Abstract

Concrete is a widely used material in structural engineering applications characterized by technical/economic convenience and end-products. Globalization and the growth of population have accelerated the dynamics of the urbanization process, however, it has made the management of the construction and demolition waste (CDW) a significant issue and big challenge to all over the world. Recycled aggregate concrete is a type of concrete that recycled aggregate, especially recycled aggregate from CDW is utilized to replace the virgin aggregate like fine and coarse aggregate. Recycled CDW aggregate concrete offers a valuable method for recycling industrial by-products and reducing greenhouse gas emissions and thus produces a novel green concrete. The superior merits of recycled CDW aggregate concrete include avoiding over-exploitation of natural aggregate, reducing landfills of CDW and diminishing existing wastes. In this dissertation, plastics, recycled crushed concrete aggregate (RCA) and recycled clay brick aggregate (RBA) were selected as the representative recycled CDW aggregates in the meanwhile, plastics consist of PET powder and Mix-plastic granules. The novel green are developed and evaluated.

Before conducting the concrete tests under high strain rate, the design and calibration of a large-scale 155-mm Split-Hopkinson Pressure Bar (SHPB) is required. The design and construction of the apparatus are described and its data processing, including wave pulse dispersion correction, is assessed to ensure accurate representation of stress and deformation conditions. The apparatus is validated through experiments on both brittle (confined concrete) and ductile (copper) specimens. The results demonstrate the ability of SHPB to characterize the dynamic properties of large-scale specimens and to correct dispersed signals in the bar, allowing for the accurate determination of specimen surface pulses. The validity of the results is confirmed through 1D, 2D, and 3D wave analyses. Therefore, the 155 mm diameter SHPB setup has shown excellent performance in deriving the dynamic properties of large-diameter specimens.

Existing studies have validated that the quasi-static compressive behavior of concrete made with different levels of substitution and types of coarse aggregate by RCA and RBA was widely investigated. Thus, herein, only the high strain rate compressive behavior of Recycled Aggregate Concrete (RAC) and Recycled clay Bricks Concrete (RBC) were in-depth investigated by s SHPB apparatus with a large bar diameter of 155 mm. Specimens were divided into 9 groups with different levels of substitution and types of coarse aggregate ranging from 0% (Natural Aggregate Concrete, NAC) up to 100% (full substitution with recycled crushed concrete or clay bricks). Tests were executed up to a strain rate of around $100\,\mathrm{s}^{-1}$.

Subsequently, difference exists in PET powder and mix-plastic granules adopted in this dissertation with previous literature, thus, in-depth investigation were conducted from mortar level. In detail, the physical and mechanical characteristics of a novel mortar that uses recycled PET powder as a replacement of the natural sand were examined. To create five distinct mortar mixes, recycled PET powder was substituted in varying proportions (0–30% by volume of the sand). The investigation focuses on the physical and mechanical characteristics of the material, including density, slump, water absorption, ultrasonic pulse velocity, flexural and compressive strength, and micro-structural and interface characterization. Then, a step further, PET powder and recycled mixed plastic granules were adopted to substitute fine and coarse aggregates. Two different substitution strategies are employed. In the first one, the PET powder is used to substitute the fine sand by volume. In the second one, the PET powder is used to substitute the fine sand while the recycled mixed plastic granules are used to substitute the coarse sand and fine coarse aggregates by volume (50% for PET powder and 50% for recycled mixed plastic granules). Four total replacement levels (5%, 10%, 20%, and 30%) by volume were considered. The fresh concrete properties (slump and density), compressive and flexural behavior, toughness, and permeability are investigated. Finally, a micro-scale characterization of the plastic-paste interface is provided. Later, the comparative experiments were conducted on the study on the characterization of the high-strain rate compressive behavior of the concrete with two different substituted recycled plastic aggregates. Tests were performed using conventional quasi-static loading with a compressive testing machine and high-strain rate tests with a diameter of 80-mm SHPB for strain rates up to $100\,\mathrm{s}^{-1}$. Moreover, stress-strain curves, and energy absorption capacity and data-driven model are proposed for all kinds of tests in this dissertation.

Overall, this dissertation could support the producers of CDW to gain considerable interest by applying the CDW aggregate into concrete and can be a promising material to be employed for protective techniques against impact and blast loads.