Effect of Initial Web Out-of-Flatness Imperfections on the Shear Strength of Low-Frequency Sinusoidal Plate Girders

Parfait M. Masungi, Maria E.M. Garlock

Princeton University, Princeton, NJ, USA

Spencer E. Quiel

Lehigh University, Bethlehem, PA, USA

Contact: pmasungi@pricnceton.edu

Abstract

Slender steel plate girders with deep webs provide flexural and shear strength to resist large loads. However, under shearing forces, web plates are susceptible to shear buckling. During the forming and fabrication of plate girders, initial out-of-flatness imperfections on the web plate are introduced and have demonstrated to reduce the shear buckling strength. Existing measures to enhance the shear buckling strength and improve the behavior of flat steel plate girders include welded stiffeners or corrugated web plate profiling. These methods introduce practical and fabrication challenges as well as increased labor and material for fabrication. Therefore, to overcome these challenges and improve the performance of steel plate girders, the authors propose an alternative to enhance the shear buckling strength of thin steel plates by imposing a low-frequency sinusoid (LFS) shape along the web's longitudinal axis. This paper evaluates the effect of initial web out-of-flatness imperfections on the shear strength and behavior of plate girders fabricated with LFS webs. Additionally, comparisons with numerically developed LFS plate girder specimens are provided. Overall, this work demonstrates that LFS webs can enhance the shear strength, design, efficiency, and economy of plate girders.

Keywords: steel; shear buckling; low-frequency sinusoidal web; bridges; finite element; plate girders, shear strength

1 Introduction

Welded steel plate girders with flat slender webs bounded by a top and bottom flange have been used for many years in the construction and design of bridges. Plate girders with slender webs provide resistance to large shear forces over short and long-span longitudinal lengths [1]. However, when subjected to shearing forces, slender webs are limited and susceptible to shear buckling failure. Furthermore, the shear strength of slender webs can decrease due to inevitable geometric web out-of-plane (out-of-flatness) imperfections that develop during fabrication and erection from the forming, welding, and assembly process [2]. To prevent shear buckling and enhance the shear strength of slender webs in the design and construction of plate girders, transverse stiffeners are welded to the web and flanges as shown in Figure 1(a) [3]. Also, corrugated webs with trapezoidal, triangular, or sinusoidal geometries as shown in Figure 1(c) have been utilized to enhance the shear strength of slender webs. Even though the use of transverse stiffeners or corrugated webs provides increases in the shear strength, these enhancement strategies have adverse impacts

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