A Novel Mechanical Process for Sustainable Concrete Recycling

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Abstract

- Concrete is the most widely used construction material worldwide. It imposes substantial environmental costs due to
  - high demand for natural resources,
  - significant greenhouse gas emissions, and
  - the generation of large volumes of concrete and demolition waste.
- A sustainable strategy to mitigate these impacts involves cleanly separating concrete's constituent phases; cement hydrates (CSH), sand, and aggregates at the end of their life cycle for reuse in new formulations without compromising structural integrity.
- Conventional physical separation methods, such as electric pulse fragmentation, magnetic separation, thermal activation, encounter numerous energy, economic, and environmental challenges
- This study investigates a novel mechanical process as an energy-efficient, low-cost method for selectively separating cement hydrates from aggregates in concrete rubble.

Background

- Conventional crushing and milling of concrete to separate CSH grind all components simultaneously → leads to high levels of aggregate contamination in CSH fines
- The novel mechanical process studied here induces particle-particle collisions without grinding media → enables selective liberation of concrete components
- The process utilizes differences in intrinsic material properties of aggregate, sand and cement hydrate in concrete → promotes fracture along grain boundaries
- ***Objective:***
  - Use this novel process to release cement hydrate attached to sand and gravel with minimal aggregate contamination.
  - Optimize selective liberation by adjusting process parameters to isolate high purity CSH from concrete waste that can be used as a primary carbonate cement

Methods

- Feed for the process:
  <1cm chunks were prepared by jaw crushing waste concrete

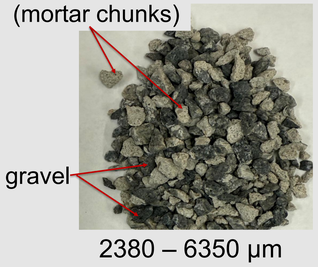

Table 1: Composition of feed concrete

Material	Wt %
Cement	16.7
#57	45.8
Concrete Sand	30.6
Water	6.9
Air	
Wt % of Cement Hydrate	23.6
Wt % of Total Aggregate	76.4

- The feed was then subjected to the novel process and samples were collected at different time intervals (2, 6, 10 min *etc.*)
- Product is then separated to coarse and fine aggregate, and cement hydrate fines by sieving
- All the size fractions after sieving were characterized using a combination of analytical techniques ICP-OES, XRF, and mass balance to determine the CSH distribution after the process

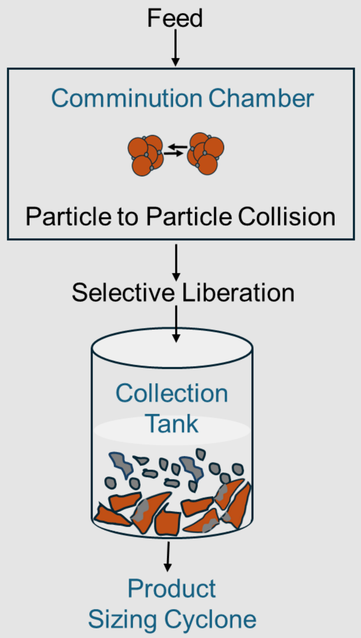

Figure 1: Schematic of novel mechanical process

Results/Discussion

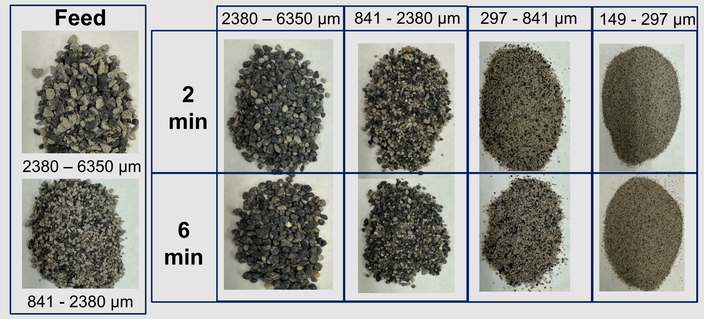

Figure 2: Pictures of concrete feed and the resulting product after 2 and 6 mins of the novel process

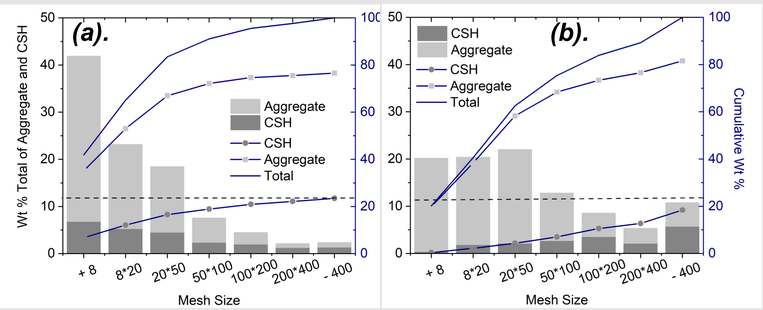

Figure 3: Distribution of aggregate and cement hydrate (CSH) across the different size fraction of ***(a).*** feed ***(b).*** after 6 min of processing

- Produced clean and smooth aggregate (coarse and fine)
- Under preliminary process conditions, CSH distribution has shifted to finer side, but with some aggregate contamination

Future Direction

- Adjust process parameters and feed characteristics to optimize the selective liberation of cement hydrate while minimizing the breaking down of aggregate particles
- Evaluate the performance of recycled aggregate produced by this process in new concrete, and compared it with virgin aggregate
- Investigate the potential of separated cement hydrate as a carbonate binder in mortar and concrete