



Structures Engineering Instructions (SEI)

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Approved: Wm. Michael Hedges **Date:** 3/31/2008
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Subject: **Design and Load Rating of Gusset Plate Connections in Steel Truss Bridges**

Administrative Information:

Effective Date: This SEI shall be effective for the Structures Section projects from the date of approval.

Superseded SEI: None.

Exceptions: No exceptions.

Disposition of SEI Content: The content of this SEI will be incorporated into a future revision to the Structures Manual.

Purpose:

To provide guidance to Structures Section Engineers on the requirements for the design and load rating of gusset plates in new, rehabilitated, and existing steel truss bridges.

Technical Information:

On Wednesday, August 1, 2007, the Interstate 35W (I-35W) highway bridge over the Mississippi River in north Minneapolis, Minnesota, experienced a failure in the superstructure of the 1,000-foot-long deck truss portion of the 1,900-foot-long bridge. Approximately 456 feet of the center span of the deck truss fell about 108 feet into the 15-foot-deep river. Approximately 110 vehicles were on the portion of the bridge that collapsed and 17 vehicles fell into the water. As a result of the bridge collapse, 13 people died and 145 people were injured.

Physical examination of the recovered bridge structure showed that some of the gusset plates were fractured, while other gusset plates in the main trusses were intact. Design methodology for gusset plates is normally very conservative, with the result that a properly designed gusset plate has a higher load carrying capacity than the members it connects. For that reason, one would not expect to find fractured gusset plates. However, the damage patterns and fracture features uncovered in the investigation to date suggest that the collapse of the deck truss portion of the bridge was related to the fractured gusset plates. Materials testing performed to date has found no deficiencies in the quality of the steel or concrete used in the bridge. Therefore, the National Transportation Safety Board (NTSB), with the Federal Highway Administration (FHWA), conducted a

thorough review of the design of the bridge, with an emphasis on the design of the gusset plates.

The investigation discovered that the original design process led to a serious error in sizing of some of the gusset plates in the main trusses. The results indicate that some of the gusset plates were originally undersized and did not provide the margin of safety expected in a proper design. Since it was built, the deck truss portion of the bridge has undergone at least two major renovations, one in 1977 and one in 1998. As part of these renovations, the average thickness of the concrete deck was increased from 6.5 inches to 8.5 inches, and the center median barrier and outside barrier walls were increased in size. These changes added significantly to the overall weight of the structure. The original error in the sizing of the gusset plates was not discovered during these renovations.

As a result of the investigation to date, the following guidelines shall be adhered to for VTrans Structures projects.

- 1) New steel truss bridges shall be designed such that the connection between members, including gusset plates, welds, pins, and/or bolts, shall meet applicable AASHTO requirements and have the required structural capacity for all applicable load cases. The load cases shall include consideration of the loading of the structure during all phases of construction.

Design calculations shall be included in the project design folder or provided by the supplier if the bridge is prefabricated. The original load rating shall include and document rating values for each of the connections. The design and rating calculations for connections in a new structure shall be AASHTO Load and Resistance Factor Design (LRFD) and Load and Resistance Factor Rating (LRFR), respectively.

- 2) Rehabilitated truss bridges shall have the structural capacity for all connections between members, including gusset plates, pins, rivets, bolts and/or welds, checked for all applicable load cases for the rehabilitated condition. The load cases shall include consideration of the loading of the structure during all phases of construction.

After rehabilitation all connections shall meet applicable AASHTO requirements and have the required structural capacity for all applicable load cases. Existing connections that do not have the required structural capacity shall be replaced. The structural capacity check shall consider section loss and the actual condition of the gusset plates, pins, rivets, bolts and/or welds. The load rating for the rehabilitated bridge shall include and document rating values for each of the connections. The design and rating calculations for connections shall be completed by the same code and methodology as all other components of the rehabilitated structure.

- 3) Existing steel truss bridge load ratings shall be reviewed (to ensure that the capacities of gusset plate connections were/are adequately considered) and shall be re-calculated as determined necessary, when:
 - a. There is inspector concern (ex. an inspector observes a gusset plate to be smaller/thinner than might be expected when compared to other gusset plates on the structure, gusset plate is showing evidence of buckling, etc.), or
 - b. Significant sectional area of a gusset plate connection has been lost due to deterioration or significant structural damage has occurred, or

- c. The loading is significantly altered by removing or adding dead loads (ex. adding rigid overlay, concrete barrier, etc.), or
- d. The loading is significantly altered by increasing the live loading on the structure (ex. increased permit loading).

The load rating of the connections for existing structures shall include the gusset plates, pins, rivets, bolts and/or welds. The rating shall include and document rating values for each of the connections. The rating calculations for the connections shall be completed by the same code and methodology as all other components of the structure.

Implementation:

The content of this SEI will be implemented immediately on all projects and existing structures and shall be in effect until further notice.

It is anticipated that FHWA will be issuing further guidance and examples for the design and rating calculations. It is also anticipated that AASHTO will be updating code provisions to address some of the design and rating requirements for connections.

Transmitted Materials:

FHWA Technical Advisory 5140.29
NTSB Safety Recommendation H-08-1