ABSTRACT

Author: Korkmaz, Cem, PhD
Institution: Purdue University
Degree Received: May 2018
Title: Evaluation of Redundancy in Composite Twin-tub-girder Bridges with Finite Element Analysis
Major Professor: Robert J. Connor

High torsional rigidity, attractive aesthetics and great economy in construction of twin-tub girder bridges make them preferable for the design of curved bridges. However, according to the concepts associated with the term "Fracture Critical (FC)" that are in place today, all two-girder bridges are always classified as non-redundant bridges and, therefore, have fracture critical elements. For a steel bridge with FC members, the fracture of any of its members may result in complete catastrophic failure or significant loss of serviceability; hence, every two years twin-tub girder bridges are subjected to very expensive hands-on field inspection.

Full-scale simple span twin-tub girder bridge tests at University of Texas Austin have demonstrated excessive load capacity of a fractured simple span bridge. A significant number of twin-tub girder bridges might be classified as redundant; however, this individual test is not adequate to define the comprehensive damage behavior of twin-tub girder bridges in general.

In this dissertation, 3D non-linear (material and geometric) detailed finite element (FE) analysis procedures which have been calibrated from full-scale testing providing confidence in the results were developed. The FE models included all the plastic and damage behavior of reinforced concrete deck, brace connections, all steel components of the super structure, stages of construction, and the effects of the dynamic amplification of the bridge immediately following the fracture. Detail work was also performed to define comprehensive shear stud behavior.

In this research, 21 twin-tub girder bridge units in the existing inventory of the Wisconsin Department of Transportation (WisDOT) were evaluated for the case where one of the two tub girders fails due to brittle fracture. The evaluation was completed using developed finite element model procedures and the failure criteria described in NCHRP (National Collaborative Highway Research Program) Project 12-87a, “Fracture-Critical System Analysis for Steel Bridges”. The analysis has concluded that all bridges analyzed possess considerable reserve strength in the faulted state and that the steel tub girders do not meet the definition of a fracture critical member. Additional analyses were also performed for some bridges with higher load factors than proposed in NCHRP 12-87a in order to investigate the actual expected failure mode. Additionally, three other typical designs commonly used by other owners were also analyzed; however, none of them has sufficient reserve strength in the faulted state. The effect of section dimensions, bridge continuity, before-fracture dead load displacement and intermediate diaphragms are discussed. Characteristics of bridges which perform well in the faulted stated, which appear to improve the after-fracture system performance of typical steel twin-tub girder bridges, are presented.