PKB ENGINEERING

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July 11, 2019

Mr. William McKelvey
Chairmen
Liberty Historic Railroad, Inc.
103 Dogwood Lane
Berkeley Heights, NJ 07922

Re: Boonton Railroad Bridge

Dear Mr. McKelvey:

PKB Engineering conducted an inspection of the abandoned railroad bridge over the Rockaway River in the Town of Boonton on April 30, 2019 to assess the current condition of the bridge. The following is a summary of our inspection findings, load rating analysis, recommendations for repairs and deficiency photos. Structural elements were checked for general condition and field measured for repairable quantities and load rating analysis. Photographs were taken of typical deficiencies and are attached. Findings were evaluated to determine repairs needed to return the bridge to both rail and pedestrian use.

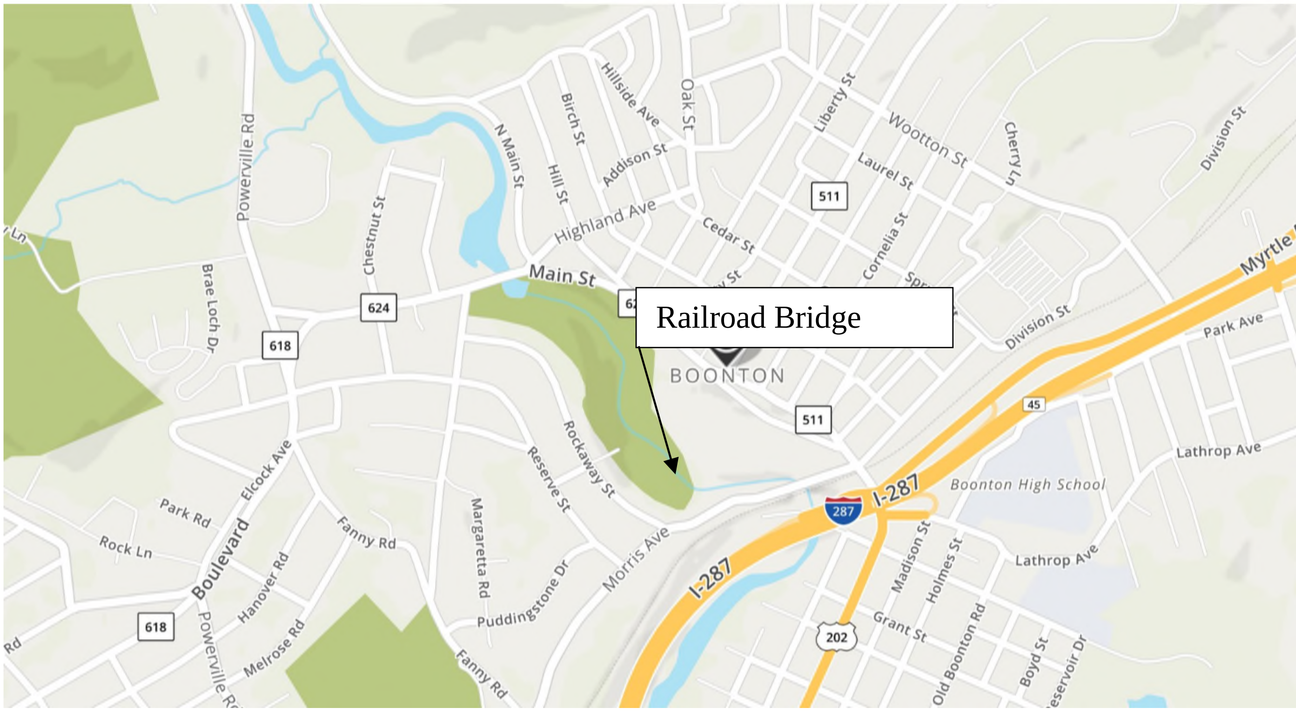
Description of Structure

The bridge spans over the Rockaway River in the Town of Boonton and was originally constructed by the Delaware and Lackawanna & Western Railroad. The bridge served as an industrial spur line providing access to the Boonton Iron Works. The bridge was constructed circa 1906, replacing an early timber bridge. Bridge plaques attached to the girder spans indicated that the girders were constructed by the Fort Pitt Bridge Works in Pittsburg PA in 1906 (See Photo 30). The bridge is currently not in service, and it has been reported that the bridge was last used for rail service in the early 1970s.

The bridge is a four (4) span structure with a total length of approximately 215 feet, consisting of two (2) Double Intersection Warren Deck Truss Spans each 68 feet long with two (2) riveted deck girder flanking spans. The truss spans designated Spans 2 and 3 are constructed with three (3) trusses, numbered west to east. The girder spans designated Spans 1 and 4 are comprised of two (2) riveted deck girders, Span 1 measuring 26’-3” and Span 4 measuring 50’-6” center to center of bearings. The substructure is comprised of poured concrete abutments and piers. The bridge carries a single set of tracks on timber ties.

The bridge orientation was taken as south (turntable side) to north (Boonton side). The girders and trusses are labeled from west to east and the piers and abutments are labeled from south to north.

BRIDGE LOCATION MAP



Conclusions and Recommendations:

The bridge is in overall Poor Condition due to the condition of the steel superstructure.

Timber Bridge Ties:
The timber bridge ties are in poor condition, due to wide spread advanced rot and decay. Several ties also exhibit fire damage (See Photos 7, 8 & 9).

Superstructure (Trusses & Steel Girders):
The superstructure is in poor condition, due to areas of corrosion and advanced section loss, particularly along the horizontal surfaces of the truss members and girder flanges.

Truss Spans 2 & 3:
The truss members are comprised of steel angles and plates riveted together to form the truss spans. The members exhibit moderate to severe corrosion, with up to 1/16" section loss typical at riveted connections and horizontal surfaces (See Photo 10). Several members exhibit up to 100% section loss to the horizontal surfaces particularly along the lower chord members. The following is a list of truss members with significant section loss:

Span	Truss	Truss Member	Condition
2	1 (west)	LoL1	100% section loss to horizontal angle legs (Photo 19)
2	1	L1L2	100% section loss to horizontal angle legs
2	1	L7L8	10" long corrosion crack to horizontal angle leg (Photo 17)
2	2 (center)	L0L1	100% section loss to horizontal angle legs (Photo 14)
2	2	L7L8	100% section loss to horizontal angle legs
2	2	L1L2	1/8" section loss to both angle legs (Photo 15)
2	2	L6L7	Horizontal angle leg cracked and bent from impact
2	3 (east)	LoL1	100% section loss to horizontal angle legs
3	1 (west)	L8U7	1/8" section loss at L8
3	1	L7L8	100% section loss to horizontal angle legs
3	2 (center)	L7L8	100% section loss to horizontal angle legs
3	2	L6L7	1/8" section loss to all angle legs
3	3 (east)	L7L8	100% section loss to horizontal angle legs (Photo 11)
3	3	L6L7	100% section loss to horizontal angle legs
3	3	L3U2	13" long corrosion crack to horizontal angle leg (Photo 12)
3	3	L1L2	100% section loss to horizontal angle legs (Photo 13)

The lower horizontal bracing exhibits moderate to severe corrosion with numerous members disconnected and 100% section loss to several of the horizontal gusset plates (See Photo 20).

The steel floorbeams supporting stringer spans between the truss spans exhibit moderate to severe corrosion with numerous large holes in the floorbeam web (See Photo 18).

The steel truss sliding plate bearings exhibit severe corrosion with heavy accumulation of dirt and debris covering the bearings (See Photo 19).

Girder Spans 1 & 4:
The girder spans are comprised of riveted deck girders. The members exhibit moderate to severe corrosion, with up to 1/6" section loss typical to all exposed surfaces. Heavy dirt and debris has accumulated on these horizontal surfaces causing severe corrosion.

- Vertical web stiffeners typically exhibit large holes near the bottom flanges (See Photos 21 & 25).
- Severe section loss with 100% section loss at several locations along bottom flanges (See Photo 24).
- Girder 2 in Span 1 exhibits a large web hole (40" long x 2" high) near the South Abutment (See Photo 21).
- Lower horizontal bracing exhibits severe section loss with up to 100% section loss (See Photos 22 & 23).

Substructure (Concrete):
The substructure is in satisfactory condition with moderate to severe scaling and spalling throughout the concrete elements (See Photos 26, 27, & 28). Moderate erosion was noted at the west embankment adjacent to the South Abutment (See Photo 29).

Load Rating:
A structural analysis load rating was performed for the steel superstructure. The load rating was calculated in accordance with the Manual for Railway Engineering (2019) by the American Railway Engineering and Maintenance-of-Way Association (AREMA), the NJDOT Highway Bridge Load Rating Manual and Section 43 of the NJDOT Design Manual, Bridges and Structures.

A bridge load rating is a measure of the bridges live load capacity, or capacity to carry vehicles. Each bridge member was rated at two loading levels. **Normal**, defined as the load that can utilize the bridge for an indefinite period of time, and **Maximum,** defined as the maximum permissible load that can be placed on the bridge. The results of the rating analysis are presented in terms of a Rating Factor (RF), such that a RF=1.0 would indicate that the bridge member has a capacity equal to the load of specific vehicle. A rating factor above 1.0 would indicate a capacity above the specified loading and rating factor less than 1.0 would indicate less load carrying capacity then specified load.

The bridge was rated for three (3) separate live loads; AREMA Standard Cooper E 80 loading, special trolley train load comprised of a 20 ton engine and a 24 ton trolley car as specified by the Liberty Historic Railroad and a Standard H-20 (20 ton) highway truck.

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The girder spans were also rated for As-Built and As-Inspected conditions. As-Built representing the capacity of the girders in their as-built condition, with no corrosion or section loss, and as-inspected ratings taking into account noted corrosion and section loss to the steel members, reducing their capacity. As- inspected ratings were not calculated for the truss spans, as it is anticipated that any significant section loss to truss members would be repaired prior to returning the bridge to services.

No plans or previous calculations were available; therefore, the member capacities were calculated based on measurements obtained during the April 2019 field inspection. The original design load and material properties are unknown due to the lack of as-built plans. The steel yield strength was taken as 30 ksi in accordance with AREMA standards.

The results of the load rating indicate the controlling member (member with lowest rating factor) is the center truss diagonal member L3US, with an E80 normal load factors of 0.36. The Trolley Train inventory rating factor for this member is 2.53 and the H20 truck inventory rating factor is 2.13. Based on the results of the analysis the bridge once rehabilitated would have sufficient capacity to carry the specified trolley train. While additional pedestrian loading was not considered in this rating, based on the high rating factors it could be anticipated that the bridge would have sufficient capacity to carry a pedestrian walkway in addition to the rail loads.

The results of the load rating analysis are summarized in the following tables.

Load Rating Summary

	Vehicle Rating Factors					
Span	E-80		Trolley Train		H -20 Truck	
Center Truss	(284 Tons)		(44 Tons)		(20 Tons)	
Truss Member - As-Built	Normal	Maximum	Normal	Maximum	Normal	Maximum
L0L1	3.35	4.92	25.32	37.20	35.19	51.69
L1L2	4.92	7.20	32.49	47.50	45.00	65.78
L2L3/L3L4	3.50	5.14	25.70	37.71	28.18	41.36
L1U1	1.70	2.53	12.69	18.86	12.71	18.89
U1U2	2.10	3.11	16.58	24.58	22.28	33.03
U2U3 U3U4	1.28	1.93	10.14	15.23	14.41	21.64
L0U1	1.26	1.88	9.87	14.78	12.52	18.75
L1U2	0.56	0.85	4.11	6.33	4.00	6.15
L2U3	0.48	0.75	**2.01**	**3.11**	3.67	5.68
L3U4	**0.36**	**0.56**	2.53	3.86	**2.13**	**3.26**
L2U1	1.02	1.54	7.74	11.66	8.99	13.55
L3U2	1.32	1.95	8.84	13.07	10.02	14.82
L4U3	1.69	2.50	10.94	16.19	7.90	11.69

	Vehicle Rating Factors					
Span	E-80		Trolley Train		H -20 Truck	
Fascia Truss	(284 Tons)		(44 Tons)		(20 Tons)	
Truss Member - As-Built	Normal	Maximum	Normal	Maximum	Normal	Maximum
L0L1	2.57	3.78	19.44	28.64	26.91	39.65
L1L2	4.03	5.91	26.38	38.62	36.47	53.40
L2L3/L3L4	3.12	4.58	23.03	33.81	25.16	36.93
L1U1	2.04	3.03	15.89	23.62	21.32	31.70
U1U2	1.19	1.80	9.47	14.26	13.44	20.24
U2U3 U3U4	0.86	1.30	6.43	9.71	6.60	9.97
L0U1	1.35	2.02	10.57	15.89	13.41	20.16
L1U2	0.80	1.21	5.89	8.89	5.91	8.92
L2U3	**0.56**	**0.86**	**4.16**	**6.35**	**3.99**	**6.09**
L3U4	0.70	1.04	4.91	7.33	4.22	6.30
L2U1	1.01	1.52	7.67	11.52	8.46	12.70
L3U2 L4U3	1.14	1.69	7.83	11.61	8.28	12.28

	Vehicle Rating Factors					
	E-80		Trolley Train		H -20 Truck	
	(284 Tons)		(44 Tons)		(20 Tons)	
	Normal	Maximum	Normal	Maximum	Normal	Maximum
Girder Span 1 - As-Built	1.14	1.66	8.43	12.31	9.80	14.31
Girder Span 1 - As-Inspected	1.03	1.50	7.58	11.08	8.82	12.88
Girder Span 4 - As-Built	1.06	1.55	7.79	11.35	6.63	9.66
Girder Span 4 - As-Inspected	0.98	1.43	7.15	10.41	6.09	8.87
Stringers over Pier 2 - As-Built	0.39	0.55	1.75	2.47	1.09	1.54

Recommended Repairs / Cost Estimate:
Based on the overall physical condition of the bridge and the result of the computed load ratings, the bridge is in need of a major rehabilitation to retard further deterioration, preserve the structural integrity of the bridge and return the bridge to service.

The following list of major work items would be anticipated as part of a major rehabilitation program. The costs estimated below are based on average prices from recent repair contracts and are not considered all inclusive.

Repair Recommendation	Unit	Quantity	Unit Price	Cost
1. Truss member repairs	Each	20	$3,000	$60,000
2. Floorbeam repairs	Each	8	$5,000	$40,000
3. Truss span bracing repairs	Each	16	$3,000	$48,000
4. Girder span vertical stiffener repairs	Each	40	$2,000	$80,000
5. Girder web and flange repairs	Each	2	$8,000	$16,000
6. Girder span horizontal bracing repairs	Each	20	$3,000	$60,000
7. Replace truss bearings	Each	12	$10,000	$120,000
8. Replace girder bearings	Each	8	$5,000	$40,000
9. Rivet replacement	Each	300	$100	$30,000
10. Clean and paint structural steel	SF	15,000	$25	$375,000
11. Concrete spall repair	SF	140	$400	$56,000
12. Slope erosion repair	CY	75	$50	$3,750
13. Replace timber ties	Each	150	$100	$15,000
			Subtotal =	$943,750
			Contingencies (15%) =	$140,000
			Engineering (15%)	$140,0000
			Total (rounded) =	**$1,085,000**

It is recommended that prior to undertaking a major rehabilitation project, the New Jersey Historic Preservation Office be consulted, as the bridge has received a certification of eligibility on the New Jersey Registers of Historic Places (ID#5698).

Should you have any questions, please do not hesitate to contact us.

Sincerely,
PKB Engineering Corporation

William Clark

William Clark, P.E.
Project Manager

Photo 1:	East Elevation, looking west.

Photo 2:	West Elevation, looking northeast.

Structure: Boonton Railroad Bridge
Inspection Date: 4/30/2019

Photo 3:	Track, from South Approach to bridge, looking north.

Photo 4:	Track, from North Approach to bridge, Looking south.

Photo 5:	Upstream Channel, looking west.

Photo 6:	Downstream Channel, looking east.

Photo 7:	Typical top of deck condition, severe rot and decay of timber ties with heavy vegetation growth, looking northwest.

Photo 8:	Severe rot and decay of timber ties, typical throughout all spans, looking west.

Photo 9:	Fire damage to timber ties, note heavy vegetation growth, typical throughout all spans, looking south.

Photo 10:	Typical condition of East Truss, Span 3, looking south. Note 100% paint loss with light to moderate corrosion of all exposed steel surfaces. Note graffiti on steel truss members.

Photo 11:	Severe corrosion and section loss with hole in angle leg at Span 3, East Truss, lower chord member L7L8 at L8, looking west on Pier 3.

Photo 12:	13” long crack in horizontal leg of Span 3, East Truss diagonal member L3U2, looking down.

Photo 13:	100% section loss to horizontal angle leg of Span 3, East Truss lower chord member L1L2 at L2, looking down.

Photo 14:	100% section loss to horizontal angle leg of Span 2, Center Truss lower chord member L0L1 at L0, looking west. Note heavy debris around bearing.

Photo 15:	Severe corrosion and section loss to Span 2, Center Truss lower chord member L1L2, looking down.

Photo 16:	Typical condition of truss members, Span 2 Center truss, looking north. Note pack rust between riveted angles.

Photo 17:	10” long crack in horizontal leg of Span 2, West Truss lower chord member L7L8 at L7, looking west.

Photo 18:	Large web hole and lower flange section loss at end floorbeam at U1, Span 2 between Center and West Trusses, looking north.

Photo 19:	Heavy dirt and debris accumulation at truss bearing over Pier 1, looking west. Note large hole in lower chord member L0L1 at West Truss.

Photo 20:	100% section loss to truss lower horizontal bracing at Span 2, East Truss L2, looking down.

Photo 21:	100% section loss and holes in girder web and vertical stiffeners, Span 1 East Girder at South Abutment, looking southeast.

Photo 22:	Severe corrosion and 100% section loss to lower horizontal bracing members, Span 2 at West Girder, looking west.

	
Photo 23:	Underside of Span 1 deck girders, looking north. Note severe corrosion to horizontal cross bracing.
	
Photo 24:	Severe corrosion to bottom flange angles, Span 1, West Girder, looking east.

	
Photo 25:	100% section loss to vertical stiffeners, Span 4, West Girder, looking north. Note heavy debris on girder bottom flange.
	
Photo 26:	Large spalls in Pier 3 seat below girder bearing, looking south.

Photo 27:	Spall in South Abutment seat, looking south. Note heavy graffiti on abutment breastwall.

Photo 28:	Heavy scaling to west face of Pier 1, looking north.

Photo 29: Severe erosion along west embankment of South Abutment, looking south.

Photo 30: Bridge plaque on girder span, “Fort Pitt Bridge Works, Pittsburg PA, 1906”.