Energy Dissipating Stiff Diaphragms for Steel Bridges in Seismic Regions

Seyyed Mehdi Zahrai and Michel Bruneau

Ottawa-Carleton Earthquake Engineering Research Centre, Department of Civil Engineering, University of Ottawa, 141 Louis Pasteur, Ottawa, Ontario, Canada K1N 6N5

Paper Number 34
Full paper on enclosed CD-ROM

Recent earthquakes clearly demonstrated the seismic vulnerability of steel bridges supported by non-ductile substructures. While damage to superstructure components of these bridges is also possible, damage to substructure elements such as abutments, piers, bearings, and others has proven to be of far greater consequence, often leading to span collapses. To take advantage of the benefits granted by the presence of a steel superstructure, an innovative seismic retrofit strategy using ductile steel bridge end-diaphragms has been developed. By replacing the steel diaphragms at supports with ductile end-diaphragms calibrated to yield before the strength of the substructure is reached, the substructure can be protected.

In this paper, the proposed retrofit concept is described, the validity of the concept is briefly demonstrated, a simple and reliable design procedure applicable for hand calculation is developed and finally the concept is verified experimentally using large scale specimens. Analytical results suggested that the proposed ductile diaphragms exhibit an appropriate ultimate seismic behaviour and that the impact of intermediate diaphragms on seismic performance of the steel-on-steel bridges is minor. Results from testing of the specimens illustrated their large initial elastic stiffness, high strength and capacity to dissipate hysteretic energy. The BBE end diaphragm eventually failed at high inelastic lateral drifts, mainly owing to fracture and rupture of link beam's web in shear and local buckling of the link beam's flanges. The full-scale specimen without lateral support for the ductile devices reached a link distortion angle of 0.11 rad, corresponding to a deflection of 14 before failure. Although the specimen without diaphragm dissipated some hysteretic energy, its strength and stiffness degradation occurred early due to buckling of the web stiffeners and fracture of its welds. For such a system, large drifts might occur during earthquakes. © 1998 Elsevier Science Ltd. All rights reserved.
KEYWORDS

Steel bridge, ductile, out-diaphragm, seismic retrofit, energy dissipation, earthquake, substructure, nonlinear analysis, inelastic behavior.