VERMONT
AGENCY OF TRANSPORTATION
RESEARCH PROGRAM

Residual Strength Assessment of a Fire-Damaged Steel I-girder from a VT-14 Bridge

STUDY TIMELINE
Dec 2023 – Dec 2024

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More information about the Agency of Transportation Research Program, including additional Fact Sheets, can be found at: http://vtrans.vermont.gov/planning/research

Introduction

Evaluating the residual capacity of a bridge's superstructure following a fire accident is critical as bridge owners are required to make rapid decisions to keep the public safe while mitigating disruption. This project investigates the residual mechanical performance of a steel I-girder structure that was exposed to a propane off-gassing fireball that burned for approximately 36-hours in Irasburg, VT on December 4th, 2023 as a result of a 10,000-gallon liquid propane tanker veering off Route 14.

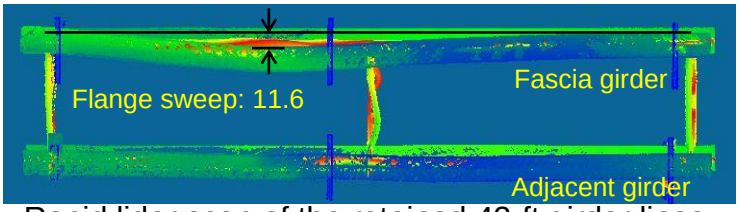
10,000-gallon liquid propane tanker off-gassing (left), subsequent damage in the steel fascia girder (right). Photos courtesy of vermontpublic.org and VTrans.

The Vermont Agency of Transportation (VTrans) decided to replace the entire bridge and abutments due to distortion of the steel, spalling of the concrete deck and integral abutments, and approximately 9 inches of deck sag near midspan of the bridge. Though the degree of damage and the difficulty to shore the bridge over a waterway to remove the camber precluded utilization of tradition repair methodologies, understanding the residual integrity of steel superstructures can inform repairs on other bridges bounded within this damage state. Also of interest is the metallurgical phase composition of the weathering steel itself, and its patina development, as the distance and relatively low combustion temperature of propane may not have dramatically affected the steel's crystalline properties.

Two 42-foot-long girder lines, connected by three intermediate cross-frames, were retained from the bridge. This section encompasses the largest flange sweep and web plate distortion on the bridge's exterior girder.

Project Methodology

The residual capacity of the fire-damaged ASTM A588 uncoated weathering steel I-girders was evaluated by employing experimental methods including geometric laser scanning, patina development assessment, uniaxial tension testing, impact testing, dye penetrant assessment, chemical analysis, and metallographic analysis.



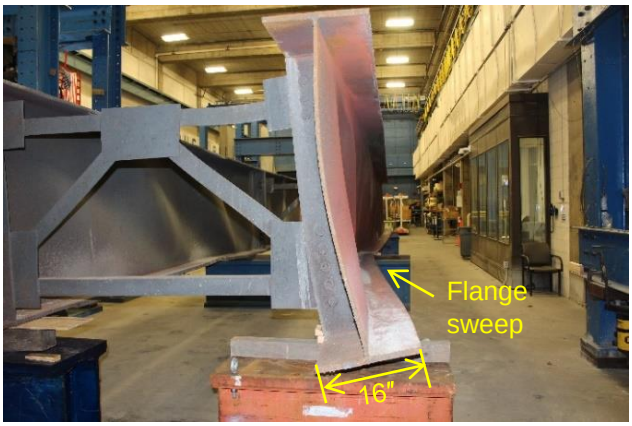
Rapid lidar scan of the retained 42-ft girder lines.

Geometric scanning revealed up to 11.6 inches of flange sweep and severe web distrostion in the retained girder lines. The retention of two girder lines connected with the cross-frames was chosen to maintain representative lateral bending and warping fixity at the locations of largest damage, such that the geometry can be reasonable correlated back to an in-situ repair situation after the deck had been removed.

To assess the residual mechanical performance, specimens were extracted from the regions with the largest degree of geometric distorsion. Referefence specimens were also obtained from regions that were sufficiently away from fire to assess the baseline mechanical properties of the steel.

Activities In-progress

- Quantifying camber, flange sweep, warpage, and web distortion to assess accumulated plastic strains based on simplified moment-rotation theory. System level, finite element analysis (FEA) could be done in the future assuming that the corresponding deck stiffness pre- and post-fire is sufficiently modeled.
- Mechanical and patina testing.
- Microstructural investigations to determine if a phase change occurred, and if so the gradient field to give an indication of heat input.



Sighting down the retained section.

Impacts and Benefits

The anticipated results will demonstrate the remaining structural capacity of the steel after being exposed to the prolonged fire event. Furthermore, it will exercise the recently updated FHWA *Manual on Heat Straightening, Heat Curving, and Cold Bending of Bridge Components* (released March 2023). The results obtained from this investigation will provide valuable insights and guidance on bridge repair strategies in wake of fire accidents. This is particularly important due to the critical nature of bridge infrastructure and high frequency of occurrence of bridge fire accidents. Although, VTrans replaced the girders that are being investigated in this study, the results obtained from this study are expected to inform on residual capacity assessments and repairs strategies for fire-affected bridges.