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Overall buckling behavior of 460 MPa high strength steel columns: Experimental investigation and design method

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ABSTRACT

Overall buckling behavior of compression columns is one of the most important research subjects in steel structures, especially for high strength steel which has been increasingly applied in recent years. An experimental investigation was carried out to study the overall buckling behavior of 460 MPa high strength steel compression members. Totally twelve columns including welded box and I-sections were comprised. The initial imperfections such as the residual stress, initial bending and loading eccentricity were all measured. Based on experimental results the buckling deformation and capacity were investigated. A finite element model was established and further validated by comparing with the test data in both present study and other previous researches, in which initial imperfections were taken into account. A large number of columns with various section dimensions and lengths were calculated by using the validated model, and their buckling capacities were compared with design values according to different steel structures specifications. It was found that the nondimensional buckling strength of such 460 MPa high strength steel columns were significantly improved compared to normal strength steel columns, and corresponding column curves and design formulae were suggested.

1. Introduction

High strength steel (HSS, with the nominal yield strength more than 460 MPa) structures have been increasingly used in recent years [1–4], due to their advantages in structure safety, architecture function, economics and resource saving etc. The scope of current design specifications in most countries are limited to normal strength steel (NSS) structures such as the Chinese code GB50017-2003 [5,6]. Some of them allow the use of HSS like Eurocode 3 [7,8] and ANSI/AISC 360-10 [9], which extend the scope up to the steel grades of S700(700 MPa) and A514(690 MPa) respectively; however the overall buckling design provisions for columns in these two standards are mainly based on relevant researches on NSS structures [10,11].

The overall buckling behavior of HSS columns may be characterized differently from that of NSS columns due to different material properties and manufacturing processes. For HSS columns, the ratio between sectional residual stress magnitude and steel yield strength is significantly reduced because the latter is much higher than NSS. It was primarily concluded that effects from residual stresses were less severe thus the overall buckling behavior of HSS columns was improved when compared on a nondimensional basis [12]. In addition, effects from initial geometric imperfections on HSS columns were indicated to be reduced because of the higher yield strength [1]. As a result, the existing design provisions may not be always applicable for HSS columns and may underestimate the buckling strength, and corresponding experimental investigations and design methods become necessary.

Up to now, only a few studies were performed to investigate the overall buckling behavior of HSS columns. 11 welded box and I-section long columns fabricated from 690 MPa HSS were comprised in [12], aiming to investigate whether HSS columns with yield strengths in the range of 450 MPa to 700 MPa can be designed according to existing specification rules or whether these rules need to be modified to include HSS. It was indicated that the overall buckling capacity of HSS columns were stronger than that of NSS columns when compared on a nondimensional basis, and a higher column curve was selected for such columns according to the Australian steel structures standard AS4100. 6 welded built-up box long columns with compact section made of 690 MPa HSS were tested in [13]. Along with other columns with noncompact sections, the local and overall interaction buckling strength of such HSS columns was studied and an empirical design formula was presented. Recently, a finite element model was established in [14] to simulate the overall buckling behavior of column specimens reviewed above, and the calculation results described the experimental buckling capacities well. The authors also tested 8 welded I-section columns with end restraints made of S690 and S960 HSS in [15] and 60 Q420 (420 MPa) steel angle columns in [16] to qualify their overall buckling behavior, and the improvement of nondimensional buckling strength for HSS columns was also found. However, there are few corresponding numerical studies in existing literatures, and more experimental investigations for other HSS grades were in need.

This paper described an experimental program to investigate the overall buckling behavior of 460 MPa HSS compression slender

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