

BURNABY SUPERMARKET ROOFTOP PARKING DECK

Structural Analysis
Beam Failure Example





OVERVIEW

- History of Structure
- Failure Details
- Background of Victims



HISTORY OF STRUCTURE

- Location: Burnaby, British Columbia, Canada
 - Flagship building for the Save-on-Foods retail chain
- Opened: April 23, 1988
- Size: 90,000 sq. ft., one-story building
 - Part of a regional community shopping center
- Owner: Wesbild Enterprises and Station Square Developments Inc.
- Architect: Urban Design Group
- General Contractor: Amako Construction Ltd.
- Engineering Firms: Tamm Tacy & Associates and MSS Engineering Ltd.

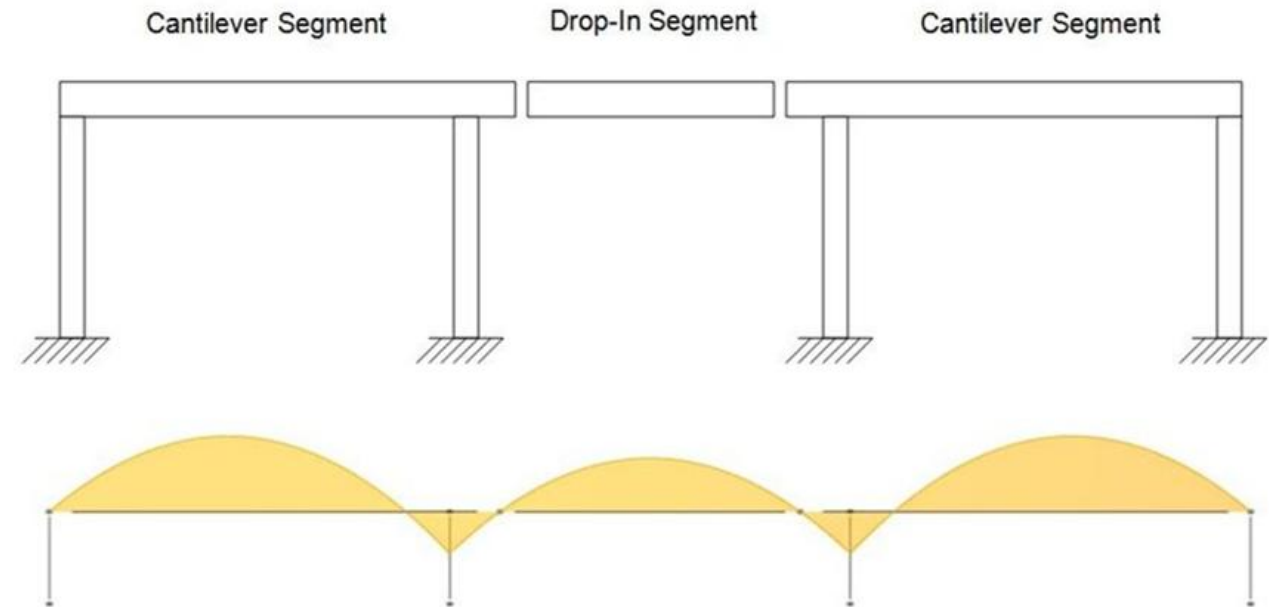
HISTORY OF STRUCTURE

- Design: Steel column and beam structure
 - Cantilevered or Gerber beam system

Composite concrete and corrugated metal deck

Open-web steel joists

Wide-flange steel beams passed over hollow steel tube columns



HISTORY OF STRUCTURE

- Rooftop
 - Parking for customers
 - Roof Cross Section (Right)

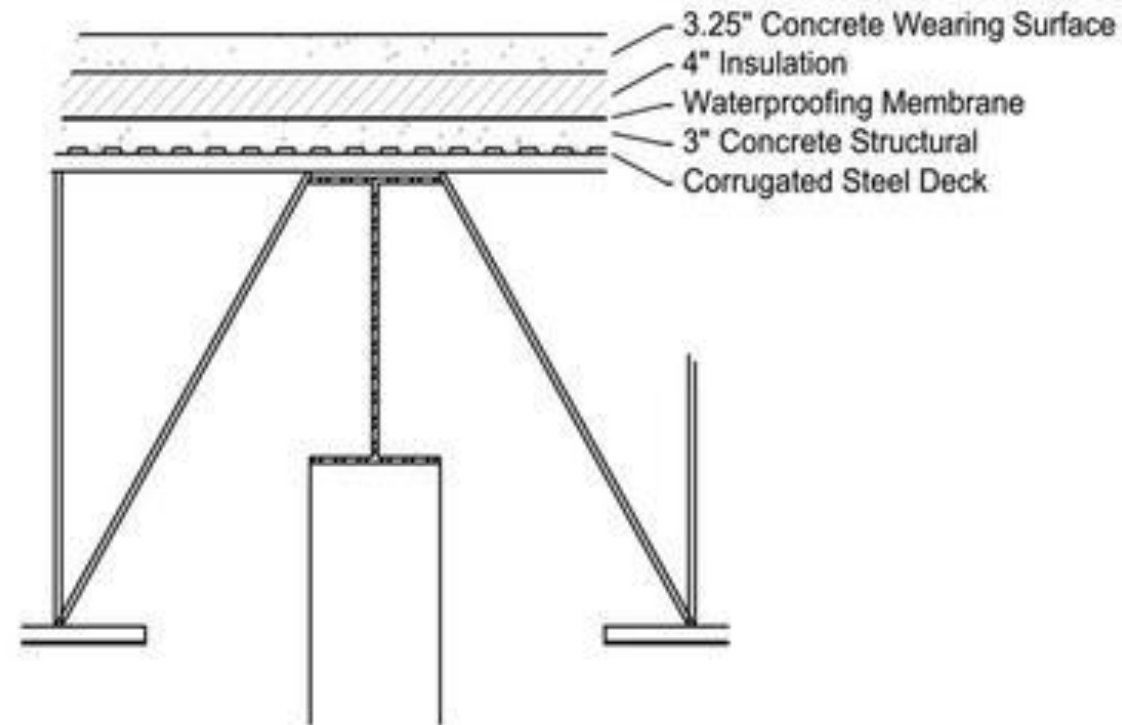
Top-Slab Wearing Surface

Light Styrofoam Insulation

Waterproofing Membrane

3" Concrete

Corrugated Steel Deck



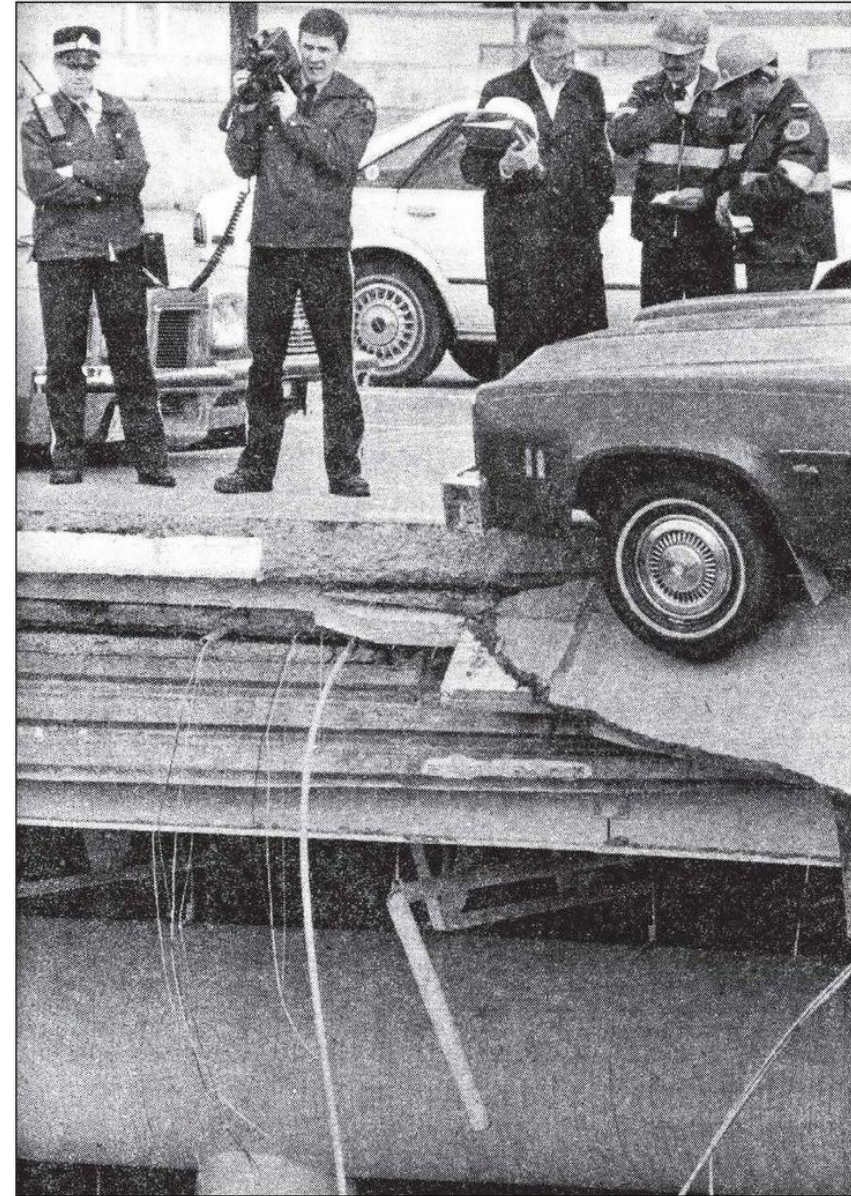
FAILURE DETAILS

- Collapse: April 23, 1988 – Grand Opening Ceremony
- Signs of Failure:
 - A loud bang was heard
 - Water flowing from a broken overhead pipe
- Evacuation Began
- Roof collapsed into shopping area
 - Collapsed Area: 87 by 75 ft.
- 21 people injured
- 20 cars destroyed



FAILURE DETAILS

- Causes:
 - Design of Steel Beam
 - Undersized
 - Concrete
 - Roof deck thickness was increased from 2" to 3"
 - Rooftop sidewalk width was increased from 5 ft. to 11 ft.
 - Live Load Miscalculation
 - MSS Group made incorrect assumptions about the live loads on the roof deck
 - Scope of Work
 - Unclear assignments and responsibilities for all members involved in the design and construction process



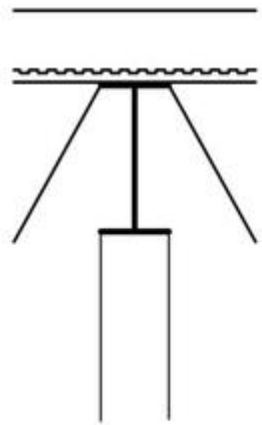
COLLAPSE

Police and fire officials inspect the damage after a rooftop parking ramp collapsed into a crowded Save-On Foods store at Station Square in April 1988. All construction on the \$75-million mall project was shut down during a investigation of the event, which saw part of a parking lot located on the roof of the supermarket cave in, sending parked cars and debris plunging into the store. An estimated 1,000 people were in the store. Fifteen people, including then-mayor Bill Copeland, were injured and taken to hospital, but no one was killed. Copeland had been at the store to give a grand opening speech. He helped evacuate the space and was credited with saving lives.

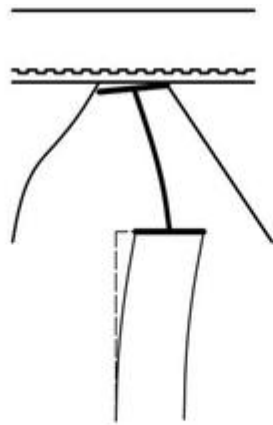
PHOTO
NOW ARCHIVES

FAILURE DETAILS

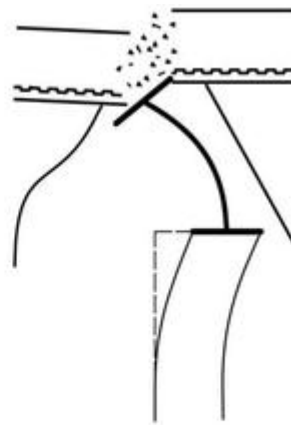
- Trevor Burkitt, a photographer, was able to take a picture of the broken pipe and severely distorted beam (Right)
- Cross Section of Column and Beam During Collapse (Left)



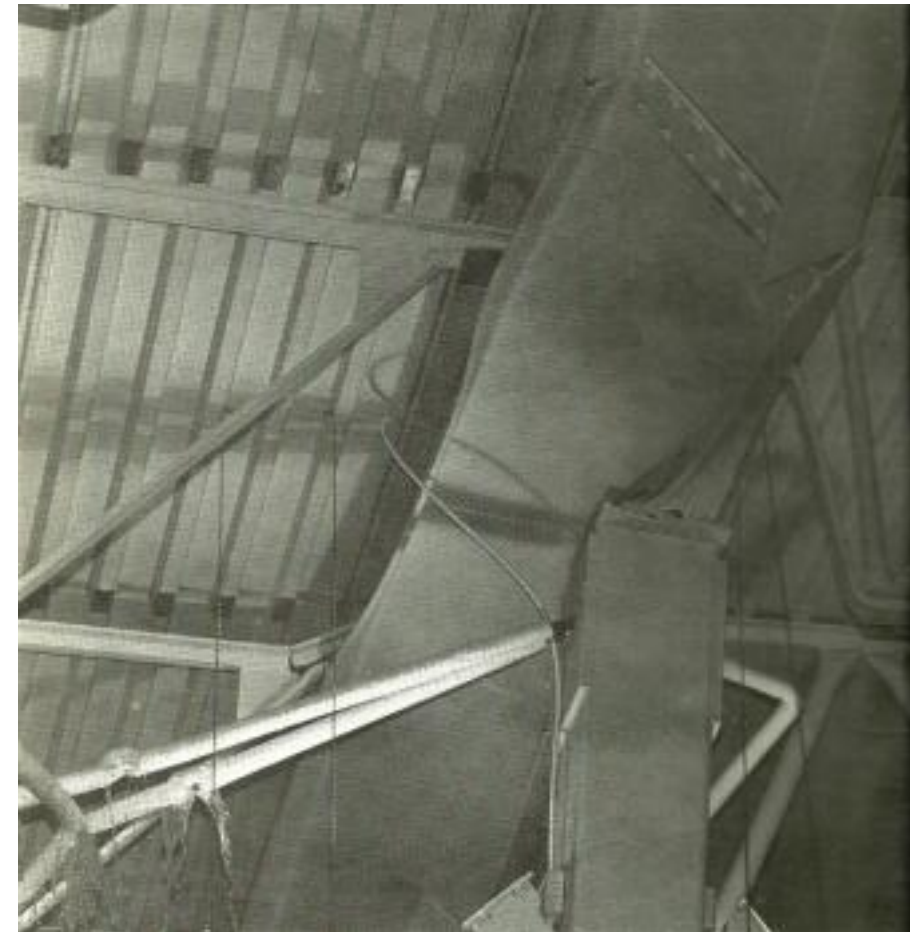
- Original Position



- Column head displaces laterally
- Lower beam flange yields
- Web begins to buckle
- Joists begin to disconnect



- Column head displacement increases
- Beam flange and web buckling continues
- Joists Fail
- Collapse immediate





VICTIMS OVERVIEW

- 600 Senior Citizens
- 370 Employees
- 0 Fatalities
- 21 Injured

“It sounded like thunder”

“Popping and cracking noises”



BACKGROUND OF VICTIMS

- The ceremony was a special preview for neighborhood senior citizens
- Mayor of Burnaby – Bill Copeland
 - Injured and taken to the hospital while assisting evacuation
- Store Employee
 - Trapped under debris and was removed by first responders using forklifts
 - Suffered a crushed pelvis
- Several Senior Citizens
 - Blown off their feet by the rushing air from the collapse

AFTERMATH

- Engineers from Tamm Tacy & Associates and MSS Engineering Ltd. were found guilty of professional misconduct and negligence
- The Save-on-Foods and rooftop parking structure was repaired and the store operated until 2012
- **Lesson Learned: The ethical responsibilities engineers have toward ensuring the safety of the public**





REFERENCES

1. Bosela, Paul A., et al. “Building Failures.” *Failure Case Studies in Civil Engineering: Structures, Foundations, and the Geoenvironment*, Second ed., Published by the American Society of Civil Engineers, 2013, pp. 110–111.
2. http://bentley198.rssing.com/chan-12408366/all_p14.html
3. <https://failures.wikispaces.com/Save-On-Foods%2C+Station+Square%2C+Burnaby%2C+BC>
4. <http://www.100milehouse.ca/save-on-foods.html>



I35W Bridge Collapse

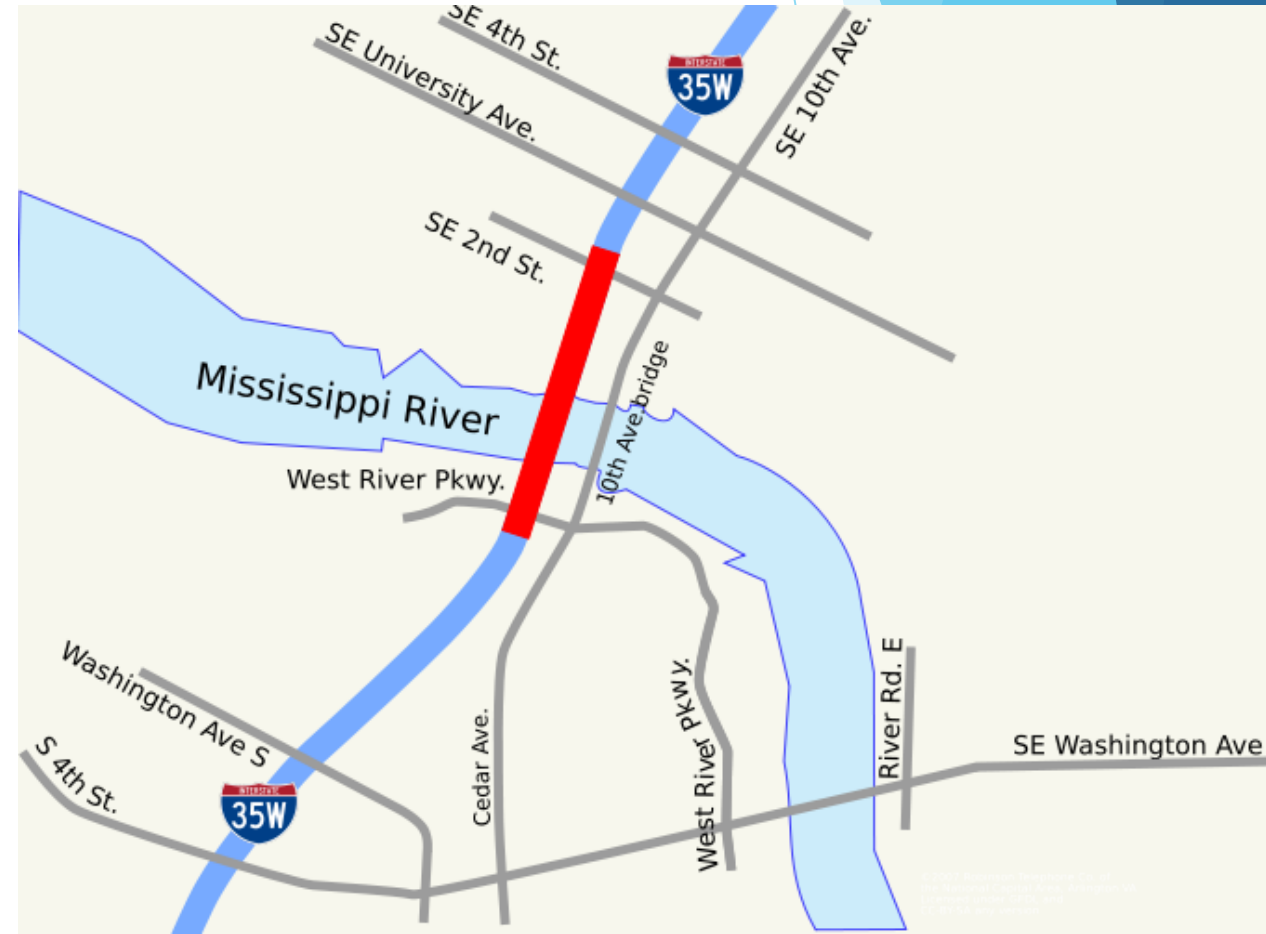
Structural Analysis

Overview

- ▶ History of Structure
- ▶ Failure Details
- ▶ Background of Victims

History of Structure

- ▶ Location: Minneapolis, Minnesota
 - ▶ Carried Interstate Highway 35W across Saint Anthony Falls on the Mississippi River
 - ▶ 8 lanes
- ▶ Opened: November 1967
- ▶ Designer: Sverdrup & Parcel and Associates
- ▶ Design: Continuous Truss Bridge
- ▶ Total Length: 1,907 feet
- ▶ Daily Traffic: 140,000 vehicles

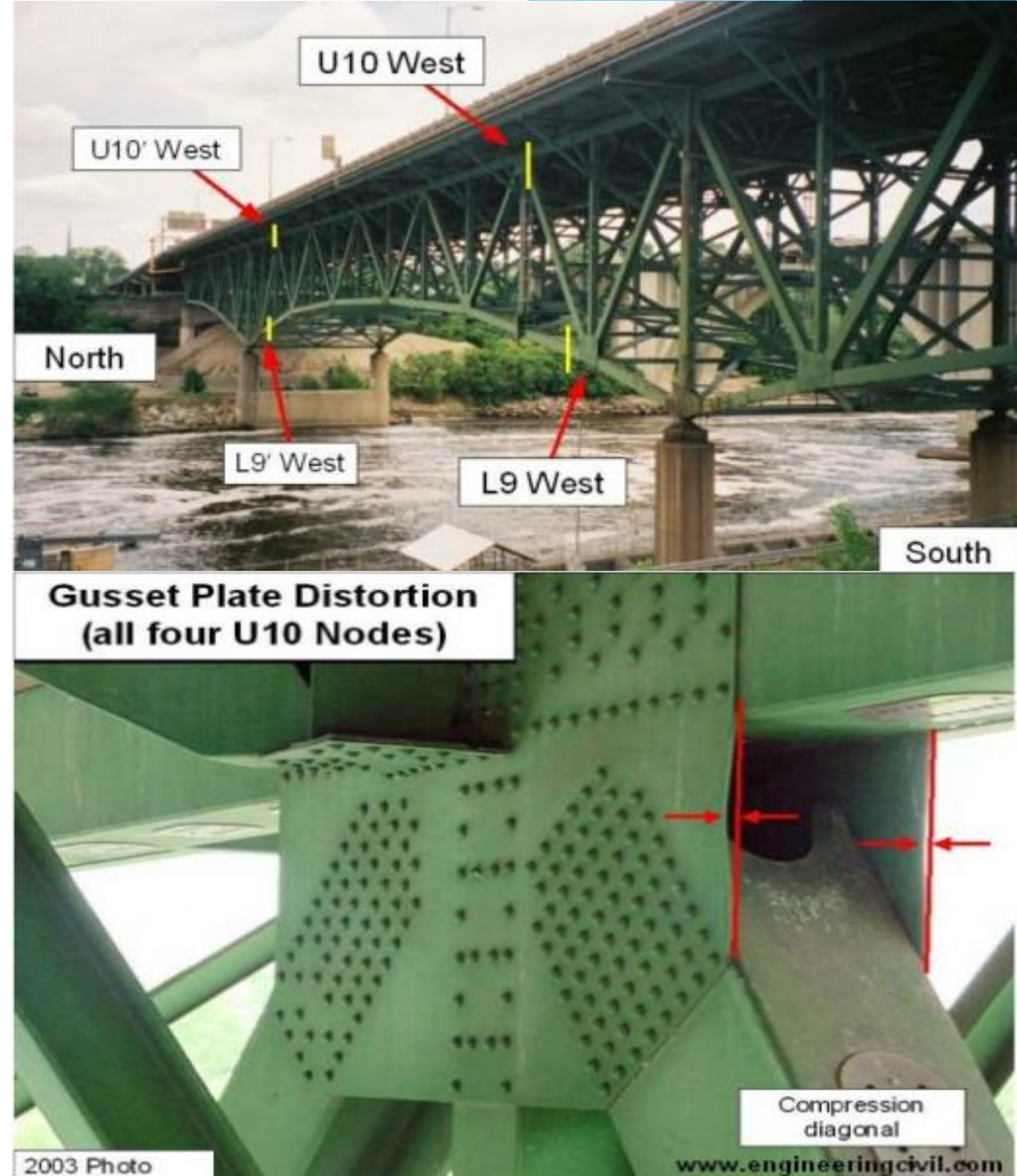


History of Structure

- ▶ 1964 - Construction begins
- ▶ 1967 - Bridge opened to traffic
- ▶ 1977 - Renovation
 - Increased deck thickness
 - Increased dead load by 13.4%
- ▶ 1998 - Renovation
 - Median barrier, traffic railings, and anti-ice system
 - Increased dead load by 6.1%
- ▶ 2007 - Repair and Renovation
 - Repaving

Failure Details

- ▶ Collapse: August 1, 2007 at 6:05 PM
- ▶ Cause: Under-Designed Gusset Plates
 - Sheets of steel used to connect truss members together
- ▶ Distortion was observed in the gusset plates during an inspection of the bridge in 2003
- ▶ *AASHTO Guide for Commonly Recognized Structural Elements* does not include gusset plates as a separate bridge inspection element



Failure Details

- ▶ High loads on the surface of the bridge
 - ▶ 2” of concrete had been added to the road deck
 - Increasing the weight of the bridge deck by 20%
 - ▶ Construction equipment and materials were on the bridge
 - 578,000 lbs. worth
- ▶ Even with these high loads, the bridge would not have collapsed had the gusset plates been the proper size

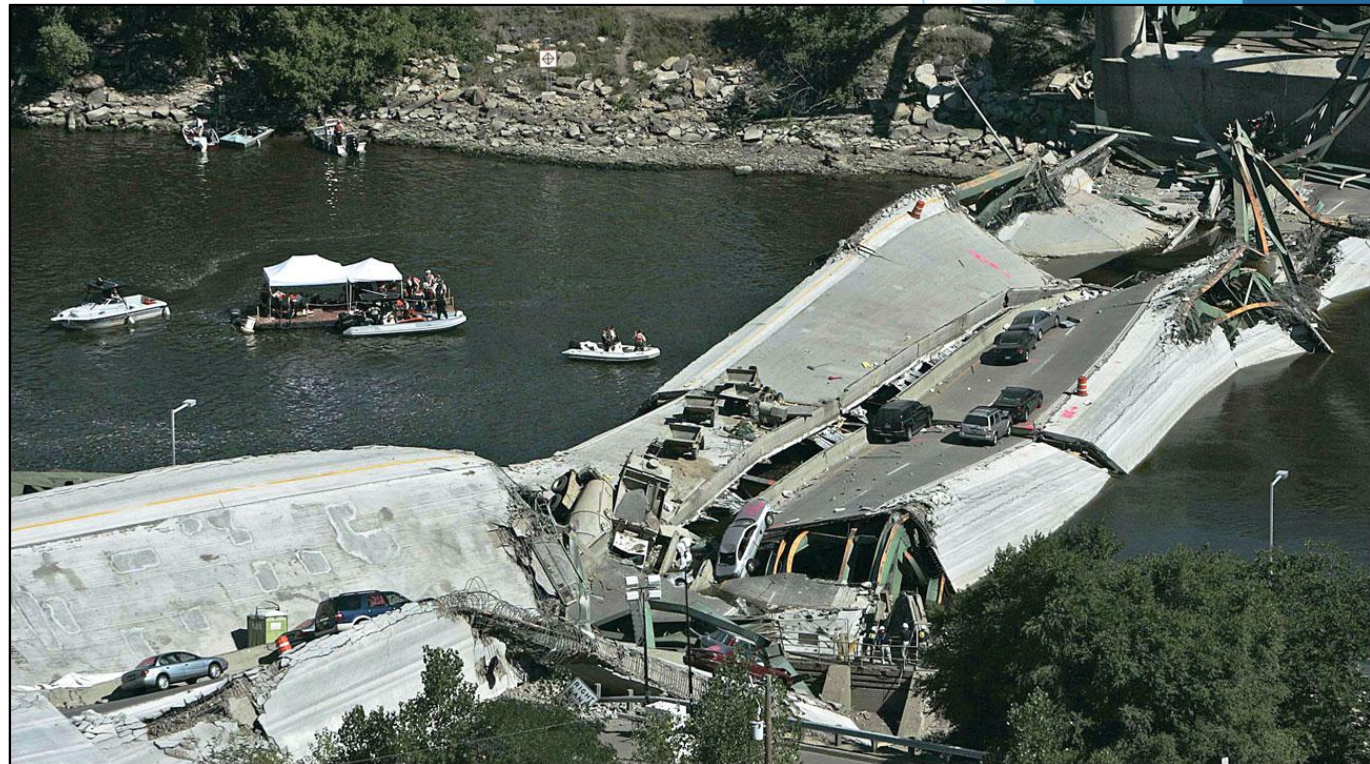
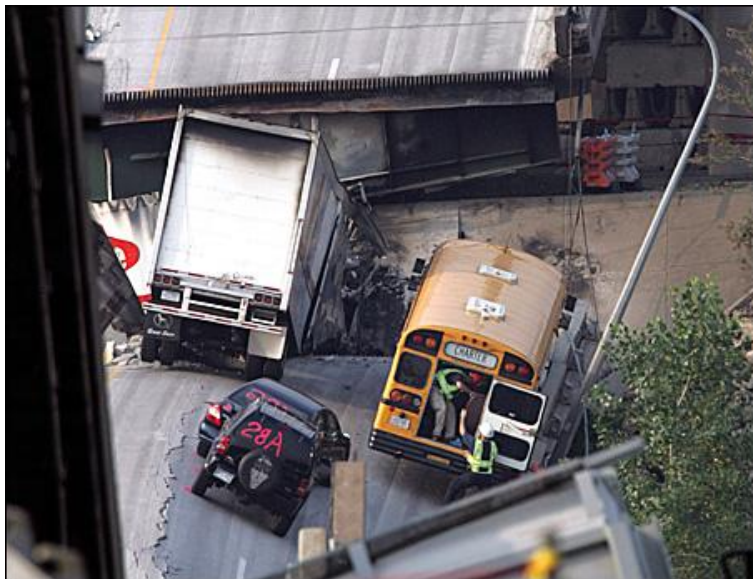


Video



Victims Overview

- ▶ 111 Vehicles
 - 25 construction vehicles
 - A school bus carrying 63 children
 - 17 vehicles were found in the river
- ▶ 18 Construction Workers
- ▶ 13 Dead
- ▶ 145 Injured
 - 22 children



Background of Victims

- ▶ Sherry Engebretsen, 60
 - Mother of two adopted daughters from Columbia
- ▶ Artemio Trinidad-Mena, 29
 - Mexican citizen
- ▶ Julia Blackhawk, 32
 - Native American
- ▶ Patrick Holmes, 36
 - Exercise therapist
 - Father of son (6) and daughter (4)
- ▶ Peter Hausmann, 47
 - Computer security specialist
- ▶ Paul Eickstadt, 51
 - Driver of delivery truck that caught fire (next to school bus)
- ▶ Greg Jolstad, 45
 - Construction worker



Background of Victims

- ▶ Scott Sathers, 29
 - Enrollment director at Capella University
- ▶ Christina Sacorafas, 45
 - Greek folk dance instructor
- ▶ Sadiya Sahal, 23
 - Nursing student from Somalia
- ▶ Hanah Sahal, 2
 - Sadiya's daughter
- ▶ Vera Peck, 50
 - Mother of Richard Chit
- ▶ Richard Chit, 20
 - Vera Peck's son who had Down's syndrome



References

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