Local Buckling Strength and its Statistical Information of Normal and Bridge High Performance Steel Plates

Viet Duc DANG
PhD student, Dep. of Civil and Environmental Eng., Saitama University, Saitama, Japan
dangviet.duc@gmail.com

Yoshiaki OKUI
Professor, Dep. of Civil and Environmental Eng., Saitama University, Saitama, Japan
okui@mail.saitama-u.ac.jp

Koichi HAGIWARA
Master student, Dep. of Civil and Environmental Eng., Saitama University, Saitama, Japan
alexander.f.f.9@gmail.com

Masatsugu NAGAI
Professor, Dep. of Civil and Environmental Eng., Nagaoka University of Technology, Nagaoka, Japan
nagai@nagaokaut.ac.jp

Summary

The current Japanese design equation for load-carrying capacity of compressive steel plates is examined for four conventional steel grades and new bridge high performance steel grades SBHS500 and SBHS700. The analysis results of FEM plate models with initial imperfections show that the current Japanese design specification is un-conservative within the range 0.5<R<0.75 and over-conservative in the range R>0.8, where R is the slenderness parameter. Statistical distribution of the normalized compressive strength is obtained by means of Monte Carlo simulation in combination with the response surface which is obtained from sufficient number of FEM plate model analyses. Both initial out-of-plane displacement and residual stress are considered as sources of variability. The mean values of normalized compressive strength in this study are similar to those obtained from experimental tests [14]. The standard deviation of the current study exhibits about half of the experimental results [14] within the practical range 0.6<R<1.2.

Keywords: bridge high performance steels, compressive strength, residual stress, initial deflection, local buckling.

1. Introduction

Box columns and box plate girders consisting of unstiffened steel plates are widely used in bridge structures. The local buckling strength of the steel plates frequently governs the load-carrying capacity of these structural elements.

The current compressive strength design equation for unstiffened plates in Japanese Specifications for Highway Bridge (JSHB) version 2002 [2] has been originally proposed in 1980 [3]. This equation was based on experimental data for normal steel with yield strengths mainly less than 450 MPa. The bridge high performance steels, which poses high yield strength and good weldability, have been standardized since 2008 as SBHS500 and SBHS700 in Japanese Industrial Standard (JIS) [4]. However, SBHS steels exhibit different inelastic behaviour from conventional steels, such as almost no yield plateau and greater yield-to-tensile strength ratio. Hence, it is necessary to examine the applicability of the current compressive strength design equation of JSHB to steel plates with new steel grades.

Regarding the compressive strength design equation of JSHB, Usami and Fukumoto [5], Usami [6], and Kitada et al. [7] show that the design equation is un-conservative within the range 0.5<R<0.75 (intermediate range) and over-conservative in the range R>0.8 (slender range), in which R is the slenderness parameter. However, studies [5], [6] consider only the normal (SM490Y) steel plates and they employed the perfectly elstoplastic assumption for modeling the inelastic behavior of steel material.

For theses reasons, the compressive strength design equation of JSHB need to be examined and

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