



## LOW CARBON RECYCLED BINDER FROM CONCRETE WASTE AS A MORE ECO-EFFICIENT ALTERNATIVE IN EARTH STABILISATION

José A. Bogas<sup>\*,a</sup>, Ricardo Cruz<sup>a</sup>, Maria Gomes<sup>a</sup>

<sup>a</sup> CERIS-Civil Engineering Research and Innovation for Sustainability, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais, 1049-001 Lisbon, Portugal  
[abogas@civil.ist.utl.pt](mailto:abogas@civil.ist.utl.pt); [ricardojrcruz@tecnico.ulisboa.pt](mailto:ricardojrcruz@tecnico.ulisboa.pt); [maria.gloria.gomes@tecnico.ulisboa.pt](mailto:maria.gloria.gomes@tecnico.ulisboa.pt)

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Due to the urgent need to reduce the carbon footprint of cement-based materials, and the consequent search for alternatives to Portland cement (PC), extensive research has been conducted at Instituto Superior Técnico, University of Lisbon (IST-UL), focusing on the development of new low-carbon binders. Since 2018, one of the main research focuses has been the development of recycled cement (RC) obtained through the low-temperature thermoactivation of the cementitious fraction of concrete waste [1]. The goal is to recover the binding properties of old cement using a process that minimizes thermal energy consumption and avoids significant CO<sub>2</sub> emissions [2]. The thermoactivation at around 650-700 °C prevents the decarbonation phase, resulting in CO<sub>2</sub> emission reductions exceeding 60% compared to conventional clinker production [3]. Moreover, RC production also mitigates natural resource depletion while promoting the effective reuse of low-value construction and demolition waste (CDW). Several studies, including those conducted by the authors, have demonstrated the excellent hydration capacity of RC, which tends to develop hydration products of the same type and volume as PC [2, 4]. Additionally, concretes with up to 40% RC replacing PC have shown similar performance to reference mixes, with only minor differences in strength and durability [5, 6]. The main limitation of RC is its high water demand [2]. Nevertheless, C25/30-grade concretes could be produced using RC as the sole binder in the mix [5].

Despite the significant advances achieved in this field, one major challenge remains: the industrial production of RC can only be feasible if the cementitious fraction is first separated from the concrete debris, a task that the construction industry has not yet been able to solve effectively. In this context, the main author developed an innovative method that enables the individualisation of the cementitious fraction from aggregates [7]. This patented method, makes it possible to obtain high-quality recycled sand (HQRS) with less than 3 wt% adhered paste, and cement waste of over 75 wt% purity. Thanks to these advances, a new generation of “green” cement-based building products has been developed at IST-UL, including rendering mortars, concretes, adhesive cements, and, more recently, RC-stabilised earth materials, which are discussed next.

Due to the growing demand for more sustainable materials, earth has regained relevance in construction, particularly for small dwellings. However, despite its very low embodied energy, high availability, and affordable cost, earthen materials exhibit poor mechanical strength and durability when exposed to outdoor environments [8]. Therefore, they typically require chemical stabilization, with PC being the most common and effective stabilizing agent. Nevertheless, as previously mentioned, PC is a highly energy-intensive binder, which considerably increases the embodied energy and carbon footprint of earth-based construction, thereby offsetting its ecological benefit [8]. Consequently, there is a need for alternative stabilizers capable of maintaining the eco-efficiency of earth while providing comparable performance to PC. Several studies have explored alternative stabilizers such as fly ash and agricultural wastes, but these have generally shown limited stabilisation efficiency, availability, and cost-effectiveness for large-scale use.



Thus, RC has been explored at IST as an alternative low-carbon binder for earth stabilization (Fig. 1). Specifically, compressed stabilized earth blocks (CSEB) were produced, combining both mechanical and chemical stabilization to achieve water-resistant materials. In this communication, key results regarding the mechanical and durability performance of RC CSEB are presented, and compared with unstabilized reference blocks (UCEB) and PC-stabilized blocks. CSEB were produced with up to 8% stabilizer, 20–100% RC, and with up to 40% of the earth replaced by CDW to further enhance sustainability. Mechanical strength had a strong correlation with total porosity, which was generally higher in RC CSEB due to its high water demand. Nevertheless, compared to UCEB, the mechanical strength of RC CSEB increased more than twofold. Moreover, unlike UCEB, RC CSEB, even at only 4% stabilizer content, proved to be water-resistant, withstanding 72 hours of immersion and 1 hour of severe water erosion at 2.5 bar pressure without significant deterioration (Fig. 2). In fact, the durability of RC CSEB was comparable to that of PC CSEB. Therefore, RC has demonstrated itself as a viable and eco-friendlier alternative to PC for earth stabilization, maintaining the integrity of CSEB even under very adverse exposure conditions.

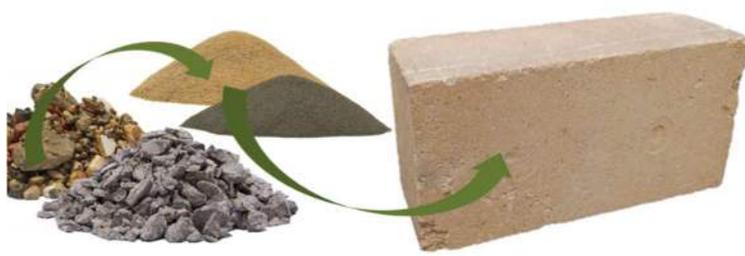


Fig. 1 – Eco-efficient blocks with RC and CDW



Fig. 2 – Water resistant RC CSEB

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