Performance of recycled concrete made with precast concrete rejects. Optimisation of mix proportions based on mechanical properties

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INTRODUCTION

Concrete is the most widely generated building material in the world, and precast concrete is increasing in weight compared to conventional concrete. The National Association of the Precast Concrete Industry, ANDECE, declares that in 2018 4.6 million tons of products were generated from concrete industrialization in Spain being a 5% of production rejected during the quality processes in the factories.

The present study analyzed the optimun percentage of substitution in the manufacture of precast concrete carried out in the laboratory with rejects elements from a precast concrete plant. The mixes were prepared with different percentages of substitution: o, 5, 10, 15, 20 and 30% of recycled aggregates come from a precast concrete plant. The laboratory production of precast concrete samples tryed to reproduce the same conditions of the precast plant (virbrocompaction), highlighted that the percentage of substitution in which the greatest resistance was found was 20%.

MATERIALS

The natural aggregates used for the mixes concrete were coarse gravel (4-10 mm), fine gravel (2-6) and sand (0-4 mm). The recyled aggregate (0-10 mm) came from block rejects of an precast industry, and CEM I 52.5-R was used.

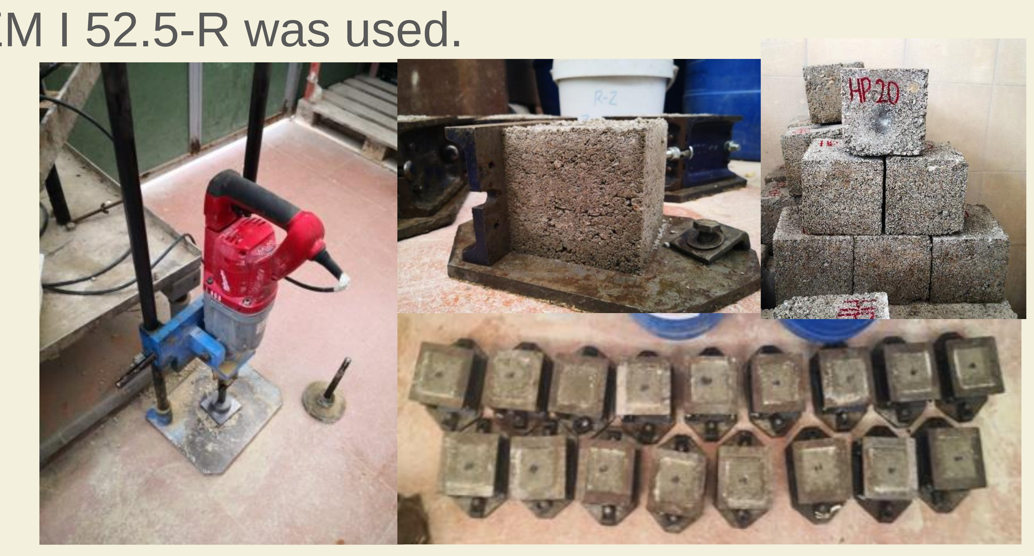

Figure 1: Images from vibro-compacting method and specimens casted

EXPERIMENTAL METHODS

Table 1: Dosage of the different concrete mixes (kg(m³)

Materials used	Ref-C	C-5	C-10	C-15	C-20	C-30
Water	69.2	69.2	69.2	69.2	69.2	69.2
Fine Gravel	601.5	571.4	541.4	511.3	481.2	421.1
Coarse gravel	300.8	285.7	270.7	255.6	240.6	210.5
Sand	902.3	857.1	812.0	766.9	721.8	631.6
Recycled Aggregate	0.0	87.8	175.7	263.5	351.3	527.0
Cement	165.4	165.4	165.4	165.4	165.4	165.4

RESULTS & DISCUSSION

Mechanical and physical properties as compressive strength, density, water absorption, porosity or capillarity were studied in the hardened state of the concrete specimens at the age of curing at 28 days.

Table 2: Properties in hardened concrete specimens

Properties in hardened concrete	Ref-C	C-5	C-10	C-15	C-20	C-30
Compressive strength (Mpa) **UNE-EN 12350-2:2009**	6.57	6.67	7.21	9.09	9.29	8.43
Dry Density (kg/m³) **UNE 83980 - 2014**	2181	2222	2193	2183	2175	2137
Water absorption (%) **UNE 83980 - 2014**	8.54	7.58	7.95	8.27	8.53	9.23
Open porosity (%) **UNE 83980 - 2014**	18.63	16.84	17.41	18.05	18.52	19.73
Capillarity coefficient, k, (kg/m²min$^{0.5}$) **UNE 83982:2008. Fagerlund Method**	5.12	3.30	3.13	3.77	4.36	4.28

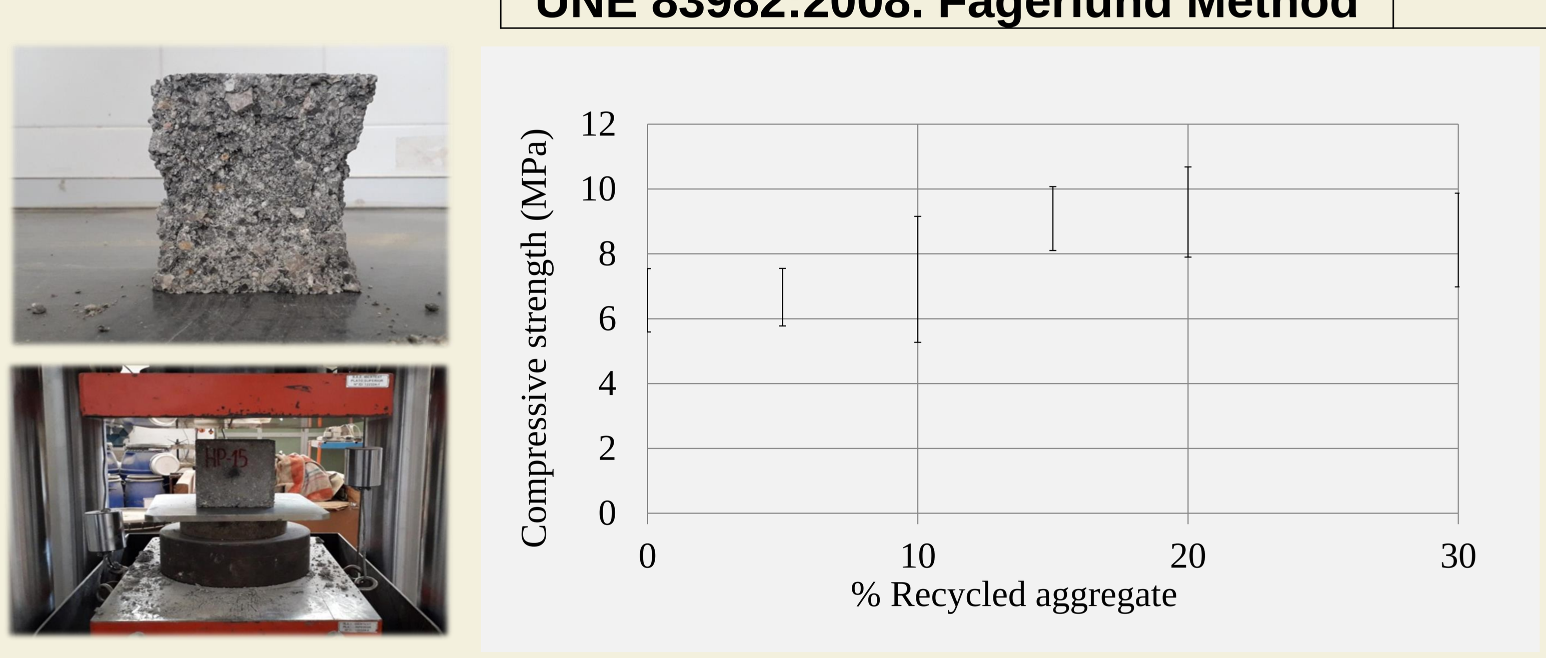

Figure 2: Images from Compressive strength test

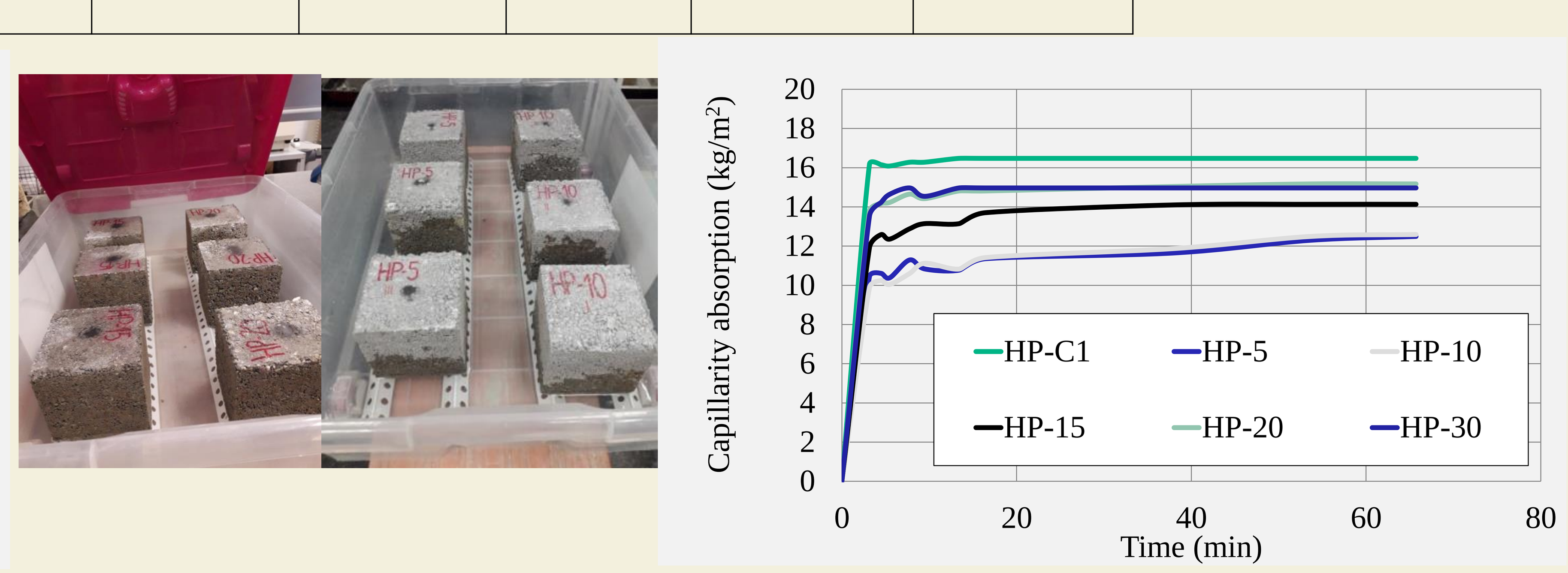

Figure 3: Images from Capillarity test

The addition of recycled aggregate enhanced the compressive strength values which reached the maximun at 20% of incroporation ratio (see Fig. 2).
The fact that the mix C-5 presented the highest dry density and the lowest water absortion and open porosity values, which could be attributed by the well-graded particle size distribution and the lower resistance to fragmention of RA.
As it is observed in Fig. 3, the greatest capillarity coefficent values presented by the mixture without recycled aggregates.

CONCLUSIONS

This study shows the feasibility of using a replacement percentage of up to 20% of recycled aggregate in the dossages. The results obtained from the tests performed worsened for the 30% replacement batch, so this percentage of substitution should be discarded.
The results are adjusted with the limitations of the regulation that advises the use of up to 20%. For future research, it would be interesting to delve into the conditions to reproduce in the laboratory the conditions given in the concrete precast plant.
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