

**LOAD RATING ANALYSIS**

The bridge superstructure components were analyzed for HS20-44 truck and lane loading for inventory and operating levels, and for the operating levels of the Ohio Legal Loads 2F1, 3F1, 4F1 and 5C1. In addition, the effect of two truck trains, one composed of a series of HS20-44 trucks and one of Ohio 5C1 trucks were considered at the operating level for spans greater than 200 feet.

Structural components were analyzed and load rating capacities were calculated using a combination of hand calculations, spreadsheets, and various finite element software. Capacities and dead loads were calculated by hand and by using Microsoft Excel workbooks. Maximum live load effects were found utilizing STAAD.Pro V8i or hand calculations. Impact and multiple presence factors were applied to the live loads in accordance with AASHTO 3.8.2 and 3.12.1. The load rating formulas were applied inside of Excel workbooks. All capacities and loads were generated based upon Load Factor Rating.

The as-built controlling rating factors for each section are presented in **Table 1**.

AS-BUILT SUMMARY CONTROLLING RATING FACTORS											
Location		HS20 Inv	HS20 Oper	2F1 Oper	3F1 Oper	4F1 Oper	5C1 Oper	HS20 Truck Train	5C1 Truck Train	Pedestrian	
										Inv	Oper
Deck - All Sections		1.20	2.00	3.20	2.81	3.10	3.15				
Concrete Spans	Arch Ribs	2.15	3.58	6.35	4.33	3.95	4.54				
	Columns	2.21	3.69	5.01	3.62	3.49	3.26				
	Upper Floorbeams	<b>0.79</b>	1.31	1.72	1.51	1.34	1.53				
	Lower Floorbeams									5.16	8.62
	Jack Arches	1.12	1.86	2.98	2.63	3.03	2.63				
Steel Main Span	Truss Members	1.65	2.06	10.41	6.87	5.93	4.51	2.22	2.75		
	Pins and Hangers	1.06	1.47	2.80	1.89	1.69	1.94				
	Upper Floorbeams	<b>0.93</b>	1.44	2.79	1.83	1.62	1.91				
	Upper Stringers	1.42	2.37	3.46	2.51	2.34	2.68				
	Lower Floorbeams									8.32	13.89
	Lower Stringers									6.13	10.23
	Gusset Plates	1.87	2.57	5.91	3.90	3.37	2.60				
Controlling for Structure		<b>0.79</b>	1.31	1.72	1.51	1.34	1.53	2.22	2.75	5.16	8.62

Table 1 – Controlling as-built rating factors for CUY-6-1456 (numbers below 1.0 are red).

The as-built rating is controlled by the upper floorbeams in the concrete approach spans. The lowest HS20 Inventory rating factor occurs in Span 11, where the governing floorbeam is controlled by positive moment at midspan. Many of the concrete floorbeams in the other approach spans exhibit similar rating factors, with controlling rating factors in each span governed by midspan moment or by shear over the concrete support columns. The steel floorbeams in the main truss span also have a controlling rating factor below 1.0 in the as-built condition.

Although deterioration was present throughout the structure, including numerous areas of advanced loss, the bridge elements were typically controlled by the as-built condition of the members. This is generally due to the location of the section loss usually does not coincide with areas experiencing the highest stress in the members controlling the load rating. The controlling factors that do change between the as-built and as-inspected conditions do not control the overall rating of the bridge. The rating factors which change due to section losses in the as-inspected condition are noted in **Table 2** below (highlighted in yellow).

AS-INSPECTED SUMMARY CONTROLLING RATING FACTORS											
Location		HS20 Inv	HS20 Oper	2F1 Oper	3F1 Oper	4F1 Oper	5C1 Oper	HS20 Truck Train	5C1 Truck Train	Pedestrian	
										Inv	Oper
Deck - All Sections		1.20	2.00	3.20	2.81	3.10	3.15				
Concrete Spans	Arch Ribs	2.15	3.58	6.35	4.33	3.95	4.54				
	Columns	2.21	3.69	5.01	3.62	3.49	3.26				
	Upper Floorbeams	0.79	1.31	1.72	1.51	1.34	1.53				
	Lower Floorbeams									5.16	8.62
	Jack Arches	1.12	1.86	2.98	2.63	3.03	2.63				
Steel Main Span	Truss Members	1.01	1.26	6.05	3.99	3.45	2.62	1.32	1.64		
	Pins and Hangers	1.06	1.47	2.80	1.89	1.69	1.94				
	Upper Floorbeams	0.93	1.44	2.79	1.83	1.62	1.91				
	Upper Stringers	0.88	1.47	2.15	1.56	1.46	1.66				
	Lower Floorbeams									5.01	8.36
	Lower Stringers									3.59	5.99
	Gusset Plates	1.87	2.57	5.91	3.90	3.37	2.60				
Controlling for Structure		0.79	1.26	1.72	1.51	1.34	1.53	1.32	1.64	3.59	5.99

Table 2 – Controlling as-inspected rating factors for CUY-6-1456 (numbers below 1.0 are red, values different from as-built are shaded yellow).

Based upon the load rating analysis, the upper floorbeams in the concrete approach spans control the overall load rating in the as-built condition. Isolated framing members in the steel main span framing system exhibit HS20 Inventory rating factors below 1.0. The upper steel floorbeams in Span 4 are controlled by their as-built condition, while the steel stringers are controlled by section losses noted during the 2012 in-depth inspection. In addition, the governing rating factor for HS20 Operating is 1.26, due to section losses noted in the South Truss lower chord members.

**CONCLUSIONS AND RECOMMENDATIONS**

The load ratings of the primary structural elements were generally governed by the as-built conditions, although select members' load ratings were reduced due to deterioration. The upper concrete floorbeams in Span 11 were determined to control the overall load rating for all load cases except HS20 Operating, which was governed by a South Truss lower chord member in the as-inspected condition. The final load rating factors along with tonnages are as follows:

Controlling Rating Factors				
Load		Rating Factor	Tonnage	Equivalent
HS20	Inventory	<b>0.79</b>	28	HS15.7
	Operating	1.26	45	HS25.2
Ohio Legal Loads (operating)	2F1	1.72	25	134%
	3F1	1.51	34	
	4F1	1.34	36	
	5C1	1.53	61	

According to the load rating analysis, Bridge CUY-6-1456 does not require any posting restrictions or immediate corrective action. However, in order to maintain the continued safe use of the bridge superstructure, TranSystems recommends the following:

1. Perform a load rating of structural elements in the concrete approach spans not included in the scope of this load rating (West Approach Tunnels, West Side Station, and East Approach Tunnels).
2. Clean and paint all structural steel truss and framing members exhibiting active corrosion in order to prevent acceleration of further section loss.
3. Provide joint filler material at locations where eyebars pass through the top concrete deck in order to alleviate rainwater infiltration onto the steel truss and framing members below.
4. Develop plan for removal and replacement of Span 4 lower stringer saddle bearings.
5. Stiffen gusset plate free edges which do not meet the free edge stiffness requirements of AASHTO 10.16.11.3.
6. Although as-inspected conditions did not significantly affect the gusset plate analysis, TranSystems recommends cleaning and painting all areas of active surface corrosion.
7. Repair deteriorated concrete columns, jack arches, and floorbeams throughout West and East Approach Spans of the structure.