University Avenue Bridge

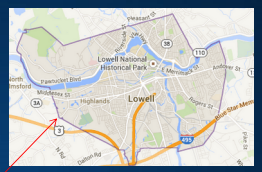
- Jerome MacKenzie, PE, Project Manager
- Evan Batchis, SE, Project Engineer

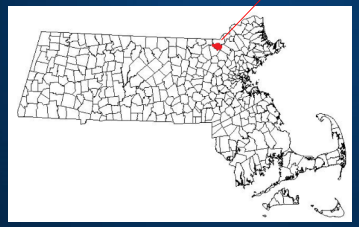
Project Overview

- Initiated as a truss bridge rehabilitation
- Performed field condition survey
- Assessed rehabilitation potential of bridge
- Developed type study
- Compared rehabilitation with replacement options

The City of Lowell

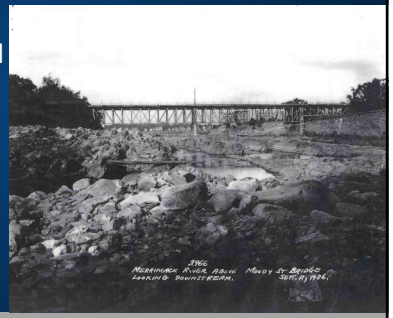
- Founded in 1823
- Population of 110,000
- Manufacturing center for textiles during The Industrial Revolution
- 30 miles northwest of Boston





University Avenue Bridge

- Built in 1895 – downtown landmark
- Pin-connected Pratt truss
- Three spans
- 499-foot length
- Located in Lowell National Historical Park District
- Eligible for listing on The National Register of Historic Places



Need for project

- Restricted live-load capacity
- Frequent roadway closures for bridge repairs
- 30.9 AASHTO sufficiency rating

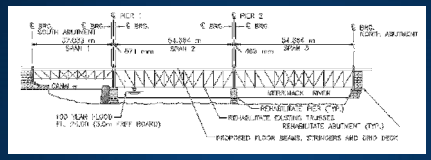
Type Study – Rehabilitation Option

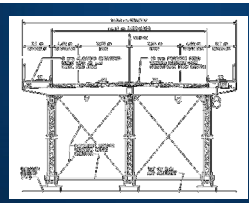
Rehabilitation Option

- Complete replacement of floor system and deck
- Strengthening or replacement of deficient truss elements
- Replacement of bearings with isolation bearings
- Reinforcement of piers and abutments
- Three phases of construction
- Detour in one direction of traffic
- Construction duration of two to three years

Type Study

Superstructure Rehabilitation Option





Type Study

Superstructure Replacement Option

- Complete superstructure replacement
  - *Steel plate girders*
  - *Steel box girders*
  - *Concrete box girders*
- Reinforcement or replacement of piers and abutments
- Two or three phases of construction
- Detour in one or both directions of traffic
- Construction duration of two to three years

Type Study Amendment 1

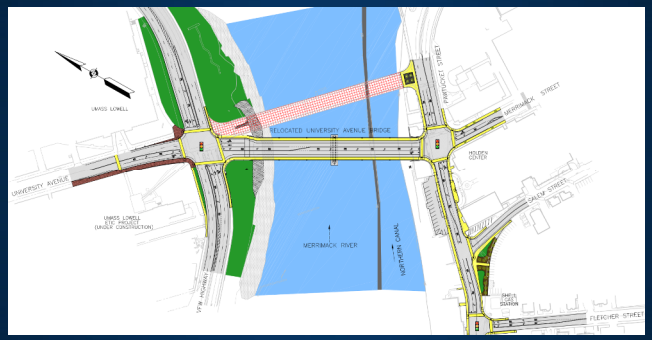
- Evaluate reduction in design live-load capacity
  - *HS-20*
  - *HS-15*
- Seismic waiver
- Reevaluate detour options
  - *One lane detour in one direction*
  - *Full roadway closure*

Presentation to Stakeholders

- City of Lowell
- University of Massachusetts – Lowell
- Boot Hydroelectric
- Lowell National Historical Park
- City and state political delegation
- Public safety and emergency response

Presentation Outcome

- Request to revise project alignment

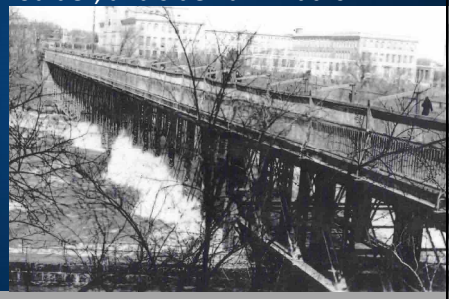


Realignment Challenges

- Demolish historic bridge
- Redesign approach intersections
- Work within the river
- Develop footprint replacement program
- Make permit revisions
- Increase bridge span
- Demolish church and multifamily dwelling

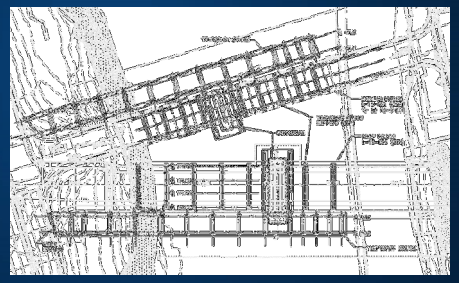
Realignment Benefits

- Eliminated traffic detours during construction
- Created new structure with contemporary detailing
- Improved traffic circulation
- Increased roadway, shoulder, and sidewalk widths
- Improved clearance over canal walkway
- Improved hydraulic clearance



Constructability

- Challenges
  - *Variable river flow (4,700-square-mile watershed)*
  - *100-foot-wide, privately owned canal*
    - No permanent or temporary work in or on canal wall
  - *Dual temporary trestle system*
  - *Temporary truss supports*
  - *Sheet-pile cofferdams*

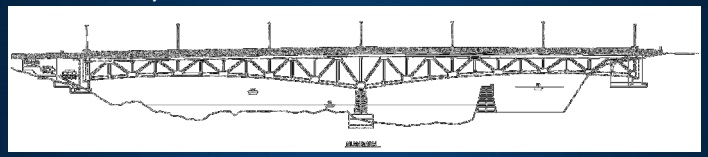


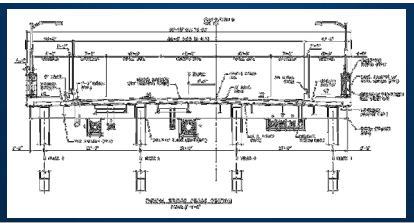
Design Considerations

- Historic Requirements
  - *Steel deck truss*
    - Curved bottom chord
  - *Historic Details*
    - Decorative bridge railing
    - Granite pilasters
    - Granite substructures to match existing canal wall

Design Schematics

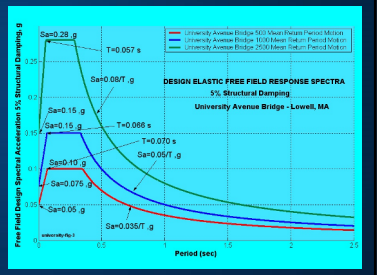
- 520-foot, 2-span continuous bridge
- Warren-style deck truss





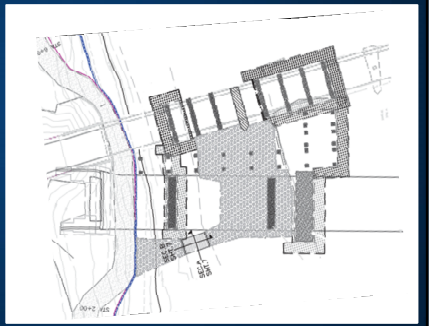
Design Considerations

- MassDOT
  - *HS-25 design*
  - *Two-span continuous design (eliminating deck joints)*
  - *Maximized roadway width with full shoulders*
  - *Ability for future 8-foot widening (either side)*
  - *2,500-year seismic return period*
  - *February 2009 FHWA gusset plate rating procedure*



Construction Phase

- Contractor revisits permit and bridge erection
  - *Single temporary trestle for both construction and demolition*
    - Shortened length; roughly 100 feet from canal
  - *Temporary infill of riverbed with timber bridge to area*
  - *Exclusion of sheet-pile cofferdams – use of sandbag cofferdam*
  - *Reduced temporary supports (only toward north abutment)*

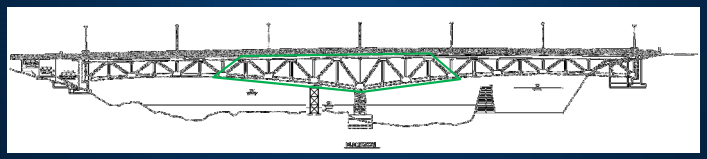


Construction Phase

- Advantages of reconfigured construction scheme
  - *Bridge/infill area provides access to bridge and substructures*
  - *Temporary bridge supports easier to install*
  - *Single trestle/sandbag cofferdam delivers savings to contractor*
- Disadvantages of reconfigured construction scheme
  - *Risk involved with potential raised water levels*
  - *No temporary supports toward south abutment and further from hydropower canal*
  - *Potential delays with permitting amendment*

Construction Engineering

- Truss erection procedure
  - ***Installed temporary truss supports and stick built out from center pier***
  - *Touched down on north abutment*
  - *Cantilevered out 195 feet over canal toward south abutment*
  - *Completed truss with final 4-bay pick*



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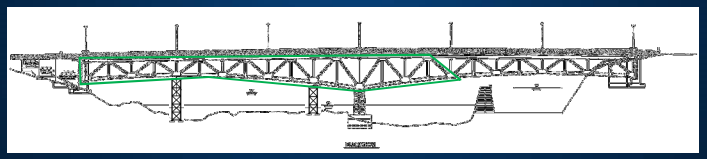

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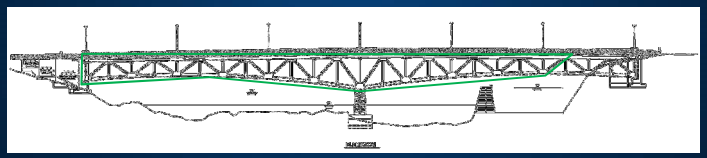

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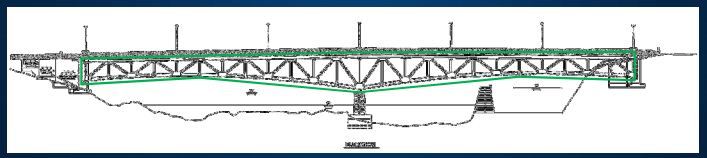
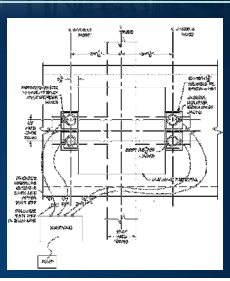
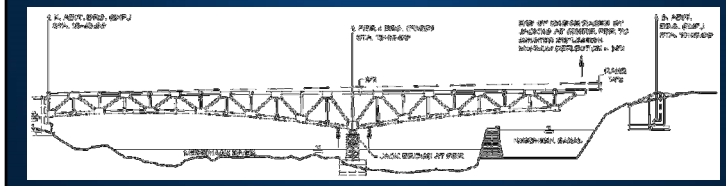


Construction Engineering

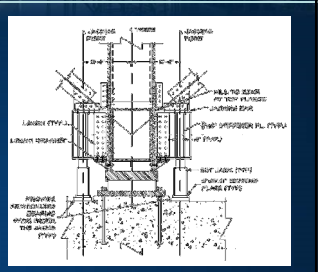
- Bridging the canal
  - *195-foot cantilever amounted to roughly 14 inches of deflection*
  - *High-capacity jacks at center pier counteracted both deflection and end rotation*
  - *Raised 8 inches at pier*

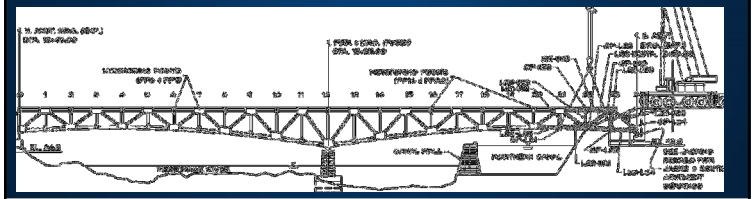




Construction Engineering

- Bridging the canal
  - *Held final four bays in place with crane while gusset connections were made*
  - *Placed jacks at abutment and raised to meet bearing*
  - *Released onto jacks*





Construction Engineering

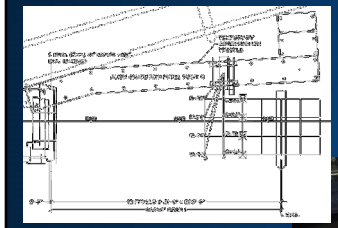
- Engineer's Erection Procedure Review
  - *Specified all steps of structure manipulation*
    - Ordering and increments of jacking
    - Failure may alter final distribution of bearing reactions
    - Corrective action may alter final geometry and lock in member stresses
  - *Provided detailed jacking procedure*
    - Follow step-by-step table of anticipated top chord monitoring point elevations
    - Verify monitoring points throughout jacking
    - Monitor jack pressures and compare theoretical versus actual
    - Take corrective action, if required

Bridge Construction

- Substructure construction
  - *Utilized sandbag cofferdam and sump pumps*
  - *Took place weeks before spring melt*
  - *Infill and access bridge benefitted formwork construction and concrete pours*
  - *Completed successfully days prior to 2-foot rise in water level*

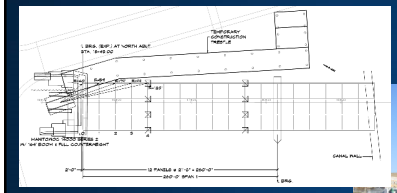
Bridge Construction

- Truss Erection
  - *Installed temporary supports and built out from center pier*



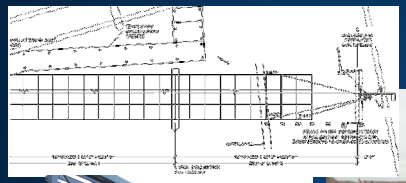
Bridge Construction

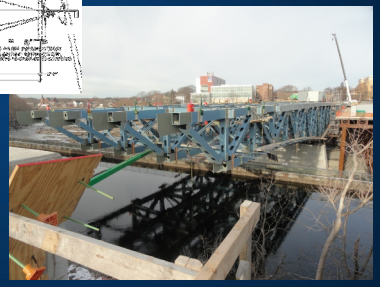
- Truss Erection
  - *Touched down at north abutment*




Bridge Construction

- Truss Erection
  - *Built cantilever out to 195 feet, partially over canal*



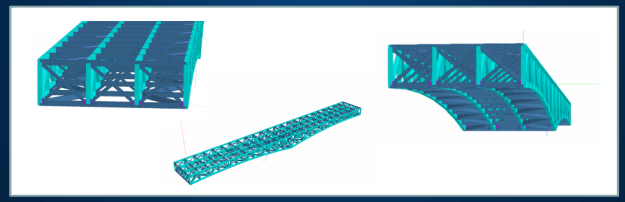


Bridge Construction

- Pre-jacking measurements and coordination
  - *Deflection at end of cantilever measured at 60% less than anticipated*
  - *Although conservative loading was used in theoretical calculations, magnitude of discrepancy required investigation*
- Gaps at mill-to-bear truss compression joints
  - *Identified by resident engineer mainly along bottom chord*
    - Potential panel point misalignment may have hand in reduced deflection
    - Potential to alter member geometry

Bridge Construction

- Back to pencils and paper
  - *Design engineer and contractor's engineer produced 3-D models to maximize accuracy and eliminate conservative assumptions*
  - *Utilized 4-D modeling program to determine potential effects and possible corrective action if proven detrimental*
  - *Investigated overall geometric effect of measured gaps*



Bridge Construction

- Outcome of investigation
  - *Produced detailed 3-D models showing deflections more in line with field conditions*
  - *Determined member effects due to potential manipulation within allowable stress levels*
  - *Measured gaps made up small portion of reduced deflection*
  - *Designed shim frame to provide bearing at compression joints*
- Contractor given "go" to jack bridge and prepare for final lift

Bridge Construction

- Final member lift preparation
  - *Jacks installed and raised to 8 inches*
  - *Monitoring points and pressures recorded and within range of theoretical*

Bridge Construction

- Final truss pick

Bridge Construction

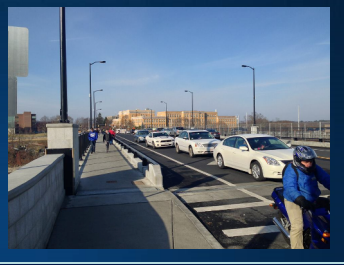
- Final touches
  - *Truss erection lasted just over five months*
  - *Deck poured in Summer of 2013*
  - *Opened to traffic in November 2013*

RICHARD P. HOWE BRIDGE

During his 40 years (1966 to 2006) on the Lowell City Council, including four terms as Mayor, Attorney Richard P. Howe was a passionate advocate for the citizens of Lowell. His courageous leadership was critical to the revitalization of the city and its schools. Richard P. Howe was devoted to his family and proudly served his community and country with honor and integrity.

STV

MASSDOT



Thank You

Questions & Answers

STV