

A vertical strip of seven small images on the left side of the slide, showing various space-related scenes: a space shuttle on the launch pad, a rocket launch with a large plume of fire, a view of the Earth from space, a close-up of a spacecraft component, a view of a spacecraft in space, a view of a spacecraft's interior, and a view of a spacecraft's exterior.

A Half-Inch to Failure: Minneapolis Bridge Collapse

Leadership ViTS Meeting

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THE MISHAP

On Wednesday, August 1, 2007, the Interstate-35 West (I-35W) bridge in Minneapolis, Minnesota collapsed into the Mississippi River. Four weak gusset plates fractured under the combined burden of rush hour traffic, concentrated construction equipment, and previous, heavy renovations on the bridge. Of the 190 people on or near the bridge, thirteen died and 145 were injured.



The I-35W Bridge

I-35W was a steel truss bridge consisting of straight beams formed into triangular units. The ends of the beams were connected with riveted metal plates called gusset plates. Well-designed gusset plates can support 2-3 times the expected bridge loads, and are stronger than the beams they connect. The as-designed gusset plates on I-35W, however, were only half an inch thick...half as thick as needed.

What Happened?

Bridge History

1967: Newly constructed bridge opens to traffic.

1977: State adds two inches to the deck thickness. (Dead load increased by 13.4%)

1991: Inspectors label bridge “structurally deficient.” (Not uncommon for this bridge design; 31% of this bridge type labeled this way)

1994: Inspectors report gusset plate rust, corrosion, and section loss. No corrective action was indicated as needed.

1998: State installs a median barrier to bridge decking. (increases dead loading by another 6.1%)

1999: Photographs show bowed gusset plates; inspectors dismiss bowing as an artifact unchanged since original construction.

June 2007: Contractors begin resurfacing the bridge.

August 1, 2007: Day of the collapse.

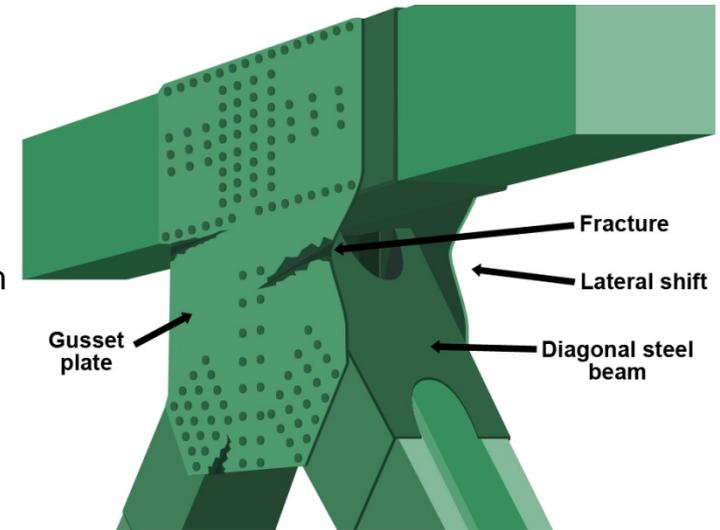
2:30 pm: Contractors place equipment and materials for the concrete pour on the bridge deck.

Evening : Normal rush hour traffic begins.

6:05 pm: The gusset plates fracture, causing the bridge to collapse. Bystanders rescue victims until emergency responders arrive.

7:26 pm: Sheriff changes response from rescue to recovery operations.

August 6, 2007: The last of the 13 people killed is recovered.



Artist's Rendering of a Fracturing Gusset Plate



PROXIMATE CAUSE

Integrity of gusset plates overwhelmed by improper design and the weight of rush hour traffic, previous additions to bridge deck and a concentration of heavy construction materials and equipment.

UNDERLYING FACTORS

Inadequate gusset plate design and insufficient review process.

- Gusset plates were half as thick as the design loading required.
- Design calculation error escaped contractor quality check.
- State design review did not provide a full verification of design work (not unusual).

Lack of attention to gusset plates in load ratings and inspections.

- Inspection engineer assumed gusset plates to be stronger than the attached beams.
- Inspectors failed to report the bowing of gusset plates for at least eight years prior to collapse assuming this to be an artifact present since construction.
- Inspectors reported corrosion but did not record dimensional changes (reduction of section thickness due to corrosion) to gusset plates over time.

Ill-Considered Creep in Loading Conditions.

- Renovations in 1977 and 1998 increased the dead load by 19.5% over the original design rated load.
- Contractor placed heavy equipment and material load in a concentrated area on the bridge deck.
- Rush hour traffic loads further stressed the bridge structure.

FOR FUTURE NASA MISSIONS AND OPERATIONS

System Evaluation

- Assess and evaluate adverse impact to systems when replacing components or removing portions of the system from design. Ensure the changes do not compromise safety, system efficiency, and system life cycle.

Need for Critical Thinking

- Prove a system is safe. Actual system performance is indifferent to human assumptions.

Design Reviews

- Provide sufficient resources (funding, education, expertise) for a proper design review.

Quality Control

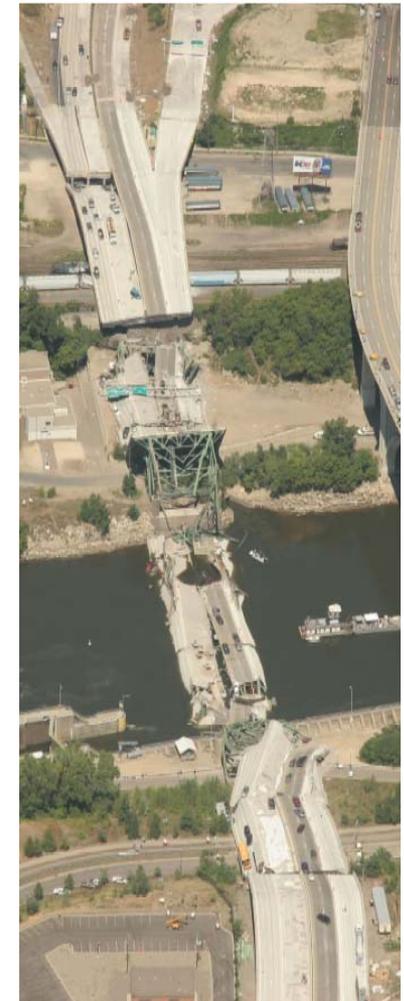
- Exercise quality control in the design process and over the design products.

Renovations

- Assess all the impacts to the original design when modifying, especially when use has changed and the design is well into its expected life.

Inspections

- Use a systematic approach and technical expertise appropriate to the task.
- Encourage and reward hazard identification beyond any checklist used for inspection.



**I-35W Bridge on August 2, 2007,
the day after the collapse**