

ABSTRACT

Sherman, Ryan J. Ph.D., Purdue University, December 2015. Standards to Control Fracture in Steel Bridges Through the Use of High-Toughness Steel and Rational Inspection Intervals .
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Non-redundant steel bridge systems have been used for major bridges in the United States since the late 1800's. Designers recognized the inherent structural efficiency and economy associated with two-girder and truss systems. Unfortunately, early knowledge was limited regarding fatigue, fracture, and overall system behavior; subsequently, a small number of these structures experienced fatigue and fracture issues leading to the creation of the Fracture Control Plan (FCP). The FCP resulted in more stringent design, material, fabrication, and inspection requirements for non-redundant steel bridges; specifically, a 24-month hands-on inspection criteria for all fracture critical members was established. Significant advances have been made over the past 40 years since the original FCP was introduced. Developments in fracture mechanics, material and structural behavior, fatigue crack initiation and growth, and fabrication and inspection technologies now allow fracture to be addressed in a more integrated manner. Through these advances, it is now possible to create an integrated FCP, combining the intent of the original FCP with modern materials, design, fabrication, and inspection methodologies. The current study is focused on the development of new design standards which founded an integrated approach to prevent fracture in steel bridges through the use of high-toughness steel. The project is comprised of small-scale material testing, full-scale fracture testing of steel bridge axial and bending members, three-dimensional finite element modeling, and an analytical parametric study. Results from this research demonstrate large defects are well-tolerated by high-toughness steel. Further, rational inspection intervals were calculated to demonstrate how an integrated FCP will allow for a better allocation of owner resources while also leading to increased steel bridge safety.