Thin-Walled Structures 66 (2013) 62–75

Contents lists available at SciVerse ScienceDirect

Thin-Walled Structures

journal homepage: www.elsevier.com/locate/tws

Experimental behaviour of recycled aggregate concrete filled stainless steel tube stub columns and beams

You-Fu Yang*, Guo-Liang Ma

State Key Laboratory of Coastal and Offshore Engineering, Dalian University of Technology, Dalian 116024, China

ARTICLE INFO

Article history:
Received 8 June 2012
Received in revised form
8 October 2012
Accepted 22 January 2013
Available online 28 March 2013

Keywords:
Recycled aggregate concrete filled stainless steel tube (RACFSST)
Stub columns
Beams
Bearing capacity
Stiffness
Design code

ABSTRACT

The behaviour of recycled aggregate concrete (RAC) filled stainless steel tube (RACFSST) stub columns and beams under short-term loadings was experimentally studied, and a total of 28 specimens, including 14 stub columns and 14 beams, were tested. The experimental investigations were carried out on circular and square specimens with recycled aggregate replacement ratio of 0, 25%, 50% and 75%, and both recycled coarse aggregate (RCA) and recycled fine aggregate (RFA) were adopted in the tests. The main objectives of these tests were threefold: first, to describe a series of tests on new composite stub columns and beams; second, to investigate the effect of cross-section type and recycled aggregate replacement ratio on the compressive and flexural behaviour of RACFSST specimens; and finally, to evaluate the accuracy of the calculated bearing capacity, bending moment capacity and section flexural stiffness of the RACFSST specimens by using the design formulae in six codes related to the design of concrete filled carbon steel tube. The experimental results showed that the RACFSST stub columns and beams under short-term loadings had the stable load versus deformation responses and the good deformation-resistant ability, and the performance of core RAC was generally enhanced due to the confinement of the outer stainless steel tube.

© 2013 Elsevier Ltd. All rights reserved.

1. Introduction

Stainless steel tube has a beautiful appearance, good durability, low-cost maintenance and good fire resistance, and it has good prospects of application in the buildings and bridges under marine environment and the important buildings requiring high aesthetics and durability. Although the stainless steel tube has superior performance, it cannot be applied largely in the structures due to the drawback of expensive cost. As a result, filling concrete into stainless steel tube, which is so-called concrete filled stainless steel tube (CFSST), is considered to be a good choice for structural application of stainless steel. CFSST can cause a significant reduction in the amount of stainless steel, so as to achieve the purpose of reducing the project cost. At the same time, the stability of the thin-walled stainless steel tube can be improved due to the existence of core concrete [1].

In recent years, CFSST has been used in several projects [1], and the performance of circular and square CFSST columns with or without inner stiffeners has been experimentally and theoretically studied, as summarised and presented in [2]. Furthermore, Feng and Young [3–5] experimentally and theoretically investigated the behaviour of CFSST T- and X-joints, and the simplified design formulae for such composite joints were suggested. Dai and Lam [6] and Lam et al. [7] presented the experimental and finite element modelling results of concrete filled stainless steel elliptical hollow sections, and the simplified equations for the bearing capacity prediction of such composite sections were also proposed. Tao et al. [8] developed a three-dimensional nonlinear finite element model for the analysis of square CFSST stub columns subjected to axial compression.

Production of recycled aggregates by recycling of the waste concrete can promote the reuse of waste concretes and further protect the natural aggregate resources. However, the quality of recycled aggregates produced from waste concrete from different sources has a greater randomness and variability. Recycling of waste concrete to produce structural grade concrete for major construction is technically feasible [9] provided that: (1) the clean, crushed and well-graded recycled aggregates are produced; (2) the grading of recycled aggregates can be brought within certain grading limits; (3) the recycled aggregates can pass the requirements for abrasion loss percentage or crushing value; and (4) the recycled aggregates can comply with maximum allowable limits on the content of contaminants. Moreover, the density and water absorption of recycled aggregates should be carefully determined before designing a mix of recycled aggregate concrete (RAC). In general, RAC has a lower performance compared with the corresponding normal concrete (NC) under the same mix proportion [9], and the application of RAC in building structures is

* Corresponding author. Tel.: +86 411 84708510; fax: +86 411 84674141.
E-mail address: youfuyang@163.com (Y.-F. Yang).

0263-8231/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.tws.2013.01.017

Nomenclature

BRF	bearing capacity reduction factor
CFSST	concrete filled stainless steel tube
D	outside diameter or width of circular or square stainless steel tube
E_c	elastic modulus of concrete
ERF	elastic modulus reduction factor
E_{sc}	elastic modulus of composite stub column
f_{cu}	cube compressive strength of concrete
K_{ic}	calculated initial section flexural stiffness
K_{ie}	experimental initial section flexural stiffness
K_{sc}	calculated serviceability-level section flexural stiffness
K_{se}	experimental serviceability-level section flexural stiffness
M	bending moment
MRF	bending moment reduction factor
M_{uc}	calculated bending moment capacity
M_{ue}	experimental bending moment capacity
N	axial load
NC	normal concrete
NCA	natural coarse aggregate
N_{uc}	calculated bearing capacity of stub column
N_{ue}	experimental bearing capacity of stub column
r	recycled aggregate replacement ratio
RAC	recycled aggregate concrete
RACFSST	recycled aggregate concrete filled stainless steel tube
RCA	recycled coarse aggregate
RFA	recycled fine aggregate
SRF_i	initial section flexural stiffness reduction factor
SRF_s	serviceability-level section flexural stiffness reduction factor
t	wall thickness of stainless steel tube
u_m	mid-span deflection of the beam
ε	strain
ϕ	curvature
σ	stress

still rare. Filling RAC into steel tube is believed to be a solution for the structural use of RAC. The studies on RAC filled carbon steel tube members subjected to short-term static loadings [10,11], long-term sustained loads [12,13] and cyclic loadings [14,15] had recently been carried out. The results showed that RAC filled carbon steel tube members generally had the similar structural properties as the traditional concrete filled carbon steel tube members. RAC filled stainless steel tube (RACFSST) is a new kind of composite structure, and the durability of the structures with RACFSST can be greatly improved. Similar to RAC filled carbon steel tube, RACFSST also makes the RAC to be in a state of protection with the outer stainless steel tube, and core RAC is less likely to be affected by the harmful environmental factors (e.g. water, temperature and wind). Furthermore, RACFSST can broaden the application area of stainless steel. To date, there is no information for the structural behaviour of RACFSST members.

The aim of the present study is to experimentally investigate the structural behaviour of RACFSST stub columns and beams under short-term loadings, and the results of 28 specimens, including 14 stub columns and 14 beams, are presented and analysed. Both recycled coarse aggregate (RCA) and recycled fine aggregate (RFA) were considered in the tests, and the recycled aggregate replacement ratio (r) varied from 0 to 75%. The experimental results showed that the RACFSST stub columns and beams still had the stable load versus deformation responses and the good deformation-resistant ability. The accuracy of the calculated bearing capacity, bending moment capacity and flexural stiffness of RACFSST specimens by using the design formulae in ACI 318-05 [16], AIJ [17], ANSI/AISC 360-05 [18], BS 5400-5 [19], DB21/T1746-2009 [20] and EC4 [21] was evaluated based on the comparison with the experimental results.

2. Experimental investigations

2.1. Test specimens

Twenty-eight composite specimens, including 14 stub columns and 14 beams, were experimentally investigated in this study. Fig. 1 shows the cross section of the specimens, where D is the outside diameter or width of circular or square stainless steel tube, respectively, and t is the wall thickness of stainless steel tube. All specimens have the same diameter (width) to wall thickness ratio. The main parameters varied in the tests include: (1) cross-section of stainless steel tube: circular and square, and (2) r: 0 (CFSST), 25%, 50% and 75%. Both RCA and RFA are considered in the tests, and r is defined as the ratio of RCA or RFA mass to the mass of all coarse or fine aggregate, respectively.

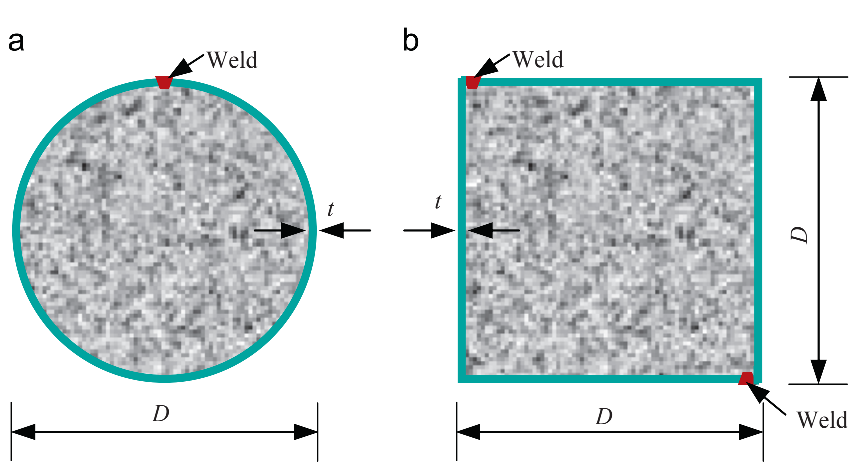

Fig. 1. Cross section of the specimens. (a) Circular section. (b) Square section.

Download English Version:

https://daneshyari.com/en/article/309268

Download Persian Version:

https://daneshyari.com/article/309268

Daneshyari.com