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Low-Frequency Sine Webs for Improved Shear Buckling Performance of Plate Girders

Peter Y. WANG
Graduate Student
Princeton University
Princeton, USA
pywang@princeton.edu

Wang is a PhD Candidate with research interests in shear buckling, steel design and bridge engineering.

Maria E. GARLOCK
Professor
Princeton University
Princeton, USA
mgarlock@princeton.edu

Prof. Garlock studies the response and design of steel structures to extreme loads such as earthquake and fires.

Theodore P. ZOLI
National Bridge Chief Engineer
HNTB Corporation
New York, USA
tzoli@hntb.com

Zoli has led the design of numerous first of its kind bridges.

Spencer E. QUIEL
Assistant Professor
Lehigh University
Bethlehem, USA
seq213@princeton.edu

Professor Quiel's research focuses on the resistance of buildings, bridges, and tunnels to extreme loads.

Contact: pywang@princeton.edu

1 Abstract

Steel plate girders are used extensively in buildings and bridges. Given shear rarely governs, minimizing web thickness is desirable. However, web slenderness can enable shear buckling and fatigue problems. The traditional strategy is to use welded transverse stiffeners; yet transversely-stiffened girders are prone to fatigue cracks and difficult to fabricate at high slenderness ratios. Thus, AASHTO currently limits web slenderness to 150. Alternatively, corrugated web girders overcome these deficiencies but require robotic welding for the web-to-flange weld. Corrugated webs are also limited to small web thicknesses (6mm or less) and girder depths (less than 1.5m) given web forming limits. The authors propose an alternative web geometry, introducing low-frequency sinusoids (LFS) in the web along its length. The LFS web can be welded to the flanges using semi-automatic weld techniques currently employed by bridge fabricators. The reduced web curvature allows for a wider array of web forming techniques with much larger plate thicknesses. In a finite element study, web geometric properties such as sinusoidal frequency and amplitude are varied. Results demonstrate a significant increase in the elastic shear buckling load and ultimate strength using a wavelength equal to the depth of the girder. The results of this study show promise for improved girder durability paired with material efficiency, demonstrating that a web product with constant amplitude and wavelength could work for various girder depths up to 3m and above.

Keywords: shear buckling; low-frequency sine web; sinusoidal web; corrugated web; finite element; bridges

2 Introduction

Steel plate girders with slender webs are used extensively in building and bridge construction, due to their advantageous ratio of self-weight to span stiffness. However, web slenderness can give rise to shear buckling and fatigue problems that compromise a structure's lifetime. Design loading can cause girder webs to buckle in-and-out of plane (i.e. web breathing), contributing to fatigue failure [1]. The goal of this paper is to enhance the shear buckling performance and longevity of slender plates by introducing low-frequency sinusoids (LFS) into the web plate geometry.

Slender plate girder design is often governed by web shear buckling, occurring at the elastic shear buckling load V_{cr} [2]. To resist web shear buckling, vertical stiffeners are often welded onto web plates at regular intervals. The space between stiffeners is equal to "a" and defines the "panel." Stiffeners increase a web plate's V_{cr} by restraining out-of-plane displacement and reducing web panel aspect ratios to a/D, where D equals the web

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