Integrated Evaluation of Recycled Aggregates and Plastic Fibers in Low-Carbon Cement Reinforced Concrete: A Technical Feasibility Study

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1 INTRODUCTION

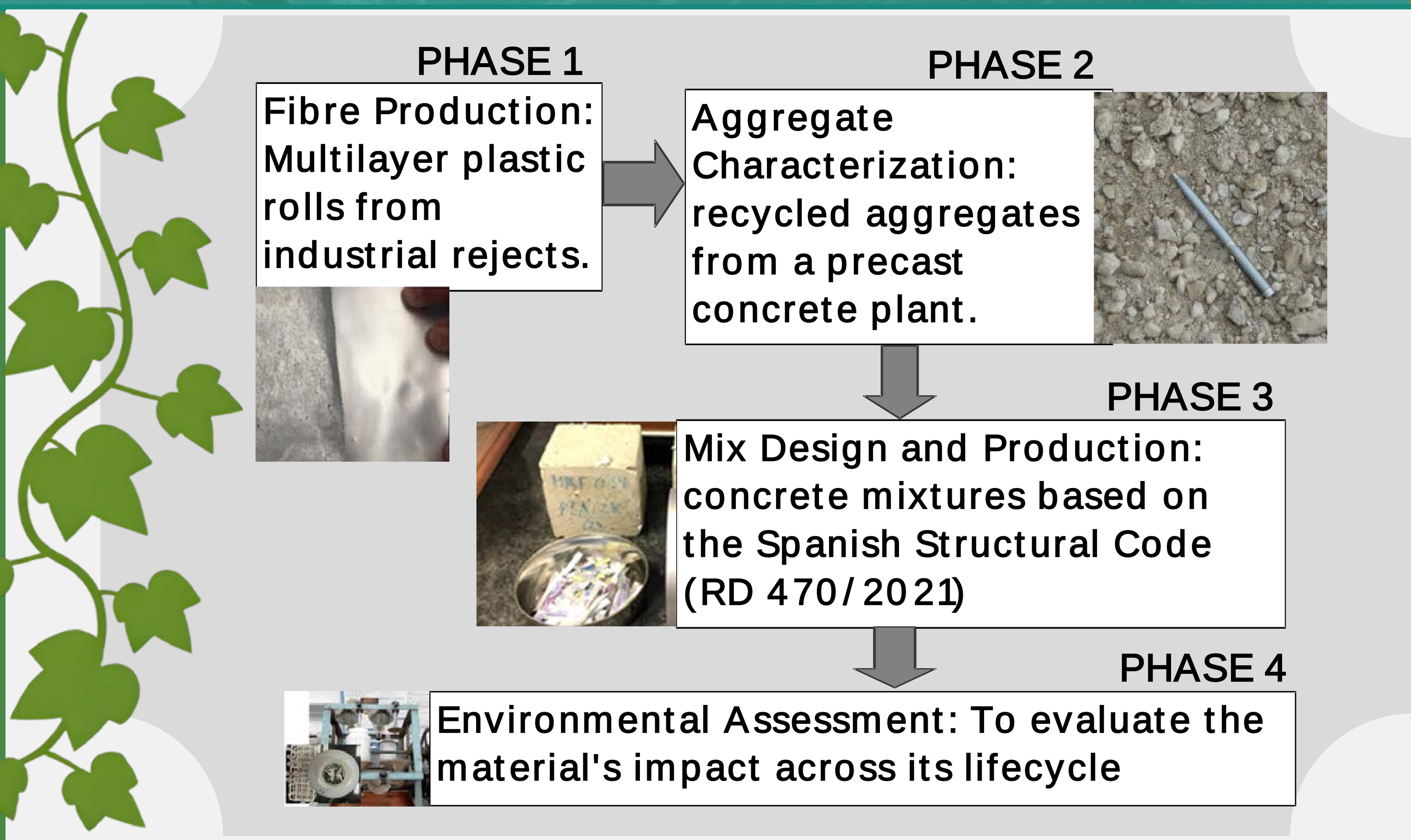
The present research adopts a triple circularity and sustainability approach, integrating: (i) recycled aggregates sourced from construction and demolition waste (CDW), (ii) recycled multilayer plastics from a packaging food company valorised as reinforcing fibres, and (iii) the use of low-carbon cement to reduce the overall environmental footprint of the composite. Multilayer plastic waste from the food-packaging industry is difficult to treat due to its laminated structure, composed of combinations of polymers (PET, PA, PVC and PE) that make it incompatible with conventional recycling processes.

This study assesses the feasibility of reincorporating it by transforming it into polymeric macrofibres for use in reinforcing eco-friendly concrete. In addition, recycled aggregates derived from production waste from a precast concrete manufacturing plant have also been incorporated as aggregate, allowing for the combined recovery of waste in a single building material system. The inclusion of the third sustainability factor—low-carbon cement—ensures that these strategies are effectively combined, resulting in a high-performance fibres reinforced concrete with a reduced environmental footprint.

2 MATERIAL AND TEST METHODS

To ensure compliance with EN 14889-2 standards, the plastic films were cut to a controlled length of 50 mm and a width of 5 mm. The tensile strength of fibres and their elastic modulus were determined through direct tension tests.

Recycled aggregates, sourced from rejects of a precast concrete plant, were physically characterized by composition analysis (EN 933-11), particle size distribution (EN 933-1), and water absorption and density tests (EN 1097-6). Concrete mixtures were then formulated according to the Spanish Structural Code (RD 470/2021) targeting a compressive strength of 25 MPa.



3 RESULTS AND DISCUSSION

As shown in Figure 1 and summarized in Table 1, the reference concrete with natural aggregate (C-REF-NA) achieved the highest compressive strength, reaching 47.68 MPa at 28 days. Replacing 5% of natural aggregate with recycled aggregate (C-RA5) reduced the strength to 39.81 MPa. The mix with natural aggregate and 2 kg of recycled fibres (C-NA+FB) reached 42.56 MPa, while the combination of 5% recycled aggregate and recycled fibres (C-RA5+FB) showed the lowest value, 31.68 MPa.

	1 day	7 days	28 days
C-REF-NA	10.38	36.14	47.68
C-RA%5	9.29	31.73	39.81
C-NA+FB	10.01	32.15	42.56
C-RA%5+FB	7.12	25.54	31.68

Table 1. Compressive strength EN 12390-3

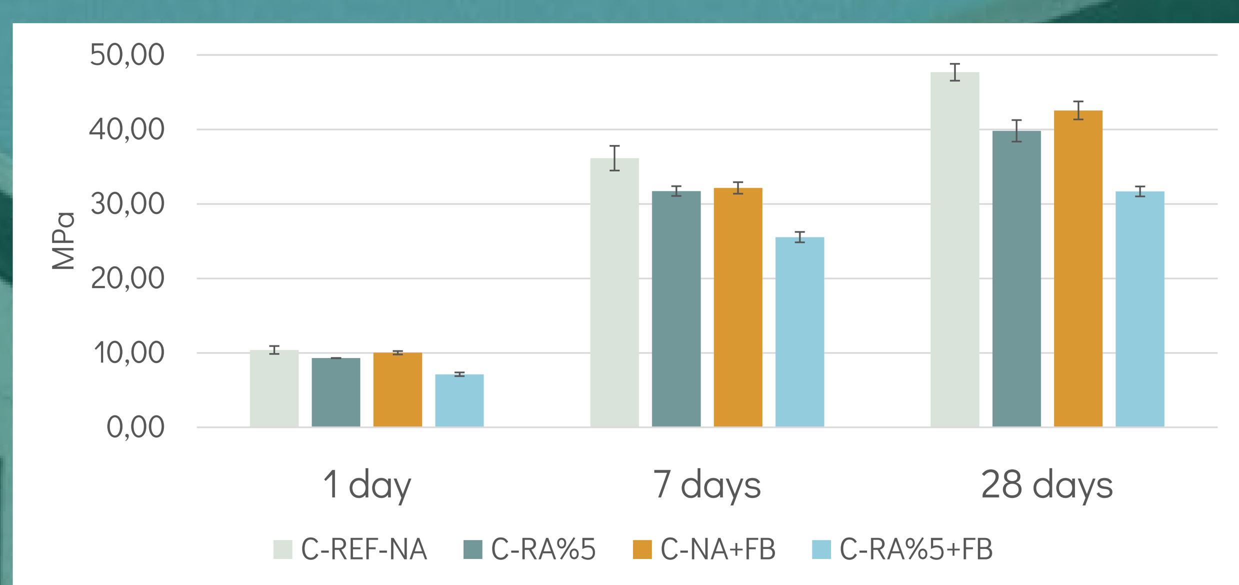


Figure 1. Evolution of compressive strength over curing time

4 CONCLUSIONS

Compared with the reference mix, the incorporation of 5% recycled aggregate reduced the 28-day compressive strength by 16.5%, while the addition of recycled fibres caused a 10.7% reduction. The combined use of recycled aggregate and recycled fibres led to the highest reduction, approximately 33.6%. Despite these reductions, all mixes exceeded the target strength of 25 MPa at 28 days, confirming their preliminary technical feasibility. Therefore, the integrated use of recycled aggregates, recycled plastic fibres and low-carbon cement is a promising circular economy strategy for sustainable concrete, particularly for non-structural or low-demand precast applications.

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