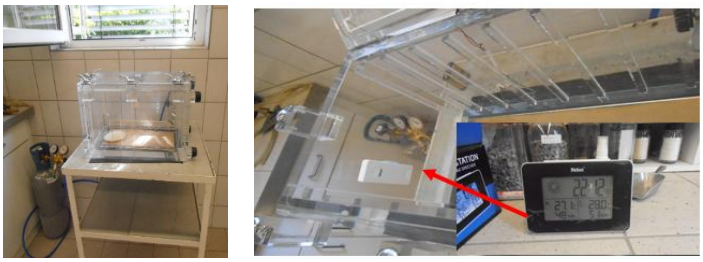


Figure 1: Carbonation chamber

Taking into account the amount of fine carbonate ARC necessary to perform the different mixtures of mortars and concrete proposed in this research, an accelerated carbonation test was carried out using a Drom as a carbonation chamber and maintaining the best combinations achieved in the carbonation chamber, highlighted in yellow in table 2.

	CO2	time	RH	%CH	% calcite
Original sand	0	0	50	7,41	13,64
Series 1 CO2 10%	**10**	**30**	**55**	**2,47**	**14,77**
Series 1 CO2 15%	15	30	55	2,06	14,55
Series 2	10	60	55	2,88	14,55
Series 3	20	30	65	2,47	13,86
Series 4 CO2 10%	10	60	65	0,82	15,00
Series 4 CO2 15%	**15**	**60**	**65**	**2,06**	**15,91**
Series 4 CO2 20%	20	60	65	4,53	12,73
Series 5	**10**	**30**	**75**	**2,06**	**17,05**
Drum	**20**	**90**	**75**	**2,06**	**23,16**

Table 2: Results of the weight loss trial by indiction for the different combinations

3.3 Encapsulation of the coarse fraction of recycled aggregate with steam cure

For the encapsulation process, a Portland Cement CEM1-22.5 MPa was used, with an a / c ratio between 0.5 for 1 kg of material to be encapsulated. Once encapsulated, the recycled aggregate was placed for 35 min in a vaporizer with controlled temperature and relative humidity parameters.

Parameters			
Cement for encapsulation	40 kg/m^3	60 kg/m^3	
Temperature	40 -60 ^{0} ^{0}		
Residence Steam	20 min	30 min	35 min

Table 3 Parameters to be measured. Source: self-made

Figure 2 : Steam curing system

3.4 Production of concrete mixtures with 100% recycled aggregate

Different mixtures of concrete were prepared by combining the two treatments carried out on the recycled aggregate using Portland Cement (CEM1 35 MPa) and an active mineral addition based on calcined clay, limestone and gypsum LC2. The Touffar program was used for the design of mixtures.

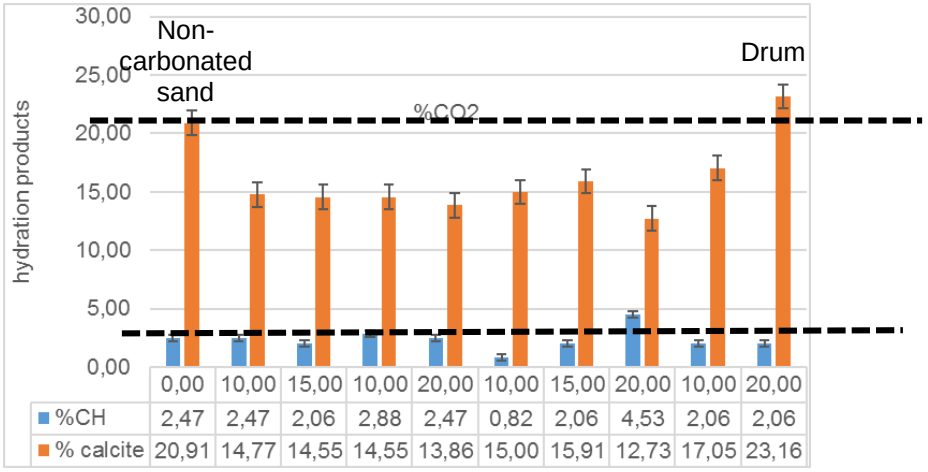
Samples	**Aggregate**		**Cement**	
	Fine	**Coarse**	**CP**	**LC^3**
H1 (Reference 1) 100 % recycle	without treating	without treating	X	

H2 Recycle fine	Carb.	without treating	X	
H3 Recycle coarse	without treating	Steam	X	
H4 (Reference 2) Recycle + LC^3	without treating	without treating		X
H5 Recycle combinado	Carb.	Steam		X
H6 Recycle combinado	Carb.	Steam	X	

Table 4: Concrete mix designs

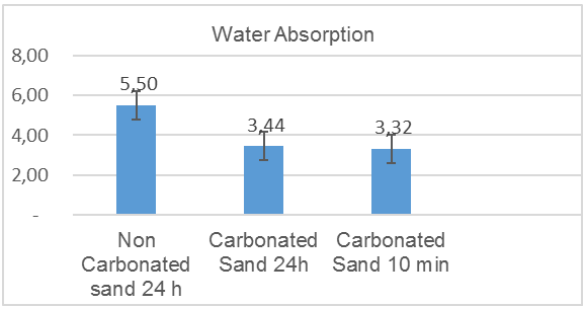
4 Analysis of results

4.1 Influence of the degree of carbonation of the fine recycled aggregate in mortars.

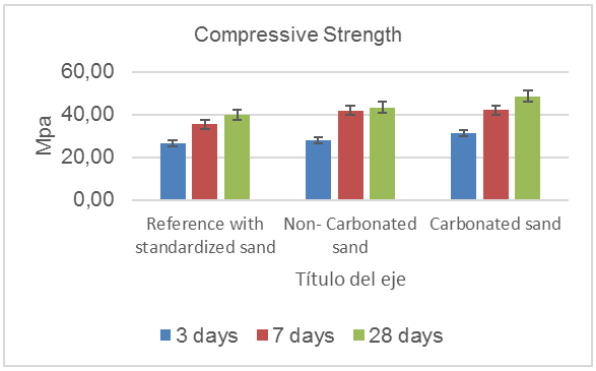


Graph 2 Hydration product formation vs CO2 concentration

With the analysis of Graph 1 were established as state parameters for the accelerated carbonation of fine recycled aggregate: RH = 75%, CO2 = 20% for a residence time of 24 hours with which 23.16% of Calcite is reached.

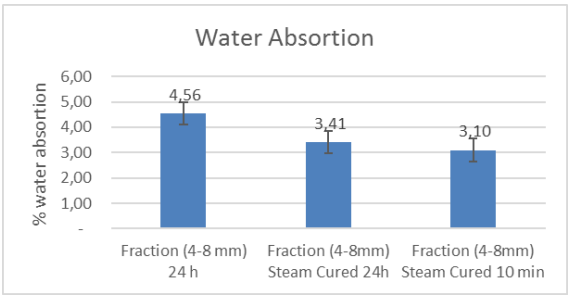


Graph 3 Results of the water absorption test to the carbonated fine recycled aggregate



Graph 4 Results of the resistance test in mortars with carbonated fine recycled aggregate

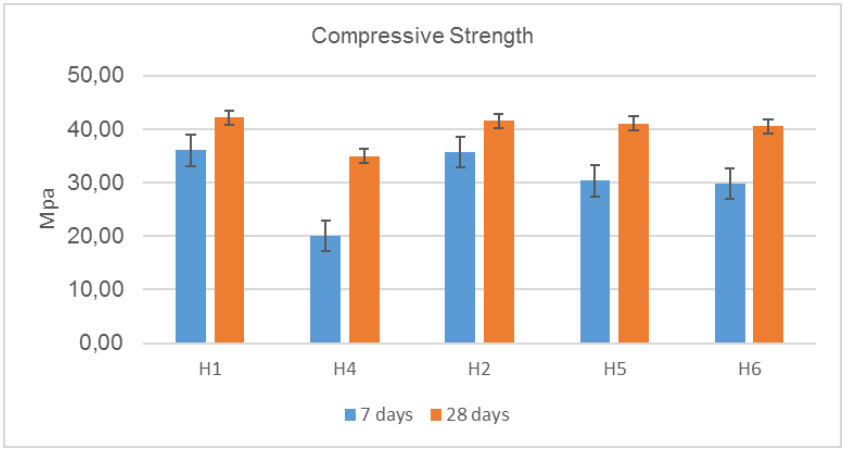
4.2 Influence of steam curing on the properties of encapsulated recycled aggregate



Graph 5 Results of the water absorption test to encapsulated recycled aggregate steam-cured

Figure 3: Encapsulated Arid viewed with an Optical Microscope

4.3 Influence of the different combined treatments on the mechanical properties of concrete



Graph 6 Results of the resistance test to understanding of the concretes produced

5 Conclusions

The accelerated carbonation of the fine fraction of recycled aggregate allows to lower the values of water absorption and does not compromise the resistance of the mortars and concretes produced.

The technique of steam curing of the coarse fraction of recycled arid must be technically improved

6 References

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