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Cyclic behavior of thin-walled square steel tubular columns filled with demolished concrete lumps and fresh concrete

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ABSTRACT

This study is part of a comprehensive project concerned with research and advocacy of the structural elements containing demolished concrete lumps (DCLs) or demolished concrete segments (DCSs) with a distinctly larger size than the recycled aggregates. Previous studies showed that the steel tubular columns filled with DCLs/DCSs and fresh concrete (FC), recycling demolished concrete in a simplified manner, have properties similar to the conventional concrete filled steel tubular columns. This research is aiming to study the cyclic behavior and to evaluate the strength and ductility of the thin-walled square steel tubular column filled with DCLs and FC. Fifteen specimens, including 10 columns filled with DCLs and FC and 5 reference columns filled with FC alone, were tested under constant axial compression and cyclic lateral loading. The main variables are: replacement ratio of DCLs, thickness of steel tube, and axial load ratio. The design codes are employed to predict the lateral strengths of the specimens. The findings indicate that: (1) the cyclic behavior of thin-walled square steel tubular columns filled with DCLs and FC is similar with that of the reference columns filled with FC alone; (2) the lateral strength of the columns filled with DCLs and FC is slightly lower than those filled with FC alone; and (3) the thin-walled columns filled with DCLs and FC exhibit acceptable deformation and energy dissipation capacities.

1. Introduction

The theme of recycling and reusing demolished concrete has been a global focus of research in recent years and is motivated by the increasing severity of environmental degradation and resource depletion. Ongoing research and practice of recycling demolished concrete mainly relate to the technology of crushing and sieving concrete debris to produce substitute aggregates for new concrete, and the physical and mechanical properties of such so-called recycled aggregates concrete (RAC) as well as its application guidelines have been documented by many researchers and organizations [1–3]. Together with the intensive studies of RAC with respect to material properties, great efforts have also been taken to investigate the performance and suitability of structural members manufactured with RAC [4–6].

Concrete filled steel tubular (CFST) column is an effective way to improve mechanical properties of concrete. It is well-accepted that the concrete infill is confined and protected by the outer steel tube, resulting in a triaxial compression state that increases the strength and inelastic deformation capacity of the concrete, whereas the concrete infill conversely prevents inward local buckling of the steel tube [7]. In view of these advantages of CFST columns, recycled aggregate concrete filled steel tube (RACFST), in which the natural aggregates are partly or totally substituted with the recycled aggregates, has been proposed to advance the study of RAC. Konno et al. [8], Yang and Han [9] and Xiao et al. [10] have performed studies on the static strength and response of RACFST columns. They found that, in general, the mechanical properties of the RACFST columns are similar to those of the companion CFST columns though the strength and stiffness of the former are to some extent lower than the latter. Yang and Zhu also investigated the seismic performance of square RACFST beam-columns and the conclusions were that the RACFST specimens show slightly lower but comparable lateral strength to the companion CFST specimens and the square RACFST beam-columns with up to 50% recycled aggregates are suitable in seismic zones [11].

Up till now, however, application of RAC has lagged behind its investigation despite the noteworthy research efforts and contributions, and a large amount of waste concrete still ends up at disposal sites. In China, for instance, the demolition of aging concrete buildings and infrastructures is resulting in significant material flows of concrete debris, amounting to over 100 million tons annually [12]. Although current practices in China include some low-end use of crushed concrete such as backfilling or base course for road construction, the use of demolished concrete in a structural lever is rare. Indeed manufacturing high-quality RAC is not easy, frequently consisting of time- and cost-consuming process of waste concrete fine crushing, screening and purification, thus making it less economical and energy-saving in actual practice. These factors together have led to a great need to explore efficient approaches to reusing the demolished concrete directly as an accepted structural

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