Seeking true sustainability by multiple recycling of thermal-activated waste concrete powder as a partial cement replacement

Construction waste, including concrete debris, accounts for a significant portion of the waste generated in many countries around the world. Recycling of construction waste has been studied by many researchers, however, to be precise, almost all research covered only 'once-recycled materials'. According to the applicant's opinion, to achieve true sustainability, waste should be recycled several times. Therefore, in this study, through a series of processes of crushing construction waste and manufacturing cement composites, waste concrete powders that are recycled three times are collected, and the multiple recycling potential of construction waste as a partial replacement for cement is investigated.

Cement production is responsible for about 7% of the annual CO_2 emissions. Among the components for concrete, cement due to its production is reported to have the highest negative impact on the environment. Therefore, finding a recycling approach that can reduce cement consumption by concrete waste is more important than recycling concrete waste into aggregate. However, in general, waste powder has low activity and does not contribute to improving the strength of cement composites. Therefore, in this study, the waste powder is thermally activated for an hour at a temperature of 700°C to improve its reactivity, and it is used for partial replacement of cement in cement composites.

In the experiment, the physical and chemical properties (i.e., specific gravity, particle size distribution, reactivity index, chemical and phase composition) of concrete waste powders obtained after different recycling times are investigated as per standards and using X-ray diffraction and thermal gravimetric analysis. After that, the waste powders are used to produce cement composites at 10%, 20%, and 30% replacement ratios for cement. Fresh properties (workability, air content, density), and hardened properties - mechanical and durability properties (compressive strength, flexural strength, dynamic elastic modulus, water absorption, drying shrinkage) of cement composites are evaluated.

Results of the experiment will be applied for the economic feasibility and environmental impact. Among the raw materials needed to produce concrete, cement has a high unit price and high CO_2 emission. Thus, it is predictable that the use of construction waste as a partial cement replacement can be to be economical and eco-friendly. This contribution will increase with the number of recycling cycles of construction waste.

This research on the multiple recycling of thermally-activated waste powder as a partial replacement of cement can provide scientists and industry with new ideas about effective re-utilization of construction waste in terms of sustainability of the concrete technology. In particular, it can make a valuable contribution to the establishment of guidelines related to the utilization of waste concrete powders.