OLDER BRIDGES
LIKE US
STILL PRODUCTIVE

JOSEPH J. PULLARO,P.E.
ACTIVITIES UNLIMITED
FEBRUARY 25, 2025

MY BACKGROUND

- 1964 GRADUATE 0F STEVENS INSTITUTE OF TECHNOLOGY
- 50 YEARS EXPERIENCE WITH THE DESIGN OF FIXED AND MOVEABLE BRIDGES
- ONE OF THREE OWNERS OF LICHTENSTEIN CONSULTING ENGINNEERS FOR 21 YEARS
- 125 BRIDGE ENGINEERS IN SIX OFFICES CONDUCTING WORK IN 22 STATES

- FIRM SPECIALIZED IN

- INSPECTION
- TESTING
- EVALUATION AND RETROFIT OF OLDER COMPLICATED BRIDGES
- WRITING OF BRIDGE INSPECTION AND DESIGN MANUALS
- FORENSIC ANALYSIS OF CAUSES OF BRIDGE FAILURES

WHAT WE WILL DISCUSS

- SOME BRIDGE HISTORY
- TYPES OF BRIDGES
- U.S. BRIDGES CONDITION
- SOME INTERSTING OLDER BRIDGES, ARCHES,TRUSSES
- SOME MOVEABLE BRIDGES
- BRIDGE FAILURES

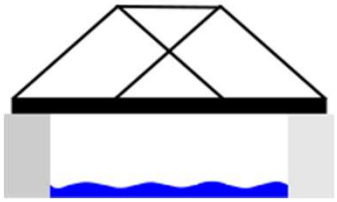
WHAT CAN WE LEARN?

- HOW WE CARE FOR BRIDGES- WHO IS RESPONSIBLE
- HOW WE INSPECT BRIDGES
- HOW WE FIX OLDER BRIDGES
- WHY DO SOME BRIDGES FAIL?

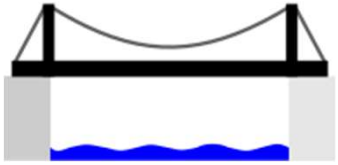
TYPES OF BRIDGES

SIMPLE BEAM

ARCH

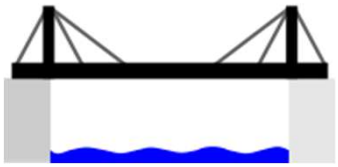


TRUSS



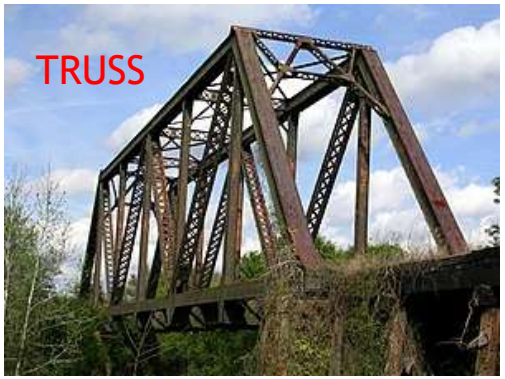
SUSPENSION

CANTILEVER



CABLE STAY

TYPES OF BRIDGES



WHAT IS THE MOST COMMON BRIDGE TODAY?

GIRDER

WHAT WAS THE MOST COMMON 100 YEARS AGO

ARCHES, TRUSSES

TIMBER BRIDGES

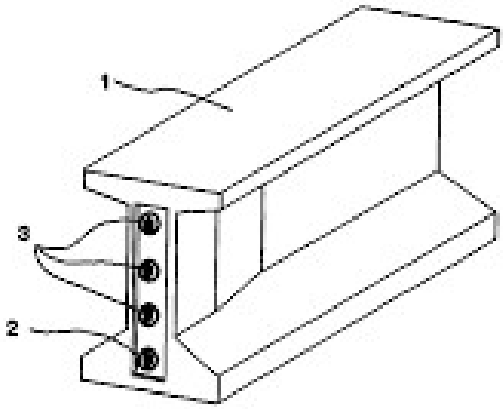
Early US Bridge- Favored by Railroads

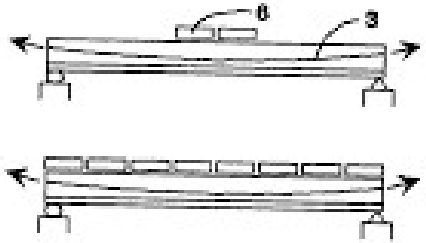
Problems

SUBJECT TO FIRE, DETERIORATION

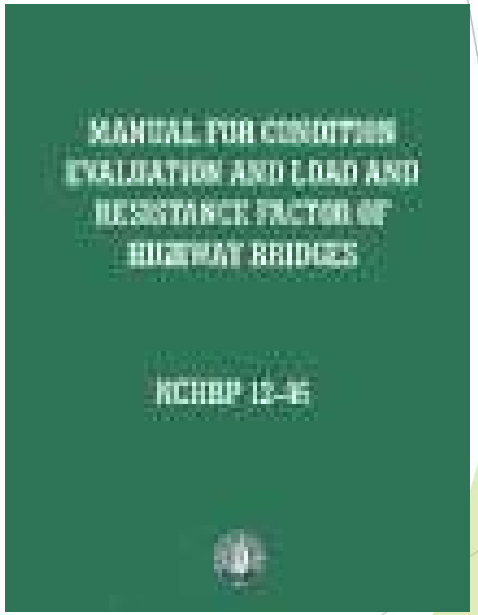
Girder Bridges

PRESTRESSED CONCRETE





Bridge Manuals



U.S BRIDGES CONDITION

Silver bridge, West Virginia, Ohio 1967

WHY DID BRIDGE FAIL?

REDUNDANCY- FRACTURE CRITICAL DEFINITION

The eyebars in the Silver Bridge were not redundant, as links were composed of only two bars each, With only two bars, the failure of one could impose excessive loading on the second, causing total failure — which would be unlikely if more bars were used. While a low-redundancy chain can be engineered to the design requirements, the safety is in question

CONSEQUENCES OF COLLAPSE- WHAT DID CONGRESS DO?

Failure resulted in congress passing laws that required bridge owners to inspect all their bridges at least every two years and report their findings to the FHWA

Background

The United States has approximately 612,000 bridges on public roads subject to the National Bridge Inspection Standards (NBIS) mandated by Congress. About 47% of these bridges are owned by state governments, and 50% are owned by local governments. State governments generally own the larger and more heavily traveled bridges, such as those on the Interstate Highway system. Less than 2% of highway bridges are owned by the federal government, primarily those on federally owned lands

BRIDGE INSPECTION REQUIREMENTS

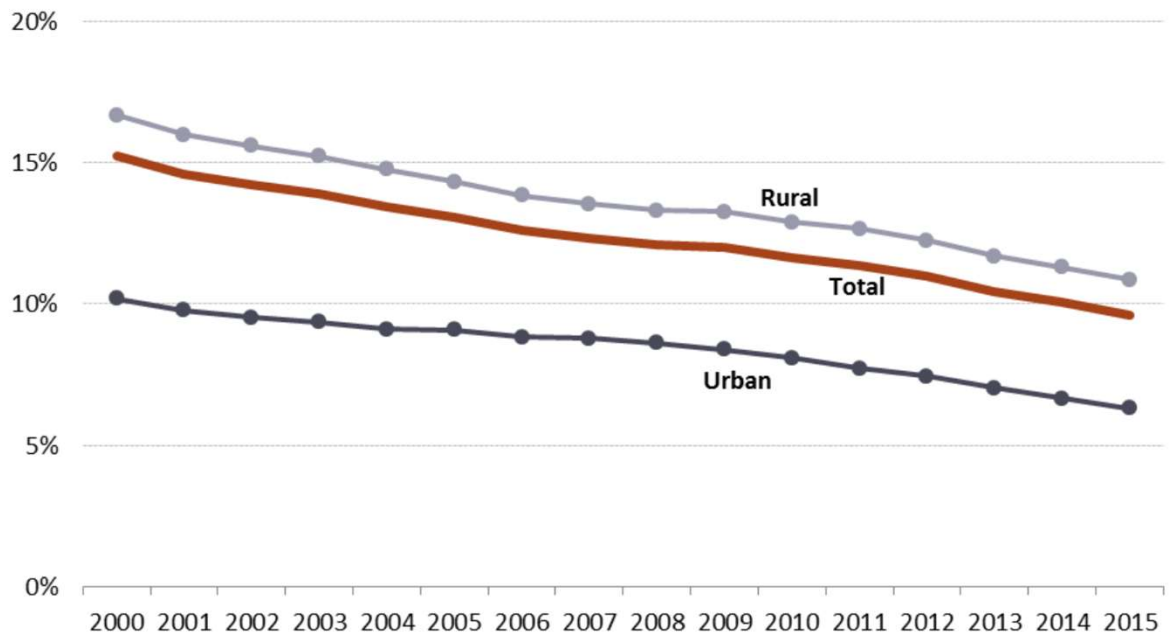
Under the National Bridge Inspection Program, all bridges longer than 20 feet on public roads must be inspected by qualified inspectors, based on federally defined requirements. Federal agencies are subject to the same requirements for federally owned bridges, such as those on federal lands. Data from these inspections are reported to FHWA, which uses them to compile a list of deficient or functionally obsolete bridges. States may use this information to identify which bridges need replacement or repair.

STRUCTURALLY DEFICIENT FUNCTIONALLY OBSOLETE

A bridge is considered *structurally deficient* "if significant load-carrying elements are found to be in poor or worse condition due to deterioration and/or damage.

A *functionally obsolete* bridge is one whose geometric characteristics—deck geometry (such as the number and width of lanes), roadway approach alignment, and over/underclearances—do not meet current design standards or traffic demands.

STRUCTURALLY DEFICIENT BRIDGES



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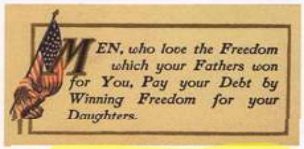
ASCE FOUNDATION

1830

1847
Seneca Falls Convention launches women's suffrage movement.



1840

1850

NINE STEEL BRIDGES
that are still in service today were open to traffic when it happened.

1860

1870

1880

5,189 SUCH BRIDGES
were already open when the Nineteenth Amendment finally granted women the right to vote in 1920.

1890

1900

1933
Police drag the Charles River after a "cod-napping" in the Massachusetts State House.

1910

At least
13,525 STEEL BRIDGES
that are still in service today were already open to traffic.

1920


Scott D Flickr

1930

1940

1863
President Abraham Lincoln delivers the Gettysburg address.

63 STEEL BRIDGES
that are still in use today were already open to traffic.

EVERY DAY IN THE U.S., AN AVERAGE OF 77 MILLION VEHICLES CROSS MORE THAN 25,000 STEEL BRIDGES BUILT BETWEEN 1838 AND 1938.

These are just a few of the stories these bridges could tell: dazzling innovation, events that changed the world, and quirky people being...well, quirky.

Visit **aisc.org/timeline** for more.

Smarter. Stronger. Steel.

National Steel Bridge Alliance
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Dunlap's Creek Bridge opens to traffic in Brownsville, Pa.

Oldest Steel Bridge in US is still in use 1839

- The first cast-iron bridge in America was the first metal bridge worldwide to use "standardized, interchangeable, manufactured parts," in the words of Capt. Richard Delafield of the U.S. Army Corps of Engineers. The tubular segments that make up the five arch ribs are similar to cylinders in use for steamboat engines at the time.
- The structure was opened to traffic in July 1838, a year before its completion and official dedication on Independence Day, July 4, 1839

TESTING AND INSPECTION

THE ONLY WAY TO INSPECT BRIDGES

WHAT ARE WE DOING?

LOAD TESTING

WHY ARE WE DOING IT

TO CHECK STRUCTURAL CALCULATIONS

ULTRASONIC TESTING

WHAT ARE WE LOOKING FOR?

CRACKS

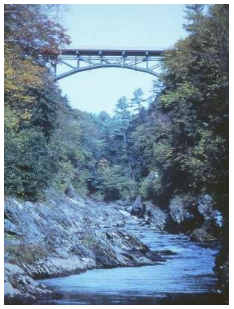
Metal Trusses

Washington Crossing

Double Intersection Warren, 1904

Nevius Street, NJ

Double Intersection Pratt (Whipple) - 1886



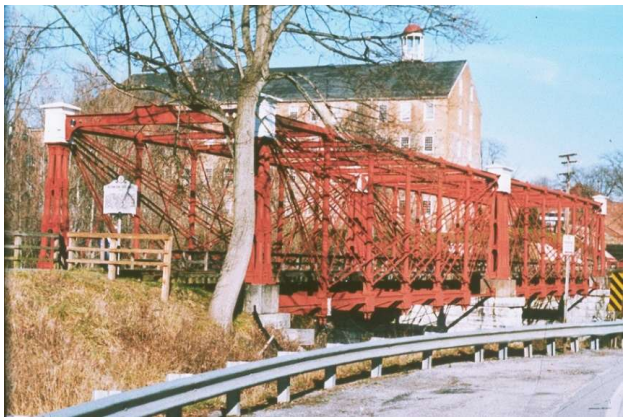
Woodstock, VT

Pennsylvania Truss 1900

- Resource that Embodies Development of Structural Engineering Profession
- Their Very Nature Required Stress Analyses, Material Testing, Attention to Detail
- Squire Whipple - “A Work on Bridge Building, 1847”
- Very Popular in 1800’s

Metal Trusses –Very Popular in 1800's

Pulaski Skyway, NJ 1932



Bollman Truss, Savage MD 1869

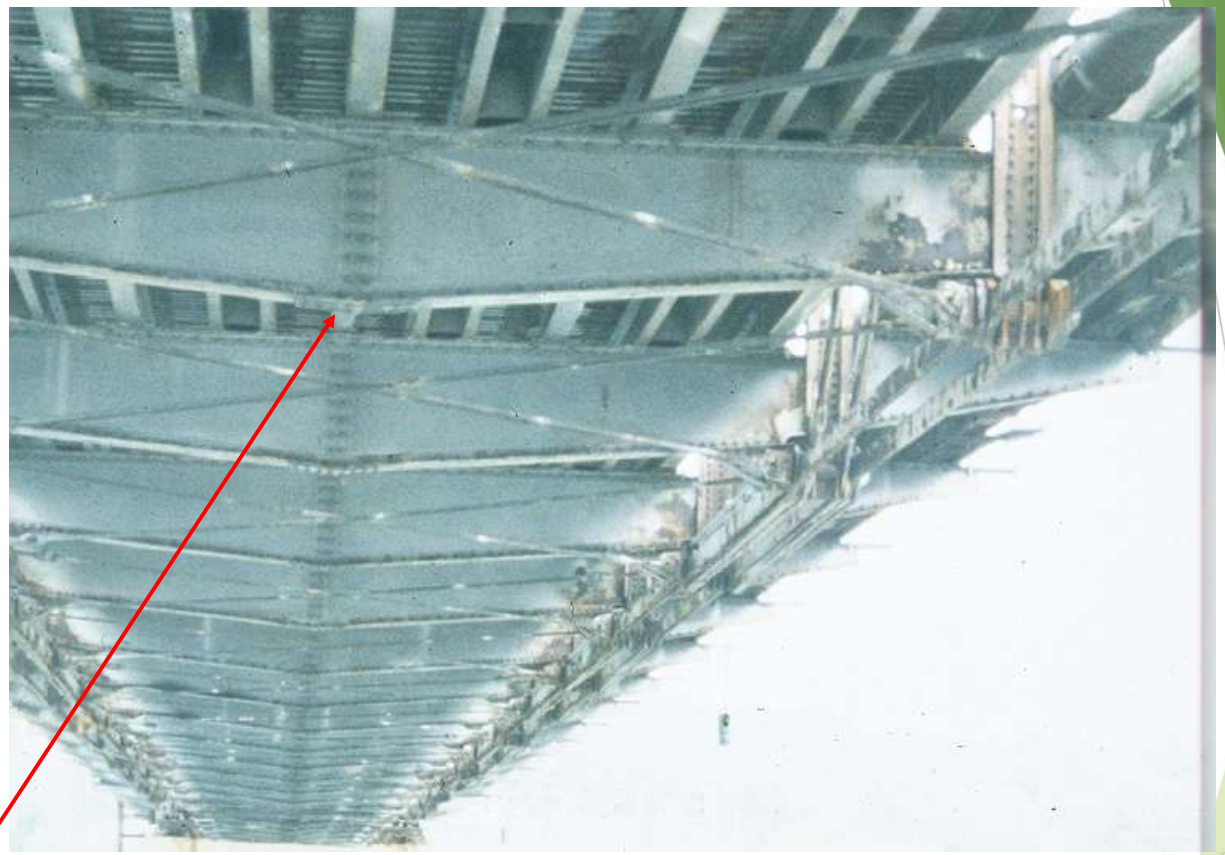
- Product of the Railroads During Their Great Growth of the Mid 19 th Century
- Wendell Bollman - Formed a Company that Became Model for Bridge Fabrication
- Early User of Wrought Iron, Then Steel

Walnut Street Bridge

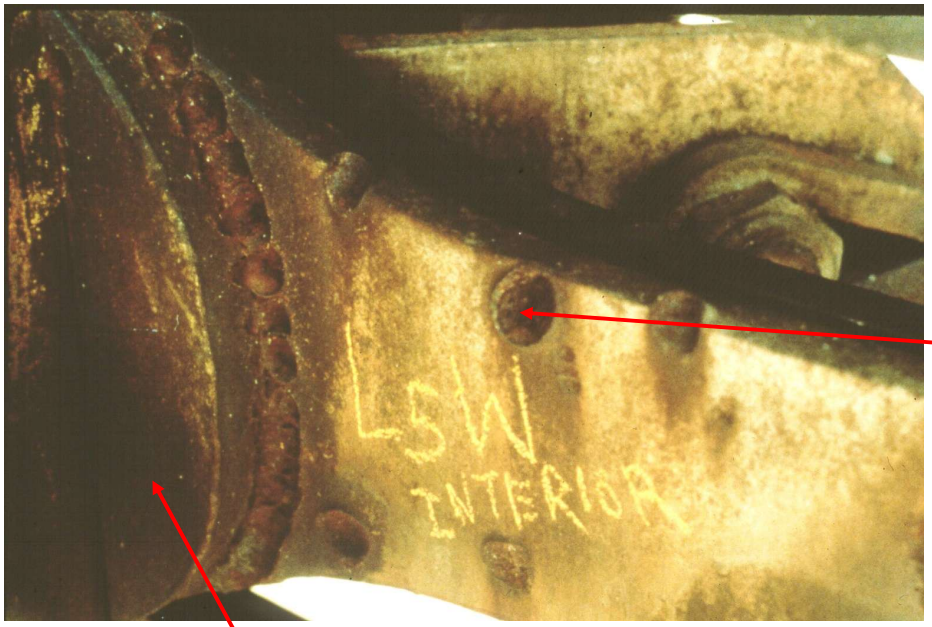
- Built in 1891
- Designed by Edwin Thatcher
- Oldest Bridge on the Tennessee River
- 320’ Pratt Metal Truss Spans
- 2,600 ft in total length
- Conversion to Linear Park
- National Register of Historic Places
- Goal- To Rehabilitate and make it focal point of city

Chattanooga, Tennessee

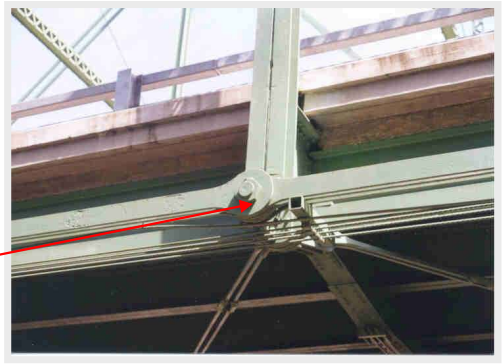
Owner: City of Chattanooga



Trusses,Floorbeams And Stringers Are Original



Deterioration of Bottom Eye Bars, Repair Required



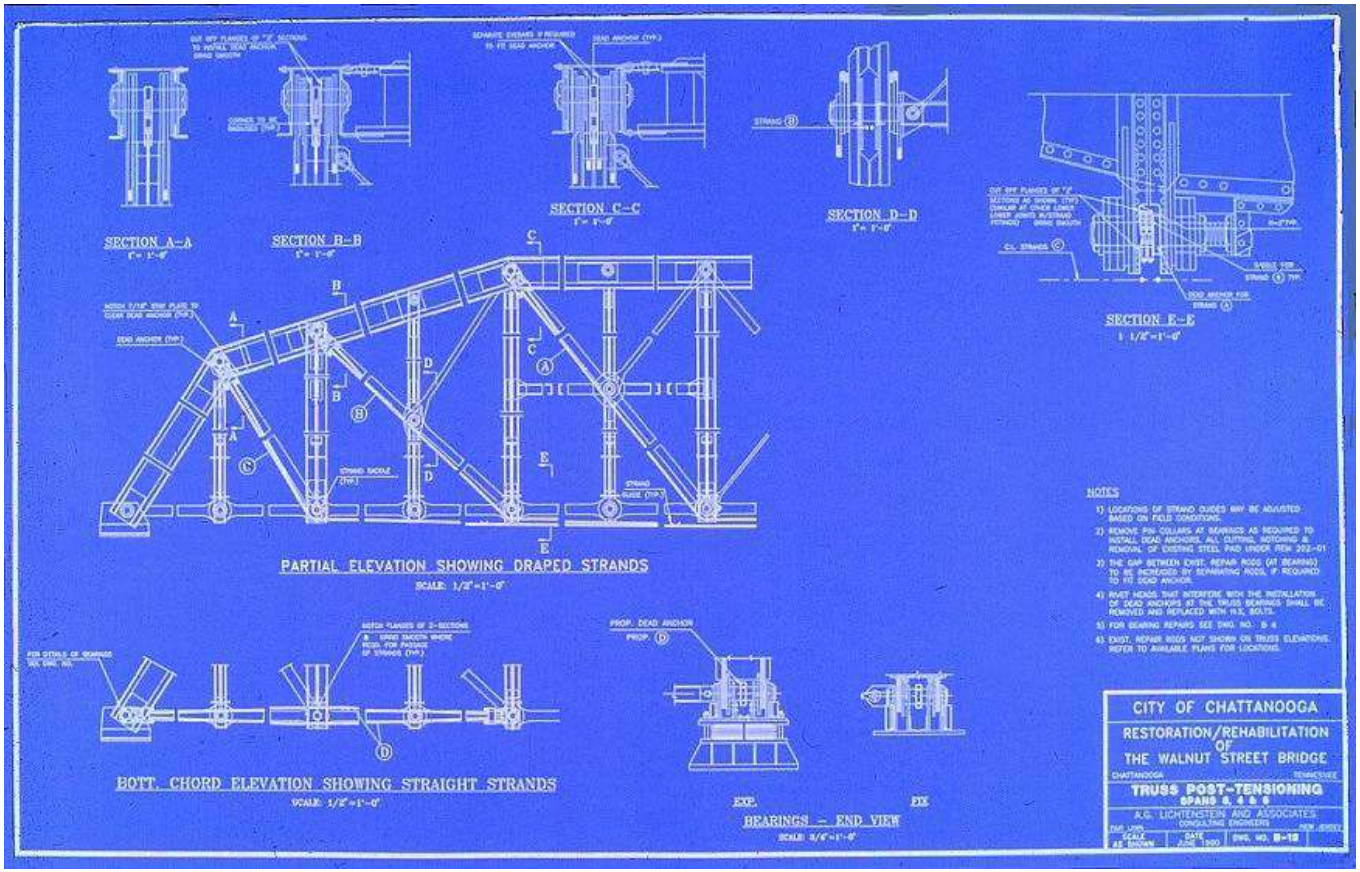
Eye Bar Head

Design Issues

- **Need to Correct Eye Bar Deficiencies**
- **Provide for Pedestrian Load Capacity**
- **All Strengthening to be Concealed as Much as Possible**

Historic and Architectural Issues

- Preserve and Restore Existing Historic Structural Elements
- Restore Railing
- Make Bridge “Pedestrian Friendly”
  - Lighting
  - Street Furniture
  - Conveniences For Festival Usage
  - Handicap Access Ramps



- Detail of Cables

- 0.6” Diameter
- GR270 Coated Strands

Tensioning cables removes load from eye bars


Bridge Strengthened with
High Strength Cables
Cables –convenient and economical
method to increase load capacity of trusses

ARCHES

ARCHES

Stone, brick and other such materials are strong in compression and somewhat strong in shear but cannot resist much force in tension. As a result, masonry arch bridges are designed to be constantly under compression, so far as is possible. Each arch is constructed over a temporary falsework frame, known as centering. In the first compression arch bridges, a keystone in the middle of the bridge bore the weight of the rest of the bridge.

ARKADIKO BRIDGE- GREECE- 13TH CENTURY BC
OLDEST KNOWN BRIDGE- SPAN 3 ft.

ARCHES

ALEXANDER HAMILTON BRIDGE-NYC

RIALTO BRIDGE- VENICE

SYDNEY HARBOR BRIDGE-AUSTRALIA

HELLS GATE- NYC

History of Concrete

- Known Since Roman Times
- Portland Cement Discovery - 1813
- Need For Reinforcing Steel

Notable Engineers

- Ernest Ransome
  - Developed Twisted Reinforcing Bars
- Edwin Thacher
  - Arches
- Joseph Melan
  - Metal Beams Inside
- James Marsh
  - Marsh Arch – Arch Shape
  - Built-up Steel Members Inside

Realities of Late 1800s

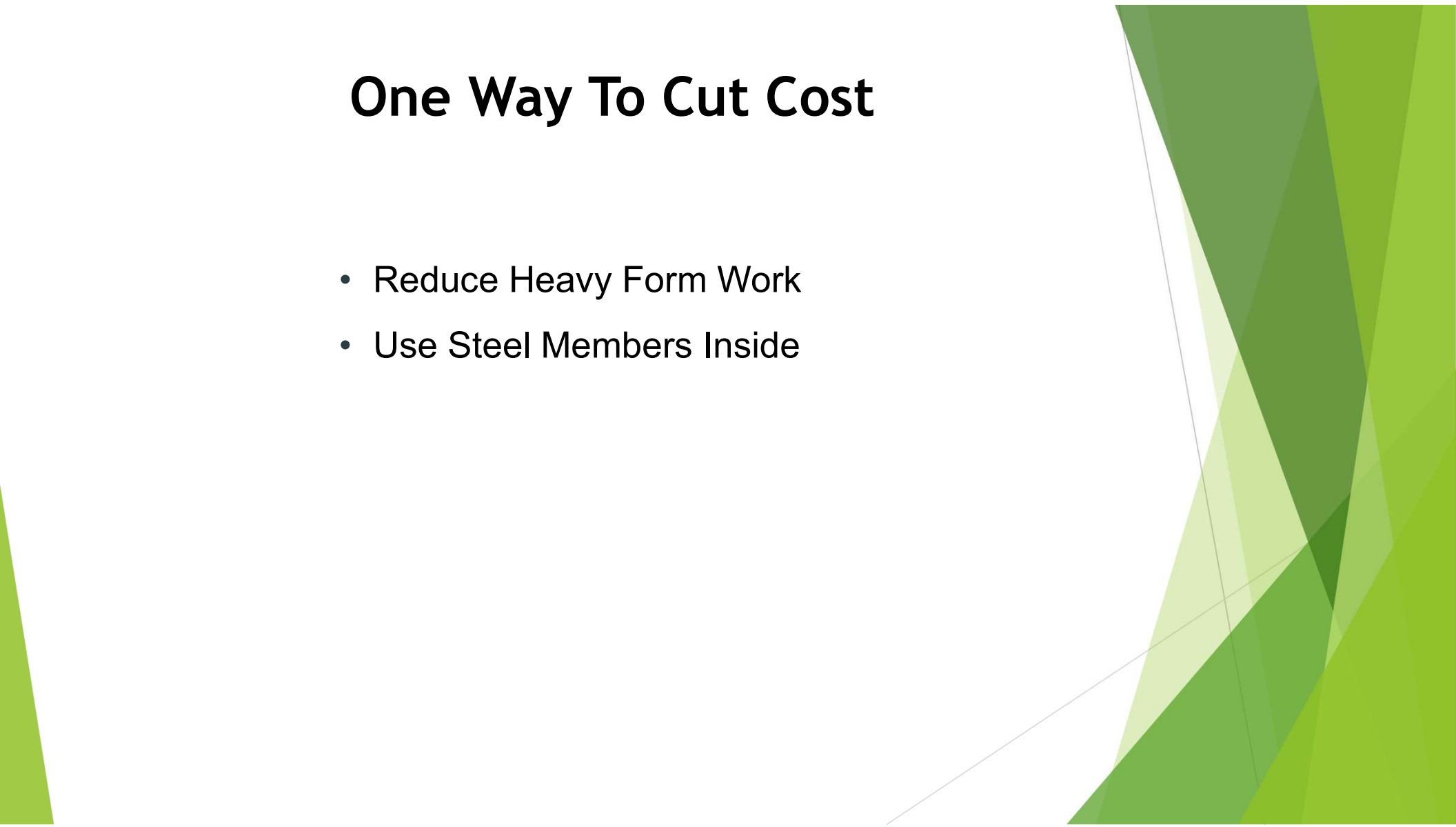
- Metal Trusses Becoming Prolific
- Many Companies Fabricating Trusses
- Span Lengths Increasing
- Railroad Preference

Concrete Bridges

- If Competitive Would Be Preferred
- Stone Was Considered Permanent
- Need To Imitate Stone

One Way To Cut Cost

- Reduce Heavy Form Work
- Use Steel Members Inside



JOHN MACK BRIDGE –Wichita Kansas

- 1912 PATENTED TIED MARSH ARCH
- NATIONAL REGISTER OF HISTORIC PLACES
- 8 SPANS AT 100’
- 30° SKEW
- 30’ ROADWAY
- STEEL MEMBERS ENCASED IN CONC.

JOHN MACK BRIDGE –Wichita Kansas

PROBLEMS

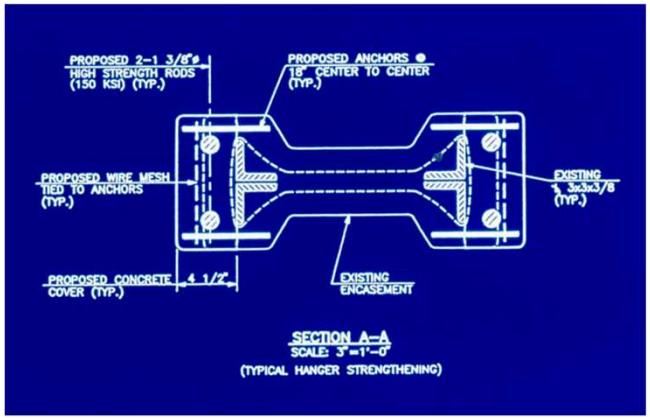
- CRACKED VERTICALS

JOHN MACK BRIDGE –Wichita Kansas

- LOAD TESTING
- 3D ANALYSIS
- MEMBER STRESSES LOW

JOHN MACK BRIDGE –Wichita Kansas

NEED TO REINFORCE VERTICALS



JOHN MACK BRIDGE –Wichita Kansas

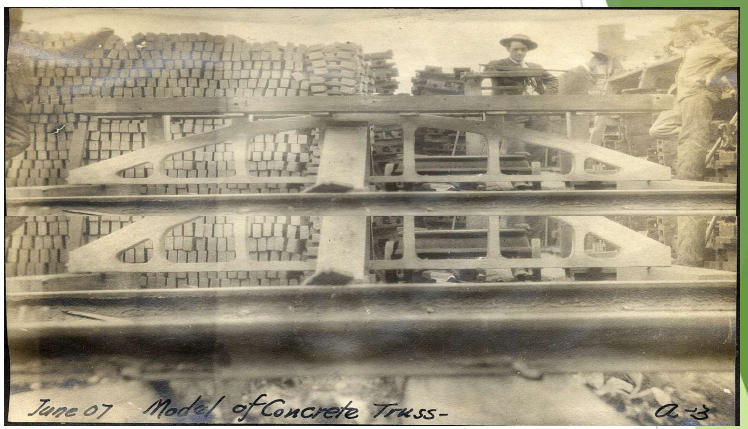
SHELBY STREET BRIDGE
NASHVILLE, TENNESSEE

- BUILT IN 1907
- 3150’ LONG –
  SPANNING CUMBERLAND RIVER, RAILROAD & LOCAL STREETS
- COMPOSED OF
  - **3 – OVERHEAD PRATT TRUSSES @ 321’, 178’, 178’**
  - **1 – PRATT DECK TRUSS – 100’**
  - **2 – REINFORCED CONCRETE TRUSSES – 98’**
  - **42 – T-BEAM SPANS**

- BRIDGE ON NATIONAL REGISTER OF HISTORIC PLACES –
- TECHNOLOGICALLY SIGNIFICANT BECAUSE OF “ONE OF A KIND” CONCRETE TRUSSES-DESIGNER HOWARD JONES

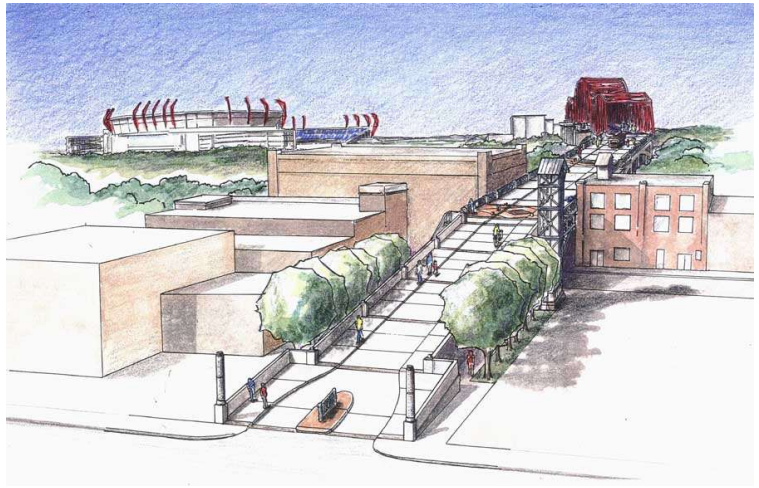
IMPORTANT FEATURE – REINFORCED CONCRETE TRUSSES

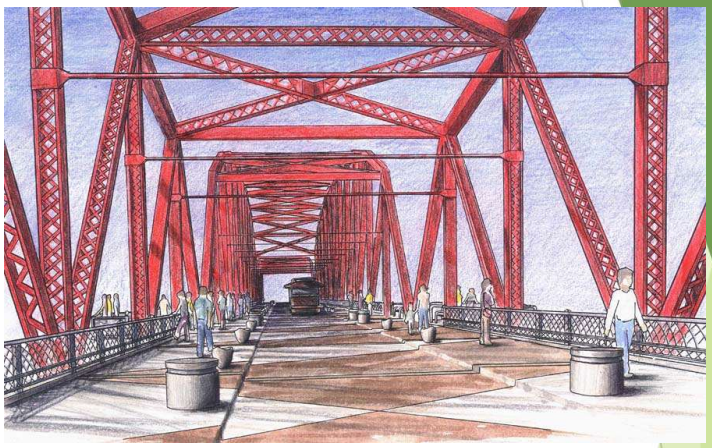
- NEEDED TO SATISFY RR REQUIREMENTS
- STUDIED ALTERNATES
  - **STEEL DECK TRUSSES – CONCERN FOR SULFUROUS SMOKE**
  - **DECK TRUSSES – ENCASED IN CONCRETE - TOO HEAVY**
  - **REINFORCED CONCRETE ARCHES - CLEARANCE CONCERNS**
  - **CONCRETE TRUSSES - SELECTED**



- FOUND NO U.S. EXAMPLE
- SOME WORK OF THIS KIND IN EUROPE
- MADE & TESTED 1/10 SIZE MODEL
- EARLY DAYS OF REINFORCED CONCRETE
- TESTED TO 6X CAPACITY

VISION FOR BRIDGE

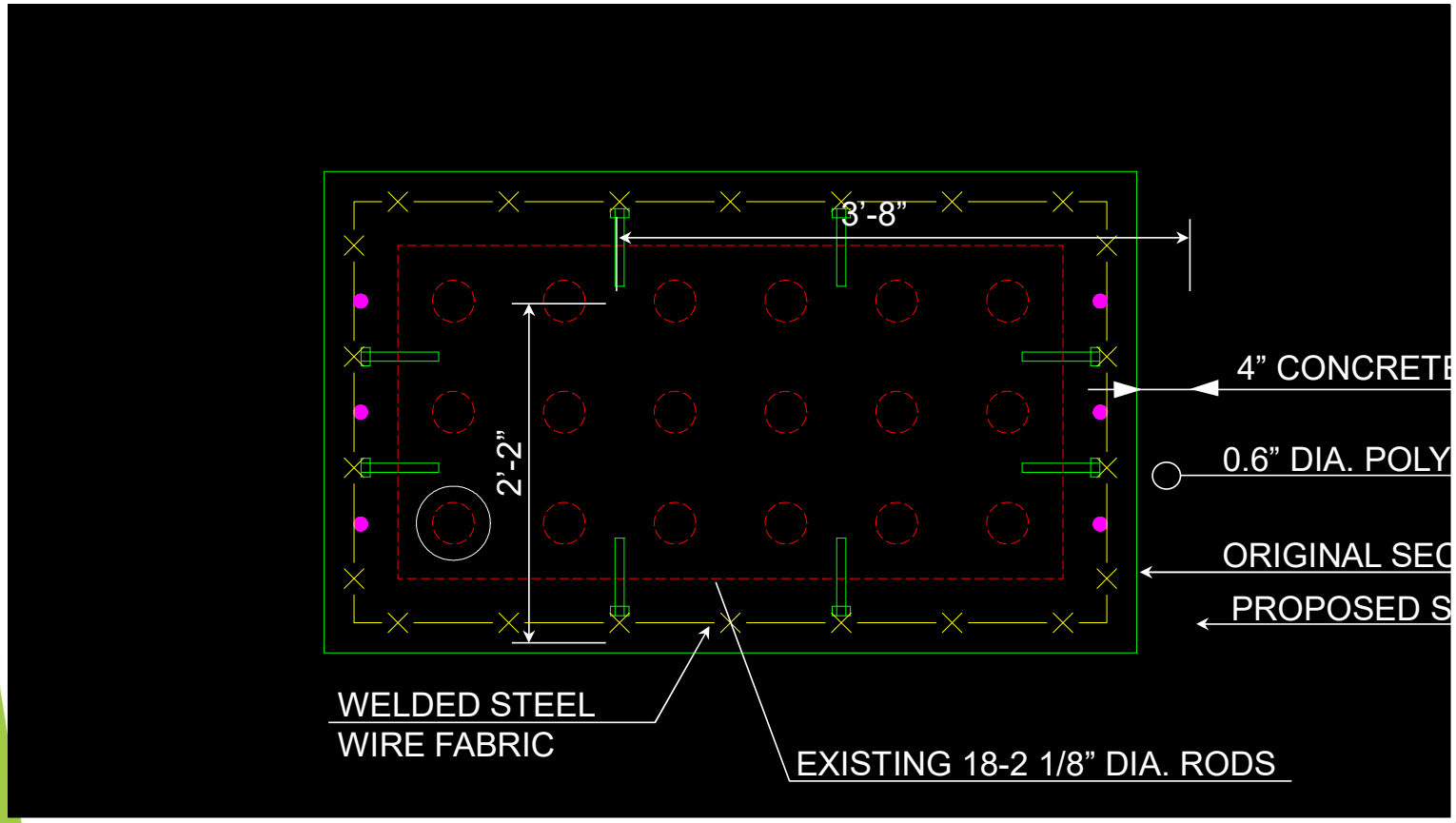




- MAKE IT FOCAL POINT FOR CITY
- LINEAR PARK DESIGN
- PEDESTRIAN ACCESS TO FOOTBALL STADIUM

- PEDESTRIAN & LIGHT WEIGHT VEHICLES
- PROVIDE OUTLOOKS
- INCORPORATE LIGHTING, ORNAMENTAL RAILINGS INTO BRIDGE

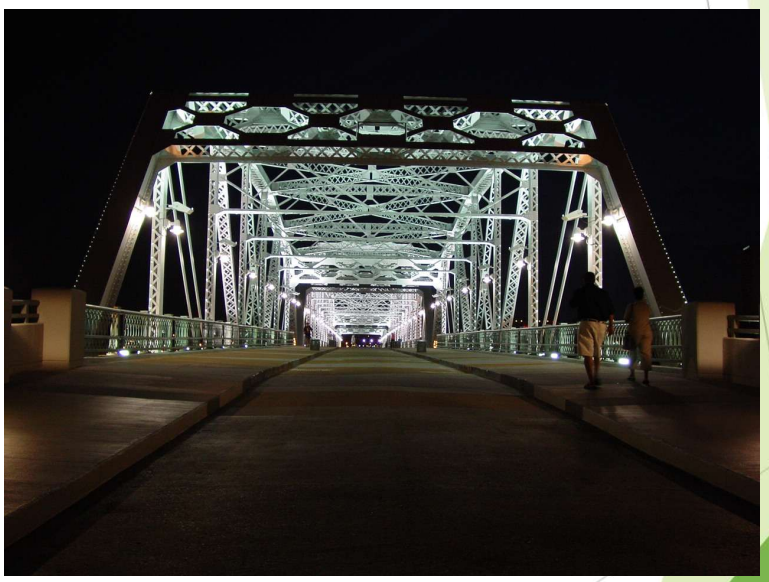
MAJOR ITEMS OF WORK



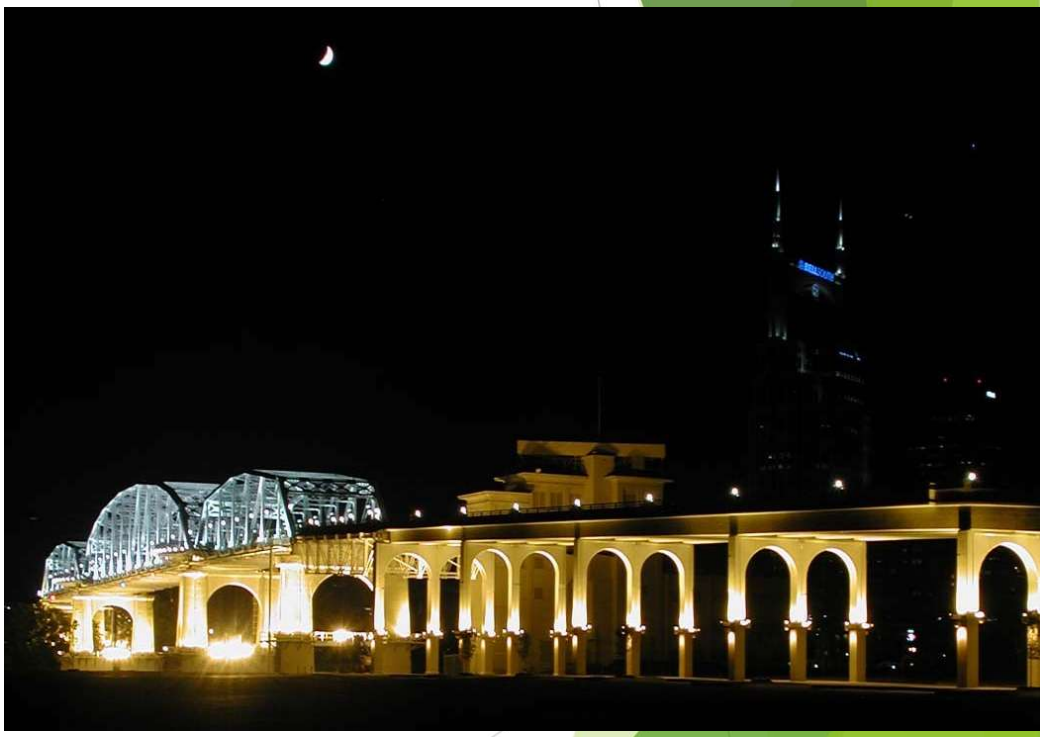
BOTTOM CHORD CROSS SECTION

COMPLETED TRUSSES

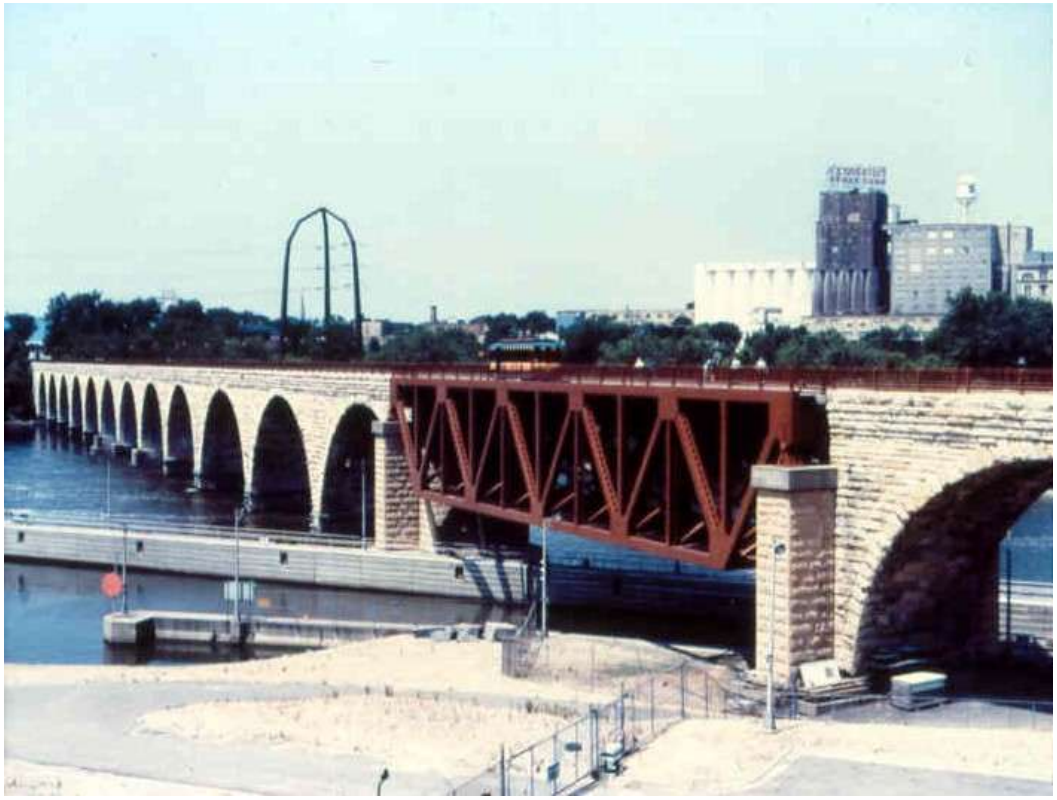
COMPLETED BRIDGE



COMPLETED BRIDGE



JAMES HILL BRIDGE, MINNEAPOLIS MINNESOTA

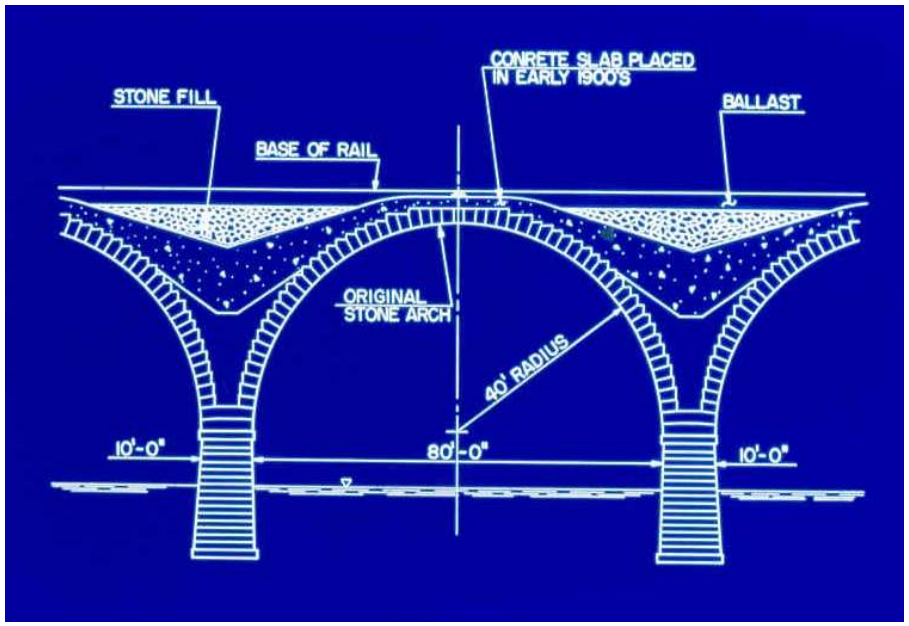


JAMES HILL BRIDGE, MINNEAPOLIS MINNESOTA

- 1883 STONE ARCH-ORIGINALLY A RAILROAD BRIDGE
- 24’ WIDE, 2100’ LONG, 40’ TO 98’ SPANS
- ONLY STONE ARCH ON MISSISSIPPI RIVER
- CIVIL ENGINEERING LANDMARK

PROBLEM- CRACKS ON UNDERSIDE OF BRIDGE

JAMES HILL BRIDGE, MINNEAPOLIS MINNESOTA



Concrete slab apparently installed after original construction

JAMES HILL BRIDGE, MINNEAPOLIS MINNESOTA

- INSPECTION AND TESTING
- VISUAL
- GPR
- SONIC

JAMES HILL BRIDGE, MINNEAPOLIS MINNESOTA

ADDED TO CONCRETE (RELIEVEING SLAB)

JAMES HILL BRIDGE, MINNEAPOLIS MINNESOTA

SOME HISTORIC BRIDGES

OVERVIEW OF FEDERAL LAWS

- **1906 - ANTIQUITIES ACT**
  - ✓ PROTECT ARCHAEOLOGICAL SITES ON FEDERAL LANDS
- **1916 - NATIONAL PARK SERVICE CREATED**
  - ✓ ADMINISTER INCREASED NUMBER OF PARKS
- **1935 - HISTORIC SITES ACT**
  - ✓ PARK SERVICE ABLE TO PURCHASE HISTORIC PROPERTIES
  - ✓ OPEN THEM TO THE PUBLIC
  - ✓ NPS BECOMES LEAD IN PRESERVATION

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OVERVIEW OF FEDERAL LAWS (cont.)

- **H.A.B.S. (HISTORIC AMERICAN BUILDING SURVEY)**
  - ✓ RECORDATION AND PHOTOGRAPHY OF HISTORIC RESOURCES
- **1930's- JOHN D. ROCKEFELLER ESTABLISHED WILLIAMSBURG**
- **WORLD WAR II**
  - ✓ PRESERVATION ON HOLD
- **INTERSTATE HIGHWAY SYSTEM AND HUD URBAN RENEWAL PROGRAM**
  - ✓ REMOVAL OF OLD NEIGHBORHOODS

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OVERVIEW OF FEDERAL LAWS (cont.)

- SCENE REPEATED IN MANY CITIES
- COLONIAL WILLIAMSBURG – POPULAR TOURIST DESTINATION
- LADY BIRD JOHNSON INTERESTED IN BEAUTIFICATION
- THE TIME WAS RIGHT FOR PRESERVATION

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OVERVIEW OF FEDERAL LAWS (cont.)

- NATIONAL HISTORIC PRESERVATION ACT OF 1966
  - ✓PRESERVATION IS A NATIONAL GOAL
  - ✓NATIONAL REGISTER OF HISTORIC PLACES
  - ✓ADVISORY COUNCIL ON HISTORIC PRESERVATION COMMENT ON EFFECT OF PROPOSED ACTION
- NATIONAL PARK SERVICE CHARGED WITH IMPLEMENTATION OF ACT
- NPS RESPONSIBILITY DECENTRALIZED
- ESTABLISHMENT OF STATE HISTORIC PRESERVATION OFFICE

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OVERVIEW OF FEDERAL LAWS (cont.)

- **DEPARTMENT OF TRANSPORTATION ACT OF 1966**
  - ✓ SECTION 106 - CONSULTATION PROCESS
  - ✓ SECTION 4F – MANDATE
- **PRUDENT AND FEASIBLE TEST**
- **ALTERNATIVE ANALYSIS**
  - ✓ NO BUILD
  - ✓ REHABILITATION WITH NO ADVERSE EFFECT
  - ✓ NEW BRIDGE - NEW ALIGNMENT
  - ✓ (HISTORIC BRIDGE BYPASS)
  - ✓ OTHER ALTERNATES

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OVERVIEW OF FEDERAL LAWS (cont.)

- SILVER BRIDGE COLLAPSES IN 1967
- CONGRESS PASSES LEGISLATION TO IMPROVE BRIDGE SAFETY
- SAFETY BRIDGE INSPECTIONS MANDATED
- GOAL IS TO REHABILITATE (IMPROVE) OR REPLACE DEFICIENT BRIDGES

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CONFLICTING DEFINITION OF REHABILITATION

- **SECRETARY OF THE INTERIOR'S STANDARDS FOR REHABILITATION DEVELOPED BY NPS**
  - ✓ DEFINES REHABILITATION AS "THE PROCESS OF RETURNING A PROPERTY TO A STATE OF UTILITY, THROUGH REPAIR OR ALTERATION, WHICH MAKES POSSIBLE AN EFFICIENT CONTEMPORARY USE WHILE PRESERVING THOSE PORTIONS AND FEATURES OF THE PROPERTY WHICH ARE SIGNIFICANT TO ITS HISTORIC, ARCHITECTURAL, AND CULTURAL VALUES."
- **1978 SURFACE TRANSPORTATION ASSISTANCE ACT**
  - ✓ BRIDGES RATED AND FUNDS AVAILABLE FOR REHAB/REPLACEMENT OF LOW SUFFICIENCY RATING BRIDGES
  - ✓ DEFINES REHABILITATION AS "THE MAJOR WORK REQUIRED TO RESTORE THE STRUCTURAL INTEGRITY OF A BRIDGE AS WELL AS THE WORK NECESSARY TO CORRECT SAFETY DEFECTS."

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HISTORIC BRIDGES

Ponte Vecchio

The late medieval Ponte Vecchio, crossing Tuscany's Arno River, is one of **Florence's best known landmarks. Famous for the shops that have called the bridge home since its construct**ion, Ponte Vecchio, built in 1345,

Part of the 50-kilometer Nîmes aqueduct, France's Pont du Gard – a three-level water bridge spanning Languedoc-Roussillon's Gardon River built midway through the 1st century

HISTORIC BRIDGES

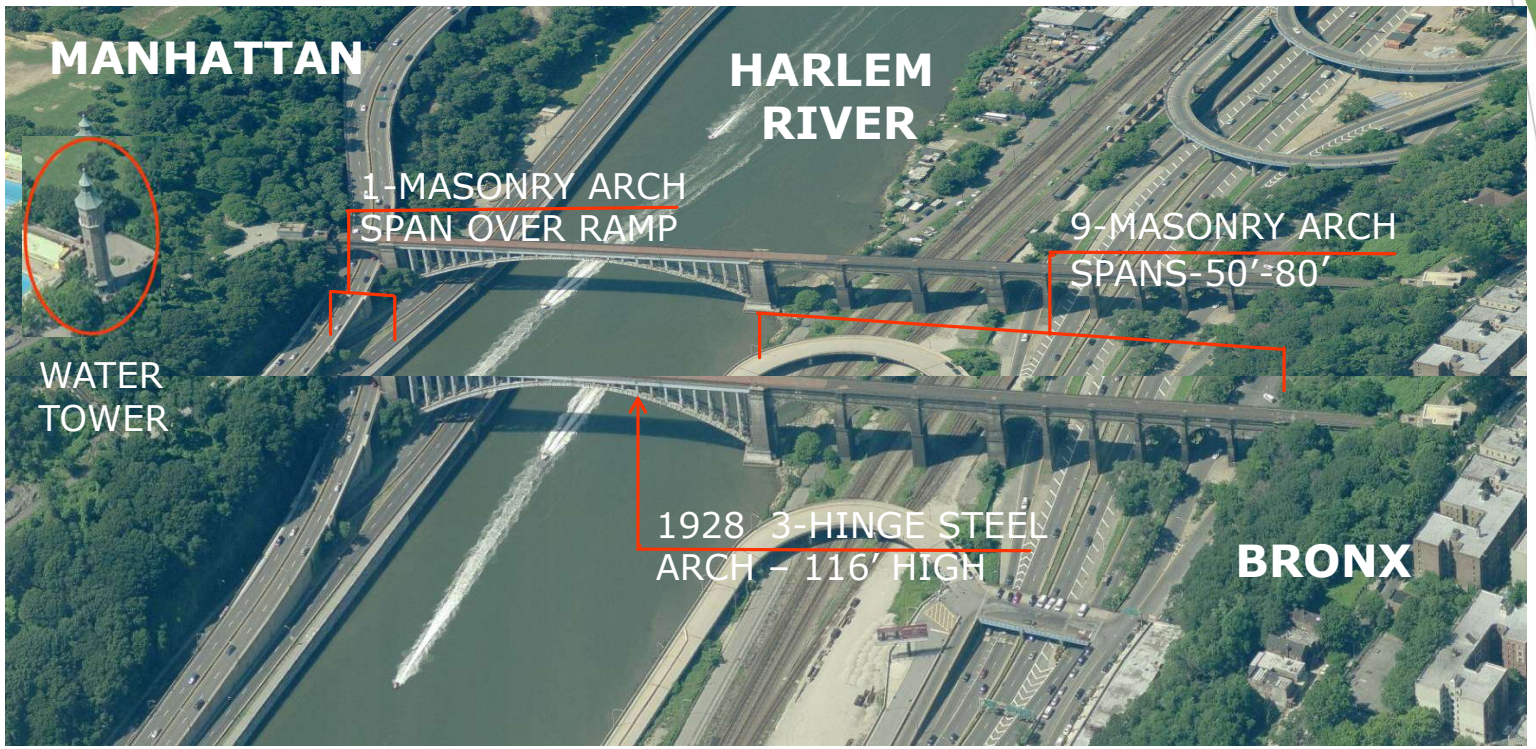
BROOKLYN BRIDGE

1883- DESIGNER- JOHN ROEBLING
MAIN SPAN 1596’
HYBRID CABLE STAY/SUSPENSION

GOLDEN GATE BRIDGE

1937-DESIGNER.JOSEPH STRAUSS, LEON MOISSOFF-MANHATTAN BRIDGE DSIGNER, CHARLES ELLIS
4200’MAIN SPAN, 746’TALL
TIME OF CONSTRUCTION LONGEST AND TALLEST IN WORLD
STILL THE TALLEST IN WORLD

REHABILITATION OF THE HIGH BRIDGE
NEW YORK CITY, NEW YORK



- BRIDGE : 1183' LONG, 25' WIDE, 116' HIGH
- ORIGINAL CONSTRUCTION: 1839-1848

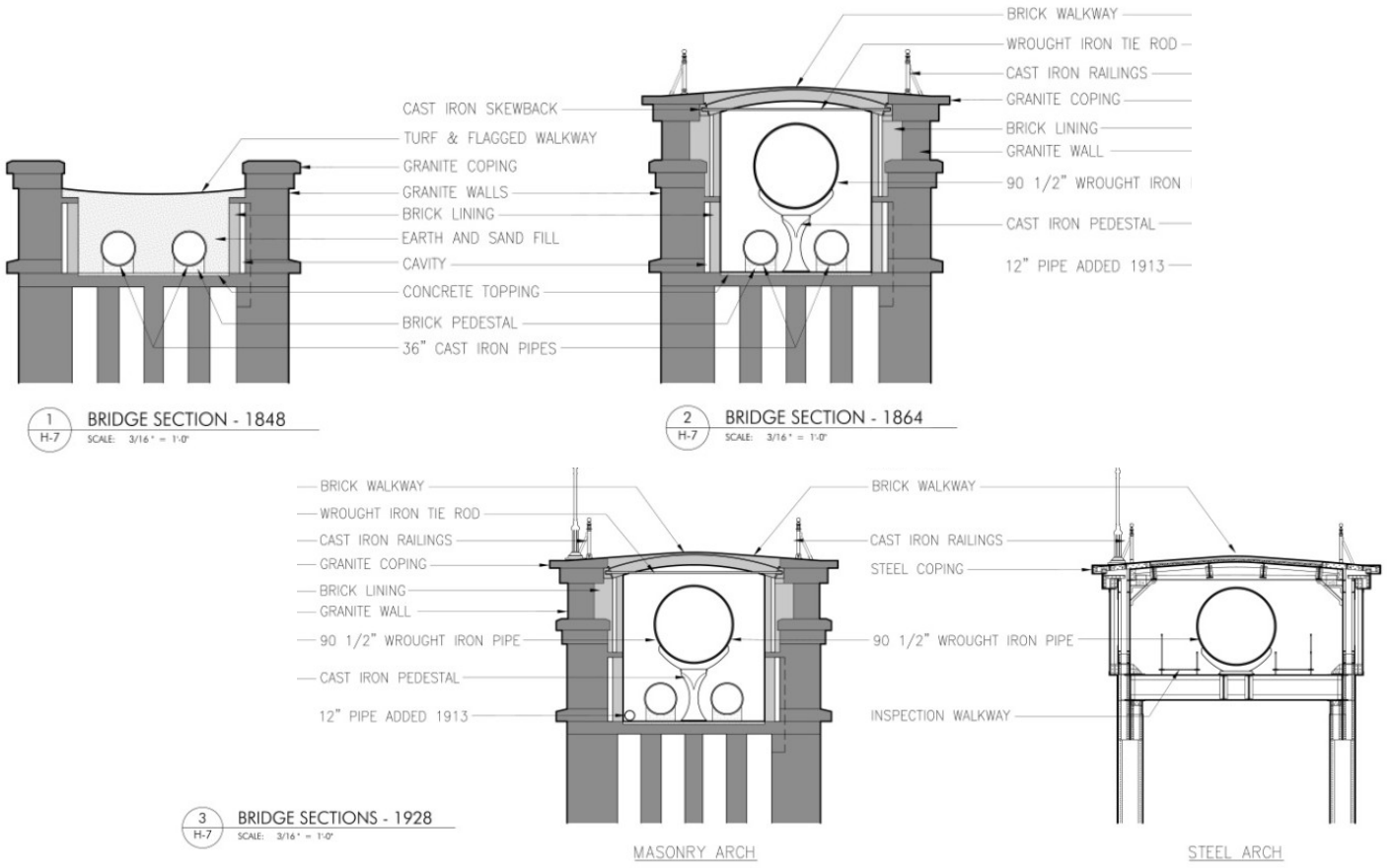
DESIGNER- JOHN JERVIS, ENGINEER OF ERIE CANAL

Project Purpose

A plan to keep New York City livable…
to prepare for 1 million more residents by 2030

Goal:
For all New Yorkers
to live within a
10-minute walk
of a park

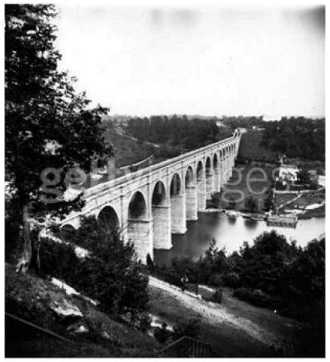
Brief History – Chronology of Alterations



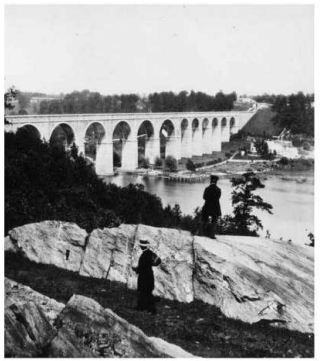
Brief History in Photographs

1839 - 1848

1843 Tower FB, High Bridge over Harlem River

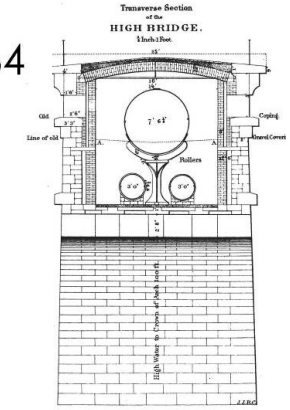


1859 Harlem Aqueduct William England

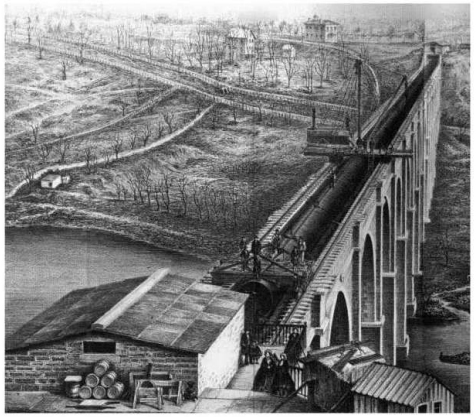


1859 High Bridge England William

1860 - 1864



1862, Annual Report of the Croton Aqueduct Dept

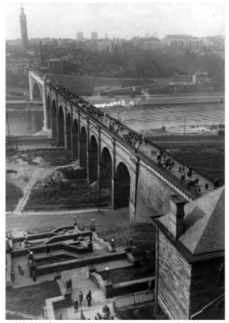


1860-61 High Bridge. Improvements underway

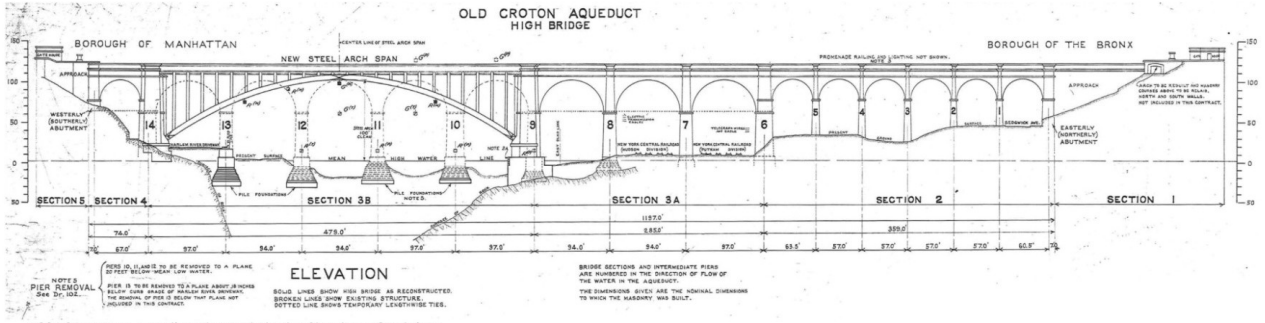
1862, High Bridge during Construction of the Large Main

Brief History In Photographs

1926 - 1928



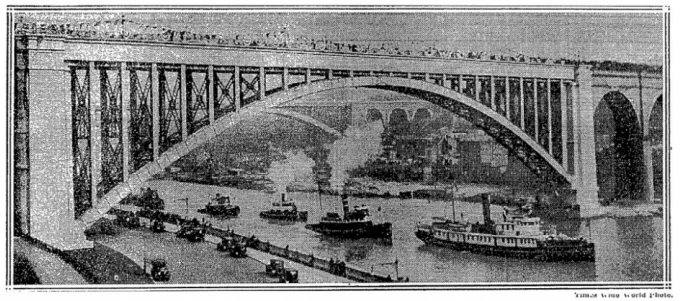
1928 High Bridge (New York Times)



1926-06 HB Rec. Location Plan Dpt Plant & Structures Container

1927-12-02 High BridgeView Showing Traveler (Municipal Archives)

1927-02-20 High Bridge General View from Harlem River Drive Looking NE (Municipal Archives)



The Harlem River Structure, Modernized and Converted Into a Single Span to Make Navigation Beneath It Safer, Was Formally Reopened Yesterday.

1928, Marine Parade Reopening of High Bridge (NY Times)

Brief History In Photographs

- 1958 Old Croton Aqueduct removed from service
- 1960 Bridge transferred to Department of Parks
- 1970s High Bridge closed
- 1970 Awarded NYC Landmark status
- 1972 Listed on National Register of Historic Places
- 1992 Aqueduct & Bridge designated National Historic Landmark

Project Vision

To respect the work of the 19th century visionaries

Restore the beauty, usefulness and grandeur of the High Bridge

Create Effective Links

Enhance New York City pedestrian environment

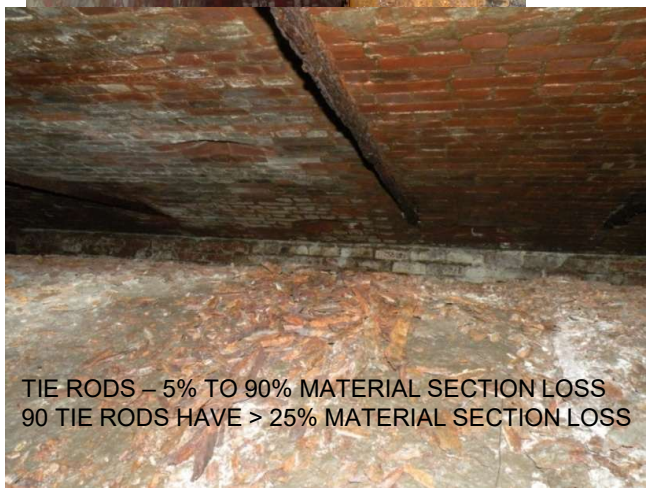
Structural Rehabilitation - Steel Repairs

- STEEL FLOORBEAM SPLICE REPAIR
- STEEL STRINGER REPLACEMENT

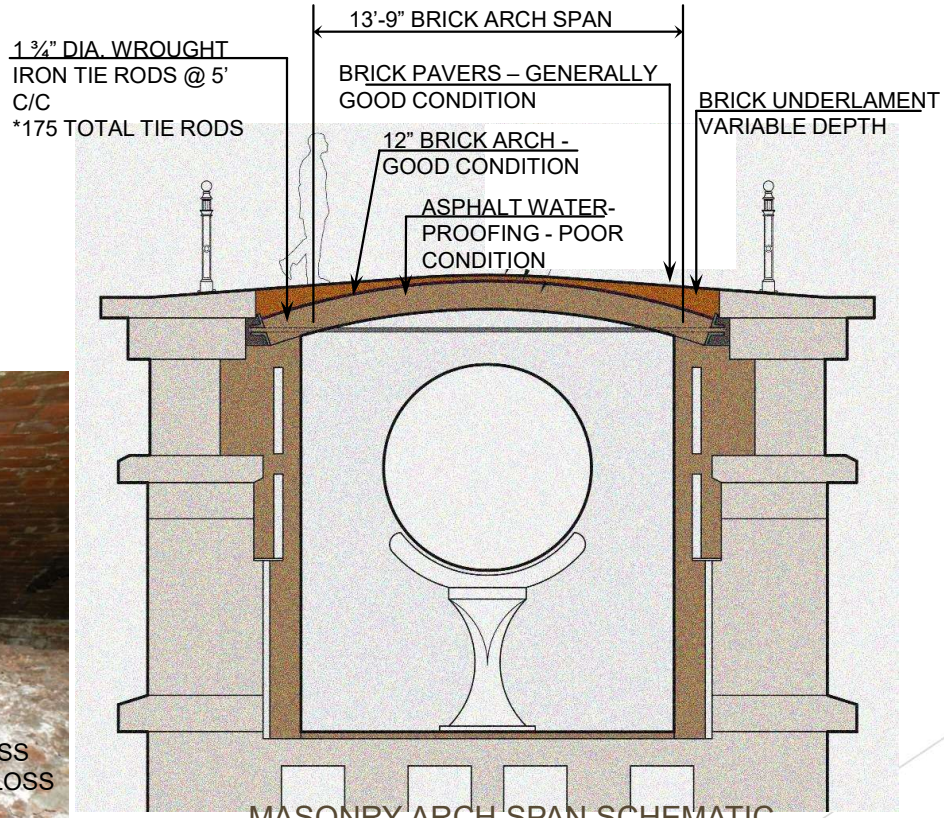
Existing Conditions - Croton Aqueduct Pipe

TYPICAL WROUGHT IRON PIPE AND CAST IRON PEDESTAL WITH SADDLE - MASONRY ATTIC

Structural Rehabilitation - Tie Rod Installation



TIE RODS – 5% TO 90% MATERIAL SECTION LOSS
90 TIE RODS HAVE > 25% MATERIAL SECTION LOSS



MASONRY ARCH SPAN SCHEMATIC
SECTION THROUGH ATTIC

Access Ramp

Lighting Ambient And Architectural Lighting

BRIDGE FAILURES

WHY DO BRIDGES FAIL?

- OVERLOAD
- COLLISION
- FAULTY DETAILS
- INADEQUATE DESIGN
- POOR MAINTENANCE

REDUNDANCY, FATIGUE, BRITTLE FRACTURE

REDUNDANCY

STRINGERS,REDUNDANT, MORE THAN 3

TRUSSES- FRACTURE CRITICAL-NON REDUNDANT

FAILURE OF ONE MEMBER MAY LEAD TO TOTAL COLLAPSE

FATIGUE/FRACTURE

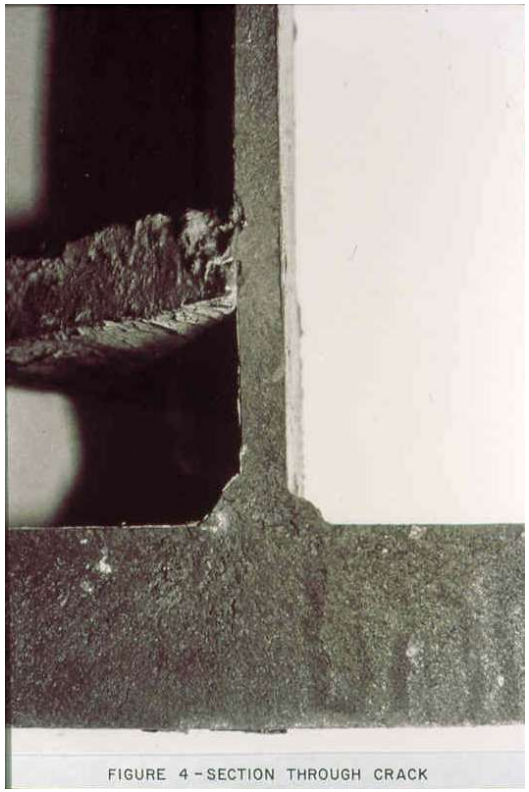
RIVETS AND BOLTS GOOD FOR FATIGUE

FATIGUE/FRACTURE

WELDING NOT GOOD FOR FATIGUE/FRACTURE

WHY???

FATIGUE/FRACTURE

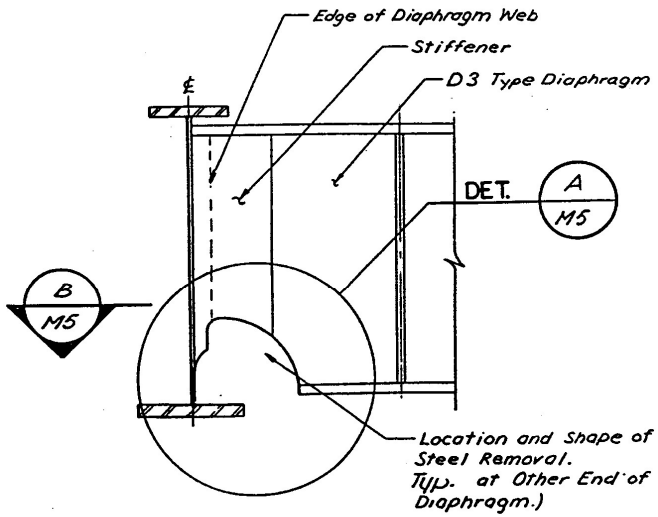


IMPROPER DETAILS LEADS TO HIGH CONSTRAINTS

WELDING INTRODUCES SMALL DEFECTS IN METAL

WITH ENOUGH CYCLES, SMALL CRACKS GROW UNTIL THEY BECOME CRITICAL

THE FIX- SOFTEN DETAIL IN AREAS OF TENSION



(D-3) & [D-3] DIAPHRAGM SOFTENING
NTS

MIANUS BRIDGE- CONNECTICUT-VIDEO

RETROFIT OF PIN AND HANGER BRIDGES

RETROFIT OF THE HOAN BRIDGE BRITTLE FRACTURE

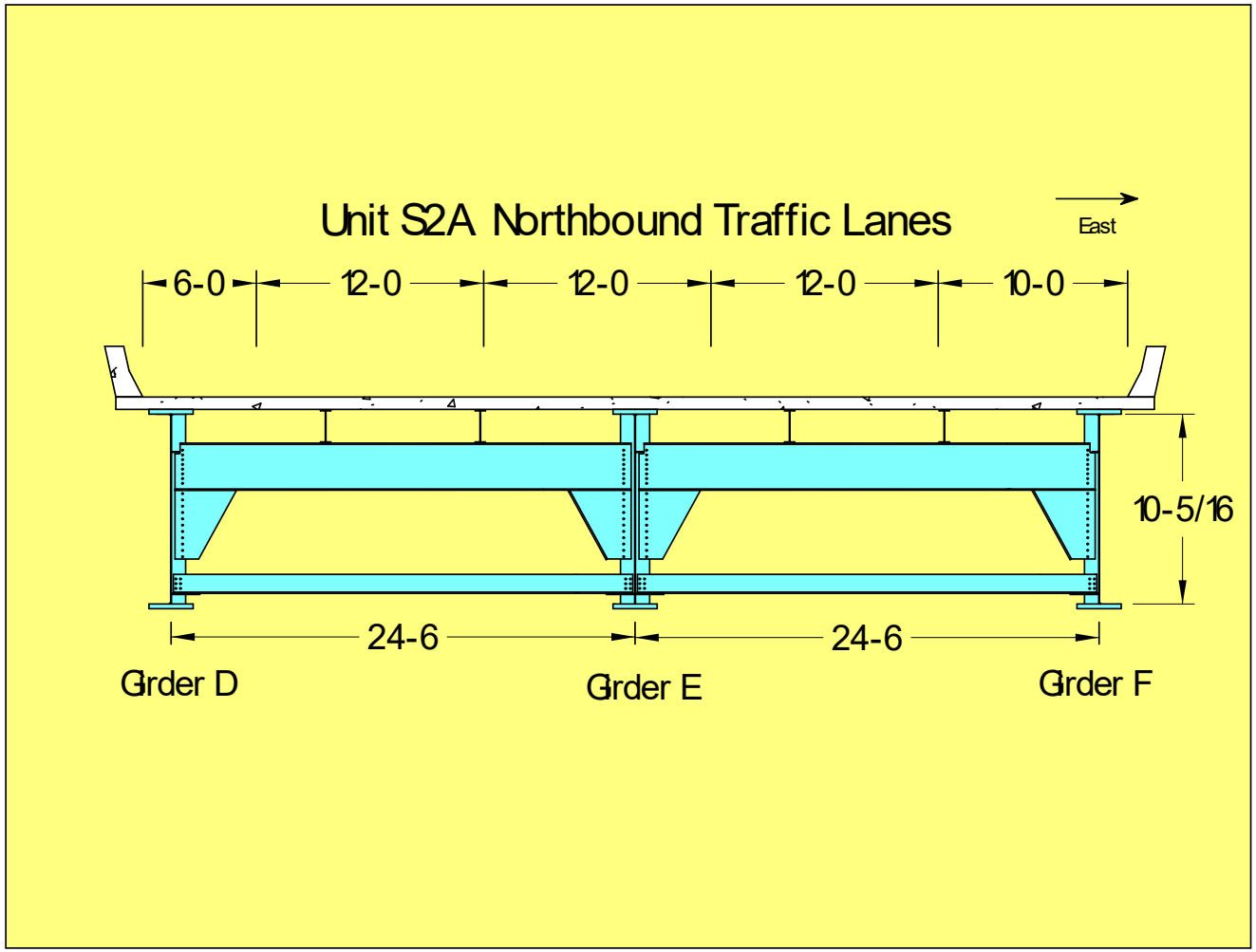
BRIDGE FAILURE – IMMEDIATE RESPONSE

- **DEC 13, 2000, AT ABOUT 7 AM, MOTORIST REPORTS A SAG IN THE ROAD. TEMP: –10 Deg F**
- **NORTHBOUND SPAN HAD SAGGED BY OVER 4 FT. POLICE CLOSE BRIDGE TO ALL TRAFFIC**

RETROFIT OF THE HOAN BRIDGE

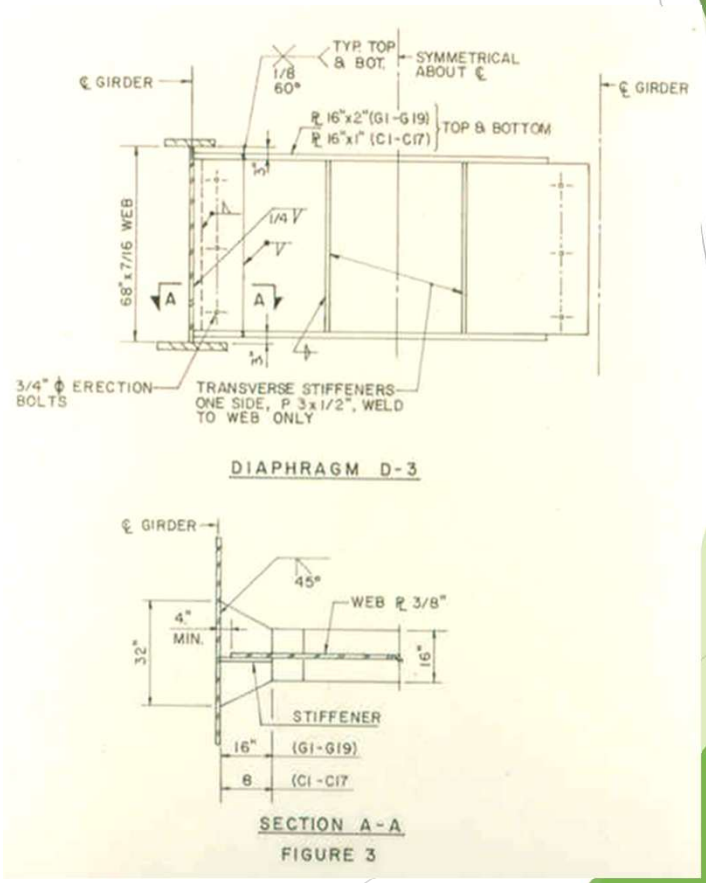
BRITTLE FRACTURE

- HOAN BRIDGE CARRIES I- 794 OVER THE MILWAUKEE RIVER & PORT OF MILWAUKEE
- 1.9 MILE LONG LANDMARK TIED-ARCH STRUCTURE
- 18 APPROACH SPANS : THREE-GIRDER TWIN BRIDGES
- 1970'S CONSTRUCTION; OPENED TO TRAFFIC IN 1977



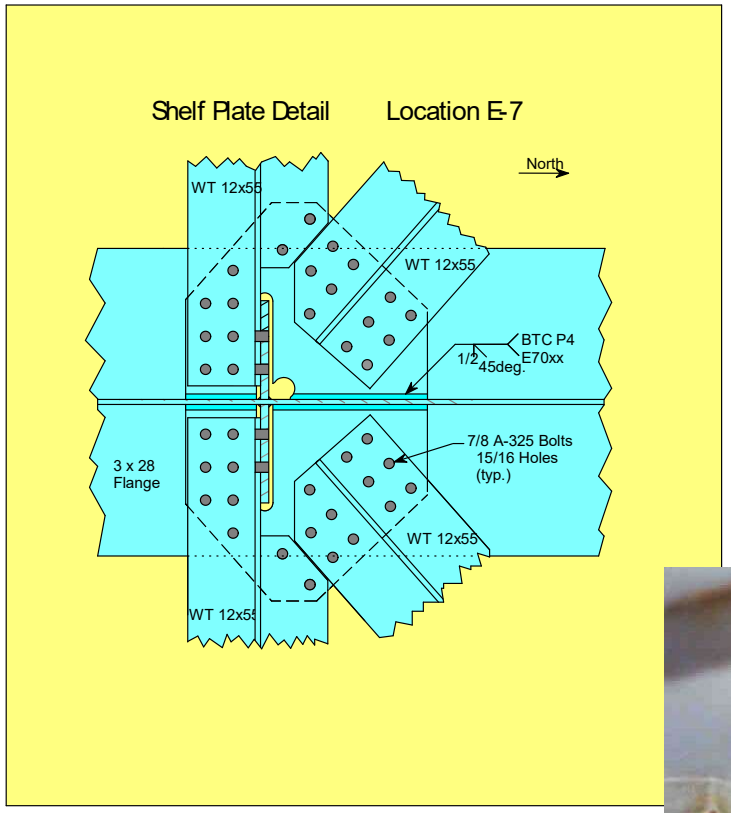
THREE-GIRDER SUPERSTRUCTURE SYSTEM

POOR DETAIL-WELDED CONSTRAINT IN TENSION ZONE

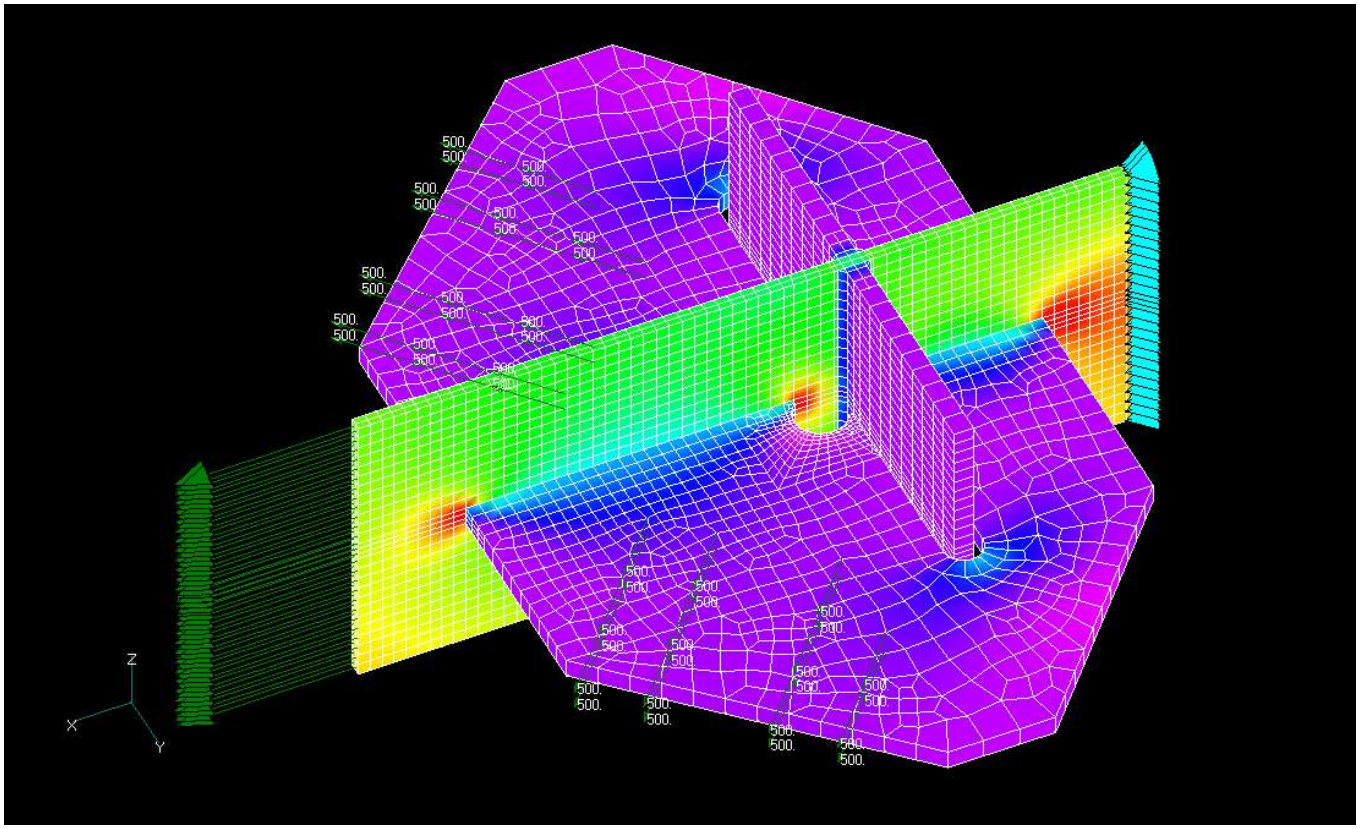



FULL-DEPTH FRACTURES
3’ CRACK IN WEB


CENTER GIRDER E


Shelf Plate Detail Location E-7
North
WT 12x55
WT 12x55
BTC P4
E70xx
1/2
45deg.
7/8 A-325 Bolts
15/16 Holes
(typ.)
3 x 28
Flange
WT 12x55
WT 12x55

Forces on the lateral bracing system increased the stress concentration in the web gap by about 38%.



SOLID FE MODEL OF JOINT ASSEMBLY

PROVIDENCE VIADUCT

THE FIX

ALL LATERAL BRACINGS AND SHELF PLATES REMOVED

I-35W Bridge Collapse

- On the Night of Wed, Aug 1, 2007 The I-35W Bridge Suddenly Collapsed, Killing 13
- MnDOT assembled the Forensic Investigation Team from the 2001 Hoan Bridge Collapse
- Thursday August 2nd, We are on site

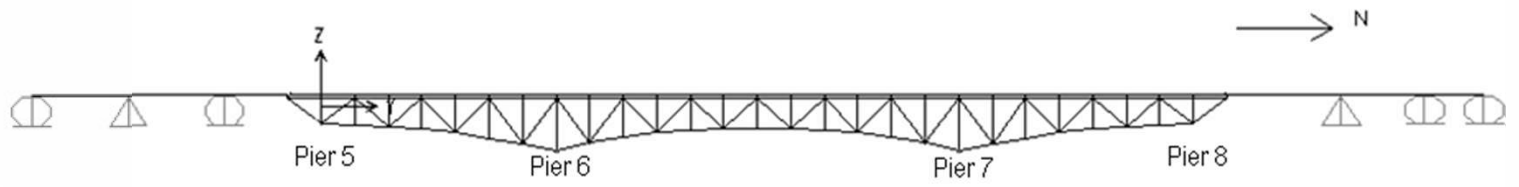
- OUR Role
  - Prepare the 3D Analytical Model
  - Documentation and Reassembly of the Failed Structure in a Nearby Lay-Down Yard

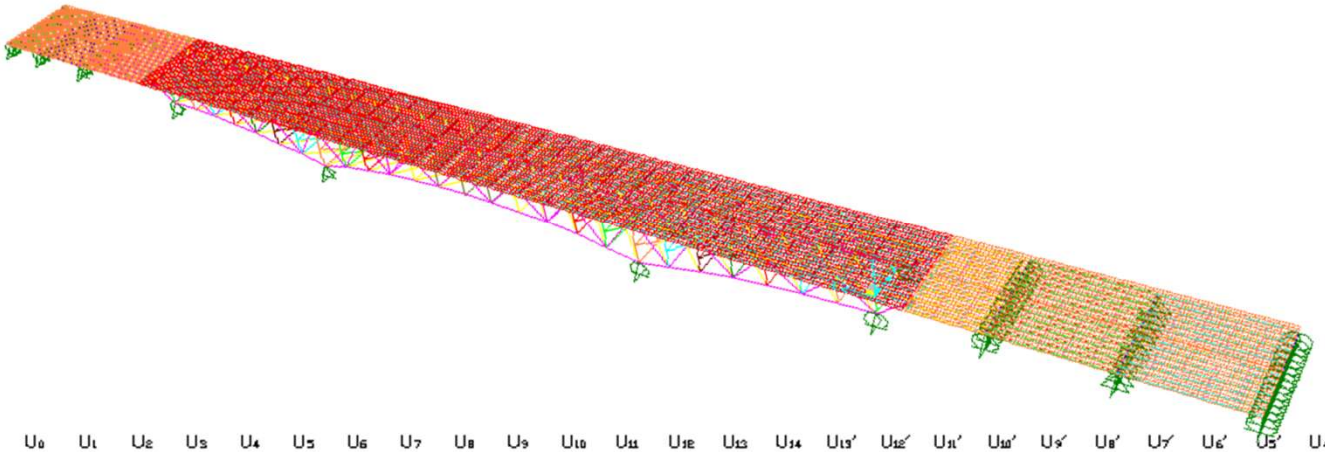
I-35W Bridge Orientation & Nomenclature

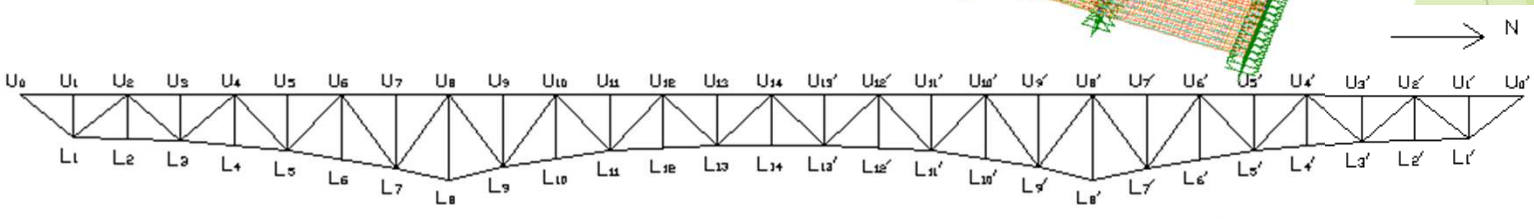
I-35W Bridge Collapse – Initial Site Assessment


LWR4
NEW VIDEO
I-35W Bridge Collapse
MINNEAPOLIS
5:30
FAIR
WILLMAR
KARE 11 NEWS

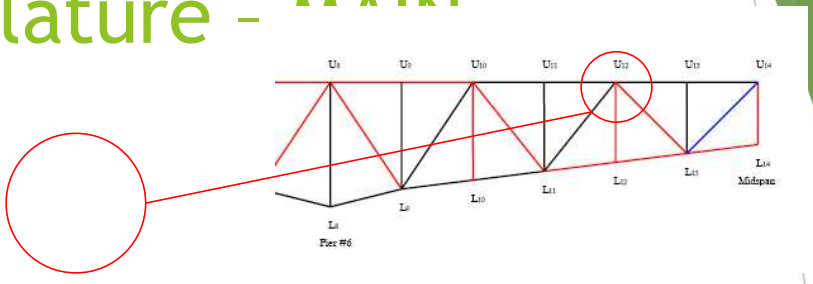
I-35W Bridge Nomenclature – MAIN TRUSS

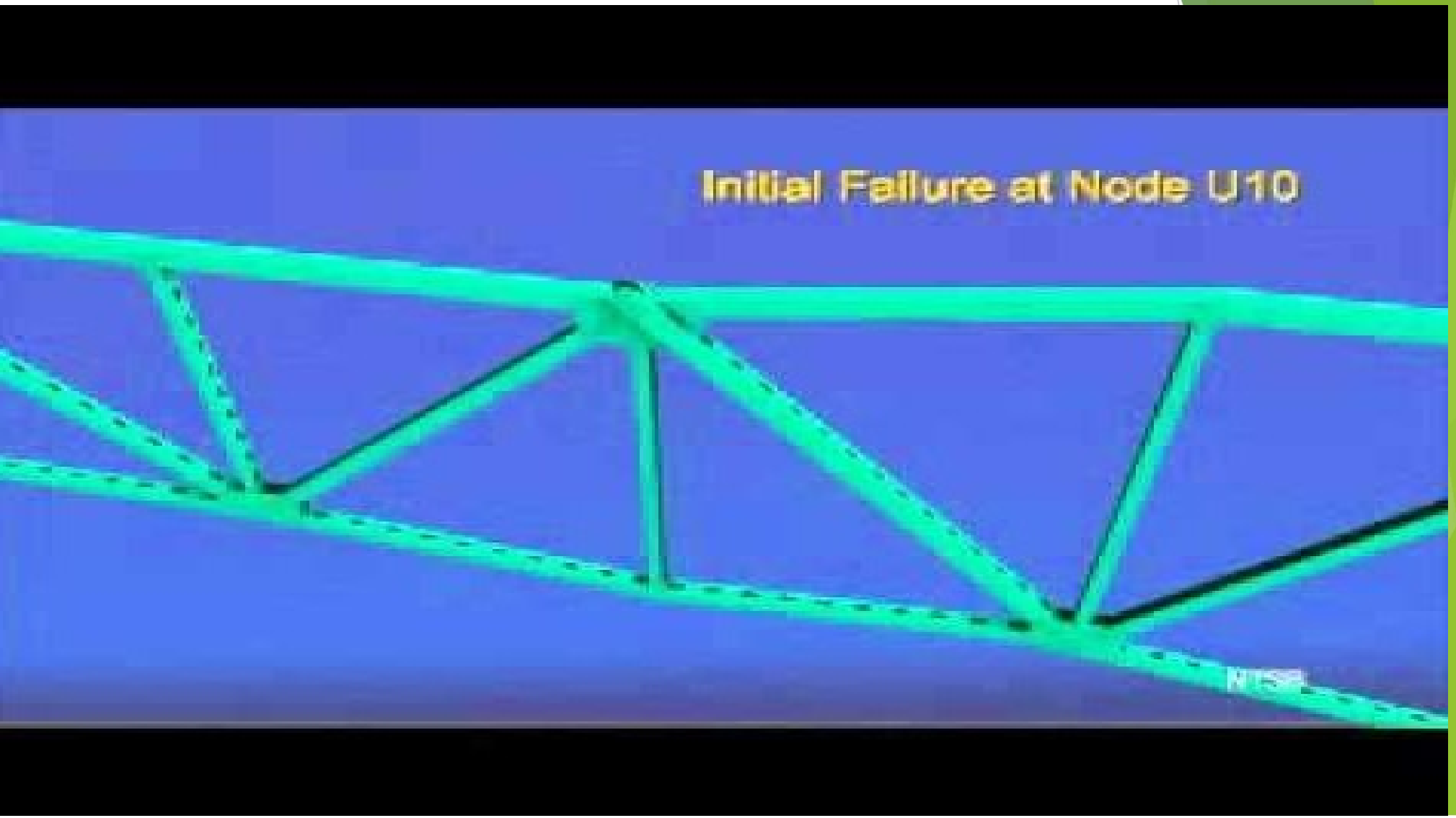




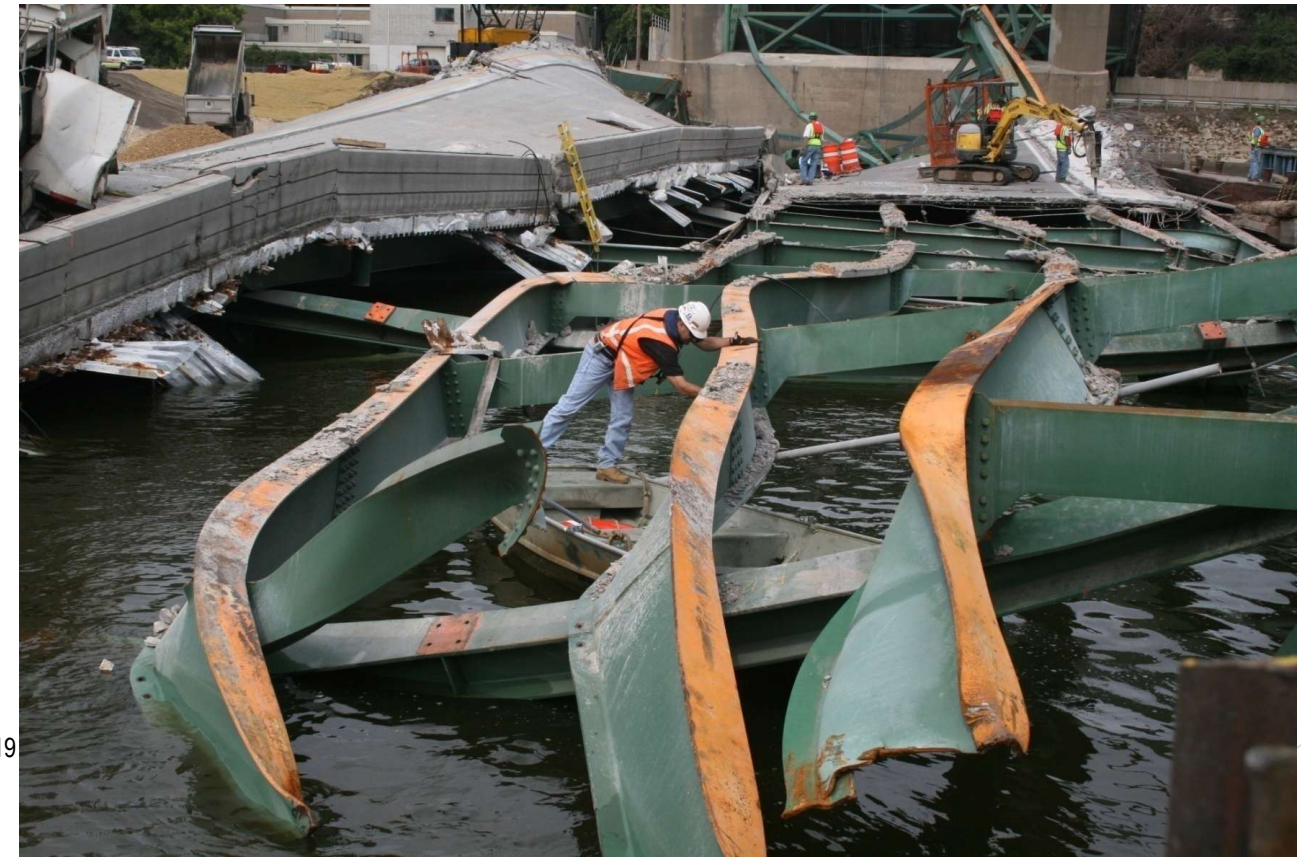


I-35W Bridge Nomenclature – MAIN TRUSS




Initial Failure at Node U10

I-35W Bridge Collapse – Member Documentation



I-35W Bridge Collapse – Lay Down Yard

I-35W Bridge Collapse – NTSB Investigation Groups

- Structural Investigation Group
  - NTSB
  - FHWA
  - MnDOT
  - WJE
  - TranSystems –Lichtenstein Consulting . Engineers
- Witness Group
- Highway Construction Factors Group
- Survival Factors Group
- Bridge Design Factors Group

MOVEABLE BRIDGES

Boynton Beach Bascule Bridge Replacement

Boynton Beach, Florida

Boynton Beach Bascule Bridge Replacement

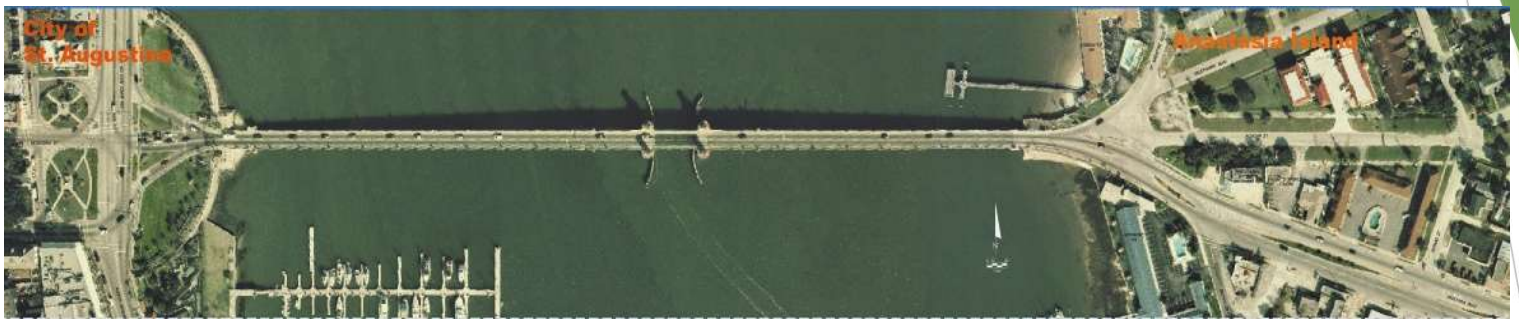
Boynton Beach, Florida

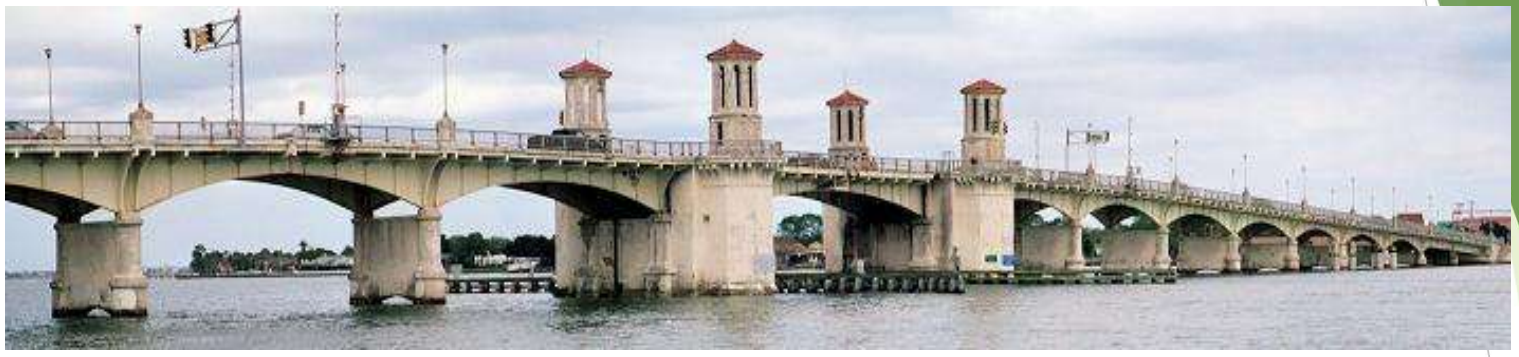
TRUNNION ASSEMBLY AT SHOP- FREEZE TRUNION TO FIT


20 TON

COMPLETED BRIDGE

BRIDGE OF LIONS- ST. AGUSTINE, FLORIDA





1545’ long, 14 spans west, 9 spans east, 1 movable span

Rehabilitate, if feasible, intact original elements; such as Approach Span Girders, Bascule Piers and Observation Towers

Replicate original elements when rehabilitation is not feasible; such as Approach Span Piers and Bascule Girders

Return lost elements; such as Railings, Luminaries, Bascule Gates

BRIDGE OF LIONS- ST. AGUSTINE, FLORIDA

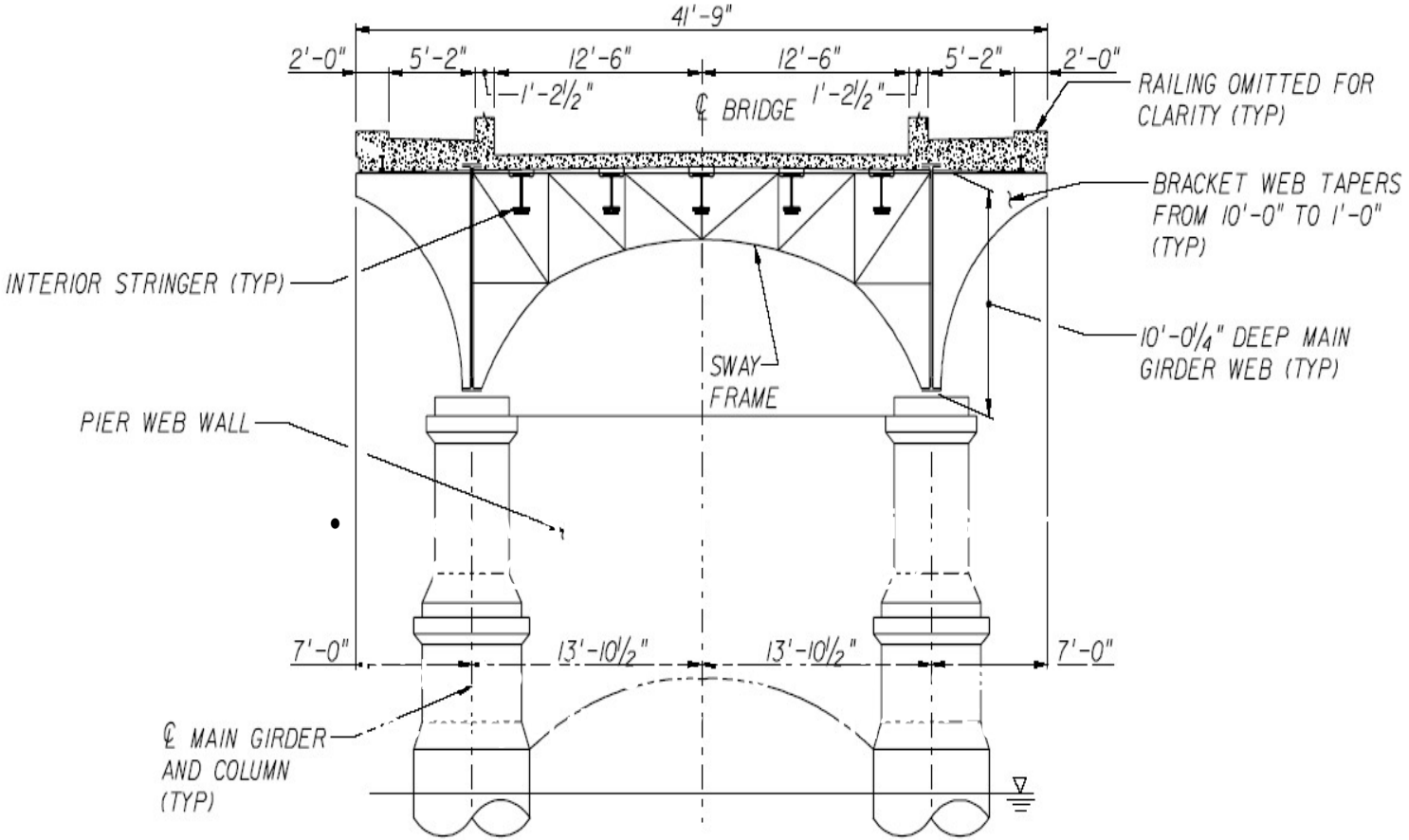


Fig. New cross section

Completed Bridge

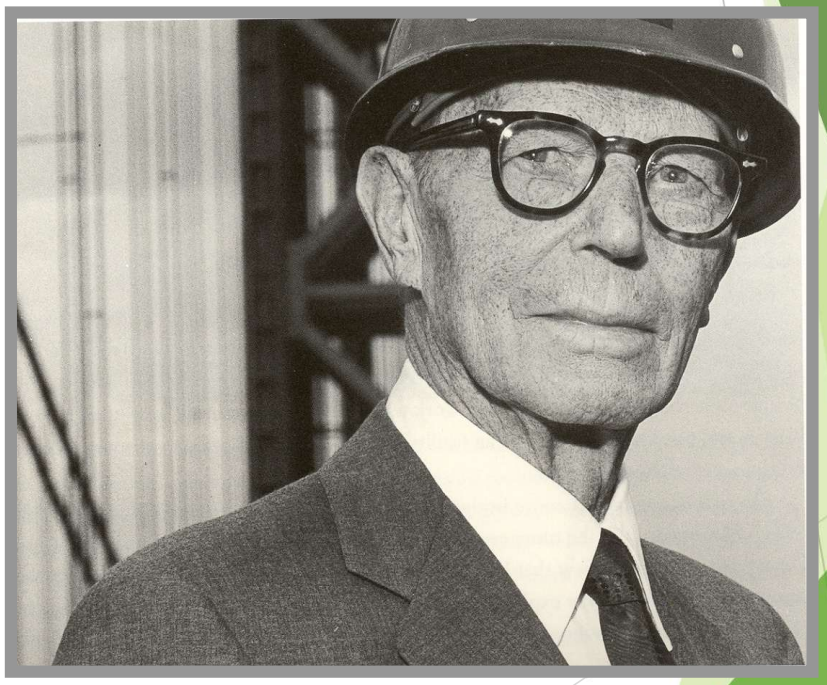
George Washington Bridge

OPENED – 1931 LOWER SPAN- 1962

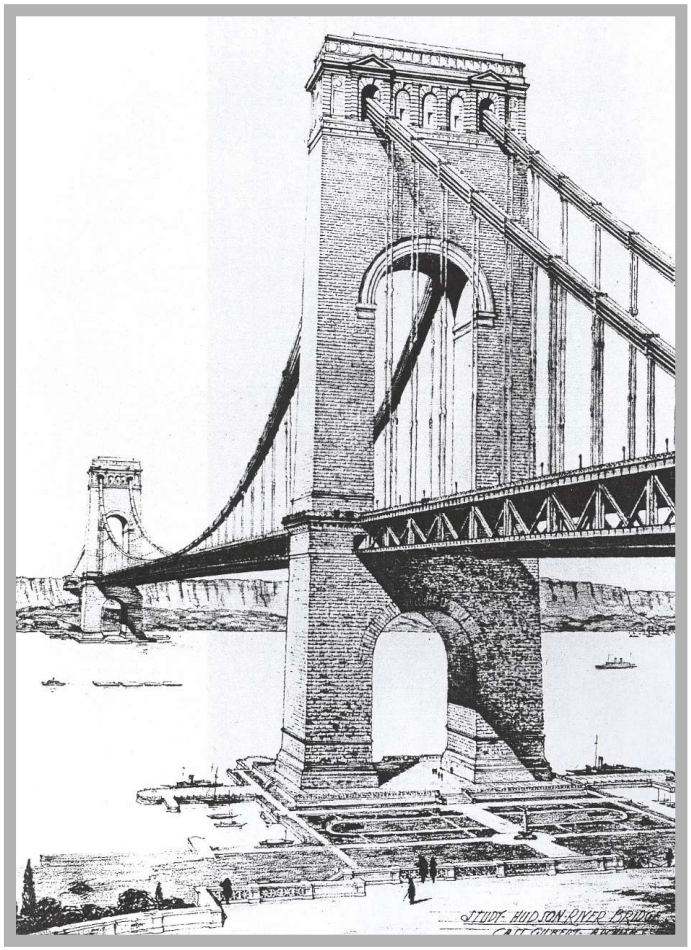
Othmar H. Ammann

1879 to 1965

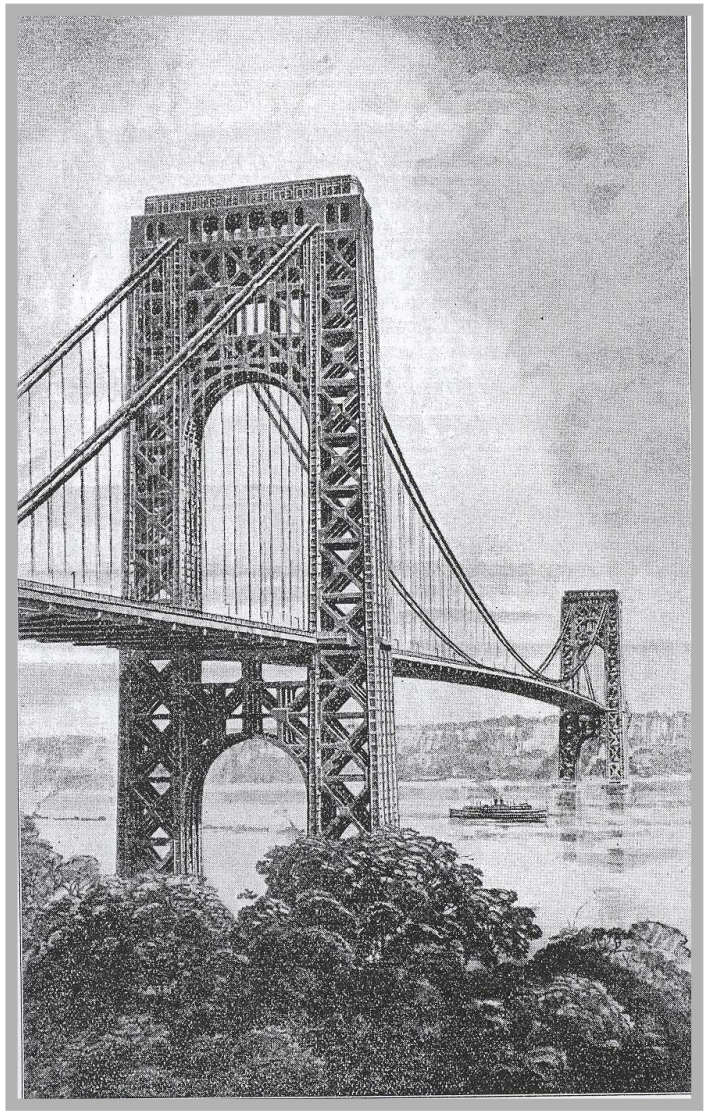
Arrives in U.S.A.
1904 Self Portrait



1963 During Construction of Second Deck - GWB

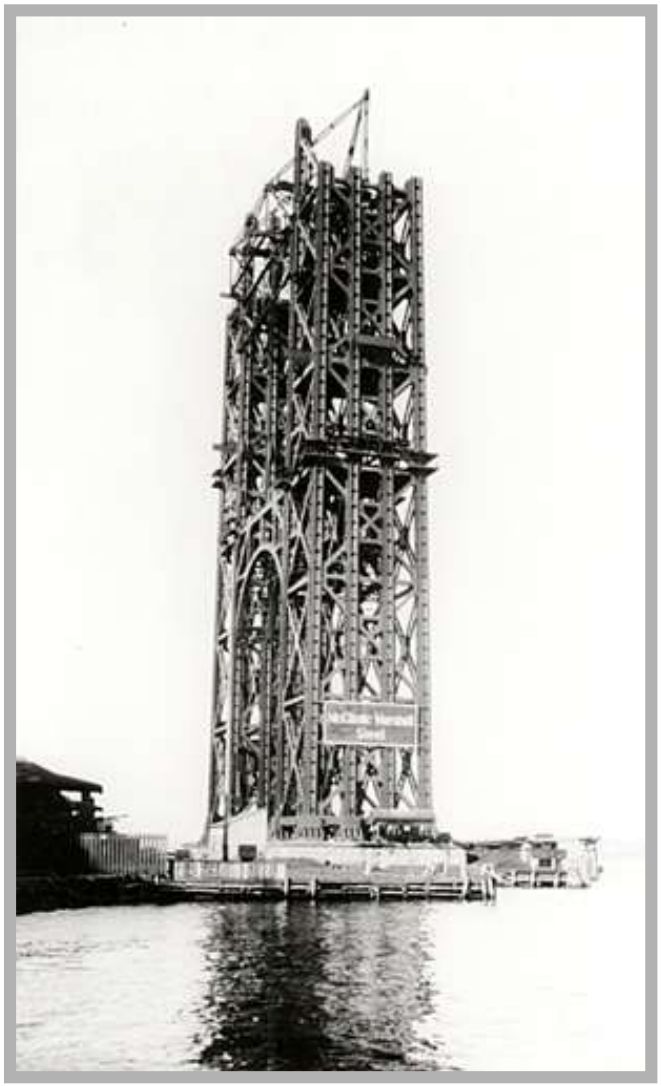


Architectural Study by Cass Gilbert for Ammann's Suspension Bridge at 179th Street – Steel Tower With Granite Facing 1926



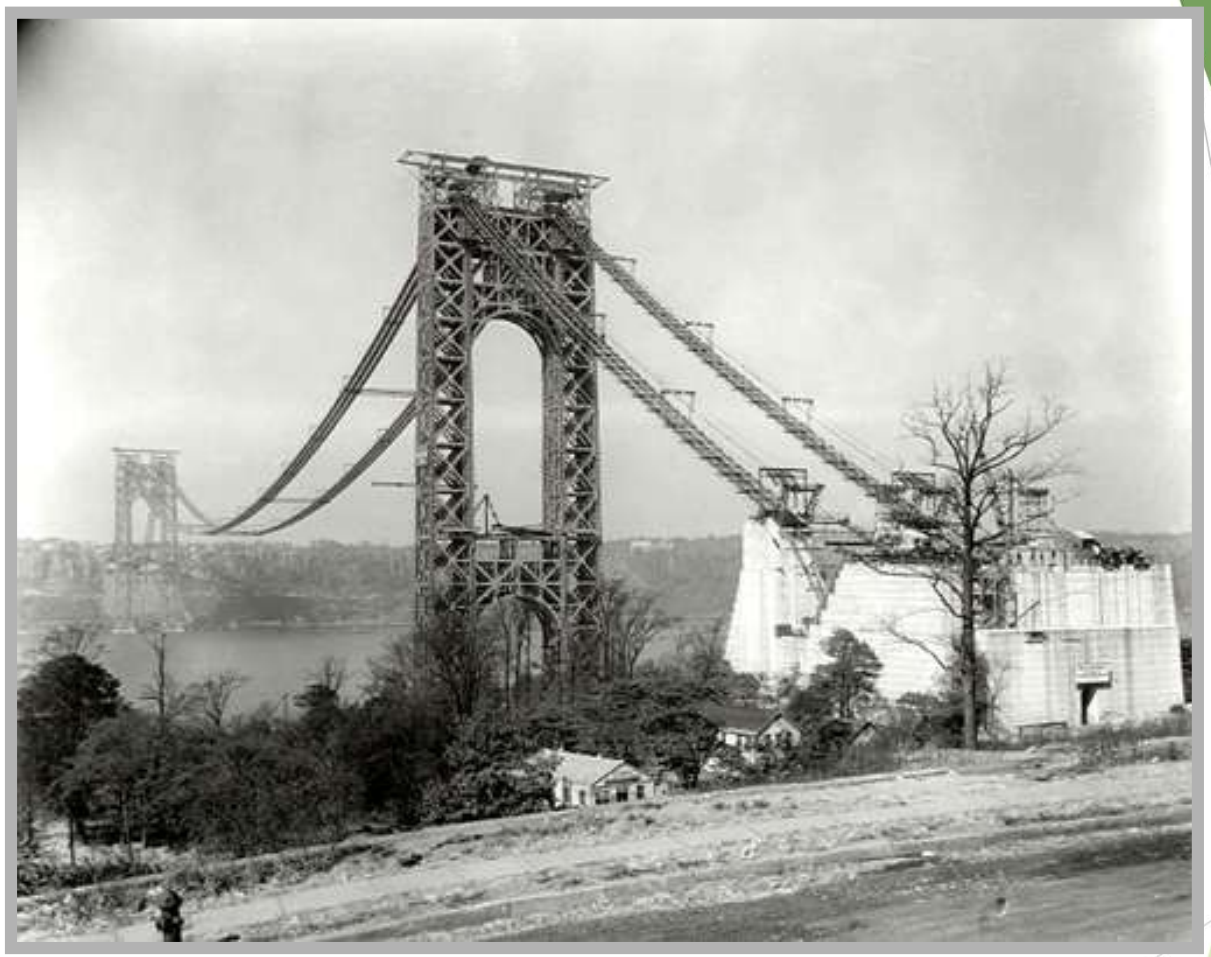
Designed by Ammann
Without Granite Facing
Plus Observation Platform - 1926

Cofferdam and Footing for New Jersey Tower
Circa - May 1928
Center of Tower – 76 Feet from Shore



New Jersey Tower 21,500 Tons of Steel
604 Feet Above Water

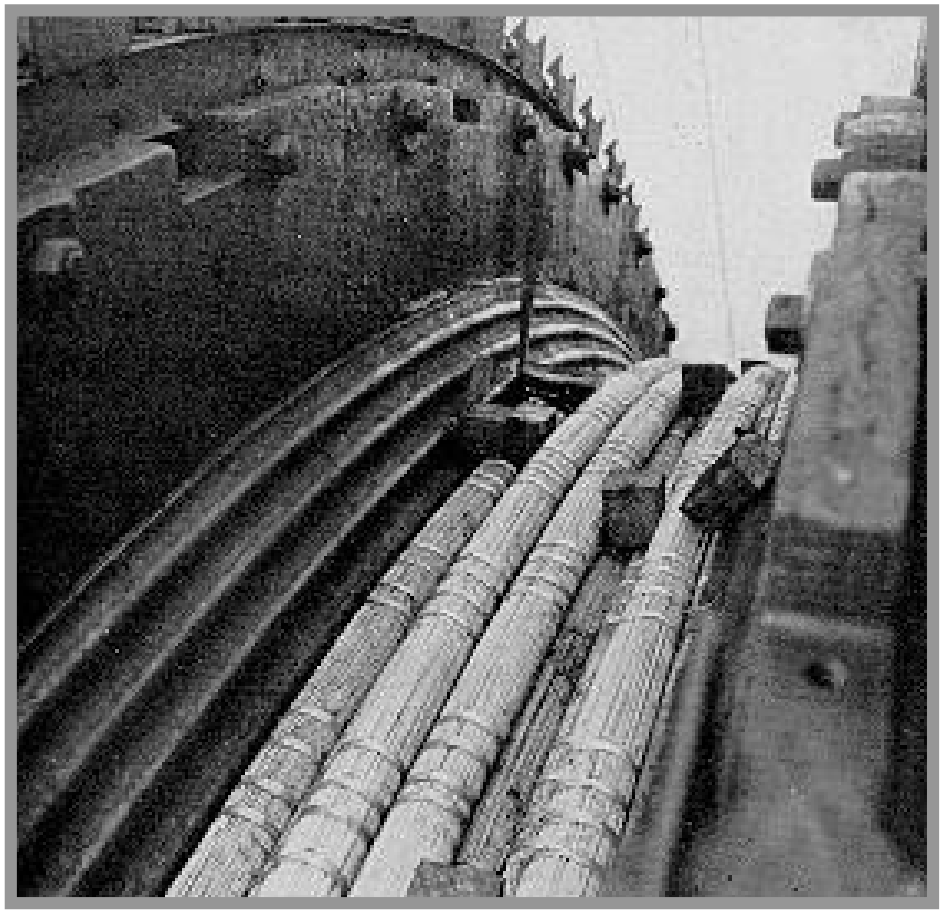
New Jersey Approach – Circa Fall 1928/Spring 1929



Cable Construction View From New York Anchorage
Main Span - 3,500 Feet, - Longest when built
Approach Spans - New York 650 Feet - New Jersey 610 Feet

Anchorage – Circa 1930

New York Anchorage – Late 1990's

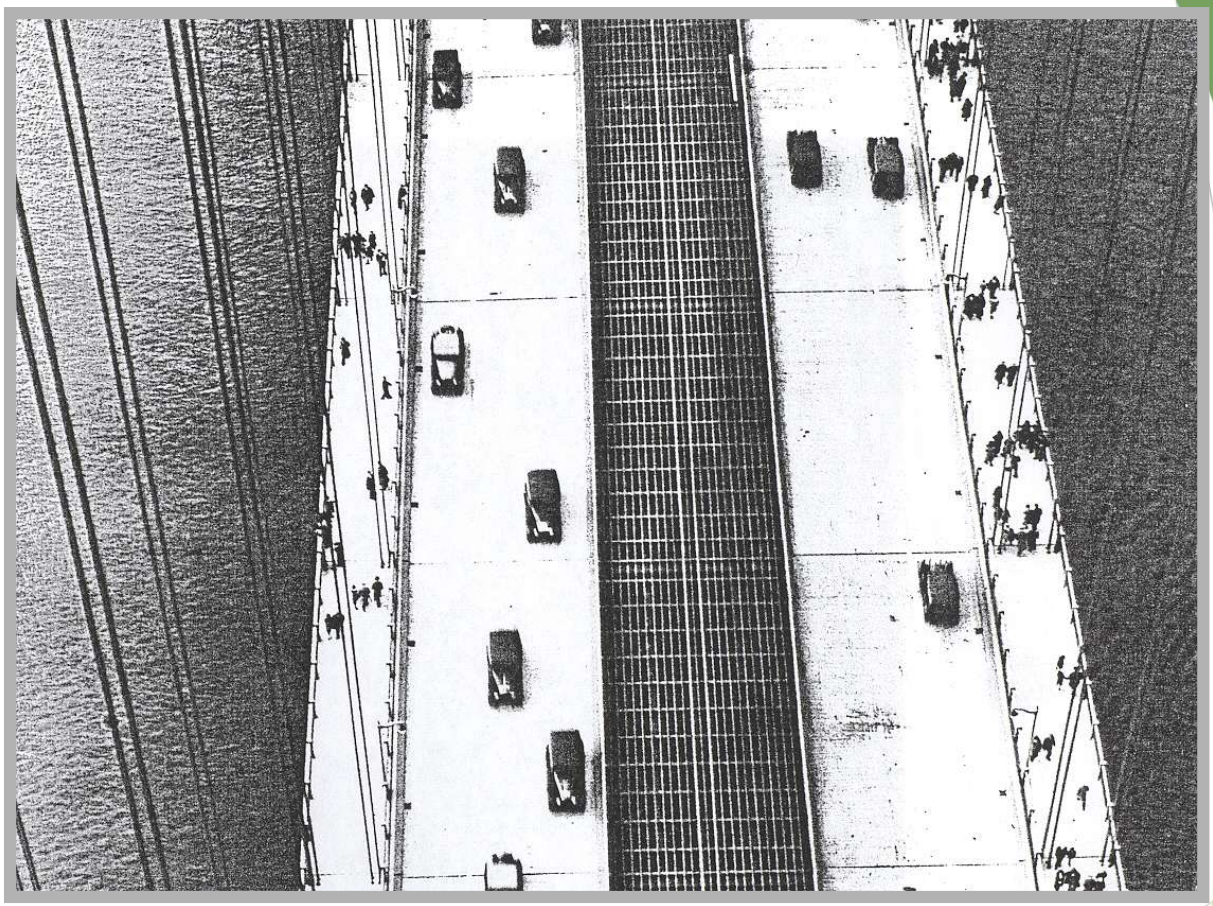


Tower Saddle Accepting Strands
8 Finished Strands – Spring 1930

Removal Of Wire Wrapping to Examine Wires in Late 1990's

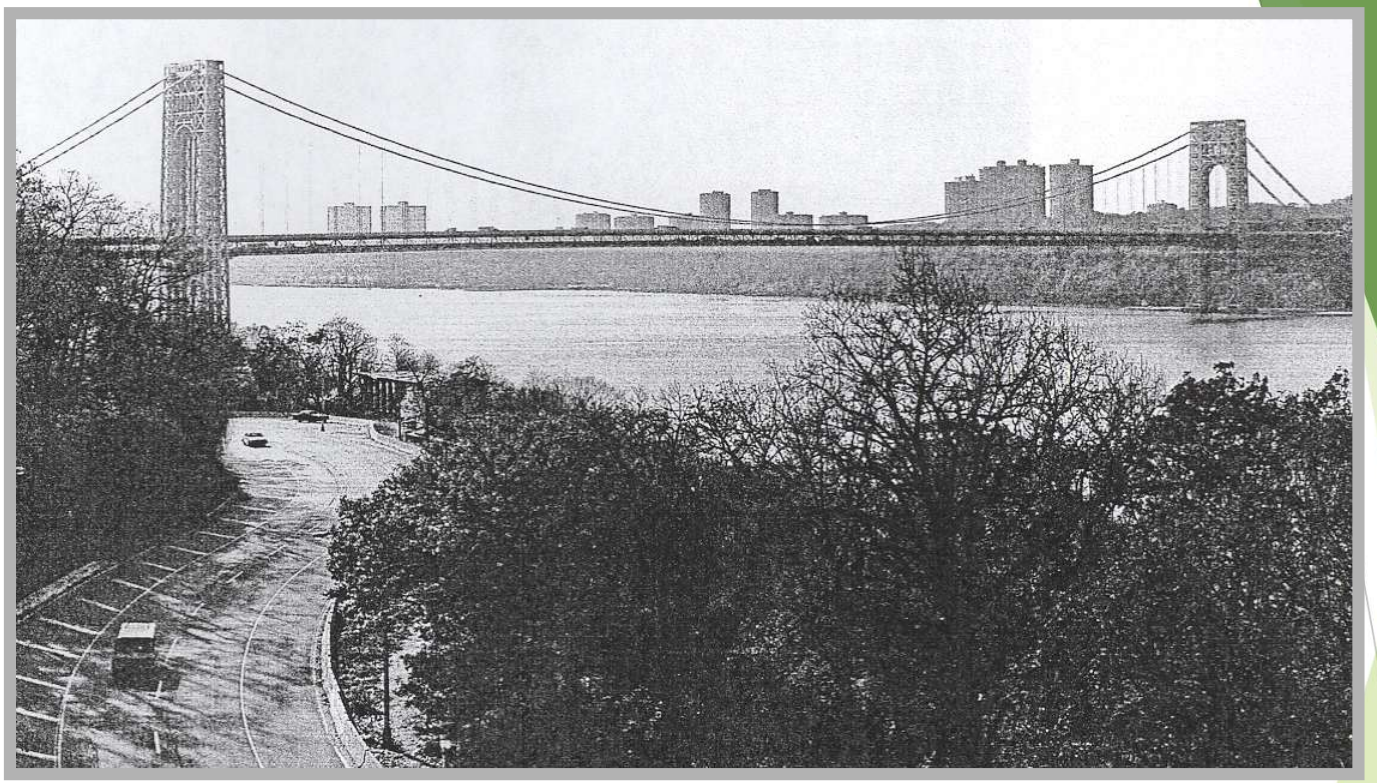
Splice In – 0.196 Inch Diameter Wire
Each Wire had Strength of 240,000 PSI

DEDICATION



Open to All Traffic October 26, 1931
6 Lanes For Traffic – 2 For Pedestrian and Bicycles
1946 - Middle is Paved – 2 Additional Lanes for Traffic

New Jersey Approach – Late 1990's



Double Deck Bridge – Circa 1986 View From Ft. Tryon Park
14 Lanes of Traffic
8 Upper Level
6 Lower Level

Largest Free Flying American Flag – 90 Feet Long
Stars are Five Feet in Diameter, Stripes Five Feet Wide
New Jersey Tower – 8 Holidays Since 1948

MAJOR SUSPENSIONS BRIDGES IN U.S

GEORGE WASHINGTION BRIDGE

OPENED 1931-MAIN SPAN 3,500 FT.
DESIGNER- OTHMAR AMMAN
CABLES- 36 INCH PARALLEL CABLE CONTAIN 26,474 WIRES

GOLDEN GATE BRIDGE

OPENED 1937- MAIN SPAN 4,200 FT.
DESIGNER- JOSEPH STRAUSS

VERAZANO NARROWS

OPENED – 1964- MAIN SPAN 4,260 FT
DESIGNER- OTHMAR AMMAN

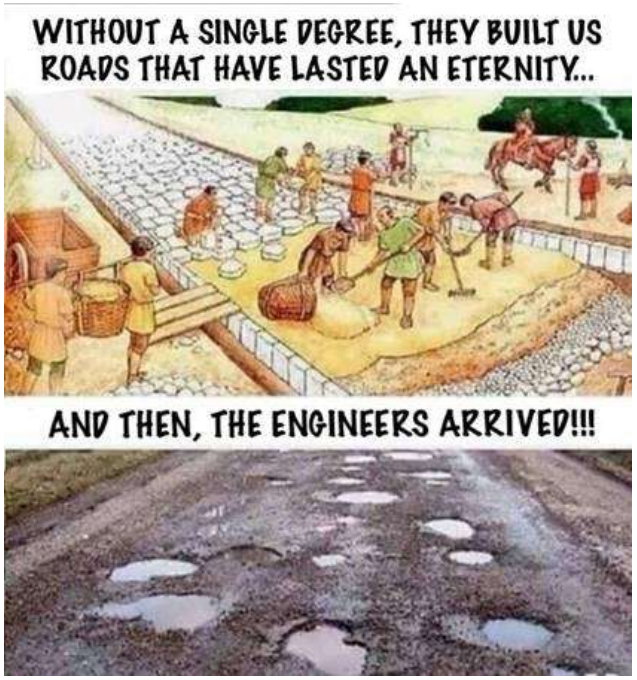
BROOKLYN BRIDGE

OPENED- 1883-MAIN SPAN 1596 FT
DESIGNER- JOHN ROEBLING

SUMMARY

- NEGLECT CAN CAUSE THIS

HOW SMART ARE WE?



QUESTIONS ?

- APPLAUSE