OHIO DEPARTMENT OF TRANSPORTATION
2014 PHYSICAL CONDITION REPORT

LORAIN-CARNEGIE BRIDGE OVER CUYAHOGA RIVER
BRIDGE NO. CUY-10-1613

SFN: 1801503

JANUARY 2015

PREPARED BY:

Jones Stuckey

1655 W. Market Street, Suite 355 | Akron, OH 44313

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I. INTRODUCTION

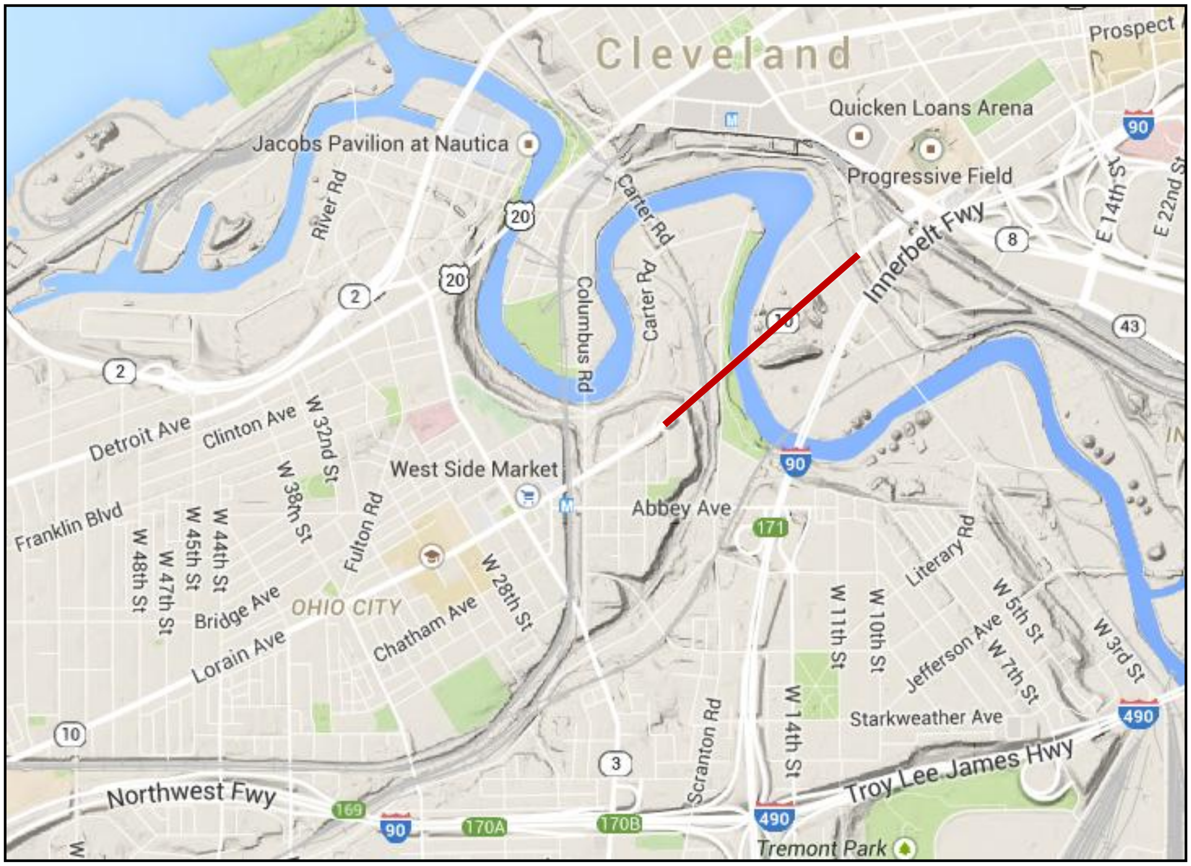

Figure 1 – Lorain-Carnegie Bridge Location Map.

CUY-10-1613 (SFN 1801503), commonly known as the Lorain-Carnegie Bridge and later renamed the Hope Memorial Bridge, carries vehicular and pedestrian traffic over the Cuyahoga River Valley. The bridge is approximately 3,515 feet long, which includes 230 feet of subway tunnel leading up to the Bridge No. CUY-10-1685. The Lorain-Carnegie Bridge was opened to traffic in 1932, and it is included n the National Register of Historic Places. The General Plan & Elevation and Typical Section are shown on Figures 1 & 2.

The Lorain-Carnegie Bridge is composed of three distinct units. The West Approach is 157'-8" long and is composed of a five-span, multiple beams set on concrete piers and steel bents. The main spans of the Lorain-Carnegie Bridge are comprised of four lines of cantilever Pratt deck trusses, ranging in length from 161'-2" to 299'-0". Total length of the main superstructure, including pylons, is 2,916'-1". A maintenance deck is in place in the center bay, below the vehicular upper deck. The third unit, the East Approach, carries traffic from the East Pylon to the West Abutment of the Carnegie Avenue over Greater Cleveland Regional Transit Authority Red Line tracks (CUY-10-1685, SFN 1801511), and consist of concrete cellular construction approximately 307 feet long and a three-line, 131'-0" long Pratt truss span.

Following FHWA definitions, all tension members of the trusses are classified as being fracture critical. Furthermore, the truss floor beams and west approach floor beams are fracture critical because their spacing is greater than 14 feet.[1]

Since the 2000-02 bridge rehabilitation, several new bridge nomenclature systems have been used, with markings at panel points and in text conflicting with each other. With the original construction and rehabilitation drawings included as a significant element of the bridge record, and past FHWA policy of recommending that original member identification system be followed for this inspection, this inspection therefore followed the structure's original member identification.[2] This practice ensures that this inspection will at a minimum conform to the original shop drawings, documentation for both prior bridge rehabilitations and the 1989 structural load rating report.

A copy of the 2014 SMS Bridge Inspection Field Report Form is included in Appendix A. Appendix B contains Structure Deficiency Maps.

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[1] Fracture Critical Inspection Techniques for Steel Bridge, Publication No. FHWA NHI 02-037, FHWA & National Highway Institute, p. 4.2.2, January 2002.

[2] Bridge Inspector's Reference Manual, Publication No. FHWA NHI 12-049, U.S Department of Transportation, Federal Highway Administration, U.S. Government Printing Office, Springfield, Virginia, December 2012, p. 4.4.1.

Construction and Maintenance History

The following is a summary of significant events in the history of the Lorain-Carnegie Bridge:

- 1930-32: Construction by Lowensohn Construction Company with steel superstructure fabricated by the Mount Vernon Bridge Company. Project is referred to as the Lorain-Central Bridge, but is later changed to the Lorain-Carnegie Bridge with the realignment of the Ontario Street, Carnegie Avenue and Central Avenue intersection east of the bridge.
- December 2, 1932: Bridge opened to traffic.
- 1950s: Spot painting to corroding structural steel.
- October 1980 to September 1983: Bridge closed for major rehabilitation, including replacement of upper and maintenance decks, replacement of deteriorated stringers and wind shear blocks and replacement of drainage system. Rededicated as the Hope Memorial Bridge.
- July 2000 to Fall 2002: Bridge received minor rehabilitation consisting of the following activities:
    - Replacement of the asphalt concrete wearing surface with microsilica concrete wearing surface.
    - Plugging upper deck subdrains.
    - Removal of delaminations from underside of upper deck and application of a sprayed-on cathodic protection anode to all exposed steel reinforcement.
    - Replacement of all expansion joints and drainage.
    - Replacement of upper chord bearing assemblies.
    - Repairs to lower lateral bracing and repairs to lower chord members.
    - Patching deteriorated concrete substructure.
    - Complete removal of the original and zone protective coating system with an OZEU protective coating system.
    - Application of packrust caulk sealant along open structural steel seams.
- 2012: The north sidewalk was widened to promote pedestrian crossings. A precast concrete vehicular railing was installed along the new north curb. Additional lighting on metal light standards was installed along the north and south sidewalks between the existing prestressed concrete light standards.

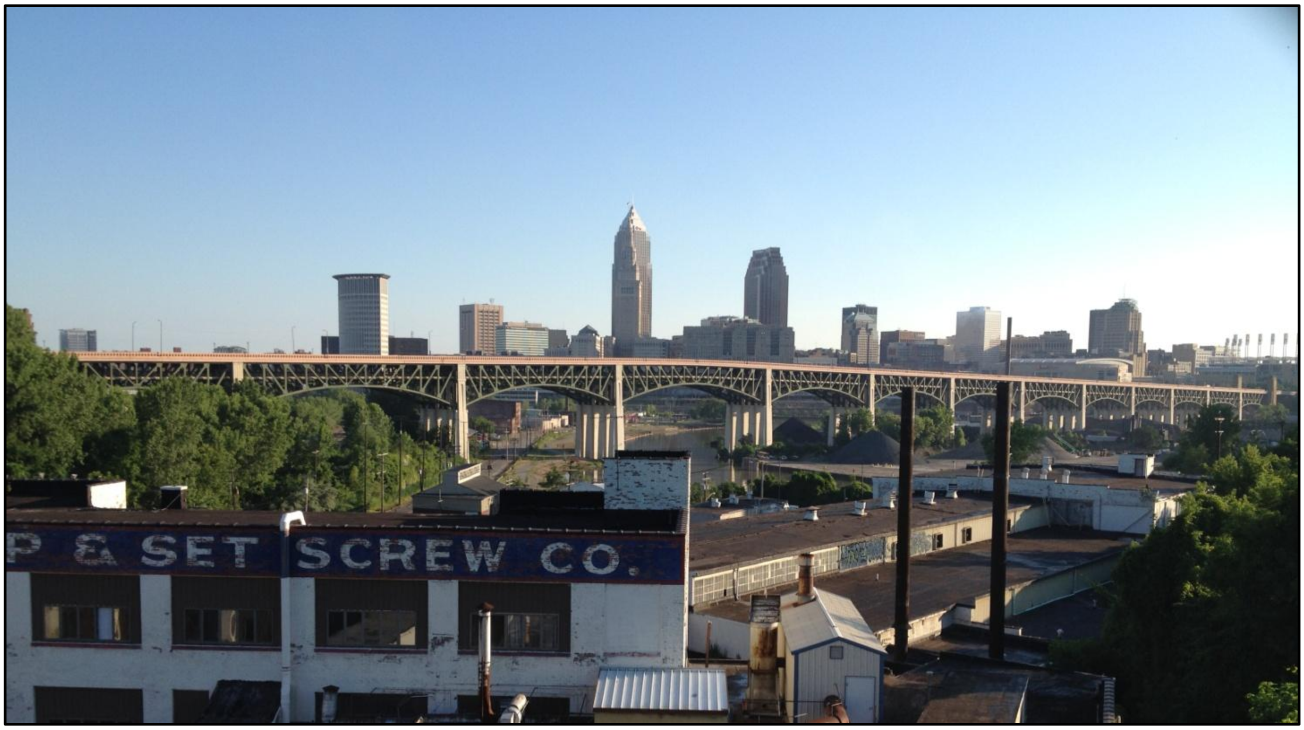
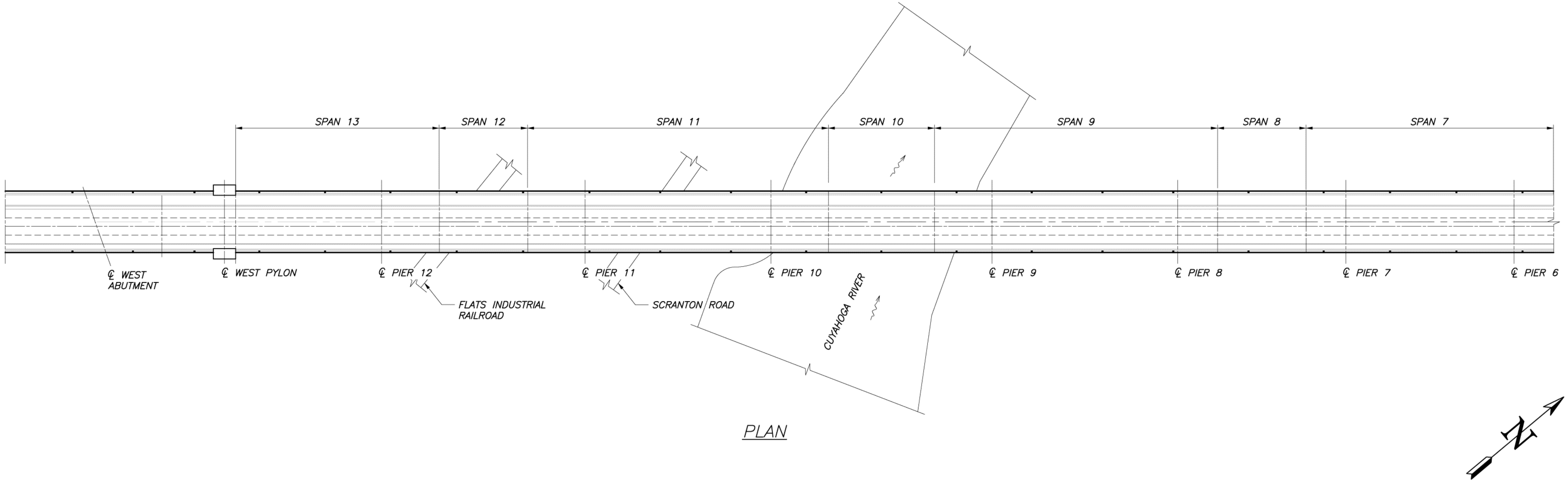
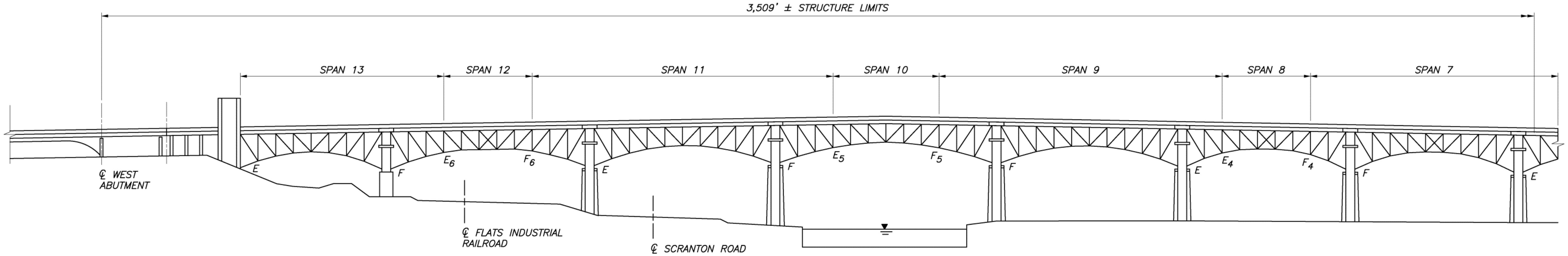


Photo 1– South Elevation, Lorain-Carnegie Bridge.

Photo 2– Lorain-Carnegie Bridge End View, Looking West.



PLAN



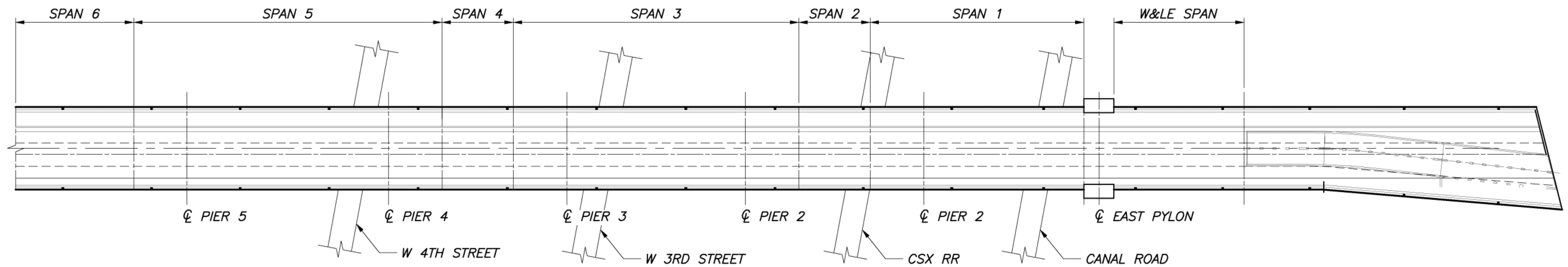
SOUTH ELEVATION

LEGEND

F = FIXED BEARING/HINGE
E = EXPANSION BEARING/HINGE

NOTE

SPANS AND PIERS ARE NUMBERED EAST TO WEST IN ORDER TO REMAIN CONSISTENT WITH ORIGINAL CONSTRUCTION AND REHABILITATION DRAWINGS.



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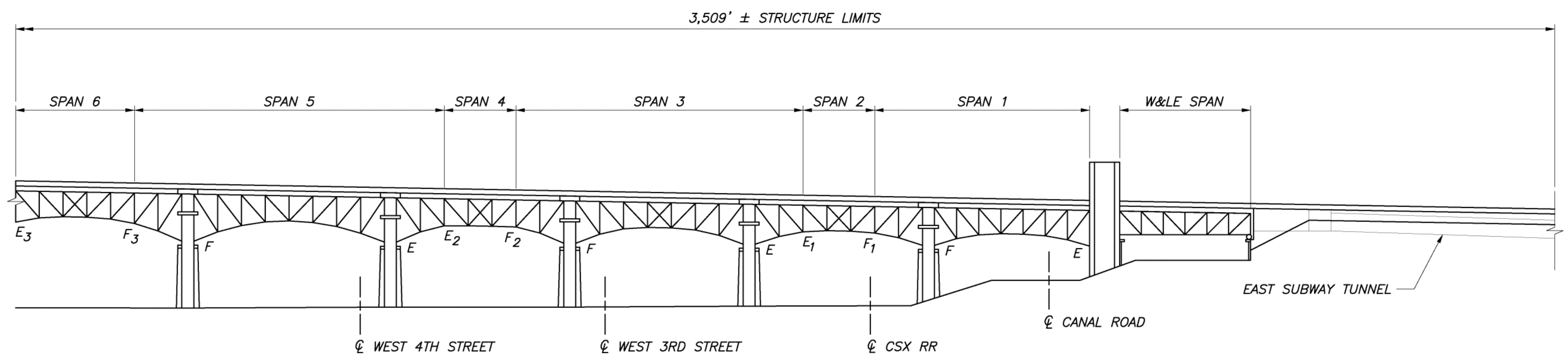

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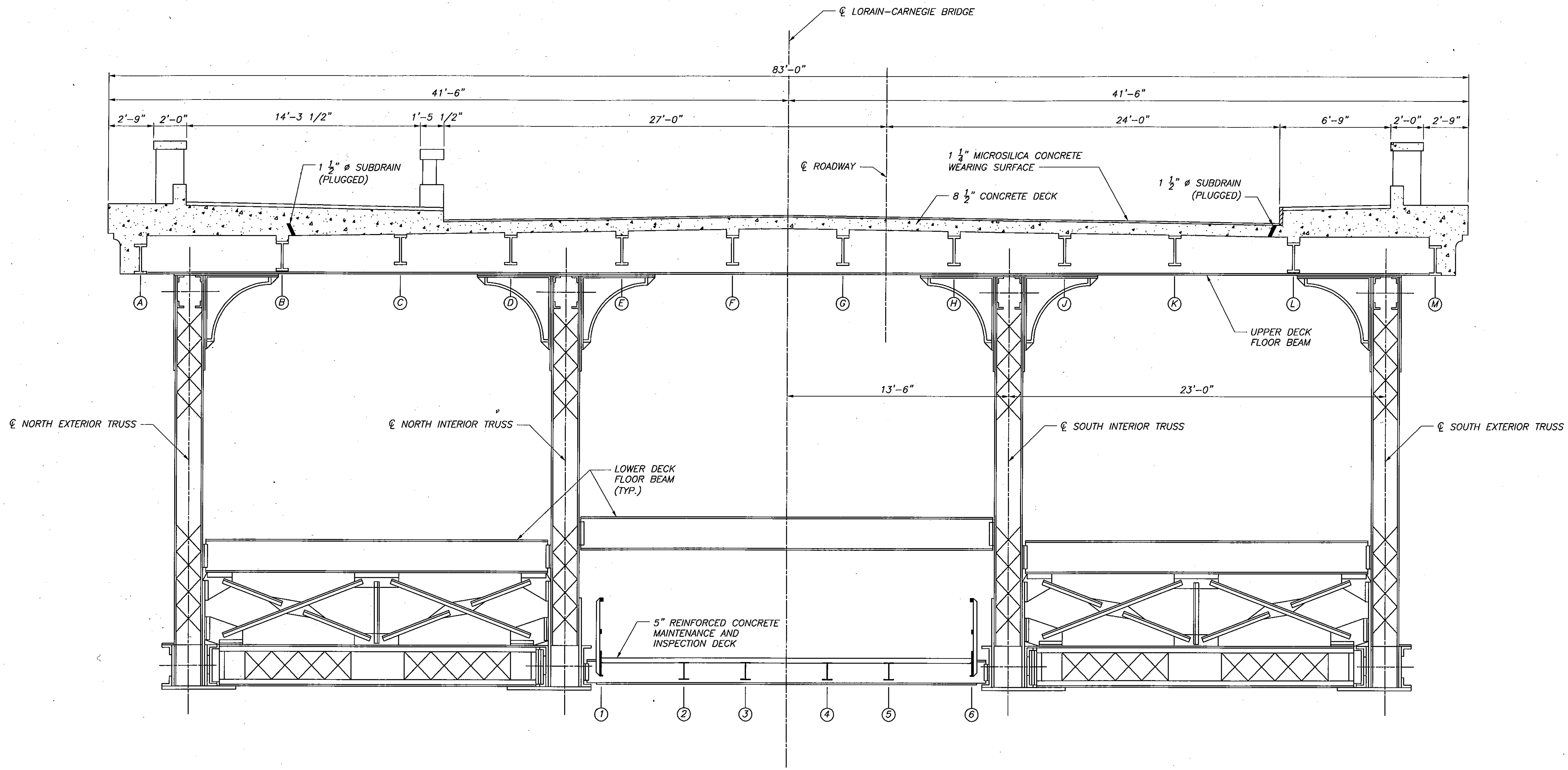

℄ LORAIN–CARNEGIE BRIDGE
83'–0"
41'–6"
41'–6"
2'–9"
2'–0"
14'–3 1/2"
1'–5 1/2"
27'–0"
24'–0"
6'–9"
2'–0"
2'–9"
1 1/2" ø SUBDRAIN (PLUGGED)
℄ ROADWAY
1 1/4" MICROSILICA CONCRETE WEARING SURFACE
8 1/2" CONCRETE DECK
1 1/2" ø SUBDRAIN (PLUGGED)
A
B
C
D
E
F
G
H
J
K
L
M
UPPER DECK FLOOR BEAM
13'–6"
23'–0"
℄ NORTH EXTERIOR TRUSS
℄ NORTH INTERIOR TRUSS
℄ SOUTH INTERIOR TRUSS
℄ SOUTH EXTERIOR TRUSS
LOWER DECK FLOOR BEAM (TYP.)
5" REINFORCED CONCRETE MAINTENANCE AND INSPECTION DECK
1
2
3
4
5
6

Inspection Procedure

Jones-Stuckey performed an in-depth inspection of this structure from July 7 through August 1, 2014. Personnel included William J. Vermes, P.E., Christian Lunt, PE, Michael Jurcak, EI, Elizabeth Trapp, EI and Dale Arnold, EI. The superstructure inspection access was achieved via modified rock climbing equipment and ladders.

Initial gusset plate alignment was performed visually. The alignment of excessive unbraced plate edges was performed by measuring the out/out distance of the plates at top, middle and bottom locations of the unbraced length. Suspect or exceptionally long unbraced lengths were measured along one-foot increments. Digital calipers and profile guides were used to measure gusset plate section loss.

A copy of the Bridge Inspection Field Report is included in Appendix A. Additionally, Appendices B and C contain the Deck and Superstructure Findings, respectively.

Condition & Element Level Rating Guidelines

Ohio and National Bridge Inspection Standards (NBIS) guidelines for evaluating the condition of bridges have been developed to promote uniformity of bridge inspections performed by different teams and at different times. Table 1 contains the bridge inspection rating matrix established by the Federal Highway Administration (FHWA), using a 0-Failure through 9-Excellent scale, and used by the Ohio Department of Transportation (ODOT). In this report, component conditions will generally be discussed based on the ODOT rating guidelines for individual components, 1-Good through 4-Critical. The General Appraisal, the Deck, Superstructure, Substructure, Channel and Approach Summaries, and the Protective Coating System rating will follow the NBIS/ODOT 0 through 9 rating guidelines.

Additionally, this bridge inspection was performed in accordance with the following documents:

- Manual of Bridge Inspection, Ohio Department of Transportation, 2014.
- Manual for Condition Evaluation of Bridge, 2nd Edition, American Association of State Highway and Transportation Officials (AASHTO), 2011.
- Bridge Inspector's Reference Manual (BIRM), U.S. Department of Transportation, revised December 2012.

RATING		CONDITION	RATING GUIDELINES
ODOT	NBIS		
1 – Good	9	Excellent	
	8	Very Good	No problems noted.
	7	Good	Some minor problems present.
2 – Fair	6	Satisfactory	Structural elements show some minor deterioration.
	5	Fair	All primary structural elements are sound but have minor section loss, deterioration spalling or scour.
3 – Poor	4	Poor	Advanced section loss, deterioration, spalling or scour.
	3	Serious	Loss of section, deterioration, spalling or scour has seriously affected primary structural components. Local failures are possible. Fatigue cracks in steel or shear cracks in concrete may be present.
4 – Critical	2	Critical	Advanced deterioration of primary structural elements. Fatigue cracks in steel or shear cracks in concrete may be present or scour may have removed substructure support. Unless closely monitored, it may be necessary to close the bridge until corrective action is taken.
	1	Imminent Failure	Major deterioration or section loss present in critical structural components or obvious vertical or horizontal movement affecting structural stability. Bridge is closely monitored is closed to traffic but corrective action may put bridge back into light service.
	0	Failure	Out of Service, beyond corrective action.

Table 1 – ODOT & NBIS Condition Rating Guidelines.

II. DECK

The deck is in ***Satisfactory*** Condition, or ***6*** on the NBIS condition rating guidelines. Deck findings are shown in Appendix B. Condition findings of individual deck items are as follows:

Floor – Upper Deck

The vehicular upper deck floor is in ***Fair*** condition with approximately 4% of the visible deck spalled or delaminated. The upper deck, opened to traffic in 1883, consists of epoxy coated reinforcement in the top mat of steel only. In the main truss spans, mapping of spalls and visible delaminations shows that new floor deterioration since the 2000-02 rehabilitation has doubled since the 2008 in-depth inspection. During the inspection, evidence of recent spalls was present on the maintenance deck and portions of the truss members (Photo 3). In several locations, the sprayed on cathodic protection applied to exposed reinforcement during the 2000-02 rehabilitation to the exposed reinforcing steel has fallen off (Photo 4). In other areas, new spalls and delaminations have developed adjacent to spalls treated with the sprayed-on cathodic protection (Photo 5). Additionally, several transverse deck cracks near the North and South Exterior trusses permit water and salt infiltration onto the upper deck floor beams and stringers (Photo 6).

In the East Subway, the dual cell tunnel is in ***Poor*** condition with approximately 13% spalled surfaces and advanced corrosion to the reinforcing steel. One spall with advanced deterioration is present 25 feet east of the East Abutment expansion joint (see Appendix B), with nine of 12 reinforcing bars exhibiting 100% loss over six feet longitudinally (Photos 7 & 8).

Photo 3 – New Fallen Concrete from Upper Deck, Span 9.

Photo 4 – Corrosion on Steel Reinforcement with Missing Sprayed-On Cathodic Protection.

Photo 5 – Deck Delamination Adjacent to 2001 Full-Depth Patch.

Photo 6 – Upper Deck Water Infiltration & Efflorescence, Floor Beam 13, Span 5

Photo 7 – Spall with Broken Reinforcement, East Subway.

Photo 8 – Close-up of Severed Broken Reinforcement, Panel 3 South, East Subway.

Edge of Floor

The edge of the upper deck floor slab is in ***Fair*** condition. Isolated spalls and delaminations covering less than 5% of total area are present at the end of the upper deck floor beams (Photo 9) and isolated areas between floor beams.

Photo 9 – Fascia Spall at Upper Deck Floor Beam, Span11, Occurring Since 2002 Sealing.

Floor – Maintenance Deck

The maintenance deck floor is in ***Critical*** condition. The current maintenance deck floor is a 5-inck thick reinforced concrete installed during the 1980-83 rehabilitation. Numerous transversely-oriented spalls and delaminations from one to two inches deep are present on the top of the deck (Photo 10). In Span 7, Panel 4, a small popout spall occurred during this inspection (Photo 11).

At the maintenance deck floor beams, the thickness of the maintenance deck reduces to two inches over the top flange. This reduction in section has resulted in common diagonal cracks throughout the width of the deck along both sides of the floor beams (Photo 12). Water infiltration through the maintenance deck cracks is common (Photo 13). At Floor Beam 8, Span 13, the deck has completely fractured and has been removed above the floor beam (Photo 14).

Photo 10 – Typical Local Deteriorated Concrete, Maintenance Deck.

Photo 11 – Recent Popout & Full Depth Spall, Maintenance Deck near Pier 7.

Photo 12 - Maintenance Deck at Floor Beam 17, Span 11.

Photo 13 – Water Infiltration through Maintenance Deck & Corrosion of Maintenance Deck Floor Beam Top Flange.

Photo 14 – Complete Fracture & Removal of Maintenance Deck above Floor Beam 3, Span 11 (Note: Exposed top flange visible).

Wearing Surface

The concrete wearing surface is in ***Good*** condition with minor map cracking in the eastbound lanes present.

Curbs & Sidewalks

The curbs and sidewalks are in ***Good*** condition with approximately 1% deficiency of the total surface area. The south metal curb plates have advanced paint failure.

Railing

The railing is in ***Fair*** condition. The exterior railing was patched and sealed during the 2000-02 rehabilitation, and is currently cracked throughout over 80% of the railing bases with rust stains (Photo 15). Isolated spalls are present on the interior faces of the railing bases and posts (Photo 16). Cracks with corrosion stains are present in less than 10% of the exterior top rails.

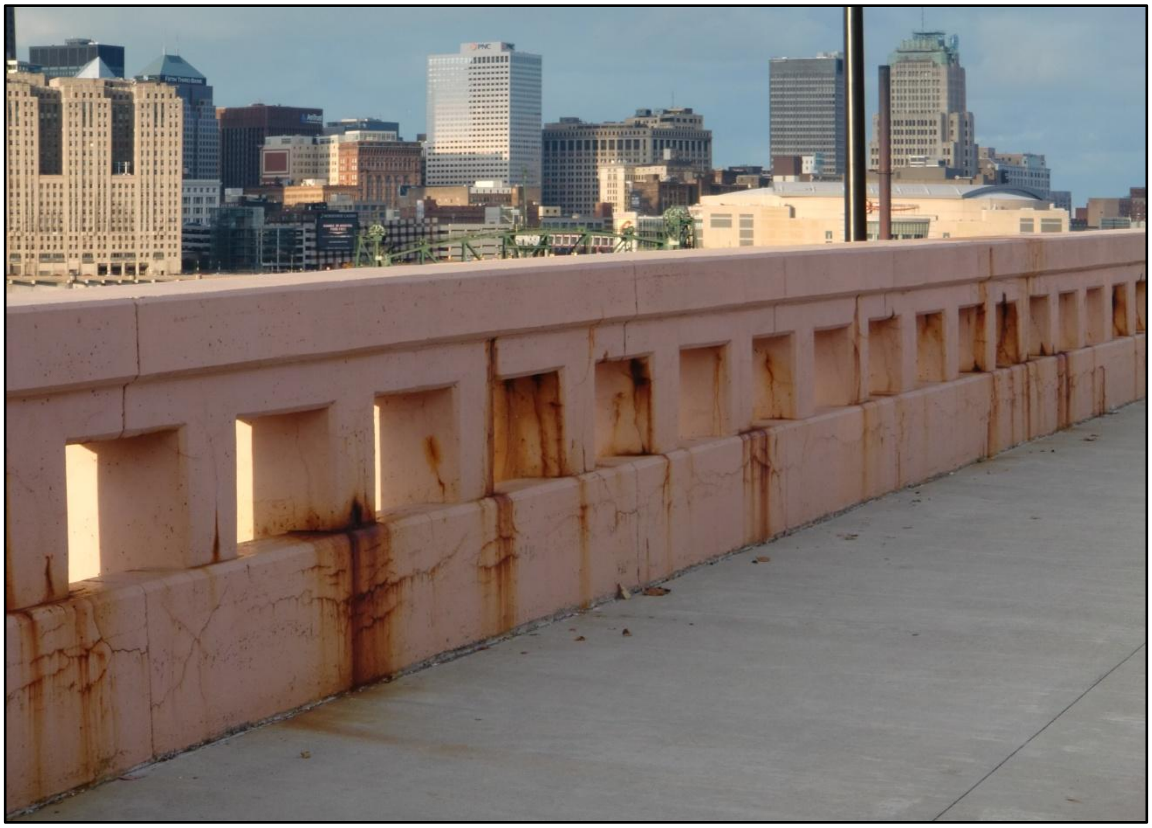

Photo 15 – Cracked North Railing with Active Corrosion, Span 11.

Photo 16 – Open Pull Box, South Sidewalk, Span 13.

Drainage

The drainage is in ***Good*** condition. No clogs or debris within the drain pipes was observed. Some debris is present within the deck catch basins, however all drainage pipes extrances are open. Adjacent to the South Exterior Pier Column, the cover is missing at the drainage manhole within the material yard.

The deck subdrains installed in the 1980-83 rehabiliation were plugged during the wearing surface replacement performed in 2001. A plugging of a few subrains along the south curbline has partially failed as evivdenced by small amounts of water dripping.

Photo 17 – Missing Manhole Cover, Pier 6 SE Column.

Expansion Joints

The expansion joints are in ***Good*** condition. Water infiltration is present at Joint No. 6E (Span 12/13). Also, the 2012 modification along the north sidewalk removed a portion of the 2002 joint membrane without placing and sealing the new membrane with the existing (Photo 18). This void has resulted in water infiltration onto the North Exterior Truss at all joints. Along the South fascia, the expansion joints terminate at the interior face of the railing.

Photo 18 – Cut Expansion Joint Membrane & Open Drainage, North Sidewalk Retrofit.

Lighting

The deck lighting is in ***Fair*** condition. The deck lighting consists of two types of light poles: prestressed concrete light standards spaced from 165 to 205 feet, installed in 1983, and single metal architectural light standards installed between the concrete poles in 2012. All architectural lights and metal poles installed in 2010 are in good condition. Several lights on the prestressed concrete poles were not functioning at the conclusion of this inspection.

Since the mid-1990s, the prestressed poles have had a history of structural and safety issues, including spalls and exposed tendons at the railing level with the collapse of at least one pole collapse (in 2008). Overall four of the 30 prestressed concrete standards between the East and West Pylons have been removed since 1998, with only three standards replaced in kind. (Note: Light Standard No. 6 South, Span 9, has not been replaced.)

The concrete standards have continued to deteriorate. Along the south railing, eight of the 14 prestressed concrete light poles exhibit exposed tendons, with one standard, No. 11 South (Span 5), having up to 50% section loss and **is in a state of imminent collapse** (Photo 19). Several prestressed light bases have shallow scaling at the base sections or narrow vertical cracks. Along the north sidewalk, one prestressed concrete light standard has an excessive lean toward the westbound roadway (Photo 20). At the sidewalk, the lean is 3/4" per 12 inches, with an increasing inward lean along the upper half (see Photo 20). The base plate of this pole is inclined inward with the exterior anchor bolt nuts apparently not fully tightened. The prestressed concrete pole at Light Standard 6S has been removed and not replaced. A summary of the deck lighting deficiencies is included in Table 2.

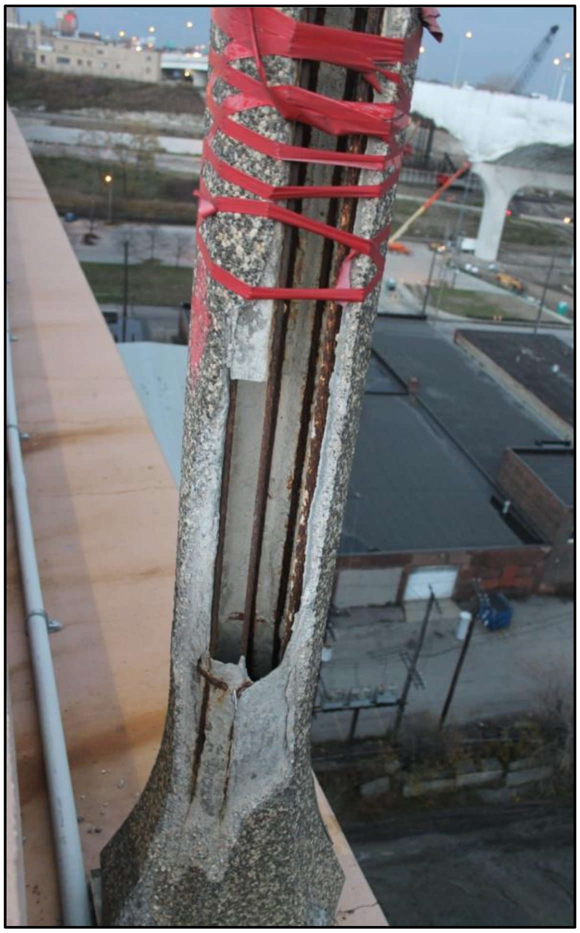

Photo 19 – Critical Deterioration of Light Pole, Span 5, South Fascia (Light Standard No. 11S).

Photo 20 – Leaning Concrete Light Pole with Open Vertical Crack (at Red Arrow), Span 8, North Fascia (Light Standard No. 5N).

Comment No.	Location	Concrete Light Standard No. *	Fascia	Comment
1	Main Truss Spans	3	South	Spall at standard base.
2		4	South	Spall at standard base.
3		5	North	Light standard leaning excessively toward roadway, light flickering.
4		5	South	Spall with exposed tendons.
5		6	South	Light standard removed.
6		7	South	Spall with exposed tendon.
7		8	South	Spall with exposed tendons & cracks. Light out.
8		9	North	Open vertical cracks in standard.
9		9	South	Open vertical cracks in standard. Light out.
10		10	South	Open vertical cracks in standard.
11		10	North	Light out.
12		11	South	Advanced section loss to standard with failure imminent. **Replacement Recommended.**
13		12	South	Deep spalls with exposed tendons. **Replacement Recommended.**
14		13	South	Deep spalls with exposed tendons. **Replacement Recommended.**
15		14	South	Deep spalls with exposed tendons. **Replacement Recommended.**
16		14	North	Light out.
17		15	North	Light out.
18	East Approach	1	North	Light out.
19		2	North	Light out.
20		3	North	Light out.
21		4	North	Light out.

* - Numbered from west to east.

Table 2 – Deck Lighting & Standard Summary.

III. SUPERSTRUCTURE

The superstructure is in ***Poor*** condition, or ***4*** on the NBIS condition rating guidelines. Superstructure findings are shown in Appendix B. Condition findings of individual superstructure items are as follows:

Alignment of Members

The alignment of primary superstructure members is ***Good***.

West Approach Spans

All components of the West Approach Spans are in ***Good*** condition.

Main Spans

Stringers

The stringers are in ***Good*** condition with little section loss due to corrosion. Stringer K between Panel Point 5 and 0, Span 10 has a flame cut notch in the web from a retrofit performed in the 1983 rehabilitation. This cut was first observed during the 1990 inspection, and appears to have not progressed.

There is isolated corrosion on the top flanges of the stringers in Line K due to water and salt infiltration through the deck. Several fascia stringers and interior stringers located near the north curb line have corrosion perforations to their webs due to corrosion prior to the 2000-02 rehabilitation (Photo 21). None of these conditions appear to require repair.

Photo 21 – 2-inch High Web Perforation, Stringer 11, Panel 4, Span 7.

Floor Beams & Floor Beam Connections

The upper deck floor beams and floor beam connections are in ***Good*** condition. Some section loss was observed adjacent to expansion joints with one occurrence of a $^5/_8$"x $^1/_4$" perforation below the south curb line on Floor Beam 10, Span 13. Isolated areas of active corrosion are present to several floor beam top flanges, especially adjacent to expansion and fixed deck joints.

Several maintenance deck floor beam connections have cracked following the 2000-02 rehabilitation. Two of the four cracks at Maintenance Deck Floor Beam 15, Span 15 have propagated since the 2013 inspection (Photo 22A & 22B).

Photo 22A – Crack Propagation. North Interior End of West Face, Maintenance Deck Floor Beam 15, Span 7.

Photo 22B – Crack Propagation. North Interior End of East Beam, Maintenance Deck Floor Beam 15, Span 7.

Truss Members – Corrosion History & Pack Rust

With the implementation of Element Level inspection, it is now more important to quantify the condition of individual elements. During the service life of the Lorain-Carnegie Bridge, the main truss members have been subjected to various degrees of maintenance, inadequate drainage superstructure and exceptional erection methods. Pack rust is prevalent throughout lower chord, diagonal and vertical members, especially on the North and South Exterior trusses. The amount and severity of pack rust is also greatest between Pier 9 and the West Pylon. Generally, the cause of the pack rust has been attributed to poor protective coating maintenance, poor drainage design, and salt water infiltration via subdrains in place from 1983 through 2001.

However, close examination of pack rust locations suggest a contributing factor may be that often the interface between member web plates and flange angles are not tight. Pack rust typically begins at the furthest corner/edge of the component. At component seams not completely filled with caulk, the corrosion appears to have started deeper in the connection with no section loss at the seam of the connection (Photo 23). Among several diagonals and verticals, local gaps between web plates and flange angles show no previous signs of corrosion or section loss. These repeated observations suggest that the corresponding section loss due to pack rust may not be as great as previously thought.

Upper Chord

The top chord is in ***Good*** condition with few significant findings noted. Water dripping from lighting junction box drains has caused light corrosion to several exterior upper chord members (Photo 24). During the 2000-02 rehabilitation, all 24 upper bearing assemblies were completely replaced due to the excessive corrosion present. These bearing assemblies are located on each truss line, immediately beneath the six expansion joints. Currently, dirt and construction debris is present inside all NE and SE upper chord section above these bearing connections (Photo 25). Some of this debris likely is topside dirt that falls over the end of the expansion joint membrane at the railing or the north sidewalk expansion joint gap (See Photo 18), which is contributing to localized failure of the twelve-year old paint system.

Remnants of brackets for an underdeck crosswalk, removed in 1980, welded to upper chord members SE U_6U_7 in Span 13 are present.

Photo 24 – Isolated Corrosion Beneath Abandoned Pull Box Drain.

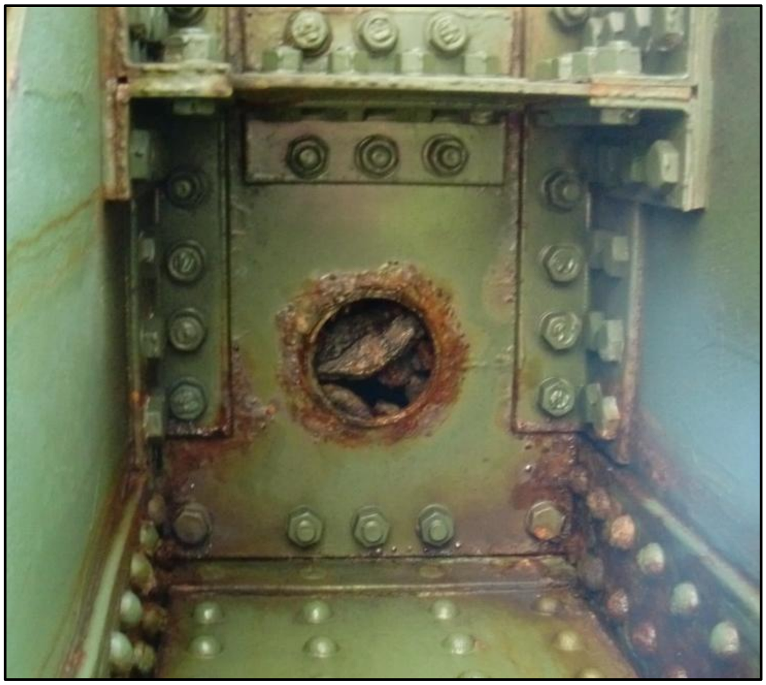

Photo 25 – Demolition Debris & Expansion Joint Water Infiltration within Upper Chord, SE U13, Span 5.

Lower Chord

The lower chord is in ***Poor*** condition based on three members identified in Table 3. Portions of the flange angles of the exterior lower chords have pockets of deep pitting or perforations. Many lower chord flange angles were repaired with both bolted and welded repairs during the 2000-02 rehabilitation, however some flange angle perforations are still present.

Furthermore, various degrees of pack rust located between the flange angles and the web plates are prevalent throughout the exterior lower chords, with isolated perforations in the web at and above the lower interior flange angles (Photo 26). The greatest net section loss generally is located in Spans 11 through 13. In these spans, twelve lower chord members have between 5% and 22% net section loss. (Note: The condition of zero load members in Spans 1, 2, 4, 6 8, 10, 12 and 13 are not included in the lower chord condition rating.)

No.	Span	Member	Deficiency
1	5	SE $L_{12}L_{13}$	21.4% gross section loss.
2	7	SE $L_{12}L_{13}$	10.5% gross section loss.
3	11	SE $L_{9}L_{10}$	11.4% gross section loss.
4	12	SE $L_{3}L_{4}$	Longitudinal crack, top north flange angle.
5	13	SE $L_{1}L_{2}$	20.0% gross section loss.

Table 3 – Controlling Lower Chord Member Summary

This longitudinal crack on SE L_3L_4, Span 12 is now 23 $^1/_2$" long, growing about $^1/_2$" since its discovery in 2008. The crack is almost entirely within the top interior flange angle/stay plate connection and should stay oriented longitudinally along the top stay plate only (Photo 27). From the angle profile obtained from a clay mold and ultrasonic thickness readings, the flange angle has experienced excessive deformation due to pack rust and 40% to 50% section loss at the angle heel and outstanding leg (Figure 5). Also in Span 12, longitudinal stress corrosion cracks were discovered during the 2000-02 rehabilitation along the heel of the lower interior flange angles of zero load members NI $L_{13}L_1$ and NI L_4L_0.

During the recent bridge rehabilitation, most exterior truss bottom cover plates located between the pier bearings were replaced due to interior corrosion found in the 1999 in-depth inspection. Access holes to prevent the re-accumulation of moisture and dirt were placed in all new plates and cut into all existing bottom cover plates that remained. Inspection into these access holes show that steel shot blast material was not completely removed and that the new paint system was not adequately applied (Photo 28).

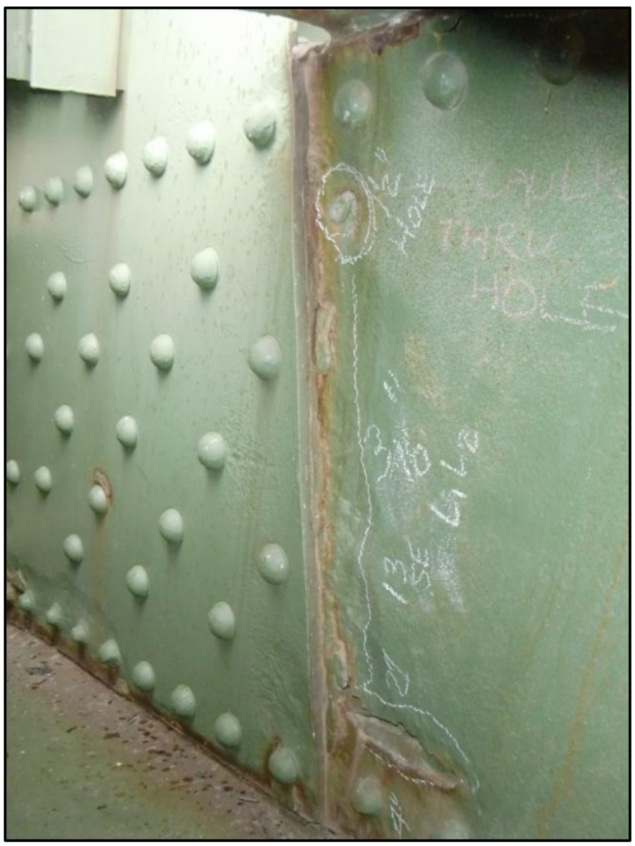

Photo 26 – Two Perforation & $^3/_{16}$" Section Loss on North Web Plate, SE L_1L_2, Span 13.

Photo 27 — Stress Corrosion Crack, Top North Flange Angle, SE L_3L_4, Span 12.

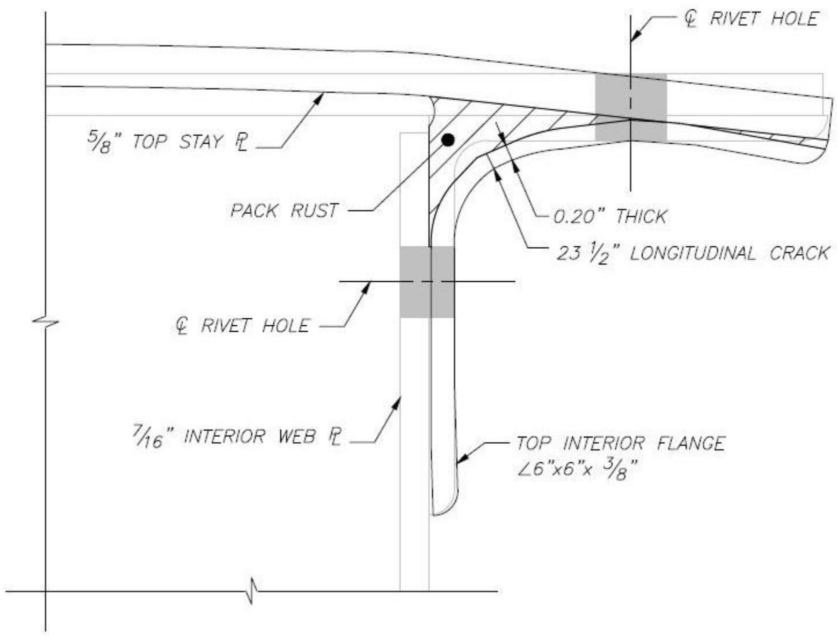

Figure 5 – Top Interior Flange Angle Deformation & Longitudinal Crack Location, L_3L_4, Span 12, SE Truss.

Photo 28 – Typical Corrosion & Debris Inside Lower Chord Between Pier Bearings (Interior of SE $L_{12}L_{13}$, Span 7 Shown).

Main Gusset Plates

All main gusset plates are composed of a special alloy of silicon steel with 0.2% copper added for corrosion resistance. The allowable and yield stress are 25 and 45 ksi respectively.[3] All plates are $^{5}/_{8}$" thick, except for the gusset plates that also connect expansion or bearing pins, which are $^{3}/_{4}$" thick.

The lower gusset plates are in ***Poor*** condition due to advanced section loss along primary load paths on 76 individual gusset plates, or 3.6% of the total primary gusset plates on the bridge. This advanced section loss is commonly located above the lower chord (Photo 29) and along the edges and ends of diagonal connection (Photo 30). These areas of section loss affect the shear planes as well as the Whitmore widths of the diagonal connections.

Kinks or bows up to $^{1}/_{2}$" out of plane along excessively long free edges were observed. Many of these misalignments are associated with pack rust between the gusset plate and truss members (Photo 31). However it is also hypothesized that these misalignments were induced by the cantilevered erection sequence used by the Mount Vernon Bridge Company in 1931. These kinks are isolated to the lower chord gusset plates near the piers in Spans 9 and 11.

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[3] Vermes, William J., *Performance of Early 20th Century High Strength Steels on American Bridges,* The First Fatigue & Fracture Conference, Philadelphia, Pennsylvania, August 7, 2006, pp.7, 13-15.

In Span 6, the south gusset plate at Panel Point L_7 has a longitudinal split that has opened from pack rust caused by the pre-2002 drainage failure above. This split is a fabrication flaw in the plate which has not progressed for some time.

The upper chord gusset plates are in good condition with little corrosion observed, except at those plates located beneath deck joints. Notches and welded plates from previous uses are present to edges of both gusset plates at U6, Span 13. Also, during the upper chord bearing assembly replacement performed in the 2000-02 rehabilitation, both gusset plates at SI U_{13} experienced excessive bowing during an improper load transfer. Construction inspection found no permanent damage, however both gusset plates currently have slight bow along the lower west edges.

Verticals

The vertical are generally ***Good*** condition, with scattered corrosion to flange angles, especially below deck joints. In Span 1, NE $U_{10}L_{10}$ has 50% section loss to the outstanding legs of its east flange angles. Nearby, SI $U_{10}L_{10}$ has deep pitting to both flange angles (Photo 32).

Diagonals

The diagonals are in ***Good*** condition, with active pack rust common to the exterior corners of the NE and SE diagonal members. In Span 13, Diagonal SE L_6U_7 has remnants of a bracket welded to it web plates. Elsewhere, several diagonals have lower stay plates with deep section losses or perforations.

Photo 29 – $^{3}/_{16}$" Deep General Pitting, Exterior Face, North Gusset Plate, SE L14, Span 5 (Note: Outline of diagonal member sketched on plate.)

Photo 30 – $^{3}/_{32}$" to $^{1}/_{4}$" Section Loss at End of Diagonal Connection with $1^{1}/_{4}$" Pack Rust, North Gusset Plate SE L_{14}, Span 5 (Note: Shown is the interior face of gusset plate in Photo 29).

Photo 31 – Slight Bow to North Gusset Plate East Pylon at SE Truss.

Photo 32 – Active Corrosion on Flange Angle Interior, SE $U_{17}L_{17}$, Span 9.

Lower Lateral Bracing

The lower lateral bracing is in ***Good*** condition. The secondary members were extensively repaired or replaced during the recent rehabilitation. Local perforations and areas of moderate section loss are present on the bracing flange angles and horizontal gusset plates adjacent to the exterior trusses.

During the 2000-02 rehabilitation, review of the shop drawings of the original construction and subsequent field measurements showed that many lower lateral bracing members were erected backwards. Most of the bracing members were fabricated with lacing and stay plates unsymmetrical about the center of member. However, the ironworkers realized the connection to the lower lateral bracing gusset plates and tie plates were symmetric, and that the direction of these members (either forward or backward) did not matter structurally. This situation did not occur in Spans 1 & 13 because these bracing members were fabricated with lacing and stay plates symmetrical to the center of the bracing member.

Sway Bracing

The sway bracing is in ***Good*** condition. Pack rust and minor corrosion is present at isolated locations. Extensive repairs were made to the sway bracing frames during the 2000-02 rehabilitation located below all six fixed deck joints.

Bearings

The bearings are in ***Fair*** condition. At the expansion bearings, construction debris, including steel shot, is often present under and between the rollers (Photo 33). At approximately half of the fixed bearings, steel shot was not removed from the casting chambers, resulting in clogged drain holes and retained rain water (Photo 34).

All truss expansion bearings were originally surrounded by grease contained within covered thin-plate steel boxes. Following the 1983 rehabilitation, most of the original grease boxes became heavily corroded and perforated, resulting in grease streaming down the faces of the piers. Most grease boxes were removed and not replaced during the 2000-02 rehabilitation, therefore the roller nests can now be physically inspected. A summary of the expansion bearing alignment is included in Table 4.

During the 1980-83 rehabilitation, the grease boxes at L_0, Span 13 and L_6, Wheeling & Lake Erie Span were replaced. These grease boxes are in good condition, however some paint failure with corrosion is present (Photo 35). No leaking grease was observed.

Photo 33 – Typical Debris within Expansion Rollers.

Photo 34 – Steel Shot Accumulation within Expansion Bearing Cover & Rollers, Panel Point L_{10}, Span 1.

Photo 35 – Active Corrosion on Grease Box Cover, Bearing South L6, Wheeling & Lake Erie Span.

Substructure Unit	Panel Point Line	Bearing Alignment			
		North Exterior	North Interior	South Interior	South Exterior
East Pylon	PP 10	1 1/4" C	1 1/4" C	1/2" C	1 1/2" C
Pier 2	East	7/8" E	5/8" E	5/8" E	5/8" E
	West	7/8" E	1/2" E	9/16" E	5/16" E
Pier 4	East	1/2" E	1 1/4" E	5/8" E	1/8" C
	West	3/4" E	1 3/8" E	1/2" E	3/8" E
Pier 6	East	1 1/2" E	7/8" E	1 5/8" E	1 3/8" E
	West	5/8" E	1 3/8" E	2" E	2" E
Pier 8	East	1/8" E – 5/8" C	3/4" C	3/4" C	1 1/4" C
	West	1/2" C	1 1/4" C	1 1/2" C	1 1/4" C
Pier 11	East	1 1/4" E	1 3/4" E	2" E	2 1/4" E
	West	1 1/2" E	1 1/2" E	1 3/4" E	1 3/4" E

Note: Bearing alignments measured at 70 to 75°F.
E – Expanded position.
C – Contracted position.

Table 4 – Expansion Bearing Alignment.

Protective Coating System

The paint system is in ***Good*** condition and is rated as a ***7*** on the modified protective coating rating system. Generally, scattered areas of the top coat have flaked from the intermediate coat in Spans 1 through 7. Local protective coating failure is common below deck joints due to poor surface prep and joint infiltration (Photo 34) Throughout the superstructure, there are numerous locations of active pack rust between truss stay plates and flange angles and areas of old rust flakes not removed prior to painting (Photo 35).

Pins & Hinges

The pins are in ***Fair*** condition. The top and bottom pins at the truss verticals beneath expansion and fixed joints have minor section loss. The outstanding legs of the stiffening angles above and below the pin at SE L_{13}, Span 5 are heavily perforated. The pins within the zero load lower chord members of the suspended spans (Spans 2, 4, 6, 8, 10, 12) were machined to a 6 $^1/_2$" diameter, allowing $^1/_4$" gap top and bottom between the pin and the cantilever spans gusset plates, suspended spans web plates and twelve plies of pin plates. The pins have up to $^1/_4$" deep loss and are commonly surrounded by advanced pack rust that hinders sliding and/or rotation of the pins.

The hinges are in ***Poor*** condition. Review of the original shop drawings show that the hinges were erected with a $^1/_{16}$" wide gap between the exterior web plates of suspended span lower chord and the interior gusset plates of the cantilever span. During the past 2000-02 rehabilitation, inspection personnel observed that three of the six lower chord expansion hinges were frozen due to excessive pack rust. The pack rust at these hinges was removed and the hinges resumed thermal movement (Photo 36). Since these repairs, the three unrehabilitated lower chord hinges now show no or little evidence of recent movement due to pack rust (Photo 37). The condition of the hinges is summarized in Table 5. Benchmarks have been established by Jones-Stuckey along both sides of the maintenance deck to monitor the performance of the expansion hinges at various temperatures.

Photo 34 – Protective Coating System Failure below Upper Deck Joint F3, Spans 5 & 6.

Photo 35 – Poorly Prepped Steel & Locally Failed Protective Coating System.

Photo 36 – Wear to Paint Indicating Hinge Movement, SE L_{13}, Span 3.

Photo 37 – Frozen Hinge Due to Pack Rust with Buckled Diaphragm, SE L_{15}, Span 7.

Hinge No.	Span	Panel Point Line	Comments
E1	3	L_{13}	Rehabbed in 2002, pack rust removed.
E2	5	L_{14}	Hinge frozen due to pack rust.
E3	7	L_{15}	Rehabbed in 2002, pack rust removed.
E4	9	L_{17}	Pack rust present, hinge possibly frozen.
E5	11	L_{18}	Pack rust present.
E6	13	L_{12}	Rehabbed in 2002, pack rust removed.

Table 5 – Expansion Hinge Performance

Fatigue Prone Connections

Fatigue prone details are present on the welded repairs placed on the tension members of the NE and SE lower chord and also on the welded stiffeners of the West Approach spans. These connections are in ***Good*** condition.

Photo 38 – Occasional Welded Frame to Upper Chord & Gusset Plate.

IV. SUBSTRUCTURE

The substructure is in ***Good*** condition, or ***7*** on the NBIS condition rating guidelines. Condition findings of individual substructure items are as follows:

Abutments

The abutments, including the East and West Pylons, are in ***Good*** condition. The West Abutment has a 20 SF area of delamination below Girder L, near the top southern corner of the abutment wall.

Backwalls

The backwalls are in ***Poor*** condition. Advanced section loss 12'-6" high x 8'-3" deep transversely is present on the East Pylon backwall, behind the NE Truss line. This section loss has exposed the sandstone façade anchors, rendering them ineffective (Photo 39). Lesser concrete section loss of the East Pylon backwall behind the SI Truss line resulted in several façade anchors partially exposed.

Photo 39 – Backwall Loss & Missing Anchorage for East Pylon Sandstone Facing.

Piers

The piers are in ***Good*** condition with minor cracks present at previously patched areas of the pier columns. Several pier seats have deep deterioration that was not patched during the 2000-02 rehabilitation. None of this deterioration is affecting the structural integrity of the bearings nearby.

A cursory inspection of several pier column interiors from the access manholes above shows that water is present below ground level of the Pier 5 columns (Photo 40). No section loss distress is expected to be present. Painting tarps from the 2000-02 rehabilitation were dropped inside approximately half of the pier column shafts from Pier 1 through 11.

Pier Towers & Pilasters

Due to their non-load carrying function, the condition of the pier towers and pilasters not included in the substructure condition summaries, however their condition is discussed in the report due to the potential impact on public safety. The pier towers and pilasters are set on top of the piers, above the truss bearings. The pier towers were constructed for both architectural considerations as well as concealment of utility junction chambers beneath the future and never built vehicular lower deck. The pilasters were constructed to conceal the continuity of the truss superstructures. These shafts are braced by concrete struts attached to the top of the adjacent pier towers and are not in contact with the deck above.

The pier towers are in ***Poor*** condition due to continued spalls, especially from the north and south tower roofs (Photo 41). Numerous pieces of newly fallen concrete are present on the top of Piers 6 and 9.

The pilasters are in ***Fair*** condition. Several mid-height architectural bands have scaled since the 2000-02 rehabilitation (Photo 42). Also, the east concrete bracket at the Pier 2 South Pilaster has a full-depth open crack (Photo 43).

Photo 41 – Standing Water Below Ground Line Inside North Exterior Pier Column, Pier 5.

Photo 42 – Deteriorating Floor & Accumulated Fallen Concrete Since 2002, North Pier Tower, Pier 7.

Photo 42 – Scaled Architectural Band, South Pilaster, Pier 8.

Photo 43 – Full Depth Crack, East Bracket, Pier 1 South Pilaster.

Wingwalls

The wingwalls are ***Good*** condition. Light efflorescence is present at the top of the northeast wingwall.

Scour

The last underwater inspection was performed in 2011, with the next underwater inspection scheduled to take place in 2016. Small scour pockets beneath the South Exterior footing of Pier 10 have been observed in past inspection. The seawall along the east bank and Pier 9 continues to lean in to the river channel.

Slope Protection

The slope protection is in ***Good*** condition and is well vegetated.

V. CHANNEL

Protection

The channel protection is in ***Critical*** condition as the east channel bulkhead continues to lean into the navigational channel (Photo 44).

Navigation Lighting

The six navigation lights are not currently operational, and thus the navigation lighting is in ***Critical*** condition. Inspection of the navigation light housings, conduit and photo sensors showed no apparent cause for this lack of operation.

Photo 44 – Failing Bulkhead along Pier 9 & East River Bank.

VI. APPROACHES & GENERAL ITEMS

Approach Pavement

The approach pavement was installed in 2002 and is in ***Good*** condition (Photo 45).

Utilities

The 20-inch gas line on the maintenance deck owned by Columbia Gas had fallen off its supports for several hundred feet in Span 3 (Photo 46). The gas line was restored to its roller bearings in August and anchor collars have been placed every 100 feet to prevent future misalignments or falls.

Security

During the inspection, it was observed that vandals have been gaining access to the maintenance deck via pallet ladders propped up along the West Pylon security fence. The barbed wire along the top of the fence has been cut. Vandal intrusion seams active over weekend periods. While the graffiti has become prolific, more active vandalism is evident. A drum of industrial solvents was tipped and rolled toward the garage door entrance with an apparent attempt to set the contents on fire (Photo 47). Also, a small grill was found inside NI L_0, Span 9 (Photo 48).

Photo 45 – Moderate Rutting with Patches, West Approach Pavement.

Photo 47 – 200-ft. Long Length of Fallen Gas Line, Span 3.

Photo 48 – Dumped Industrial Solvent Barrel, West Approach Interior.

Photo 49 – Grill Hidden within Lower Chord Panel Point, Span 10.

Land Use

The limits of the property line extend 15 feet from the face of the abutments and pier columns. At Pier 5, coke stockpiles are encroaching within the property line and are against the face of the south exterior column (Photo 50). The surcharge from this load may produce a down drag force on the concrete piles and produce settlement of the pier. Following inspections in the 1990s, the property owner was directed to move the stockpiled material away from the piers.

Photo 50 – Encroaching Stockpile on Pier 5 South Exterior Column.

Architectural Lighting

The architectural lighting installed in 2010 is in overall ***Good*** condition with adequate illumination. One of the two light standards for the west face of the Southeast Pylon is missing (Photo 51).

Pylons

The sandstone pylons are is ***Fair*** condition. Spalled stone and general surface erosion are present on the interior surfaces up to six feet above the sidewalk (Photo 52). This deterioration is worse at the Northeast and Northwest Pylons. During the 2000-02 rehabilitation, mortar repair was performed on deficient mortar joints until it was determined that the contractor was not performing the task properly.

The carvings of the Guardians of Transportation are generally intact, however four fingers total are missing among the figures of the Southeast Pylon. All other components of these sculptures and those of the other three pylons are intact.

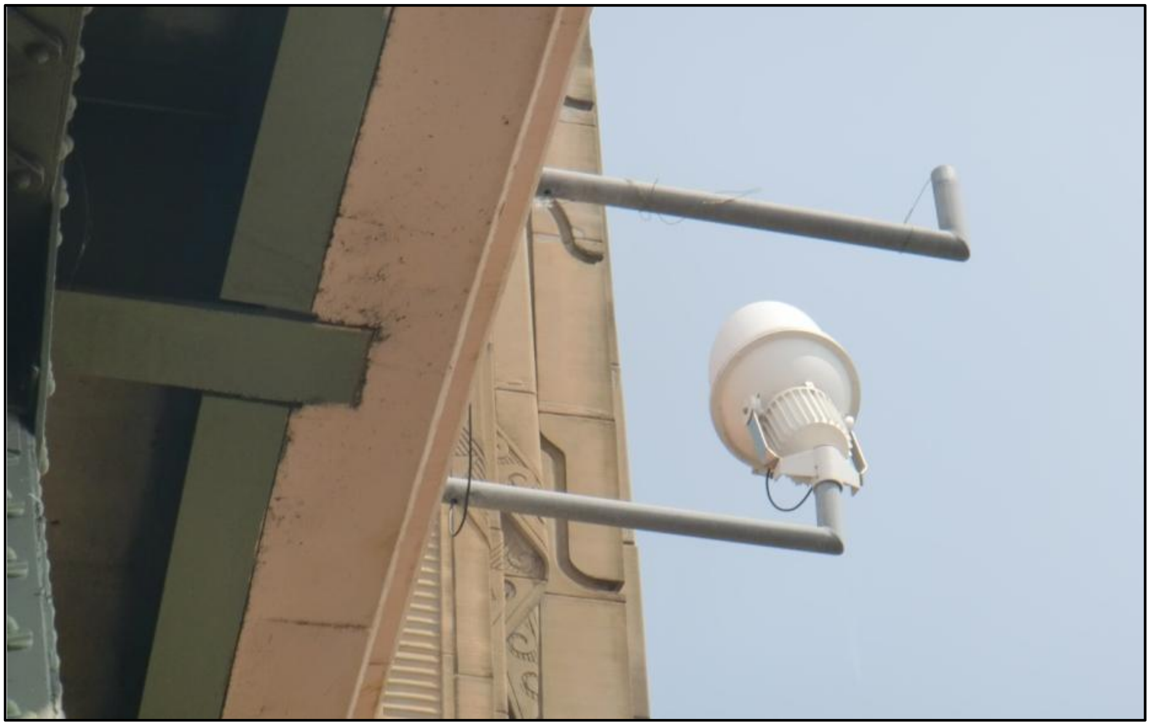

Photo 51 – Missing Architectural Spot Light, West Face, South East Pylon.

Photo 52 – Spalled Sandstone at Sidewalk, Northeast Pylon.

VII. SUMMARY & RECOMMENDATIONS

The Lorain-Carnegie Bridge over the Cuyahoga River is in ***Poor*** c
ondition, or ***4*** on the NBIS rating guideline (Table 1, Page 9). The complete Bridge Inspection Report Form is included in Appendix A. The following repairs and maintenance tasks shown in Table 6 are recommended to improve the General Appraisal of the Lorain-Carnegie Bridge to minimize future repair costs, and to extend the service life of the bridge.

Soon after completion of the 1980-83 rehabilitation, a general concern developed regarding an anticipated short service life for the new upper deck with its asphalt wearing surface and subdrains. By 1990, a second rehabilitation was programmed as a means to extend the service life of the upper deck with the removal of the asphalt wearing surface, plugging subdrains, and placement of a micro-silica wearing surface along with other needed repairs.

While the new wearing surface has stopped water infiltration through the deck and slowed the progression of deterioration, the concrete corrosion has continued to steadily spread throughout the 31-year old deck. Considering the history of the upper deck along with the current rate of deterioration, it is recommended that a preservation/replacement plan be developed in which the following two options are evaluated:

1. Investigate methods (e.g impressed current, electrochemical chloride extraction, cathodic protection) to arrest the ongoing concrete corrosion and further extend the service life of the deck.
2. Evaluate the remaining service life of the upper deck at its expected rate of deterioration, including estimated deck replacement costs and length of interruption to vehicular and pedestrian traffic.

Obtaining deck cores along with the performance of chloride ion tests will greatly assist the development of the above preservation/replacement plan for the upper deck.

	Repair/Maintenance Task	2015	2016	2017	2018	2019
1.	Restore navigation lights.					
2.	Replace deficient light standards.	X				
3.	Install hidden security camera on maintenance deck at West Pylon.	X				
4.	Perform minor rehabilitation including: • Perform zone painting beneath expansion and fixed joints. • Investigate repair for deficient floor section in the East Subway. • Rehabilitate SMS Condition State 3 lower chord members. • Rehabilitate SMS Condition State 3 lower chord gusset plates. • Free three lower chord expansion hinges. • Strengthen excessive gusset plate unbraced edges. • Repair cracked maintenance deck floor beams and restore bearing contact at maintenance deck expansion joints. • Perform zone painting.		X			
5.	Perform in-depth and underwater inspections.		X			
6.	Investigate rehabilitation/replacement options for the upper and maintenance deck.					X

Table 6 – Five-Year Repair & Maintenance Schedule.

APPENDIX A

2014 BRIDGE INSPECTION FIELD REPORT

APPENDIX B

2014 DECK INSPECTION FINDINGS

APPENDIX C

2014 SUPERSTRUCTURE INSPECTION FINDINGS