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Summary

On August 1, 2007, the I-35W highway bridge over the Mississippi river in Minneapolis, MN collapsed. The subsequent National Transportation Safety Board (NTSB) investigation identified the U10W truss node as a likely initiation site for the failure. (Bridge main truss nodes were numbered from the south starting at 0. U indicates a node along the upper chord, and L indicates a node along the lower chord. E and W indicate a node on the east or west truss) [1, 2, 3].

Finite element analyses were performed to study the states of stress and strain in the gusset plates of the U10W joints, and to investigate potential instability in the bridge structure. A global-local approach was taken, in which a detailed three-dimensional U10W local model was embedded into the global bridge model provided by FHWA [1, 2, 3, 4].

As reported in [2], “the finite element computations indicated the bridge failure was initiated by a local structural instability before any localized material failure occurred. Additionally, the computations indicate that the structural instability that triggered the bridge collapse was a local bending instability in the U10W gusset plates.”

In this Technology Brief, the use of Abaqus in the investigation of the collapse of the I-35W bridge is outlined.

Key Abaqus Features and Benefits

- Riks method for the analysis of unstable, geometrically nonlinear structural collapse
- Ability to include stress-free geometric imperfections in a structure
- Submodeling capability for the study of a local part of a model with a refined mesh based on interpolating the solution from a global model
- Wide variety of kinematic constraints, including:
  - Shell-to-solid coupling
  - Mesh-independent fasteners
  - Kinematic coupling

Background

The I-35W bridge in Minneapolis was 1,907 feet long, with fourteen spans supported on thirteen piers carrying four lanes of traffic in each direction. The central 1,064 foot long deck truss portion of the bridge crossed the Mississippi river, and consisted of two parallel Warren-type trusses with verticals [1]. Each main truss had 56 connection points (nodes), where the vertical, horizontal, and diagonal members were joined with riveted gusset plates.

As part of studies and evaluations of the bridge during its working life, photographs of the east and west U10 nodes were taken in 1999 and 2003. While reviewing these photographs as part of the collapse investigation it was noted by the NTSB that all four gusset plates in the east and west U10 nodes showed visible ‘bowing,’ or out-of-plane displacement. This displacement was on the