First Tied-Arch Bridge in Chicago
Presentation Outline

- Project overview
- Substructure details
- Superstructure details
- Construction sequencing
North Halsted Street Bridge

Project Overview
North Halsted Street Bridge

Location Map
Project Scope

- Remove the existing bascule bridge
- Install new fixed bridge
Existing and New Bridge

**Existing Bridge**
- Two travel lanes
- No bike lanes

**New Bridge**
- Four travel lanes
- Two-way bike lanes
- Can accommodate future river walk
- Improved aesthetics of the area
Existing Bascule Bridge

- Structurally deficient
- Functionally obsolete
Factors Affecting the Selection of a Bridge Type
Factors Affecting the Selection of a Bridge Type

- Aesthetics
- Surrounding (Context Sensitive Design)
- The need for the infrastructure improvement to act as a focal point for revitalization of the area and to stimulate commerce
- Bridges provide opportunities to create landmarks/signature bridges can become enduring symbols for cities or neighborhoods.
- Structural constraints: span, redundancy, loading, soil conditions,
- Geometric constraints (hydraulics, horizontal and vertical required river clearance, adjacent buildings, under/above ground utilities, availability of adjacent land
- Budget
- Constructability
Bridge Type Study: Multi-Girder
Bridge Type Study: Multi-Girder with Center Pier
Bridge Type Study: Multi-Arch

Aesthetic Bridge: Multi-Arch Bridge
Bridge Type Study: Through Truss

Through Truss
Bridge Type Study: Tied-Arch

Aesthetic Bridge: Tied-Arch
Arch Bridges
True Arch (or Thrust Arch) Bridges

- The arch is in compression
- The horizontal thrust is resisted by the abutments

True Arch Bridge (Thrust-arch Bridge)
- The arch is in compression
- The horizontal thrust is resisted by the horizontal tie

Tied-arch Bridge
North Halsted Street Bridge

Substructure Details
Cofferdam / Abutment
Cofferdam / Abutment
Cofferdam / Abutment
Cofferdam / Abutment
North Halsted Street Tied-Arch Bridge

River Walk
Three-Sided Precast Concrete Underpasses
Three-Sided Precast Concrete Underpasses
Three-Sided Precast Concrete Underpasses
Three-Sided Precast Concrete Underpasses
Three-Sided Precast Concrete Underpasses
North Halsted Street Bridge

Superstructure Details
Superstructure Overview
Superstructure Overview

35'
Superstructure Overview
Superstructure Overview

54’
Superstructure Overview
Superstructure Overview

- Strut
- Rib
- Hanger
- Tie
The rib was selected to be **parabolic shape**, which minimizes bending moment in the rib (Rib moment is only 25% of the moment in a floor beam)
North Halsted Street Bridge

DEFLECTION DIAGRAM UNDER HALF SPAN LIVE LOAD

½ of the span is deflected down and the other ½ is deflected upward
Redundancy - Definition:

A redundant structure can *redistribute the forces to other members* (upon failure of a member) without causing collapse of the entire structure.
Three types of redundancy are provided:

- **Internal Redundancy in the Tie**
  
  tie using bolts (rather than weld)

- **Load Path Redundancy**
  
  Composite and continuous deck

- **Structural Redundancy**
  
  Hangers provide continuity for the tie
**Composite System:**

- *Using shear studs:* The tie, floor beams, and stringers are connected with the deck
- Allow the use of much shallower superstructure
North Halsted Street Bridge

➢ Floor Framing
➢ Steel Detailing
➢ Member Cambering
Lower Framing Plan
Lower Framing Plan

Lower Framing Plan

Standard Hole on Stringer & Stiff.

Standard Hole on Stringer: Short Slotted Hole 1/8" x 1 3/8" on Stiff. P

Lower Framing Plan
North Halsted Street Bridge

➢ Floor Framing
➢ Steel Detailing
➢ Member Cambering
North Halsted Street Bridge - Tie
North Halsted Street Bridge – Arch (Rib)

SECTION C-C
TYPICAL SECTION THRU RIB

Arch
North Halsted Street Bridge - Knuckle

Due to the complicated stress distribution at this location, finite element analysis was performed.
North Halsted Street Bridge - Hangers

Each of the two cables are designed to support the entire force temporarily.

Two 1 ¾” Φ HANGERS
North Halsted Street Bridge

➢ **Floor Framing**
➢ **Steel Detailing**
➢ **Member Cambering**
In order to achieve the theoretical design shape, all major force-carrying-members are cambered.
North Halsted Street Bridge - Cambering

Cambered arch

Cambered tie

Rib Camber Working Line

R1

T0 T1 T2 T3 T4 T5 T6 T7 T8 T9 T10

Tie Camber Working Line

10 Panels of 15'-8" (-) = 156'-7\frac{3}{4}" For Fabrication

ARCH CAMBER DIAGRAM FOR FABRICATION

Tie and hangers are made shorter. The arch is made higher
Floorbeams are also cambered:

1) Conventional flexure upward camber
2) The two ends are cut in slant angle to anticipate the end rotation
North Halsted Street Bridge

ARCH FRAMES ARE FORCED TO BE CONNECTED WITH TOP STRUTS
North Halsted Street Bridge

FINAL GEOMETRY UNDER FULL DEAD LOAD
North Halsted Street Bridge

Construction Sequencing
Tied-Arch Bridges - Two Construction methods:

1. ABC (Accelerated Bridge Construction)
2. Build-in-place
North Halsted Street Bridge

Erection Stages - Stage 1
North Halsted Street Bridge

Erection Stages - Stage 2
North Halsted Street Bridge

Erection Stages - Stage 2
North Halsted Street Bridge

Erection Stages - Stage 3
North Halsted Street Bridge

Erection Stages - Stage 3
North Halsted Street Bridge

Erection Stages - Stage 4
North Halsted Street Bridge

Erection Stages - Stage 4
North Halsted Street Bridge

Erection Stages - Stage 5
North Halsted Street Bridge

Erection Stages - Stage 5
North Halsted Street Bridge

Erection Stages - Stage 6
North Halsted Street Bridge
North Halsted Street Bridge

CABLE HANGER: FORCE TESTING
Construction Sequencing
Completed Bridge Photos
North Halsted Street Bridge
North Halsted Street Bridge
North Halsted Street Tied-Arch Bridge
North Halsted Street Tied-Arch Bridge
North Halsted Street Bridge
Owner:
Chicago Department of Transportation

Engineering Team:
Prime Consultant – H.W. Lochner
Main Sub-consultant – HBM Engineering
Peer Reviewer – Parson Brinckerhoff

Architectural Team:
Architect – Muller & Muller
Lighting Architect – Schuler Shook
Historic Documentation – Johnson Lasky

Construction Management:
Benesch

Contractor:
Walsh Construction
Thank you