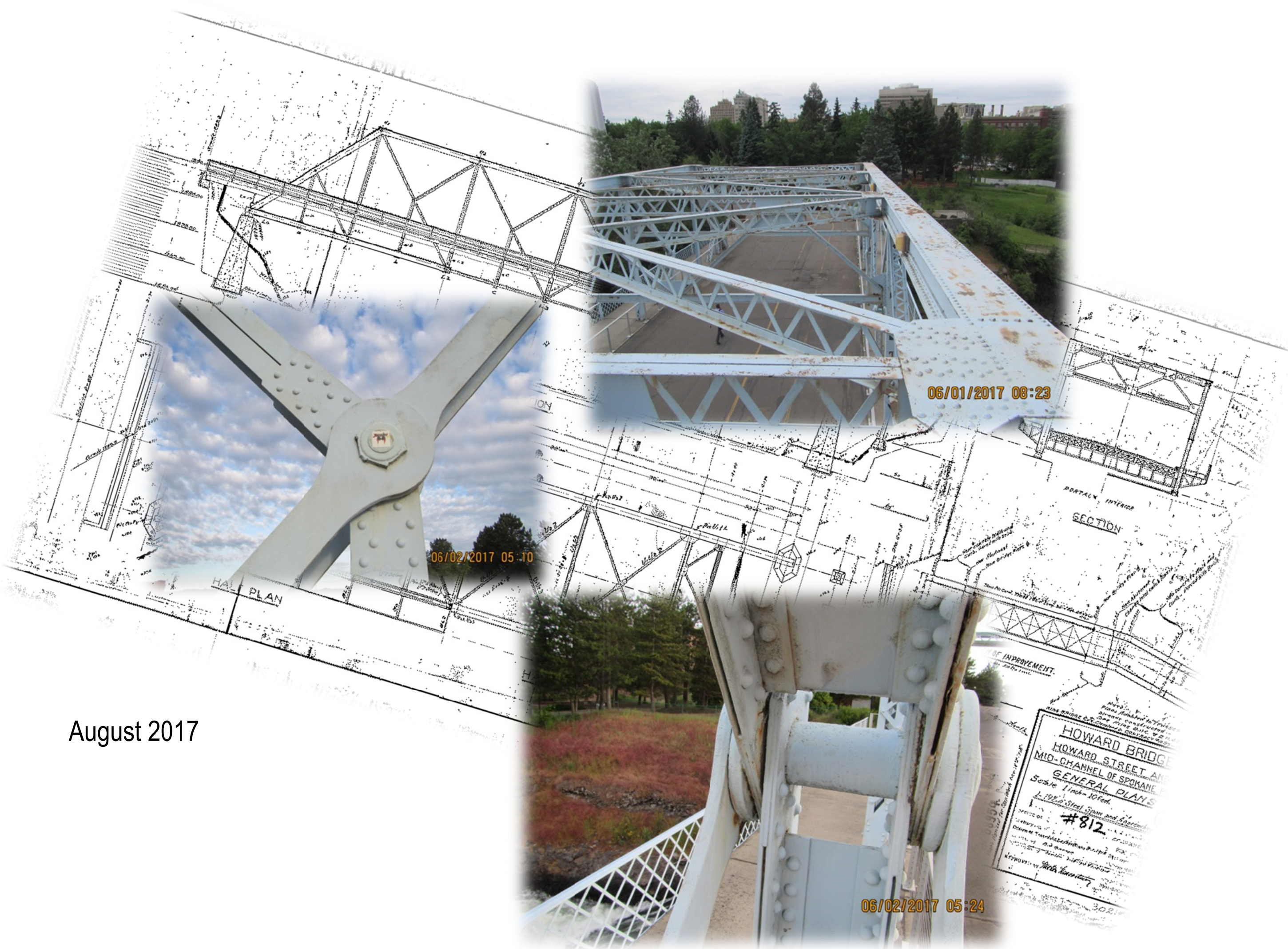
BRIDGE ASSESSMENT REPORT for

Howard Street Mid-Channel Bridge



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City of Spokane

CITY OF SPOKANE

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INTRODUCTION

As requested by the City of Spokane, we are providing this report as a summary of what we have determined in our visual assessment and load ratings for the Howard Street Middle Channel Bridge in Spokane, Washington. The Howard Street Middle Channel Bridge is a 243-foot long bridge consisting of a single span steel thru-truss (Blue Truss) with a prestressed concrete approach span at each end. The Blue Truss was originally constructed as part of the falsework for the construction of the Monroe Street Bridge around 1911 and a portion of that original falsework truss was moved to Howard Street around 1915. It appears that in 1963 the truss was modified to allow for the installation of the existing prestressed concrete girders for the approach spans and at the same time, prestressed concrete stringers were added to create the roadway and sidewalks on the truss span.

VISUAL ASSESSMENT

A site visit was performed on June 1 and 2, 2017 for the visual assessment of the bridge. The visual assessment was performed from a man-lift to observe the above deck portions of the steel truss, and via climbing techniques for the below deck portions of the truss. Based on the visual assessment, the inspectors noted that the main structural members of the truss were in good condition considering the age of the truss. They did note a few items of concern including:

- Pack rust causing distress in the riveted connections of the floor beams and the truss members (see Fig. 1). There is minor rusting with pack rust in almost all of these connections, but only a few have significant enough pack rust that we felt it necessary to discount the number of rivets used in the load rating analysis.
- Some significant corrosion and section loss at one of the floor beam bearing points (See Fig. 2). This corrosion and section loss is significant enough that we feel it needs to be repaired in order to continue using the bridge for vehicular traffic.
- More corrosion and section loss was found in the floor beams than expected, especially at floor beams at the main panel points of the bridge which occur below joints between the ends of the prestressed concrete stringers (every other floor beam). These floor beams showed signs of significant section loss in the cover plates and top plates of the floor beams (see Fig. 3).
- Minor pack rust at the connections of the upper sway bracing members and wind plates was noted throughout the bridge. However, no significant section loss or distressed rivets were observed.
- Deformation in the upper sway bracing members appeared to be an as-built detail present in all transverse upper sway bracing members.
- Cracking and spalling of the bearing of many of the prestressed sidewalk stringers (see Fig. 4). Our inspectors noted their concern that a few of the sidewalk stringers appeared to be at risk of slipping off their bearing seats which they felt could lead to the stringer falling into the river below or causing damage to other portions of the bridge.

LOAD RATING ASSESSMENT

We have completed three different load ratings for the bridge based on different configurations of the bridge and traffic lanes on the bridge. Configuration One assumes the bridge is left in its current condition with a maximum of three lanes of vehicular traffic on the bridge. Configuration Two assumes the bridge is left in its current condition but is limited to a single lane of vehicular traffic (alternating one-way traffic) down the center of the bridge. Configuration Three assumes the sidewalk stringers and the existing asphalt and ballast are all removed from the existing bridge, a maximum of two-inches of asphalt is added to the bridge to smooth the riding surface, and a single lane of traffic down the center of the bridge. **As noted above, for ALL of these Configurations the rating factors are essentially 0.0 until the City repairs the corrosion and section loss at the floor beam bearing.**

The rating factors for Configuration One with full traffic are as shown in Table 1 below. Per Table 1, the rating factors for most of the trucks are still well below 1.0 and we would recommend the current bridge posting sign be revised to 9 tons, 16 tons, and 17 tons for the Type 3, Type 3S2, and Type 3-3 trucks. Removing the sidewalk stringers will not have any impact on these ratings as the ratings are controlled by the precast girders used for the north approach span. However, if the City were to replace the existing north approach span, the next controlling member is the truss pins at which point the ratings could be increased by removing the sidewalk stringers. Also, of note in this Configuration is the rating factors for the EV2 and EV3 (the two emergency vehicles) are below zero meaning they would not be allowed across the existing bridge with trucks in adjacent lanes of the bridge.

The rating factors for Configuration Two with a single lane of traffic down the center of the bridge are as shown in Table 2 below. As seen in the Table, the load ratings improve but the bridge would still need to be posted. The posting sign could be revised to 11 tons, 21 tons, and 26 tons for the Type 3, Type 3S2, and Type 3-3 trucks. Again, this rating is controlled by the precast girders used for the north approach span. If these girders are replaced, then the next controlling element is either the two span precast stringers on the truss or the truss pins, both of which has rating factors very near or above one for all of the legal trucks. Finally, of note in this Configuration is that the very low for the two EV trucks unless the north approach span is replaced at which point the EV2 would be allowed to cross the bridge.

The rating factors for the final configuration, Configuration 3, with a single lane of traffic on a lightened bridge are shown in Table 3. Per Table 3, the rating factors see a decent improvement, however, a posting of 23 tons for the Type 3 truck would still be recommended in order to account for the low ratings of the SU trucks. Again, this rating is controlled by the precast girders used for the north approach span. If the north approach span is replaced, the next controlling element is the two span precast stringers on the truss which has a rating factor above one for all trucks except the EV3.

RECOMMENDATIONS AND ESTIMATES

Due to the severity of the damage to the existing floor beam bearing, we would highly recommend closing the bridge to vehicular traffic until the City can repair the corrosion and section loss at the floor beam bearing. Budgetary estimate to do this work would be $50,000. We would also recommend either repairing the damaged sidewalk stringer bearings or removing the sidewalk stringers from the bridge. Budgetary estimate for removal (our recommendation) would be $150,000. Looking at the lifespan of the bridge, performing these repairs would easily add another ten years to the useful life of the bridge, but more importantly the repairs would allow traffic back on the bridge and mitigate the hazard of the sidewalk stringers possibly falling off the bridge.

Should the City decide they want to replace the north approach span which is currently the controlling element for most of the ratings, we would recommend the span be replaced with adequately designed prestressed concrete slabs. As mentioned above in the ratings section, doing this would increase the ratings to around one for all of the legal trucks.

Obviously, if the City chooses to do nothing with the bridge, it should not be used for vehicular traffic and we would expect it to be closed to pedestrian traffic within the next five years due to the continued corrosion and section loss at the floor beam bearing which will ultimately lead to failure of that floor beam. The other repairs or modifications to the traffic lanes across the bridge really do nothing for the City as far as longevity is concerned. Other elements the City could look into if it was concerned about longevity is removing the existing asphalt and ballast and installing a waterproof membrane and repairing/sealing existing expansion joints in the bridge deck. This repair would help keep the water away from the structural steel elements below and likely add 10 or more years to the life of the bridge. A budgetary estimate for this work would be $100,000. The last longevity recommendation is obviously to repaint the bridge. This would also involve some minor repairs to structural members and connections which would also help increase the rating factors for the bridge. The upside to this work is that you likely add another 50 years to the life of the bridge, the downside is that this is likely a million dollar project.

Figure 1 – Pack Rust and Rivet Distress at Floor Beam Connection

Figure 2 – Section Loss of Floor Beam Bearing Stiffeners

Figure 3 – Heavy Corrosion on Top Cover Plate of Floor Beam

Figure 4 - Damaged Sidewalk Stringer Seats

Table 1 - Configuration One Rating Factors

	Truss Members	Truss Pins	Floor Beams						Stringers (2 Span)		Girder (S. Approach)		Girder (N. Approach)			Controlling Section
Rating Trucks			Flexure	Shear	Flexural Stress	26 Rivet Conn.	14 Rivet Conn.	Bearing	Flexure	Shear	Flexure	Shear	Flexure	Shear	Summary	
Design Inv	0.32	0.17	0.55	0.73	0.73	0.89	0.28	0.66	0.40	0.20	0.40	0.61	0.57	0.10	0.10	N. Appr. Girder Shear
Design Opr	0.41	0.22	0.71	0.95	0.95	1.16	0.37	0.86	0.52	0.37	0.52	0.93	0.74	0.14	0.14	N. Appr. Girder Shear
Type 3	0.76	0.61	1.41	1.96	1.40	2.41	0.76	1.85	1.05		1.05			0.40	0.40	N. Appr. Girder Shear
Type 3S2	0.77	0.46	1.48	2.06	1.47	2.46	0.78	1.88	1.12		1.15			0.45	0.45	N. Appr. Girder Shear
Type 3-3	0.95	0.43	1.64	2.28	1.62	2.99	0.95	2.13	1.27		1.27			0.48	0.43	N. Appr. Girder Shear
NRL	0.49	0.40	0.89	1.24	0.89	1.49	0.47	1.21	0.87		0.89			0.31	0.31	N. Appr. Girder Shear
OL1	0.63	-0.13	1.11	1.56	1.10	1.59	0.51	1.23	1.04		1.07			0.30	-0.13	Truss Pin
OL2	0.59	-0.07	1.03	1.43	1.02	1.54	0.49	1.16	0.88		0.91			0.28	-0.07	Truss Pin
SU4	0.54	0.56	1.25	1.74	1.23	1.97	0.63	1.61	0.92		0.93			0.34	0.34	N. Appr. Girder Shear
SU5	0.51	0.49	1.15	1.59	1.13	1.88	0.60	1.43	0.87		0.89			0.31	0.31	N. Appr. Girder Shear
SU6	0.59	0.45	1.03	1.44	1.02	1.65	0.52	1.31	0.87		0.89			0.31	0.31	N. Appr. Girder Shear
SU7	0.49	0.41	0.94	1.31	0.93	1.54	0.49	1.25	0.87		0.89			0.31	0.31	N. Appr. Girder Shear
EV2	0.64	-0.31	1.21	1.69	1.20	1.56	0.50	1.26		0.83	0.92			0.22	-0.31	Truss Pin
EV3	0.40	-0.19	0.81	1.13	0.80	1.42	0.45	1.12		0.54	0.57			0.15	-0.19	Truss Pin

- controlling location
- next controlling location

Table 2 - Configuration Two Rating Factors

	Truss Members	Truss Pins	Floor Beams						Stringers (2 Span)		Girder (S. Approach)		Girder (N. Approach)			Controlling Section
Rating Trucks			Flexure	Shear	Flexural Stress	26 Rivet Conn.	14 Rivet Conn.	Bearing	Flexure	Shear	Flexure	Shear	Flexure	Shear	Summary	
Design Inv	0.77	0.41	0.86	1.82	1.27	2.15	0.68	1.60	0.53	0.23	0.64	0.78	0.68	0.13	0.13	N. Appr. Girder Shear
Design Opr	1.00	0.53	1.12	2.36	1.65	2.79	0.89	2.07	0.69	0.45	0.82	1.30	0.88	0.17	0.17	N. Appr. Girder Shear
Type 3	1.83	1.46	2.40	5.06	2.62	5.80	1.84	4.45		1.19	1.65			0.54	0.54	N. Appr. Girder Shear
Type 3S2	1.85	1.10	2.43	5.14	2.65	5.93	1.88	4.52		1.30	1.81			0.59	0.59	N. Appr. Girder Shear
Type 3-3	2.28	1.04	2.76	5.82	3.01	7.21	2.29	5.11		1.45	2.00			0.64	0.64	N. Appr. Girder Shear
NRL	1.18	0.95	1.57	3.31	1.71	3.59	1.14	2.91		1.03	1.46			0.39	0.39	N. Appr. Girder Shear
OL1	1.52	0.85	1.81	3.83	1.98	3.79	1.20	2.81		1.21	1.69			0.40	0.40	N. Appr. Girder Shear
OL2	1.42	0.47	1.61	3.39	1.75	3.55	1.13	2.48		1.05	1.49			0.38	0.38	N. Appr. Girder Shear
SU4	1.29	1.34	2.09	4.42	2.28	4.74	1.51	3.89		1.10	1.49			0.42	0.42	N. Appr. Girder Shear
SU5	1.22	1.18	1.86	3.92	2.03	4.51	1.43	3.45		1.07	1.46			0.39	0.39	N. Appr. Girder Shear
SU6	1.38	1.07	1.70	3.59	1.85	3.97	1.26	3.15		1.07	1.46			0.39	0.39	N. Appr. Girder Shear
SU7	1.15	0.98	1.62	3.42	1.77	3.70	1.18	3.01		1.03	1.46			0.39	0.39	N. Appr. Girder Shear
EV2	1.62	1.33	1.99	4.20	2.82	4.82	1.53	3.70		1.00	1.41			0.28	0.28	N. Appr. Girder Shear
EV3	1.01	0.84	1.36	2.86	1.92	3.25	1.03	2.52		0.66	0.90			0.19	0.19	N. Appr. Girder Shear

- controlling location
- next controlling location

Table 3 - Configuration Three Rating Factors

	Truss Members	Truss Pins	Floor Beams						Stringers (2 Span)		Girder (S. Approach)		Girder (N. Approach)			Controlling Section
Rating Trucks			Flexure	Shear	Flexural Stress	26 Rivet Conn.	14 Rivet Conn.	Bearing	Flexure	Shear	Flexure	Shear	Flexure	Shear	Summary	
Design Inv	1.39	1.67	1.17	1.71	1.06	2.51	1.04	2.11	0.58	0.34	0.69	0.83	0.79	0.27	0.27	N. Appr. Girder Shear
Design Opr	1.80	2.16	1.52	2.22	1.37	3.25	1.35	2.74	0.75	0.64	0.89	1.24	1.03	0.39	0.39	N. Appr. Girder Shear
Type 3	3.30	5.11	3.26	6.49	3.19	6.76	2.81	5.88		1.41	1.78			1.14	1.14	N. Appr. Girder Shear
Type 3S2	3.34	4.48	3.31	6.58	3.24	6.91	2.87	5.97		1.54	1.95			1.26	1.26	N. Appr. Girder Shear
Type 3-3	4.12	4.20	3.75	7.46	3.67	8.40	3.49	6.75		1.72	2.16			1.36	1.36	N. Appr. Girder Shear
NRL	2.12	3.28	2.13	4.24	2.09	4.19	1.74	3.84		1.22	1.58			0.76	0.76	N. Appr. Girder Shear
OL1	2.74	3.46	2.47	4.91	2.41	4.42	1.83	3.71		1.43	1.83			0.79	0.79	N. Appr. Girder Shear
OL2	2.56	1.89	2.19	4.34	2.14	4.14	1.72	3.28		1.25	1.61			0.75	0.75	N. Appr. Girder Shear
SU4	2.32	4.24	2.85	5.66	2.79	5.53	2.29	5.13		1.30	1.61			0.84	0.84	N. Appr. Girder Shear
SU5	2.21	3.97	2.53	5.03	2.47	5.26	2.18	4.55		1.27	1.58			0.78	0.78	N. Appr. Girder Shear
SU6	2.48	3.59	2.31	4.60	2.26	4.63	1.92	4.16	1.26		1.58			0.78	0.78	N. Appr. Girder Shear
SU7	2.08	3.42	2.21	4.39	2.16	4.31	1.79	3.97		1.22	1.58			0.78	0.78	N. Appr. Girder Shear
EV2	2.92	4.52	2.71	5.38	2.71	5.62	2.33	4.88		1.19	1.53			0.66	0.66	N. Appr. Girder Shear
EV3	1.82	2.82	1.85	3.67	1.85	3.79	1.57	3.32		0.78	0.98			0.45	0.45	N. Appr. Girder Shear

- controlling location
- next controlling location

APPENDIX A – EXISTING STRUCTURE, FULL TRAFFIC RATING CALCULATIONS

See attached document

APPENDIX B – EXISTING STRUCTURE, ONE TRAFFIC LANE RATING CALCULATIONS

See attached document

APPENDIX C – LIGHTENED DECK, ONE TRAFFIC LANE RATING CALCULATIONS

See attached document