ELSEVIER
Journal of Constructional Steel Research
Volume 53, Issue 2, February 2000, Pages 121-147

Assessment of current methods for the design of composite columns in buildings

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https://doi.org/10.1016/S0143-974X(99)00062-0
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Abstract

This paper presents the design assessment of encased I-sections and concrete filled composite columns based on the approaches given in Eurocode 4: Part 1.1, BS 5400: Part 5 and AISC LRFD. This includes studies on the design parameters, comparison of the nominal strength predicted by the three codes and comparison of the predicted strengths with the available test results. In some cases, results obtained from the above three codes may vary considerably. This is because of the different design considerations adopted in these codes. However, the design methods are found to be mostly conservative when compared with the test results. Eurocode 4: Part 1.1 has major factors in its favour in terms of its comprehensiveness and wide scope of application.

Introduction

A composite column is defined as a compression member which may either be a concrete encased steel section or a concrete filled hollow section. Some typical cross-sections of double-symmetrical composite columns are shown in Fig. 1. Composite columns have gained acceptance for high-rise buildings as an alternative to pure reinforced concrete during the past decades. The advantages of using composite column are: (1) smaller cross-section and higher strength-to-weight ratio than a conventional reinforced concrete member, (2) significant savings in material and construction time, (3) inherent ductility and toughness for use in repeated and reversal loads, (4) enhanced fire resistance characteristics when compared to plain steel, (5) higher load carrying capacity due to the composite action of steel and concrete and confinement of concrete in the case of in-filled columns, and (6) higher rigidity for use in lateral-load resisting systems.

Several commonly used methods, which are now available for designing composite columns, include Eurocode 4: Part 1.1 [1] (to be referred to as "EC4"), BS 5400: Part 5 [2] (to be referred to as "BS 5400"), and AISC LRFD [3] (to be referred to as "LRFD"). In the United States, design provisions for composite columns are currently included in both the ACI-318 [4] and LRFD specifications. The concept of applying LRFD to composite columns was first presented by Furlong in 1976 [5]. The method of EC4 was based on the work of Roik and Bergmann [6] and others, while the recommendations given in the BS 5400 were developed by Basu and Somerville [7] and modified by Virdi and Dowling [8].

The aim of the present investigation is to assess the current methods for evaluating the ultimate load behaviour of steel–concrete composite columns and to recommend design guidelines for these columns. Major codes such as EC4, BS 5400 and LRFD are studied and compared to investigate their differences. Typical designs were carried out to determine the similarities and discrepancies of various codes. Discrepancies in the predicted nominal strengths by the three codes were also highlighted. Finally, conclusions are given and future research needs are identified.

Section snippets

Comparison of EC4, BS 5400 and LRFD methods

A study performed by Liew et al. [9] shows that the use of EC4, BS 5400 and LRFD for the design of composite columns does not necessarily converge to the same result. This is because of the differences in load and resistance factors, design parameters and other design considerations such as creep, eccentricity, etc. The following sub-sections will discuss and compare some of these parameters used in the three codes....

Strength comparsion of EC4, BS 5400 and LRFD

A comparison is made between the nominal strength of columns computed using EC4, BS 5400 and LRFD methods. All the partial factors of safety for materials used in EC4, BS 5400 and the resistance factor used in the LRFD are set to unity. This will give an unbiased comparison of the resistance predicted by the three methods since each method has its own resistance factors which are used with the corresponding load factors.

For this study, the column is assumed to be pin supported at both ends and...

Comparison with test results

The predicted column strength based on EC4, BS 5400 and LRFD are compared with the test results of SSRC Task Group 20 [13] and Shakir et al. [14]. In this comparison, both the axially loaded and eccentrically loaded fully encased, concrete filled circular and rectangular composite columns are considered.

In order to compare the predicted strength with the test results, the material partial safety factors of both steel and concrete are taken to be equal to unity. It should be noted that in the...

Conclusions and further research

The comparisons and conclusions given in this paper are based on a limited range of published experimental data. Within the present scope of work and investigation carried out, the following conclusions may be made:

1. The approach in BS 5400 gives a higher increase in concrete strength due to the confinement effect of concrete at low slenderness ratio as compared to EC4....

2. There is a marked difference between EC4 and BS 5400 in the critical slenderness parameter, λ, above which the confinement...

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Acknowledgements

The investigation presented in this paper is part of the research programme on "advanced analysis for the design of composite structures" carried out in the Department of Civil Engineering, National University of Singapore, and is funded by research grants RP 3981614....

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2022, Structures

Citation Excerpt :

...Because of the application of shear connectors and the bonding action between materials, the H-shaped steel, rebars, and the concrete can provide a strong composite action by working together and leverage their respective advantages [3]. SRC structures have the merits of high strength and high stiffness and are suitable for structures with heavy loads [4]. Through several earthquakes and numerous experimental studies, the superior seismic performance of SRC structures has been approved [5–6]....

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...Thus, investigation on the bending behaviour of CFST columns with UHPFRC becomes a key concern to promote the applications of this new structural member. The axial compressive performance of the CFST columns with NWC have been extensively reported [8–11]. Zhou et al. [12] studied slender CFST columns with NWC over combined axial compression and bending moment....

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...Few studies have been conducted on composite structures such as steel reinforced concrete (SRC) structures. SRC composite members are mainly used in large scale buildings such as high-rise buildings (Saw and Liew, 2000; Shanmugam and Lakshmi, 2001; Spacone and El-Tawil, 2004); 54% of high-rise buildings over 200 m completed in 2014 employed composite members, which is the largest proportion to date and is still increasing according to a report (Safarik and Wood, 2014). Because SRC is a composite member consisting of three component materials of concrete, steel shape, and steel rebar, its performance and CO2 emissions are dependent on the proportion or combination of each component material....

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