



U.S. Department of Transportation
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Turner-Fairbank
Highway Research Center

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

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Contents

- **Background**
- **Problem Statement**
- **Methodology**
- **Results and Ongoing Work**



Background

- On December 4, 2023, a **propane tanker** crashed in Irasburg, VT, resulting in a fireball that burned for 36-hrs several feet from a VT-14 bridge.
- The fire caused **significant distortions** in the exterior steel girder, and deck sag.
- VTrans decided to **replace** the bridge abutments due to **extensive damage**.



Fig. Map of VT-14 and Bridge 129.



Fig. Bridge-129 during fire.



Fig. Bridge-129 after fire.

Background

Assessment of Fire-Affected Steel Structure

Category-1

- No noticeable deformation



Category-2

- Noticeable deformation



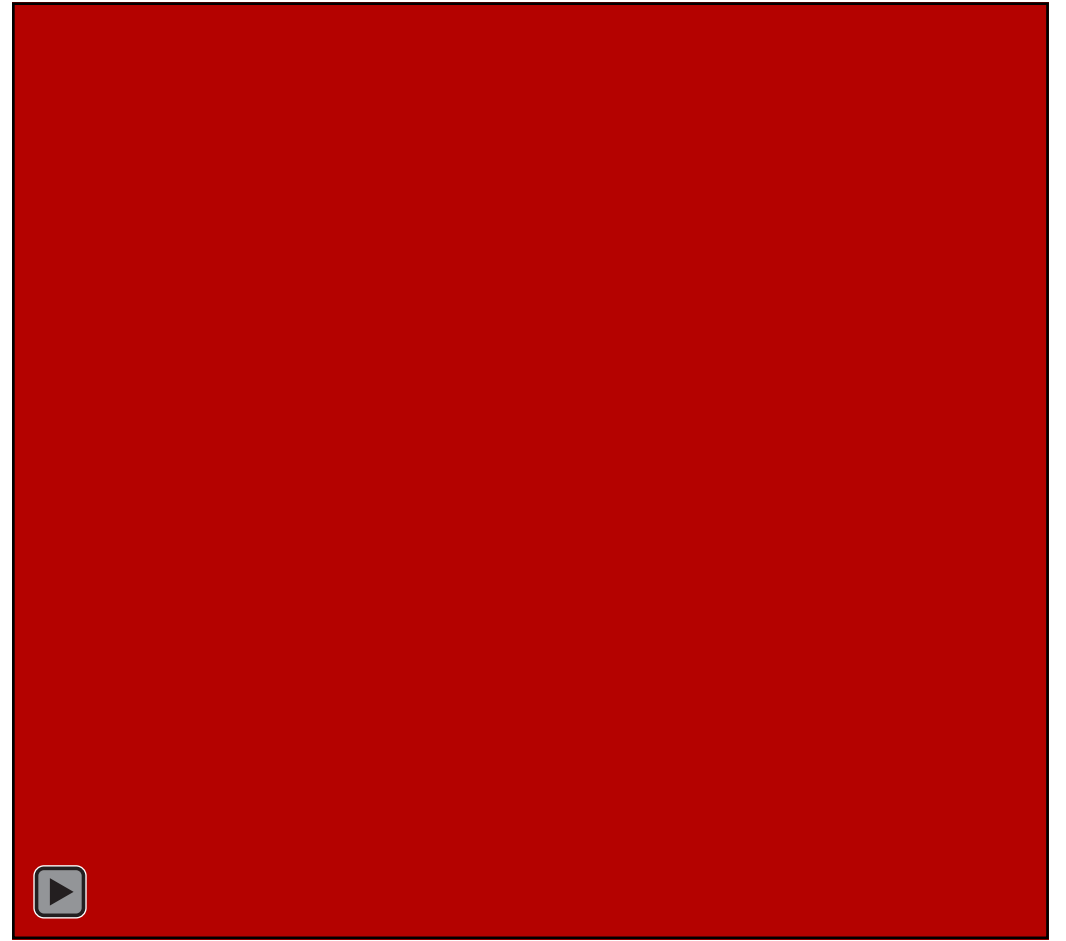
Category-3

- Severe deformation



(Source: Băetu et al. 2020. Procedia Engineering, 181, 265-272)

Brent Spence Bridge Fire-damaged Girder



(Source: Sajid et al. 2024. Residual strength assessment of a heat straightened ASTM A 7 Steel I-section member exposed to a fire even. Engineering Structures, 315, 118432.)

Repair of Fire-damaged Steel

FHWA Manual for Heat Straightening, Heat Curving and Cold Bending of Bridge Components

Problem Statement

- What is the residual post-fire capacity of the steel?
- Did the fire cause metallurgical phase changes in the steel?
- Could the steel girder have been repaired?



Methodology

1

Geometric laser scanning and surface condition assessment

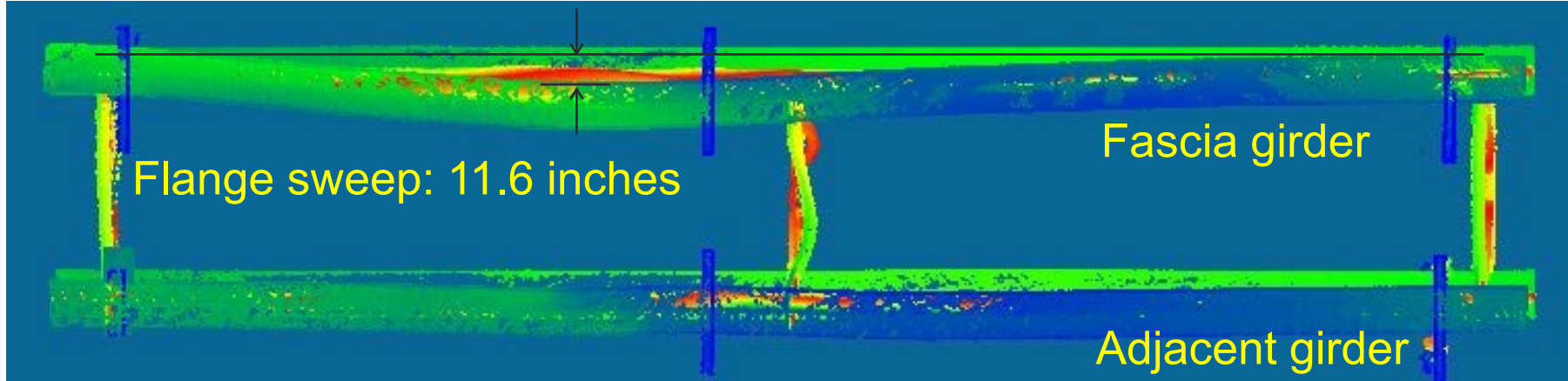


Fig. Rapid lidar scan of the 42-ft girder line depicting distortions.

- Evaluate the zones of maximum distortion.
- Identify the zones for extracting specimens representative of fire damage.
- Identify presence of surface cracks, if any.

Methodology

2

Post-fire steel microstructure characterization

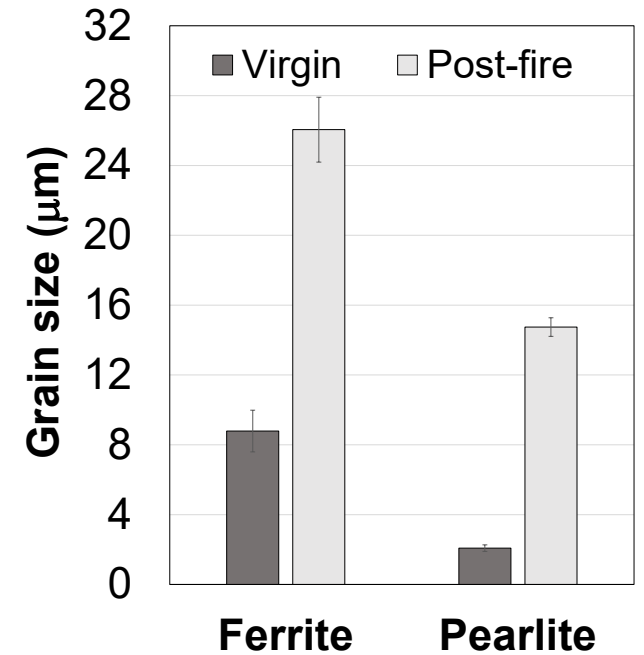
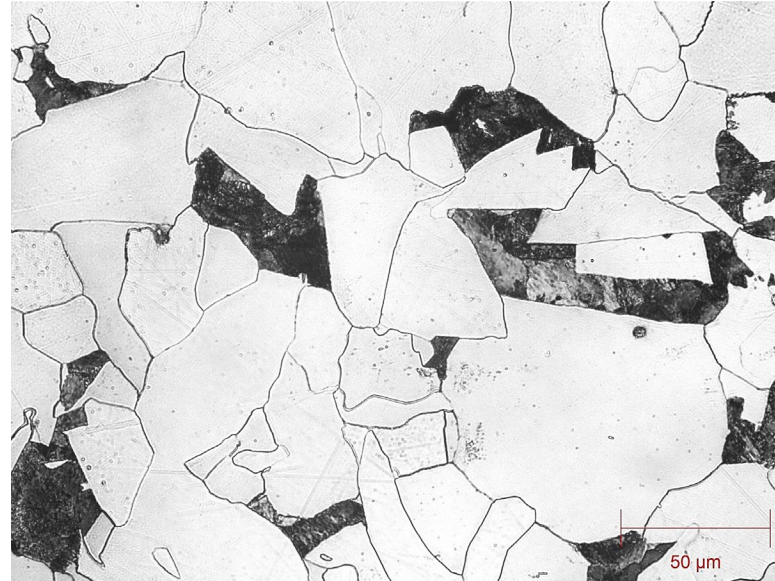
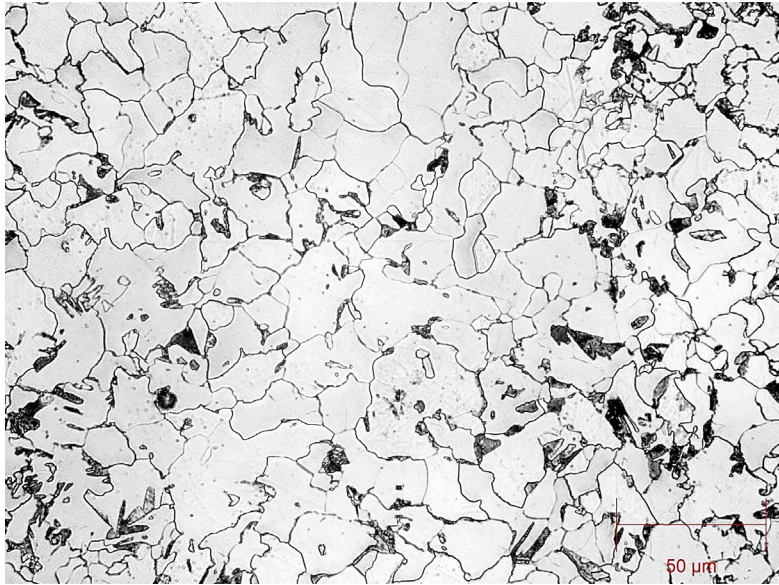


Fig. Microstructure of virgin and post-fire girder steel.

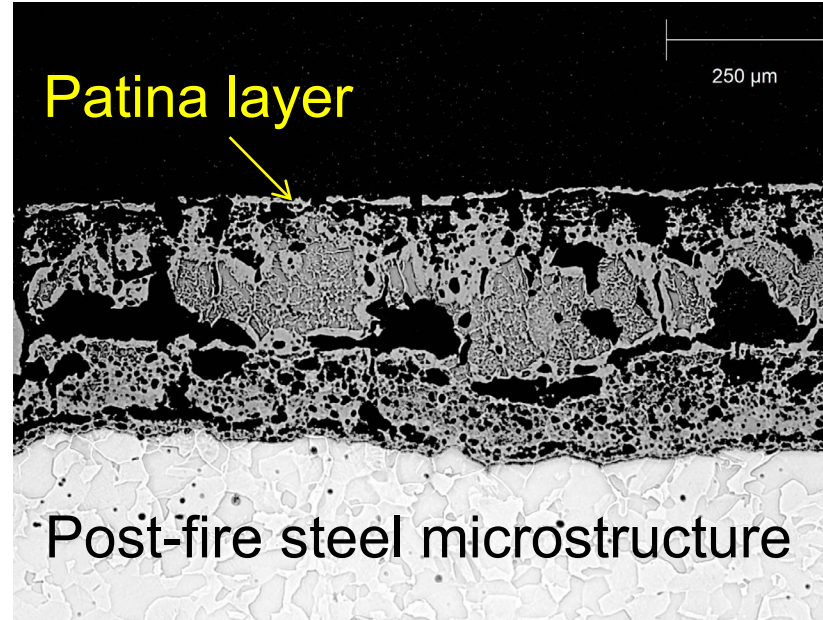
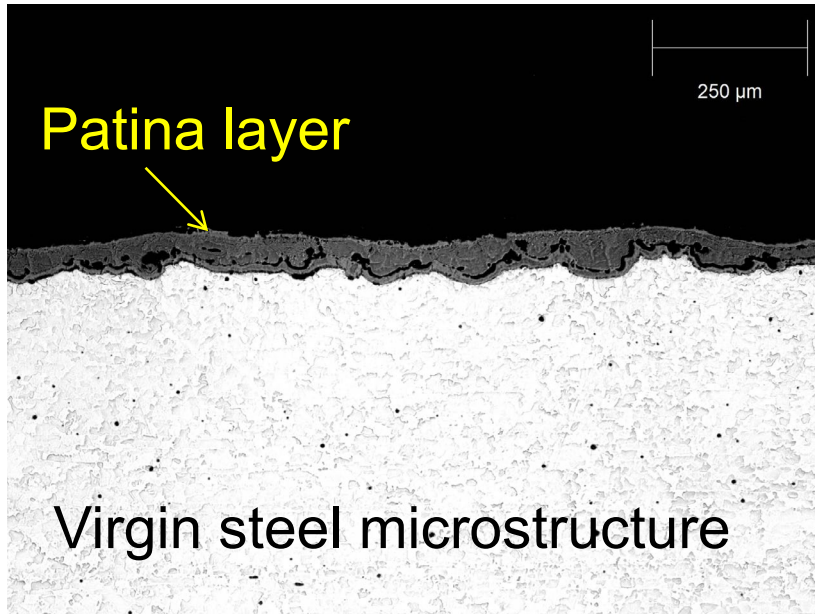
Fig. Grain sizes in virgin and post-fire girder steel.

- Significant grain enlargement in fire-affected steel.
- The fire exposure did not cause any metallurgical phases changes in steel.

Methodology

3

Weathering steel patina layer characterization



Average patina thickness (microns):

Virgin steel: 55

Post-fire steel: 407

Fig. Cross-section of patina layer in virgin and fire-affected steel.

- Fire caused significant increase in the patina layer thickness.
- Patina layer chemistry is being currently being evaluated.

Methodology

4

Evaluate residual mechanical and toughness properties

- Uniaxial tension tests.
- Charpy V-notch impact tests.
- Microstructural analysis.
- Hardness tests.
- Chemical analysis.

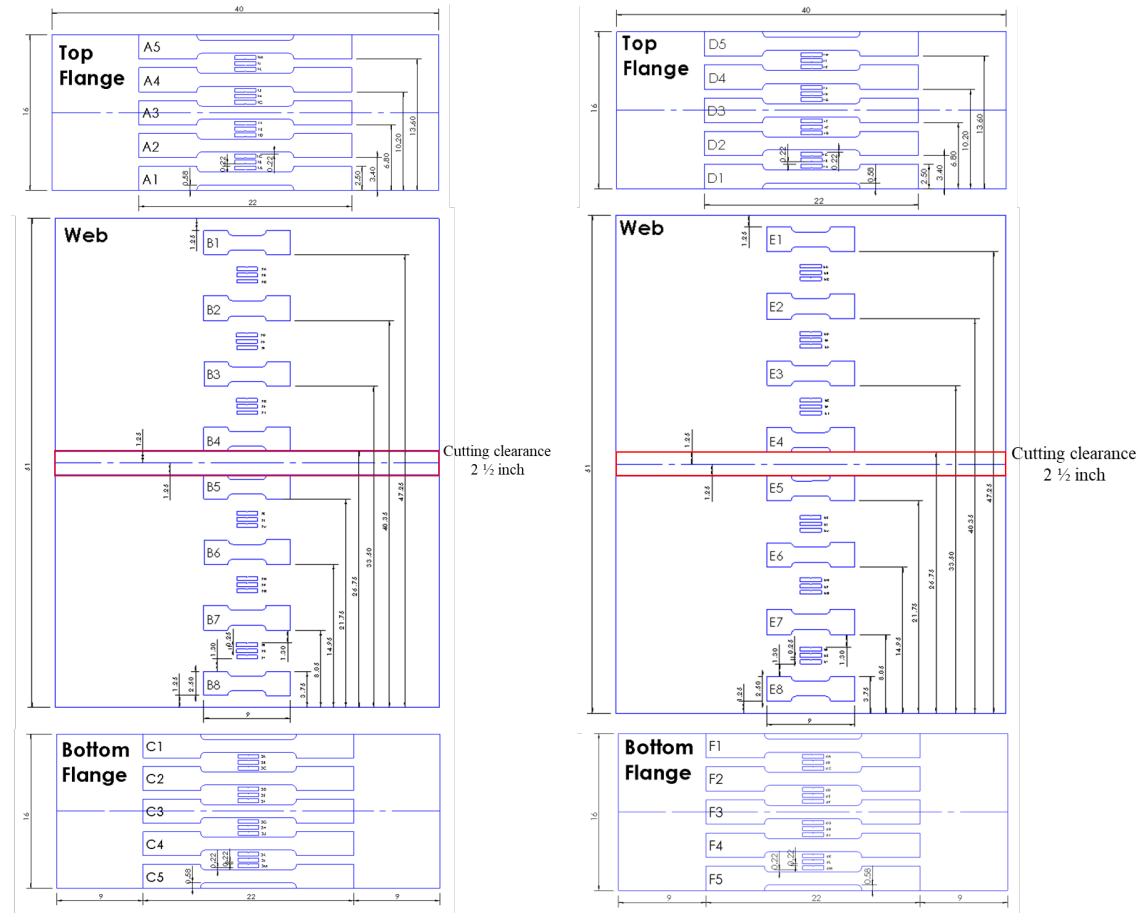


Fig. Specimens (tension coupons and CVNs) extraction plan.

Results and Ongoing Work

Important Findings

- Prolonged fire exposure caused approximately 11.6 inches flange sweep.
- Fire exposure resulted in nearly a 3 times increase in the steel ferrite and pearlite grain size. However, no metallurgical phase change occurred.
- The uncoated weathering steel's protective patina layer increased in thickness up to 8 times its normal thickness during the fire.

Ongoing Work

- Patina layer characterization
- Mechanical, toughness, and hardness testing.



Questions?

