Thin-Walled Structures 98 (2016) 351–359

Contents lists available at ScienceDirect

Thin-Walled Structures

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

Local-distortional buckling interaction on cold-formed steel lipped channel beams

M. Anbarasu

Department of Civil Engineering, Government College of Engineering, Salem 636 011, Tamilnadu, India

ARTICLE INFO

Article history:
Received 16 April 2015
Received in revised form
3 October 2015
Accepted 3 October 2015
Available online 19 October 2015

Keywords:
Direct strength method
Distortional buckling
Local buckling
Lipped channel column
Local-distortional interaction
Finite element analysis

ABSTRACT

This paper deals with the ultimate strength, post-buckling behaviour and design of cold-formed steel lipped channel beams affected by local-distortional buckling mode interaction, subjected to uniform bending of the major axis. The cross-sectional dimensions and length of the beams were chosen to have almost equal local and distortional critical buckling stresses by using the G_{BTUL}-2.0β and CUFSM software. The beams are analysed under pinned with warping free end conditions. 12 sections were selected for this study. The selected sections satisfy the geometric limitations for pre-qualified sections in AISI-S100:2007. Elastic buckling and non-linear finite element analyses were carried out using ABAQUS. The results were compared with corresponding results from experiments available in the literature. The numerical parametric study of 60 analyses of different geometries and yield stress values was undertaken. Based on the comparison of ultimate strengths obtained from the finite element analysis and Direct Strength Method (DSM), a design equation is proposed for lipped channel sections which have their elastic local and distortional buckling moments nearly equal.

1. Introduction

Cold-formed steel beams are widely used in the construction industry because they are light in weight, easy to install and erect and are economical. Cold-formed steel beam members which are commonly used as girts and purlins are C- and Z- sections. The behaviour and strength of bending member are mainly influenced by coupled instabilities. Local plate buckling, distortional buckling, global flexural or lateral-torsional buckling modes can occur separately or interact with each other depending on the cross-section shape and length. The buckling modes that may arise in lipped channel beams are (i) local modes, either triggered by the web or by the compressed flange, (ii) distortional mode and (iii) global (lateral-torsional) modes. Local buckling is particularly prevalent and is characterized by the relatively short-wavelength buckling of individual plate elements. Distortional buckling involves both translation and rotation at the compression flange/lip fold line of the member. The commonly used cold-formed steel C-section beam members (cross-section dimensions and length) may lead to rather similar local (L) and distortional (D) buckling moments. Their post-buckling behaviour, ultimate strengths and failure mechanisms are likely to be strongly affected by coupling / interaction effects involving these two buckling modes.

A detailed literature survey of previous work related to the flexural behaviour of and strength of the CFS C-section with L–D interaction was conducted. Very little information was found.

Linder and Aschinger [1] proposed alternative design procedures to address the load capacity of cold-formed steel beams subjected to both lateral-torsional buckling and local plate buckling effects. Put et al. [2] performed lateral buckling tests of simply supported and unbraced cold-formed steel lipped channel beams subjected to mid-span loading. Pi et al. [3] conducted a numerical study to investigate the elastic lateral-distortional buckling, inelastic behaviour and strengths of cold-formed steel beams and developed improved design rules for lateral-distortional buckling. An extensive series of tests was performed on industry standard cold-formed steel C and Z beams to study local buckling [4] and distortional buckling [5,6] failures. Silvestre and Camotim [7] proposed closed-formed formulae for distortional buckling, although limited to specific sections and based on simplifying assumptions. Schafer developed a comprehensive method for the design of thin-walled cold-formed steel columns and beams including distortional buckling using Direct Strength Method (DSM) [8].

Dinis and Camotim [9] numerically investigated the post-buckling behaviours of lipped channel beams affected by L/D interaction involving flange and web-triggered local buckling with different imperfection magnitudes over two cross sections. They conclude that, in the flange triggered beams, the pure local initial imperfections are the most detrimental ones, in the sense that

E-mail address: gceanbu@gmail.com

http://dx.doi.org/10.1016/j.tws.2015.10.003
0263-8231/

Nomenclature

A	cross-sectional area (mm^2)
b	flange width (mm)
d	lip depth (mm)
E	Young's modulus of elasticity (MPa)
f_y	yield stress (MPa)
h	web depth (mm)
L	Length of column (mm)
M_{crd}	critical elastic distortional buckling moment (kN m)
M_{cre}	critical elastic lateral-torsional buckling moment (kN m)
M_{crl}	critical elastic local buckling moment (kN m)
M_n	nominal flexural strength (kN m)
M_{nd}	nominal flexural strength for distortional buckling (kN m)
M_{ne}	ominal flexural strength for lateral-torsional buckling (kN m)
M_{nl}	nominal flexural strength for local buckling (kN m)
M_{nld}	nominal interaction flexural strength (kN m) accounting for interaction of local and distortional buckling
$M_{u,FE}$	ultimate moment capacity obtained from finite element analysis (kN m)
$M_{u,test}$	ultimate moment capacity obtained from the experiment (kN m)
M_y	yield moment capacity (kN m)
t	thickness (mm)
Φ	capacity reduction factor

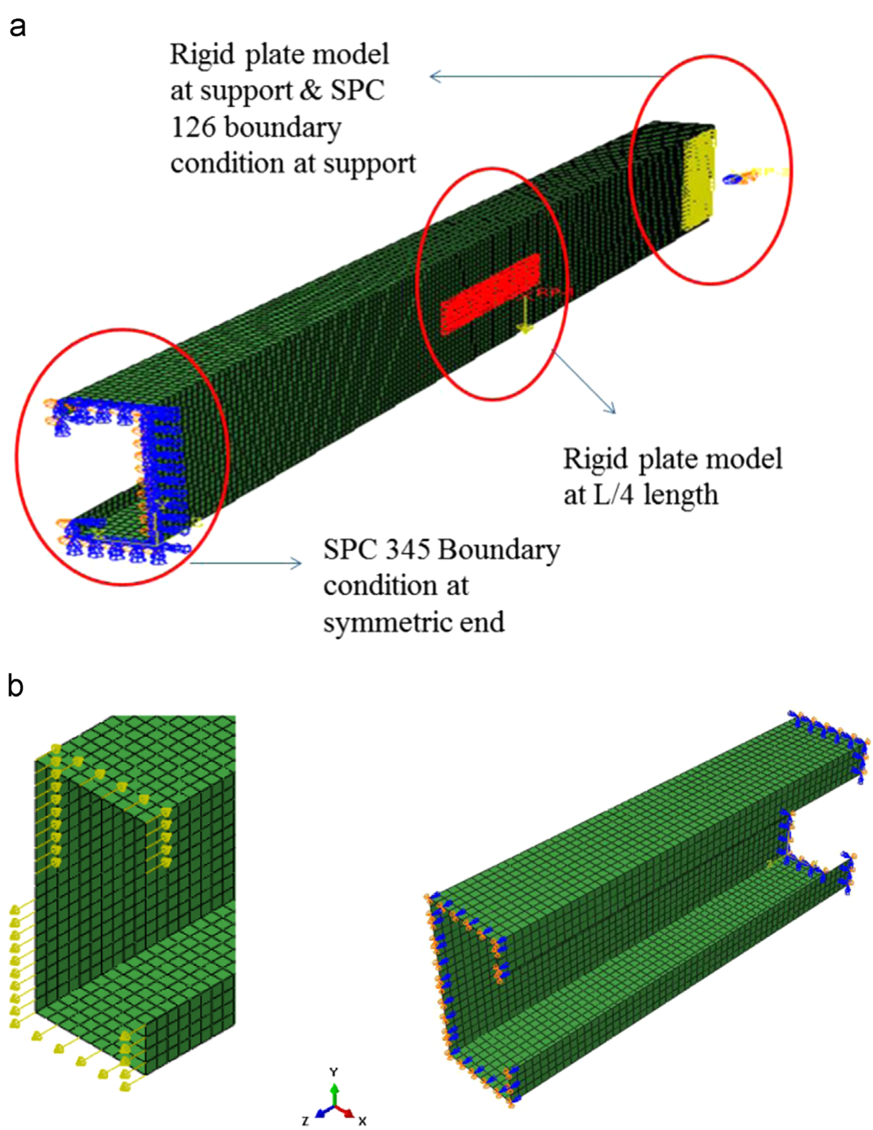

Fig. 1. Loading and Boundary Condition.

they lead to the lowest beam post-buckling strengths and ultimate moments. The study reveals that web triggered beams may exhibit a fair amount of elastic–plastic strength, reserve and ductility before the collapse. Moreover, the most detrimental initial imperfections are now the pure distortional ones with outward flange-lip motions. Nandini and Kalyanaraman [10] numerically