HBRC Journal (2015) 11, 339–352

Housing and Building National Research Center

HBRC Journal

http://ees.elsevier.com/hbrcj

Experimental and finite element study on the inelastic lateral buckling behavior of coped I-beams

Abdelrahim K. Dessouki, Sherif A. Ibrahim, Seham A. El-Sa'eed *

Structural Engineering Department, Ain Shams University, Abbasia, Cairo, Egypt

Received 7 March 2014; revised 6 June 2014; accepted 16 June 2014

KEYWORDS

Lateral torsional buckling;
Coped I-beams;
Finite element;
Local buckling

Abstract An experimental study of inelastic lateral torsional buckling of coped beams with simply supported ends is presented in this paper. Six full scale coped steel I-beam tests were conducted. The test parameters include the aspect ratio of cope length to beam depth at coped region as well as the ratio of cope depth to beam depth. The results of tests were compared with finite element model results. The test results showed that a reduction in the inelastic buckling load due to coping could reach more than 60% of the uncoped buckling capacity. A group of twelve finite element models for steel coped beams are investigated. The study takes into consideration variable parameters such as cope depth and length. A comparison between uncoped models and models with different geometrical parameters, is performed. The finite element results showed that both the cope length and cope depth have a significant influence on the lateral torsional buckling capacity. A parametric study of coped beams with stiffeners at coped region is reported in this paper. Based on the results of coped beams strengthened with either horizontal or vertical stiffeners, it is found that for cope depth to beam depth $(d_c/D) \geqslant 0.25$; both horizontal and vertical stiffeners are required to prevent local web buckling at the coped region.

Introduction

In steel construction, when beams are connected to girders at the same elevation, beam flanges must be coped to provide sufficient clearance for proper attachment as shown in Fig. 1. Beams can be coped at the top, bottom, or at both flanges. When a beam is coped, the lateral torsional buckling of the beam will be affected [1]. Cheng and Snell [2] carried out both experimental and analytical studies on elastic lateral buckling of coped beams. Very little experimental data are available regarding in-elastic lateral buckling of coped beams. Michael

* Corresponding author. Tel.: +20 1006922483.
E-mail address: arrows_ahmed@yahoo.com (S.A. El-Sa'eed).

Peer review under responsibility of Housing and Building National Research Center.

Production and hosting by Elsevier

1687-4048 © 2014 Production and hosting by Elsevier B.V. on behalf of Housing and Building National Research Center.
http://dx.doi.org/10.1016/j.hbrcj.2014.06.009

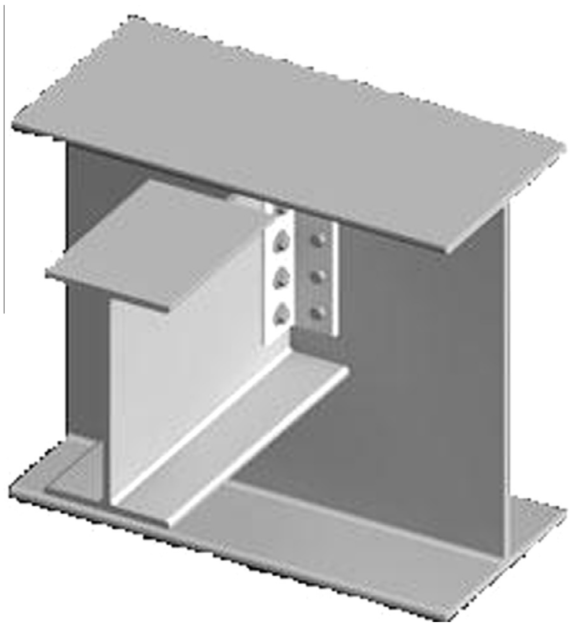

Fig. 1 Typical coped beam-to-beam connection.

and Lam [3] studied experimentally the effect of inelastic buckling of coped beams, and compared the results with the theoretical results by Cheng and Snell [2], they found the maximum reduction in strength due to the effect of residual stresses and initial imperfections to be 35% for short and braced specimens. Maljaarsa et al. [4] presented numerical models to study the effect of lateral torsional buckling to (coped) beams with end plates and they recommended not to use stocky beams with large copes in combination with short end plates, as this gives the largest reduction of the ultimate buckling resistance of all studied connections. Yam et al. [5] presented an experimental study of the strength and behavior of reinforced coped beams, they recommended for a coped beam section with a larger d/t_w ratio, a stiffener arrangement consisting of longitudinal and transverse stiffeners. Yam and Chung [6] proposed reinforcement details accounted for the effects of various cope details and the results show the reinforcements were able to increase the capacity of the coped beam specimens.

Cheng et al. [7] studied both lateral and local buckling of coped beams, as well as possible strengthening of coped region. They recommended using stiffeners at the coped region in order to improve the buckling strength of coped beams. However, no theoretical data are available for stiffening coped I-beams for inelastic lateral torsional buckling. A parametric analysis of coped beams for inelastic buckling behavior is presented herein and is developed to investigate the influence of stiffened copes on coped beam lateral buckling resistance.

An experimental study of coped I-beams under two symmetrical point loads is considered herein. The effect of coping on the type of failure of coped beams is also studied. Six tests are conducted for coped beams with different coping details. Fig. 2 shows the coped beam details. Finite element analyses of all test specimens are also presented in this paper.

In light of these investigations, a finite element analysis methodology has been developed to investigate the influence of cope depth and length ratios. The results of the parametric study along with general recommendations are also presented.

Problem statement

The study of the elastic lateral torsional buckling of coped beams by Cheng et al. [7] investigated only coped beams under mid-span point load. Study of two symmetrical point loads is taken into consideration in this study both experimentally and numerically. It also discusses the effectiveness of using different types of horizontal and vertical stiffeners for strengthening coped beams.

Test program

Tested coped beams

Six tests were conducted to study the inelastic lateral torsional buckling strength of coped beams loaded at their top flanges of the beams. The copes and connection details are shown in Fig. 3. Built-up sections with web 200×5 mm and flanges 125×8 mm of nominal yield strength of 345 MPa are investigated. The beams' cross sections are classified as compact sections to insure avoiding local buckling in the failure mode. The nominal measured dimensions are given in Table 1. Test beams have designations as described below;

180-B-0.25

C"cope length" - Beam - d_c/D"cope depth to beam depth"

"Uncoped specimen" with no cope is used as a pilot test for comparison. Specimens 120 and 360-B-0.25 have the same cope depth but with different cope lengths. Conversely, 180-B-0.1 to 0.50 have the same cope length but with different cope depths. All models have a span of 3000 mm. In order to minimize the end restraints, a conservative pined ended condition is assumed. A double clip angle connection is used in the tests as shown in Fig. 3. The clip angle was bolted between the web

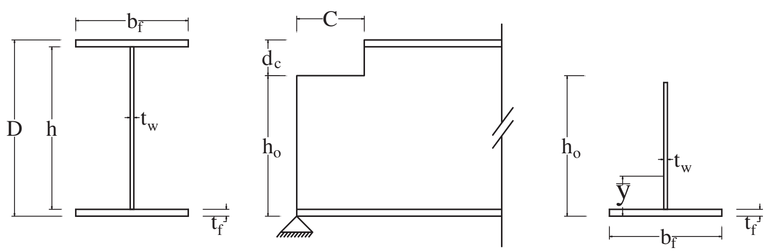

Fig. 2 Cope details designation **"After Cheng and Yura" [5].