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Thin-Walled Structures 43 (2005) 1831–1851
THIN-WALLED STRUCTURES
www.elsevier.com/locate/tws

Simplified design approach for cold-formed stainless steel compression members subjected to flexural buckling

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Received 8 December 2004; accepted 26 August 2005

Abstract

The design criteria of stainless steel compression member are more complicated than those of carbon steels due to the nonlinear stress strain behavior of the material. In general, the tangent modulus theory is used for the design of cold-formed stainless steel columns. The modified Ramberg–Osgood equation given in the ASCE Standard can be used to determine the tangent modulus at specified level of stresses. However, it is often tedious and time-consuming to determine the column buckling stress because several iterations are usually needed in the calculation. This paper presents new formulations to simplify the determination of flexural buckling stress without iterative process. Taylor series expansion theory is utilized in the study for numerical approximations. The proposed design formulas are presented herein and can be alternatively used to calculate the flexural buckling stress for austenitic type of cold-formed stainless steel columns. It is shown that the column strengths determined by using the proposed design formulas have good agreement with those calculated by using the ASCE Standard Specification. A design example is also included in the paper for cold-formed stainless steel column designed by using the ASCE Standard equations and the proposed design formulas.

Keywords: Cold-formed stainless steels; Compression members; Specification; Tangent modulus; Flexural buckling; Numerical approximation

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0263-8231/$ - see front matter
doi:10.1016/j.tws.2005.08.006

Notation

A	Area of the full, unreduced cross section
A_e	Effective area of the cross section
b	Effective design width of compression element
C	Slenderness ratio, KL/r
C_o	Specified slenderness ratio at $F_n = F_y$
C_1	Limiting slenderness ratio at $F_n = F_1$
E_o	Initial modulus of elasticity
E_t	Tangent modulus
f	Nominal stress
F_y	Specified yield strength
F_1	Specified buckling stress with respect to C_1
F_n	Nominal buckling stress
$F_{n,\mathrm{ASCE}}$	Nominal buckling stress determined from ASCE Standard Specification
$F_{n,\mathrm{prop}}$	Nominal buckling stress determined from the proposed design formulas
I_x	Moment of inertia of x-axis
I_y	Moment of inertia of y-axis
k	Plate buckling coefficient
K	Effective length factor
L	Unbraced length of member
n	Coefficient used for determining the tangent modulus
P_n	Nominal axial strength of member
r	Radius of gyration
t	Thickness of the section
w	Flat width of element exclusive of radii
α	$E_o/E_t - 1$
β	Constant
ϕ_c	Resistance factor for axial strength
λ_o	Parameter used for determining buckling stress
λ_1	$1 - \lambda_o$
ρ	Reduction factor
λ	Slenderness factor

1. Introduction

For the design of cold-formed stainless steel compression members, the ASCE Standard Specification can be used to determine the design axial strength. The current specification was published in 2002 by ASCE as SEI/ASCE 8-02 [1]. This updated edition of the Specification is a revision of the ASCE Standard published in 1991 [2]. Due to