VOLUME I
RATING REPORT SUMMARY
FOR THE 2011 IN-DEPTH INSPECTION

MAIN AVENUE BRIDGE
BR#: CUY-2-1441
SFN: 1800035

OHIO DEPARTMENT OF TRANSPORTATION
DISTRICT 12
PID #90993

Inspected: November 7 through December 12, 2011
Report: September 28, 2012

TranSystems

LOAD RATING REPORT
of
Main Avenue Bridge

BRIDGE NO. CUY-2-1441

SFN: 1800035

CUYAHOGA COUNTY, OHIO

STATE OF OHIO
CAROLYN THERESE GUION
E-75189
REGISTERED
PROFESSIONAL ENGINEER
9-28-12

Prepared by:

Carolyn Guion, PE
OH PE#: 75189

Reviewed by:

Wesley R. Weir, PE
OH PE#: 69991

STATE OF OHIO
WESLEY REED WEIR
69991
REGISTERED
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TranSystems
55 Public Square, Suite 1900
Cleveland, OH 44113

OHIO DEPARTMENT OF TRANSPORTATION

OFFICE OF STRUCTURAL ENGINEERING

BRIDGE LOAD RATING SUMMARY REPORT

SFN	BRIDGE NUMBER	DISTRICT
1800035	CUY-2-1441	12
ORIGINAL CONSTRUCTION YEAR	**REHABILITATION YEAR**	**OVERALL STRUCTURE LENGTH (FT)**
1938 - 1940	1991 - 1992	6580
FEATURE INTERSECTED:	NUMEROUS LOCAL STREETS, RTA RAILROAD TRACKS AND THE CUYAHOGA RIVER	
SPECIAL ASSUMPTIONS & COMMENTS		
RATING & ANALYSIS OPTION:		
LOAD RATING PURPOSE:	LOAD RATING FOR FUTURE REHABILITATION RECOMMENDATIONS	
RATING SOFTWARE:	STAAD	
BASIS OF ANALYSIS:	EXISTING PLANS AND FIELD MEASUREMENTS	
METHOD OF ANALYSIS:	LOAD FACTOR	
DESIGN LOADING (ORIGINAL):	H20-33	
STRUCTURE RATING SUMMARY		
LOADING & RATING TYPE	**RATING FACTOR - RF (ROUNDED TO 2 DECIMAL POINTS**	**RATING LOAD**
INVENTORY CURRENT DESIGN	0.26	HS5.2
OPERATING CURRENT DESIGN	0.43	
OHIO LEGAL - 2F1	1.18	**OHIO LEGAL LOADS OVERALL MINIMUM RATING FACTOR**
OHIO LEGAL - 3F1	0.77	0.49
OHIO LEGAL - 4F1	0.67	**OHIO LEGAL LOADS OVERALL CONTROLLING TRUCK**
OHIO LEGAL - 5C1	0.49	4F1 & 5C1
RATED BY, PE#	**REVIEWED BY, PE#**	**REPORT DATE**
Anthony Koloze, PE 76258	Carolyn Guion, PE 75189	6/22/2012
AGENCY/FIRM	**PHONE NUMBER**	**EMAIL**
TranSystems	216-861-1780	ctguion@transystems.com

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EXECUTIVE SUMMARY

GENERAL

The Main Avenue Bridge (CUY-2-1441), located in downtown Cleveland, Ohio, carries State Route 2 over the Cuyahoga River, GCRTA railroad tracks, and numerous surface streets. The overall length of the bridge is 6,500 feet and it is the longest highway bridge in the State of Ohio. The structure was originally built in 1938-40. In 1991-92, the bridge received a major rehabilitation wherein the entire deck and drainage system were replaced, including new stringers. Cleaning and painting of the Main Truss spans were completed in 2007, while the approach spans were painted in 1984.

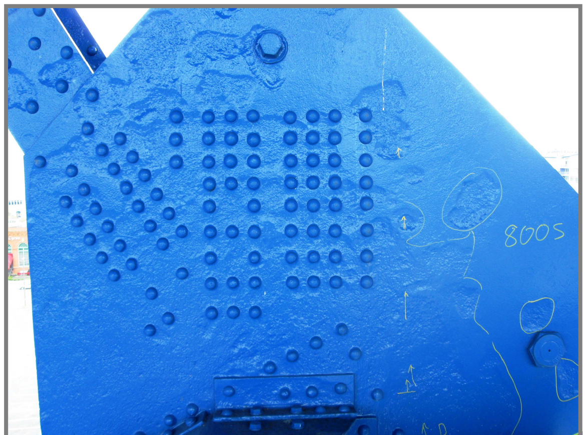


Photo 1 – Elevation of the gusset plate at panel point L71 showing section loss.

TranSystems was contracted by the Ohio Department of Transportation to perform and in-depth structural inspection of the main truss spans and all approach spans in 2011. A load rating analysis of the all the primary structural members in all the bridge sections was performed based on the as-built conditions and the as-inspected conditions from the 2011 inspection and previous reports.

AS-INSPECTED CONDITIONS

The Main Avenue Bridge is in Poor Condition [4-NBIS] overall. Deterioration was noted throughout the structure. The Main Truss Span lower chord members, diagonals, verticals, and gusset plates exhibit advanced section loss **(See Photo 1)**. The loss is typically concentrated at the joint locations and where the drainage system has failed. The upper chord gusset plates and chord members exhibit moderate section loss adjacent to the expansion joints. The steel stringers in the Main Truss Spans were in typically in very good condition.

The steel approach spans exhibited section loss in isolated locations. The steel floorbeams exhibited advanced section loss, primarily near joint locations. The girders and columns were noted to have moderate section loss in isolated locations. The stringers were typically in good condition.

The concrete approach spans near joint locations exhibited large spalls with minor loss to the steel reinforcing. The concrete stringers had moderate to large spalls in isolated locations.

SUMMARY OF CONDITION ITEMS - NBIS				
Section		Item 58 - Deck	Item 59 - Superstructure	Item 60 - Substructure
West Approach	Section J'	7	5	5
	Section K	7	6	6
	Section L	7	7	6
	Section M	7	5	5
	Section B'	7	5	5
	Section C	7	6	6
	Section D	7	5	5
	Section N	7	6	6
	Section P	7	6	6
Main Truss Spans		7	4	5
East Approach	Forward Section	7	5	5
	Lakefront Trestle	7	6	5
	Lakefront Ramp	7	6	6
Overall		**7**	**4**	**6**

Table 1 – Item condition ratings based on 2011 In-Depth inspection

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'.

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 MDX Version 6.5, STAAD.Pro V8i or Bentley CONSYS. Impact was applied to the live loads. 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 2**.

AS-BUILT SUMMARY CONTROLLING RATING FACTORS								
Location			HS20 Inventory	HS20 Operating	2F1 Operating	3F1 Operating	4F1 Operating	5C1 Operating
Concrete Deck (All Sections)			0.90	1.50	2.40	2.54	2.93	2.54
West Approach	Eastbound	Section J'	1.02	1.70	2.25	1.94	1.96	1.94
		Section K	0.85	1.42	2.25	1.71	1.61	1.77
		Section L	0.69	1.16	2.25	1.51	1.34	1.39
		Section M	1.00	1.66	2.45	1.90	1.95	1.92
	Westbound	Section B'	1.07	1.78	2.62	2.03	1.90	2.03
		Section C	0.73	1.22	2.04	1.43	1.35	1.47
		Section D	1.07	1.78	2.64	2.04	2.10	2.04
		Section N	0.83	1.38	2.79	1.96	1.74	1.71
		Section P	1.15	1.91	3.05	2.59	2.40	2.59
Main Truss Spans		Framing	0.71	1.19	2.24	1.54	1.36	1.59
		Truss	0.26	0.43	1.49	0.97	0.84	0.49
East Approach	Forward Section	Span 11 Framing	0.93	1.56	2.36	1.77	1.59	1.81
		Span 11 Truss	0.28	0.47	1.18	0.77	0.67	0.51
		Eastern Part	0.51	0.85	1.35	0.92	0.84	0.95
	Lakefront Section	Trestle	0.74	1.24	1.93	1.35	1.28	1.43
		Ramp	0.54	0.90	1.45	1.48	1.72	1.48
Controlling for Structure			**0.26**	**0.43**	**1.18**	**0.77**	**0.67**	**0.49**

Table 2 – Controlling as-built rating factors for CUY-2-1441 (numbers below 1.0 are red)

The as-built rating is controlled by the gusset plates of the Main Truss Spans and Span 11. The gusset plates have low rating factors as a result of the shear connector strength.

Although deterioration was present throughout the various sections of the bridge and in isolated locations was advanced; the structure was typically controlled by the as-built condition of the members. This occurred because the location of the section loss on the members typically did not coincide with the highest stressed areas of the member controlling the rating. The controlling factors that change between the as-built and as-inspected conditions do not control the overall rating of the bridge. The changed factors due to section loss are highlighted in **Table 3** below.

<table>
<tr><th colspan="9">AS-INSPECTED SUMMARY
CONTROLLING RATING FACTORS</th></tr>
<tr><th colspan="3">Location</th><th>HS20 Inventory</th><th>HS20 Operating</th><th>2F1 Operating</th><th>3F1 Operating</th><th>4F1 Operating</th><th>5C1 Operating</th></tr>
<tr><td colspan="3">Concrete Deck (All Sections)</td><td>0.90</td><td>1.50</td><td>2.40</td><td>2.54</td><td>2.93</td><td>2.54</td></tr>
<tr><td rowspan="9">West Approach</td><td rowspan="4">Eastbound</td><td>Section J'</td><td>1.02</td><td>1.70</td><td>2.25</td><td>1.94</td><td>1.96</td><td>1.94</td></tr>
<tr><td>Section K</td><td>0.85</td><td>1.42</td><td>2.25</td><td>1.71</td><td>1.61</td><td>1.77</td></tr>
<tr><td>Section L</td><td>0.69</td><td>1.16</td><td>2.25</td><td>1.51</td><td>1.34</td><td>1.39</td></tr>
<tr><td>Section M</td><td>1.00</td><td>1.66</td><td>2.45</td><td>1.90</td><td>1.95</td><td>1.92</td></tr>
<tr><td rowspan="3">Westbound</td><td>Section B'</td><td>1.07</td><td>1.78</td><td>2.62</td><td>2.03</td><td>1.90</td><td>2.03</td></tr>
<tr><td>Section C</td><td>0.73</td><td>1.22</td><td>2.04</td><td>1.43</td><td>1.35</td><td>1.47</td></tr>
<tr><td>Section D</td><td>1.07</td><td>1.78</td><td>2.64</td><td>2.04</td><td>1.97</td><td>1.97</td></tr>
<tr><td rowspan="2"></td><td>Section N</td><td>0.83</td><td>1.38</td><td>2.79</td><td>1.96</td><td>1.74</td><td>1.71</td></tr>
<tr><td>Section P</td><td>1.15</td><td>1.91</td><td>3.05</td><td>2.46</td><td>2.27</td><td>2.59</td></tr>
<tr><td rowspan="2" colspan="2">Main Truss Spans</td><td>Framing</td><td>0.71</td><td>1.19</td><td>2.24</td><td>1.54</td><td>1.36</td><td>1.59</td></tr>
<tr><td>Truss</td><td>0.26</td><td>0.43</td><td>1.49</td><td>0.97</td><td>0.84</td><td>0.49</td></tr>
<tr><td rowspan="5">East Approach</td><td rowspan="3">Forward Section</td><td>Span 11 Framing</td><td>0.93</td><td>1.56</td><td>2.36</td><td>1.77</td><td>1.59</td><td>1.81</td></tr>
<tr><td>Span 11 Truss</td><td>0.28</td><td>0.47</td><td>1.18</td><td>0.77</td><td>0.67</td><td>0.51</td></tr>
<tr><td>Eastern Part</td><td>0.40</td><td>0.67</td><td>1.35</td><td>0.92</td><td>0.83</td><td>0.88</td></tr>
<tr><td rowspan="2">Lakefront Section</td><td>Trestle</td><td>0.74</td><td>1.24</td><td>1.93</td><td>1.35</td><td>1.28</td><td>1.43</td></tr>
<tr><td>Ramp</td><td>0.54</td><td>0.90</td><td>1.45</td><td>1.48</td><td>1.72</td><td>1.48</td></tr>
<tr><td colspan="3">Controlling for Structure</td><td>0.26</td><td>0.43</td><td>1.18</td><td>0.77</td><td>0.67</td><td>0.49</td></tr>
</table>

Table 3 – Controlling as-inspected rating factors for CUY-2-1441 (numbers below 1.0 are red, values different from as-built are shaded)

One gusset plate in Span 6 of the Main Truss (L59N), two in Span 10 (U110N, U110S) and five in Span 11(U127N, U127S, U128S, U135N, U135S) have rating factors below 1.0 for one or more Ohio Legal Loads. The gusset plate in Span 6 is rating below 1.0 in the local compression buckling check due to section loss of the plate along the bottom chord under the vertical member. The seven remaining gusset plates rate below 1.0 for the connector capacity check in the as-built condition based upon the yield stress of the rivets.

In the East Approach – Forward Section, two stringers and two floorbeams rate below 1.0 for one or more Ohio Legal Loads. Both stringers rate below 1.0 in the positive moment region in the as-built condition. Floorbeam 3 rates below 1.0 in the as-built condition in the negative moment region. Floorbeam 8 rates below 1.0 in the as-inspected condition in the negative moment region.

Conclusions and Recommendations

Based on the results of the structural analysis and the 2011 In-Depth Inspection Report, TranSystems has concluded that the *General Appraisal & Operational Status,* of CUY-2-1441 should be downgraded to **4P – Poor – Posted for load-carrying capacity restriction**.

The ratings of the primary structural elements were generally governed by as-built conditions, although select members' ratings were reduced due to section loss. Two gusset plates in the North Truss (U110 and U127) were determined to control the overall rating of the structure. The gusset plate ratings are typically controlled by the rivet connector capacity. The controlling rating factors along with tonnages are as follows:

Controlling Rating Factors					
Load		Gusset Plate	Rating Factor	Tonnage	Equivalent
HS20	Inventory	U110	0.26	9	HS5.2
	Operating	U110	0.43	15	HS8.6
Ohio Legal Loads (operating)	2F1	U127	1.18	17	49%
	3F1	U127	0.77	17	
	4F1	U127	0.67	18	
	5C1	U127	0.51	20	
	5C1 Truck Train	U110	0.49	19	

Per Section 918.3 of the *2004 ODOT Bridge Design Manual (October 2011 Interim)*, the tonnage on Bridge CUY-2-1441 is recommended to be restricted by posting the bridge as follows:

Ohio Legal Truck	Ohio Legal Truck (Tons)	Safe Posting Load (Tons)
2F1	15	15
3F1	23	15
4F1	27	14
5C1	40	11

The restriction on loading should remain in place until repairs are made that will raise the rating factors for all members above 1.0 for the Ohio Legal Loads. *Please note that at the date of this final report, the bridge has been posted to restrict Ohio Legal Truck Loads.*

The recommendations presented in this report are intended to provide a short and long term rehabilitation plan to ensure the CUY-2-1441 – Main Avenue Bridge has an extended service life and to maintain a safe load capacity for the traveling public. These recommendations are based on the results of the load rating analysis, the *2011 In-Depth Physical Condition Report* submitted March 2012, and discussion held with ODOT personnel on May 29, 2012 at District 12.

We present our recommendations for CUY-2-1441 in the following three phases:

Phase 1 - Priority Work:	Work which should be performed as soon as possible to address deficiencies which affect the capacity of the structure and require the posting of the bridge.
Phase 2 - Rehabilitation:	Recommendations for large-scale deficiencies which are extensive in nature and require engineering analysis.
Phase 3 - Bridge Painting & Joint Replacement:	Continue the long term maintenance program of providing a protective paint system and replacing the joints to prevent deterioration of the structural components of the bridge.

Phase 1 - Priority Repairs

The Phase 1 – Priority Repair items are the bridge elements that were found to be structurally deficient due to the insufficient safe load capacity of the members. Twelve (12) members are not adequate to carry the Ohio Legal Truck Loads and therefore govern the recommended load restriction for the bridge. TranSystems recommends these members be rehabilitated to provide a capacity of 110% or greater for the Ohio Legal Loads (Rating Factor = 1.1).

Phase 1 - Construction Cost Estimate

- **Priority repairs = $543,000**

Phase 2 – Rehabilitation Repairs

The Phase 2 – Rehabilitation Repairs are intended to repair structural deficiencies and to address maintenance items that affect the long term service life of the bridge. The deficiencies may include structural members exhibiting advanced section loss, but do not restrict the load posting of the bridge. The maintenance repairs do not affect the capacity of the structure; however, they are necessary to prevent further deterioration of the bridge components or to improve the serviceability of the bridge. All structural repairs are recommended to increase the members capacity to 110% or greater for the Ohio Legal Loads.

Phase 2 - Construction Cost Estimate

- **Rehabilitation Repairs = $6,480,000**

Phase 3 – Bridge Painting & Joint Replacement

The Phase 3 – Bridge Painting is recommended to continue the long term maintenance program of providing a protective paint system to prevent deterioration of the structural components of the bridge. In 2007, a new protective coating system of the truss spans was completed. The 1984 paint system in the steel approach spans has many deficiencies including: chalking paint, peeling paint, and active surface rust. The structure is not uniformly coated, utilizing multiple paint systems and/or painting at different times, producing vastly different coating conditions even in localized areas. TranSystems recommends painting all the steel approach span sections to stop corrosion and prevent future deterioration.

The joints are typically leaking with isolated torn glands and damaged joint armor. The joints should be replaced to allow the optimal performance of the replaced drainage system and to prevent future deterioration of the structural components of the bridge. TranSystems recommends replacing the strip seal joints and modular joints completely and replacing the seals in the compression joints and stress relief joints.

Phase 3 - Construction Cost Estimate

- **Bridge Painting = $21,997,600**

INTRODUCTION

The Ohio Department of Transportation (ODOT) has identified the need to perform a load rating analysis for the CUY-2-1441 (Main Avenue) Bridge **(see Location Map)**. The bridge superstructure components were rated utilizing the following specifications and documents:

- ODOT Bridge Design Manual, 2004 Edition
- AASHTO Standard Specifications for Highway Bridges, 17th Edition 2002
- FHWA Load Rating Guidance and Examples for Bolted and Riveted Gusset Plates In Truss Bridges, February 2009
- AASHTO Manual for Bridge Evaluation, 2^{nd} Edition 2010
- AASHTO Guide Specifications for Fatigue Evaluation of Existing Steel Bridges 1990

Location Map

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 sections qualifying as “long span”. The structure has undergone a number of rehabilitations and modifications since its initial erection in 1938-1940. The As-Built analysis utilizes the members currently in place without section loss from the following list of available drawings:

- 1938 Original Design Drawings
- 1938-1940 Original Shop Drawings
- 1983 Rehabilitation Plans
- 1990/1994 Rehabilitation/As-Built Plans
- 1991 Rehabilitation Shop Drawings

The As-Inspected analysis applies the section losses noted during the following TranSystems bridge inspections:

- 2006 Routine Inspection
- 2007 Routine Inspection
- 2008 In-Depth Inspection
- 2009 Routine Inspection
- 2010 Routine Inspection
- 2011 In-Depth Inspection

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 excel workbooks. Maximum live load effects (moments and shears) were found utilizing MDX Version 6.5, STAAD.Pro V8i or Bentley CONSYS. The load rating formulas were applied inside of Excel workbooks. The steel truss loads were calculated through a combination of hand calculations and Excel workbooks. The loads were applied to the 3-Dimensional models in STAAD. The load effect outputs were inserted into customized Excel workbooks which calculated the member capacities and load rating factors. In addition, the forces were input into a modified version of the 2009 ODOT Rating Excel workbook provided by the Office of Structural Engineering. This workbook is based upon the FHWA “Load Rating Guidance and Examples for Bolted and Riveted Gusset Plates in Truss Bridges” (FHWA-IF-09-014).

BRIDGE DESCRIPTION

The CUY-2-1441 (Main Avenue) Bridge carries four to six lanes of State Route 2 traffic for 6580 feet through downtown Cleveland, over numerous local streets, RTA railroad tracks, Norfolk Southern/CSX railroad tracks and the Cuyahoga River. The bridge was fabricated and erected from 1938 to 1940. The West Approach, Main Truss Spans, and East Approach – Forward sections were opened to traffic on October 6, 1939; and the Lakefront Trestle and Lakefront Ramp were opened to traffic in 1940. The bridge was closed for a major rehabilitation project from April 13, 1991 to October 6, 1992. Work included replacing and widening of the deck, updating safety features, improving the drainage system, installing new floor system members, and strengthening or replacing deteriorated sections.

The Main Avenue Bridge consists of five distinct sections of varying structure types within each section:

West Approach **(See Figure 1)** – Volumes II, III, IV
Main Truss Spans **(See Figures 1, 2, and 3)** – Volume V
East Approach – Forward Section **(See Figure 3)** – Volume VI
East Approach – Lakefront Trestle Section **(See Figures 3 and 4)** – Volume VII
East Approach – Lakefront Ramp Section **(See Figure 4)** – Volume VIII

Site plans of the structure with the members labeled can be found in **Appendix A**.

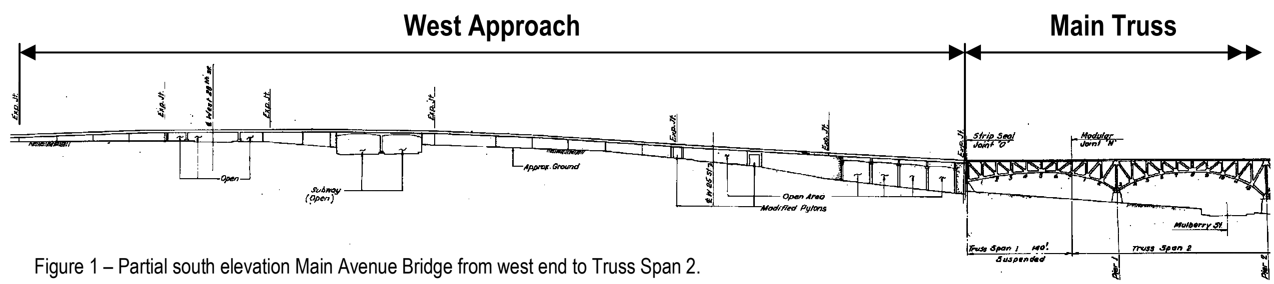


Figure 1 – Partial south elevation Main Avenue Bridge from west end to Truss Span 2.

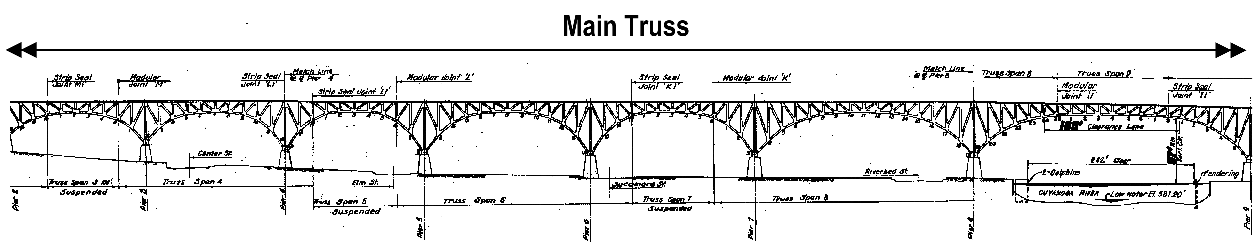


Figure 2 – Partial south elevation Main Avenue Bridge from Truss Span 3 to Truss Span 9.

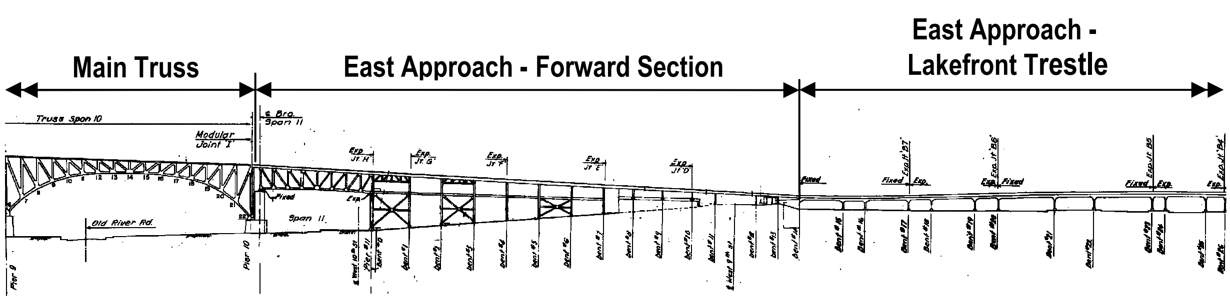


Figure 3 – Partial south elevation Main Avenue Bridge from Truss Span 10 to Bent 26 of the Lakefront Trestle.

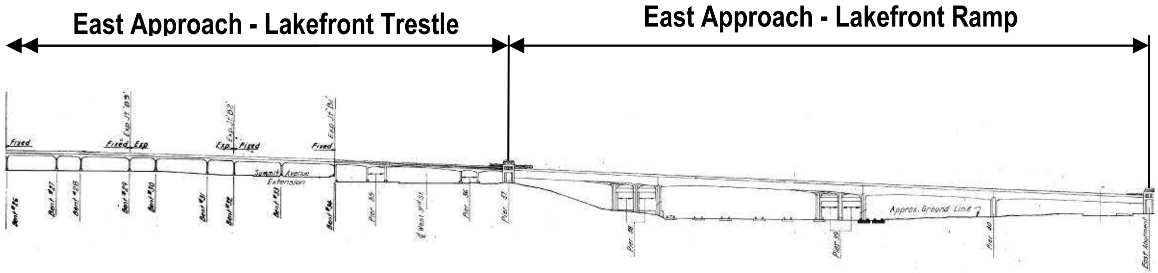


Figure 4 – Partial south elevation Main Avenue Bridge from Bent 26 of the Lakefront Trestle to the East Abutment.

West Approach

The West Approach section consists of similar eastbound and westbound structures, each carrying three lanes of traffic from West 29th Street to 250' east of West 25th Street. These structures merge into one structure near West 25th Street. The West Approach section consists of four main structure types: Transverse rigid concrete frames supporting a concrete deck slab (Sections B', D, J', and M); concrete stringers and diaphragms (Section P); longitudinal rigid steel frames supporting floorbeams and stringers (Sections C, K, and L); and a steel floorbeam/stringer system (Section N). The steel floorbeam/stringer system consists of continuous stringers bearing on top of floorbeams, which are supported by steel columns. The various steel sections consist of rolled beams, welded plate girders, and riveted built-up plate girders.

Main Truss

Starting at the termination of the West Approach Section, the Main Truss Spans carry six lanes of traffic over the east and west banks of the flats to near West 10th Street. The Main Truss Spans section consists of a 10 span cantilevered modified Pratt deck truss. The cantilevered deck truss chord members are composed of riveted built-up box sections that support a mixture of riveted built-up floorbeams and welded floorbeams. Rolled stringers rest on top of the floorbeams, and frame into the floorbeam cantilevers. Truss web members consist of rolled sections.

East Approach – Forward Section

The Forward Section carries the six lanes of traffic from the Main Span at West 10th Street, at the base of the Flats from the Cuyahoga River Valley up to West 9th Street. The western part of the section consists of a single simply supported Pratt deck truss (Span 11). The Pratt deck truss members consist of rolled wide flange sections, with a similar deck framing system to the main truss span. The eastern part of the Forward Section consists of steel truss bents that support rolled steel floorbeams with rolled steel stringers bearing on top. The steel truss bent members consist of rolled steel sections connected by riveted gusset plates. A lower utility/parking deck exists below the eastbound lanes of this section.

East Approach – Lakefront Trestle

This section starts at West 9th Street and continues to West 3rd Street carrying four lanes of traffic. The Lakefront Trestle superstructure carries four lanes of traffic and is supported by two lines of longitudinal rigid steel frames composed of riveted built-up beams and columns. Transverse floorbeams frame into the longitudinal frames and support rolled stringers.

East Approach – Lakefront Ramp

The Lakefront Ramp carries four lanes of traffic, beginning at West 3rd Street, continuing over the RTA and the Norfolk Southern/CSX railroad tracks, and terminating at the southeast entrance to Cleveland Browns Stadium. The superstructure consists of 3 riveted, built-up plate girders with rolled floorbeams and stringers.

The structure's alignment varies over the length of the bridge **(See Figure 5)**. Nomenclature of this bridge will follow the rehabilitation plans and 2011 inspection reports for consistency in accordance with current ODOT standards in which the alignment is in the west to east direction. All compass directions will be based upon this relative alignment.

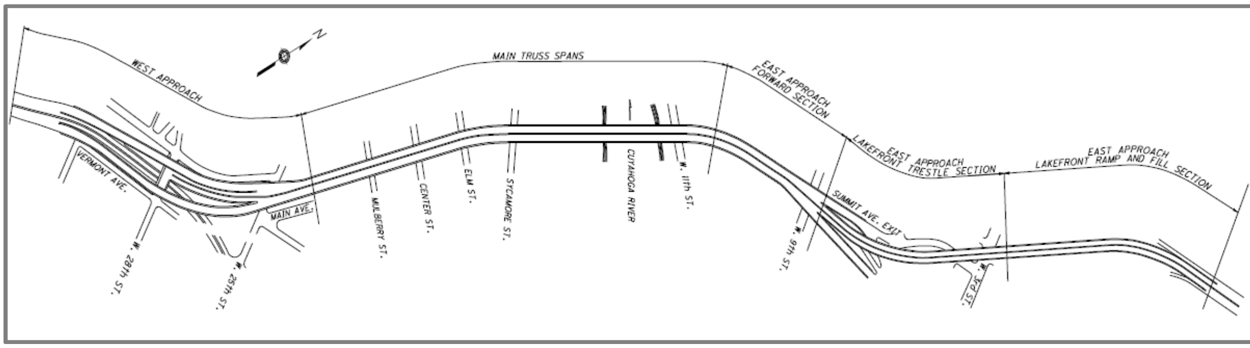


Figure 5 – Schematic plan of Main Avenue Bridge.

GENERAL LOADING AND RATING ANALYSIS ASSUMPTIONS

All capacities and loads were generated based upon Load Factor Rating. The primary load carrying members were analyzed with AASHTO HS20-44 truck and lane loads and ODOT 2F1, 3F1, 4F1 and 5C1 trucks **(See Figure 6)**. In addition, for spans greater than 200' long, two truck trains, one composed of HS20-44 trucks and one composed of 5C1 trucks, were utilized. The train length was varied to maximize load effects on individual members. Centrifugal force effects were included in the curved deck sections of the bridge.

	Load Designation	Load Configuration	Gross Weight
AASHTO	HS20-44	8 k, 32 k, 32 k; 14', varies 14' to 30'	36 Tons
OHIO LEGAL LOADS	2F1	10 k, 20 k; 10'	15 Tons
	3F1	12 k, 17 k, 17 k; 10', 4'	23 Tons
	4F1	12 k, 14 k, 14 k, 14 k; 10', 4', 4'	27 Tons
	5C1	12 k, 17 k, 17 k, 17 k, 17 k; 12', 4', 31', 4'	40 Tons

Figure 6 – AASHTO Truck Load and Ohio Legal Loads

The material properties used in the original construction and major rehabilitation are shown in **Figure 7**.

Material Properties	1938 Plans	1990 Rehabilitation	Weight
Structural Steel - F_y (ksi)	33.0 (carbon)	36.0 (A36)	490 pcf
	45.0 (silicon)	37.5 (A668 D)	490 pcf
Reinforcing Steel - F_y (ksi)	33.0	60.0	490 pcf
Lightweight Concrete - f'_c (ksi)	---	4.5	112-113 pcf
Normal Weight Concrete - f'_c (ksi)	3.0	4.0	150 pcf

Figure 7 – Material properties

GENERAL DESCRIPTION OF LOAD RATING ANALYSIS

Bridge load rating calculations provide a basis for determining the safe load capacity of a bridge. Load ratings require engineering evaluation in determining a rating value that is applicable to maintaining the safe use of the bridge and arriving at posting and permit decisions. A rating factor of less than 1.00 indicates that the structure does not have sufficient capacity to carry the specified loading. As part of every inspection cycle, bridge load ratings should be reviewed and updated to reflect any relevant changes in condition or dead load noted during the inspection.

The Inventory rating (Inv) generally corresponds to the customary design level of stresses, but reflects the existing bridge and material conditions with regard to deterioration and loss of section. Load ratings based on the Inventory level allow comparisons with the capacity for new structures and, therefore, result in a live load, which can safely utilize an existing structure for an indefinite period of time.

Load ratings based on the Operating rating (Opr) level generally describe the maximum permissible live load to which the structure may be subjected. Allowing unlimited numbers of vehicles to use the bridge at the Operating level may shorten the life of the bridge.

The Load Factor method was used to rate all primary members of the bridge. The Load Factor method is based on analyzing a structure subject to multiples of the actual loads (factored loads). Different factors are applied to each type of load, which reflect the uncertainty inherent in the load calculations. The rating is determined such that the effect of the factored loads does not exceed the strength of the member **(See Figure 8)**.

$$\text{Inventory Rating Factor (Inv RF)} = \frac{\text{Capacity} - 1.3 \times \text{Dead Load}}{2.17 \times (\text{Live Load} + \text{Impact})}$$

$$\text{Operating Rating Factor (Opr RF)} = \frac{\text{Capacity} - 1.3 \times \text{Dead Load}}{1.3 \times (\text{Live Load} + \text{Impact})}$$

Figure 8 – Rating Factor Equations

STRUCTURE RATINGS

DECK – ALL SECTIONS

The lightweight concrete deck with latex modified concrete wearing surface replaced a concrete filled steel grid deck in the 1990 rehabilitation. The deck and roadway were widened and the sidewalk was removed **(See Figures 9 and 10)**.

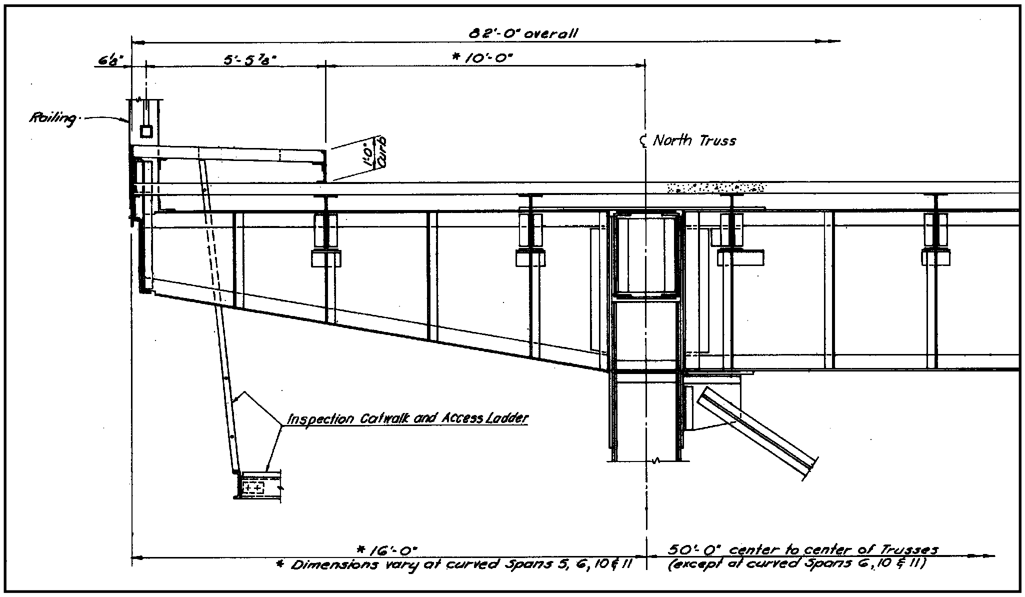


Figure 9 – Cross Section of the original configuration of Main Avenue Bridge with 82'-0" out to out bridge deck and 6'-0" sidewalks.

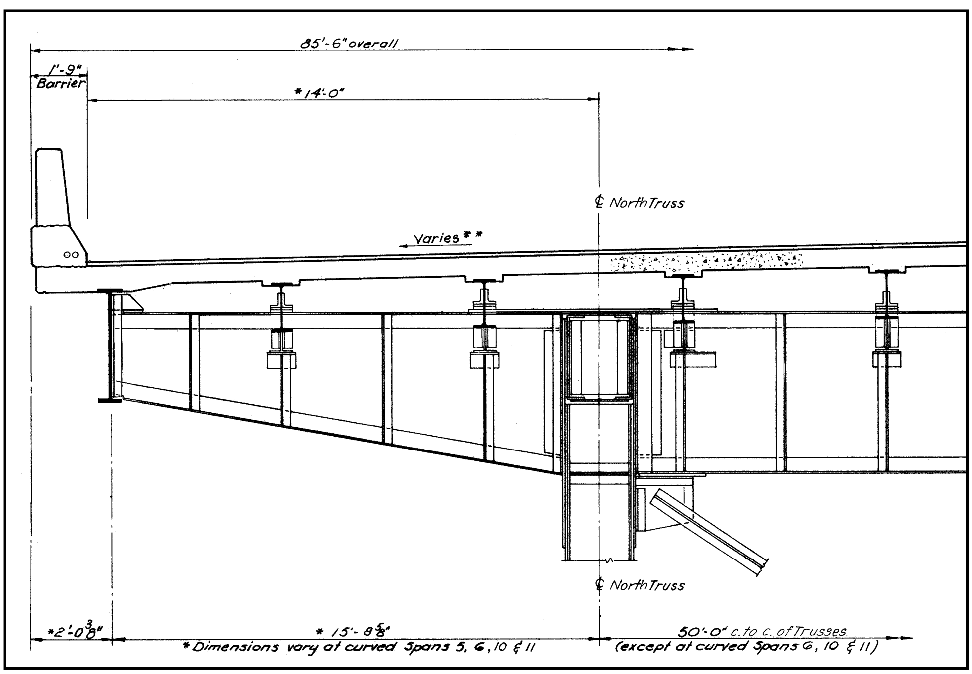


Figure 10 – Cross Section of the existing configuration of Main Avenue Bridge with 85'-6" out to out bridge deck.

The concrete deck was analyzed as a continuous deck for each of the sections. The concrete wearing surface was included in the dead load, but neglected in the deck's capacity. The sections with steel or concrete stringers supporting the deck (C, K, L, N, P, Main Truss, Forward Section, Lakefront Trestle, and Lakefront Ramp) were considered to be AASHTO Case A with the main reinforcement perpendicular to the traffic. The live loads for these sections were based upon the recommended AASHTO equations. The sections with the deck supported by concrete frames (B', D, J', and M) were analyzed as AASHTO Case B, with the main reinforcement parallel to traffic. The live loads for these sections were based upon a simple continuous span model in CONSYS, a Bentley program for static and live load analysis for simple and continuous span structures. The deck rates above 1.0 for all the operating load cases. The Main Truss section and East Approach – Forward Section rate below 1.0 for HS20 Inventory **(See Table 4)**.

AS-BUILT / AS-INSPECTED DECK CONTROLLING RATING FACTORS							
Location		HS20 Inventory	HS20 Operating	2F1 Operating	3F1 Operating	4F1 Operating	5C1 Operating
West Approach	Section J'	1.31	2.18	3.49	2.55	2.93	2.55
West Approach	Section K	1.18	1.97	3.16	3.71	4.51	3.71
West Approach	Section L	1.14	1.89	3.03	3.57	4.33	3.57
West Approach	Section M	1.30	2.17	3.47	2.54	2.93	2.54
West Approach	Section B'	1.31	2.18	3.49	2.55	2.93	2.55
West Approach	Section C	1.18	1.97	3.16	3.71	4.51	3.71
West Approach	Section D	1.30	2.17	3.47	2.54	2.93	2.54
West Approach	Section N	1.22	2.03	3.25	3.82	4.64	3.82
West Approach	Section P	1.23	2.06	3.29	3.88	4.69	3.88
Main Truss Spans		0.95	1.58	2.54	2.98	3.62	2.98
East Approach	Forward Section	0.90	1.50	2.40	2.82	3.43	2.82
East Approach	Lakefront Trestle	1.19	1.99	3.19	3.75	4.54	3.75
East Approach	Lakefront Ramp	1.05	1.75	2.80	3.29	4.00	3.29

Table 4 – Controlling deck rating factors (numbers below 1.0 are red, overall controlling values are shaded)

The concrete deck is in good condition with only minor cracking and minor spalls **(See Photo 2)**. The minor deficiencies do not affect the rating of the concrete deck; therefore the as-built and as-inspected rating factors are the same.

Photo 2 – Minor diagonal cracking in Bays 2 and 3 at the extreme east end of Section P.

WEST APPROACH – SECTIONS J', M, B', D (Volume II)

Sections J', M, B', and D consist of transverse concrete rigid frames supporting a concrete deck slab. An integral curtain wall spans between the concrete frame columns. Since the sections are alike, they were analyzed in a similar manner. For complete rating calculations refer to **Volume II**.

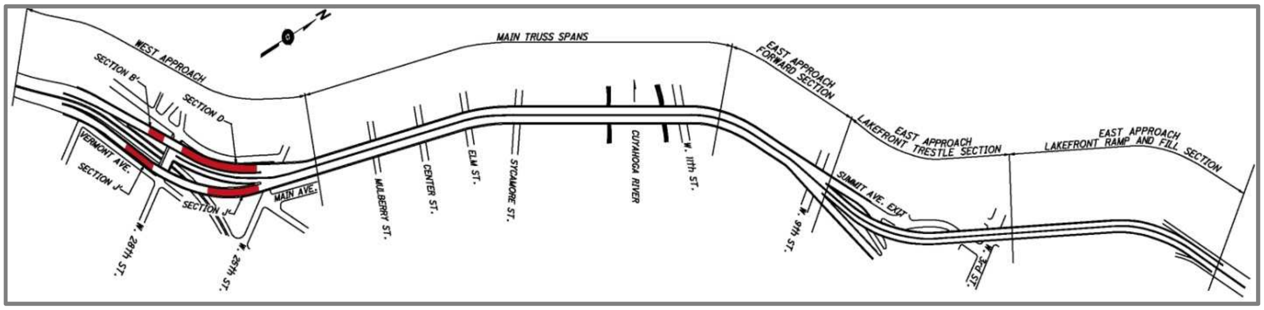


Figure 11 – Location of Sections J', M, B', D

During the 1990 rehabilitation the deck and upper portion of the floorbeams were removed in all four sections. The deck and top of the floorbeams were reconstructed using lightweight concrete **(See Figure 12)**. Approximately half the deck joints were eliminated during the rehabilitation.

The capacity calculations and rating factors for the frame caps were calculated using customized spreadsheets and STAAD. The dead load and live load effects were determined using CONSYS. The load effects were entered into 2D STAAD models to determine the axial forces, moments, and shears at the critical locations of select frames. The moments and shears were input into the customized rating spreadsheets to calculate the live load ratings of the frame cap. The axial forces and bending moment from the models were input into spreadsheets and an iteration process was used to determine the axial and moment capacities for the frame columns. The frames rate at or above 1.0 for all the load cases **(See Table 5)**. The positive moment in the frame cap typically controls the rating.

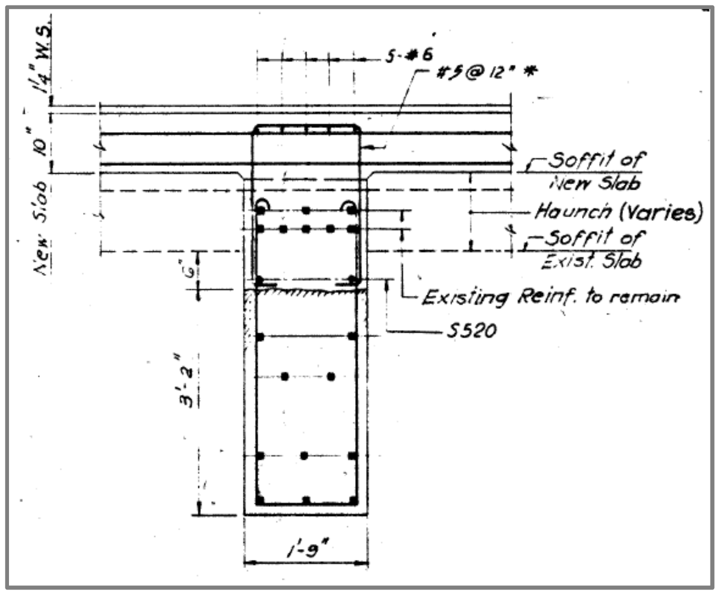


Figure 12 – Cross section of a typical floorbeam showing the increased height, additional concrete, and existing slab height.

AS-BUILT FRAME CONTROLLING RATING FACTORS							
Section	Frame	HS20 Inv	HS20 Opr	2F1 Opr	3F1 Opr	4F1 Opr	5C1 Opr
B'	1	1.07	1.78	2.62	2.03	2.06	2.03
	9	1.19	1.99	3.12	2.11	1.90	2.11
D	21	1.07	1.78	2.64	2.04	2.10	2.04
J'	10	1.02	1.70	2.25	1.94	1.99	1.94
	19	1.23	2.06	3.22	2.23	1.96	2.18
M	13	1.00	1.66	2.45	1.90	1.95	1.92

Table 5 – Controlling as-built frame rating factors and rating factors below 1.0 for Sections J', M, B', D (numbers below 1.0 are red, controlling values are shaded)

The concrete frames were generally in fair condition. Spalling and delamination were noted in many of the frames. Several frames exhibited exposed reinforcing steel in the bottom of the frame, but the reinforcing loss noted was minimal **(See Photo 3)**. The curtain walls exhibited large sheet delaminations and spalls with exposed reinforcement in isolated locations. The spalling, delamination, and exposed reinforcing were generally located directly under deck joints.

Photo 3 – The west face of Bent 21 in Section D of the west approach exhibits a large spalled area with exposed reinforcement.

Typically the location of the section loss did not coincide with the section of the frame controlling the rating. Therefore, the as-inspected rating factors of those sections are actually higher than the as-built rating factors at the controlling locations. Section D, was one exception where the section loss did affect two rating factors. The as-inspected condition causes the 4F1 and 5C1 Operating rating factors for the frames in Section D to decrease from 2.10 to 1.97 and 2.04 to 1.97, respectively **(See Table 6)**.

AS-INSPECTED FRAME CONTROLLING RATING FACTORS							
Section	Frame	HS20 Inv	HS20 Opr	2F1 Opr	3F1 Opr	4F1 Opr	5C1 Opr
B'	1	1.07	1.78	2.62	2.03	2.06	2.03
	9	1.19	1.99	3.12	2.11	1.90	2.11
D	16	1.09	1.83	3.05	2.07	1.97	1.97
	21	1.07	1.78	2.64	2.04	2.10	2.04
J'	10	1.02	1.70	2.25	1.94	1.99	1.94
	19	1.23	2.06	3.22	2.23	1.96	2.18
M	13	1.00	1.66	2.45	1.90	1.95	1.92

Table 6 – Controlling as-inspected frame rating factors and rating factors below 1.0 for Sections J', M, B', D (numbers below 1.0 are red, controlling values are shaded)

Although deterioration is present, the as-inspected locations typically do not control the overall rating of the frames. A comparison between the as-built and as-inspected rating factors for HS20 loading is shown in **Table 7**.

COMPARISON BETWEEN AS-BUILT AND AS-INSPECTED FRAMES					
Section	Frame	HS20 Inv		HS20 Opr	
		As-Built	As-Inspected	As-Built	As-Inspected
B'	1	1.07	1.07	1.78	1.78
	9	1.19	1.19	1.99	1.99
D	16	1.22	1.09	2.04	1.83
	21	1.07	1.07	1.78	1.78
	26	1.41	1.27	2.35	2.12
	36	1.53	1.49	2.55	2.48
J'	10	1.02	1.02	1.70	1.70
	19	1.23	1.23	2.06	2.06
M	13	1.00	1.00	1.66	1.66
	33	1.22	1.20	2.03	2.00

Table 7 – Comparison of as-built and as-inspected rating factors.

WEST APPROACH – SECTIONS K, L, C (Volume III)

Sections K, L, and C were analyzed in similar manners since they all consist of longitudinal steel frames supporting floorbeams and stringers. None of the sections exhibited section loss that would affect the primary member ratings. For complete rating calculations refer to **Volume III**.

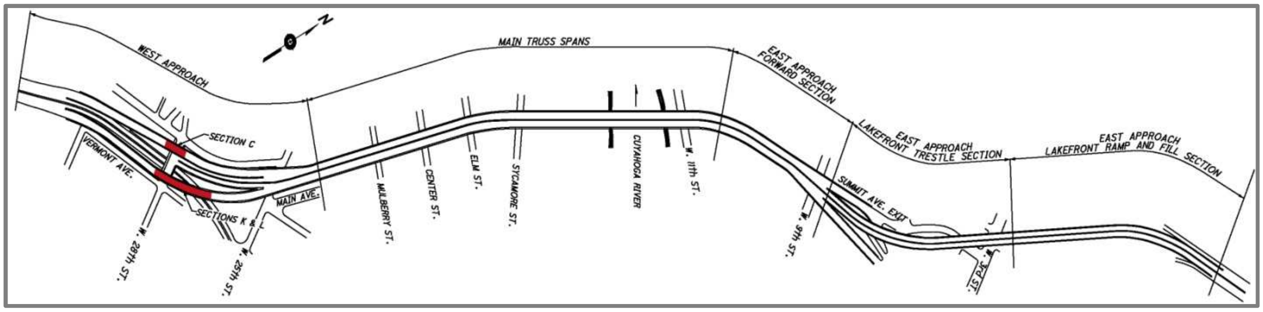


Figure 13 – Location of Sections K, L, and C

The stringers were replaced in the 1990 rehabilitation. MDX Version 6.5 girder system models were created to determine load effects on the stringers. Stringers in each section have the web and bottom flange coped out around the floorbeam. The coped location is reinforced along the bottom with bolted angles creating a built-up I type section **(See Figure 14 & Photo 4)**. These coped stringers were originally modeled as continuous in MDX at the cope locations with a cutout in the beam. After discussion with District 12, the stringers with copes were reanalyzed as simple span stringers. The forces from the stringers applied to other components such as the floorbeams were not changed. This method of analysis is similar for all sections with coped stringers.

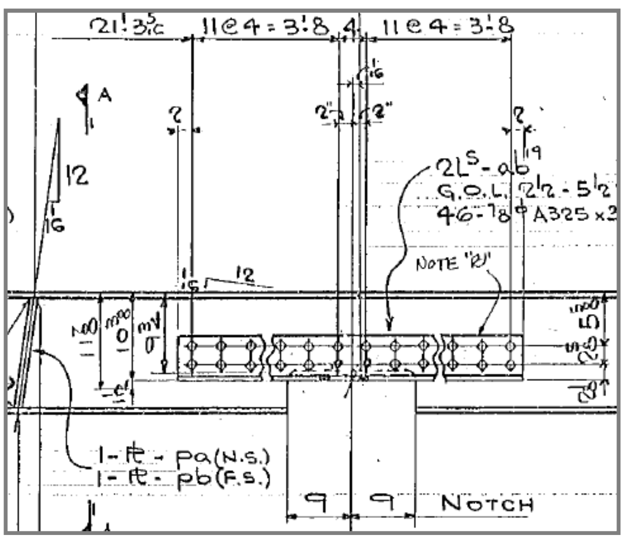


Figure 14 – Typical coped stringer shop drawing detail

Photo 4 – Stringer coped at floorbeam location (Section K shown, other sections similar)

The moments and shear forces calculated by MDX were input into an Excel spreadsheet to calculate rating factors for the stringers. The capacity of full height stringers was calculated by hand or taken from MDX, while the capacity of the coped stringer locations was calculated using Excel spreadsheets.

Results of the rating show that three stringers in Section K and four in Section C rate below 1.0 for HS20 Inventory. These stringers are rating below 1.0 due to positive moment at the midspan of the stringer **(See Table 8)**. The stringers rate above 1.0 for the operating level of HS20 and the four Ohio Legal Loads.

AS-BUILT / AS-INSPECTED STRINGER CONTROLLING RATING FACTORS							
Section	Member	HS20 Inv	HS20 Opr	2F1 Opr	3F1 Opr	4F1 Opr	5C1 Opr
K	S3-1	0.98	1.64	2.42	1.84	1.72	1.90
	S2-2	0.88	1.46	2.25	1.71	1.61	1.77
	S3-2	0.88	1.47	2.26	1.73	1.63	1.79
L	S2-4	1.08	1.81	2.73	2.05	1.96	2.16
C	S4-1	0.99	1.65	2.49	1.79	1.77	1.87
	S3-2	0.93	1.55	2.43	1.73	1.69	1.78
	S4-2	0.78	1.30	2.04	1.43	1.40	1.47
	S5-2	0.73	1.22	2.09	1.45	1.35	1.49

Table 8 – Controlling stringer rating factors and rating factors below 1.0 for Sections K, L, and C (numbers below 1.0 are red, controlling values are shaded)

The end floorbeams of Sections K and C, as well as Floorbeams 2 and 3 of Section L were replaced in the 1990 rehabilitation. Various brackets in Section L were also retrofitted during the rehabilitation. The floorbeams, including floorbeam brackets, were analyzed using STAAD.Pro. A model of each floorbeam was set up and wheel loads were run transversely to capture the worst moment and shear effects. A longitudinal distribution factor was calculated based on the span length between floorbeams and the continuous condition of the stringers. The longitudinal and transverse distribution factors were applied to the load effects experienced by the beam to determine the final moments and shears. These loads were input into a rating spreadsheet. The capacity of the floorbeams was calculated using spreadsheets.

Three floorbeams in Section K, six in Section L, and three in Section C rated below 1.0 for HS20 Inventory **(See Table 9)**. The floorbeams are being overstressed by positive moment. The floorbeams rate above 1.0 for the operating level of HS20 and the four Ohio Legal Loads.

AS-BUILT / AS-INSPECTED FLOORBEAM CONTROLLING RATING FACTORS							
Section	Member	HS20 Inv	HS20 Opr	2F1 Opr	3F1 Opr	4F1 Opr	5C1 Opr
K	FB 2	0.89	1.48	2.82	1.93	1.72	1.98
	FB 4	0.94	1.57	3.00	2.03	1.83	2.09
	FB 5	0.89	1.48	2.86	1.96	1.74	2.01
L	FB 2	0.95	1.58	3.07	2.06	1.82	2.14
	FB 3	0.90	1.50	2.86	1.92	1.71	2.00
	FB 5	0.91	1.51	2.89	1.94	1.73	2.02
	FB 8	0.69	1.16	2.25	1.51	1.34	1.57
	FB 10	0.93	1.56	2.74	1.90	1.73	2.04
	FB 11	0.85	1.41	2.89	1.92	1.69	1.97
C	FB 2	0.74	1.23	2.56	1.70	1.48	1.74
	FB 4	0.79	1.32	2.69	1.79	1.58	1.85
	FB 5	0.75	1.25	2.57	1.71	1.50	1.77

Table 9– Controlling floorbeam rating factors and rating factors below 1.0 for Sections K, L, and C (numbers below 1.0 are red, controlling values are shaded)

The girders and columns for all three sections are of original construction. The girders and columns were modeled as a 2D frame in STAAD.Pro. Dead loads above the girder were applied to the girder at the floorbeam locations. A live load was run across the girder longitudinally with live load being transferred to the girder at the floorbeam locations. At locations where the columns were welded to the girders or framed into the girders with a moment connection the columns were modeled as fixed-pinned **(See Photo 5)**, otherwise the columns were modeled as pinned-pinned. The capacities of the girders and columns were calculated using spreadsheets. The load effects from the STAAD.Pro model and the capacities were input into a spreadsheet to rate the girders.

Photo 5 – Elevation showing girder to column welded connection and floorbeam framing into the girder (Section C shown)

The girders in each section, except for the south girder in Section L, rate below 1.0 HS20 Inventory for moment **(See Table 10)**. The girders rate above 1.0 for the operating level of HS20 and the four Ohio Legal Loads.

AS-BUILT / AS-INSPECTED GIRDER CONTROLLING RATING FACTORS							
Section	Member	HS20 Inv	HS20 Opr	2F1 Opr	3F1 Opr	4F1 Opr	5C1 Opr
K	North Girder	0.89	1.48	3.08	2.05	1.79	2.05
	South Girder	0.85	1.42	2.94	1.95	1.71	1.96
L	North Girder	0.98	1.64	3.34	2.23	1.95	1.87
	South Girder	1.16	1.94	3.29	2.28	2.10	2.29
C	North Girder	0.85	1.42	2.94	1.96	1.71	1.96
	South Girder	0.97	1.62	3.20	2.20	1.93	2.22

Table 10 – Controlling girder rating factors and rating factors below 1.0 for Sections K, L, and C (numbers below 1.0 are red, controlling values are shaded)

The pinned-pinned columns were rated with a spreadsheet using only axial loading. The centrifugal effect was assumed to be taken by the ends of the frame where the pinned-pinned columns and sway bracing exist. The fixed-pinned columns were rated in a spreadsheet using the load output from STAAD.Pro and a macro to solve the combined axial and bending equation (AASHTO Section 10.54.2) **(See Figure 15)** to determine the corresponding rating factor (β). For example, the inventory rating equation would be set up as shown in **Figure 16**.

$$\frac{P}{0.85A_sF_{cr}} + \frac{MC}{M_u\left(1 - \frac{P}{A_sF_e}\right)} \leq 1.0$$

Figure 15 – Standard AASHTO combined axial-moment condition equation

$$\frac{2.17\beta P_{LL} + 1.3P_{DL}}{0.85A_sF_{cr}} + \frac{(2.17\beta M_{LL} + 1.3M_{DL})C}{M_u\left(1 - \frac{2.17\beta P_{LL} + 1.3P_{DL}}{A_sF_e}\right)} \leq 1.0$$

Figure 16 – Modified AASHTO combined axial-moment condition equation to allow calculation of rating factor (β)

One column in Section K and one in Section L rate below 1.0 for HS20 Inventory **(See Table 11)**. The columns rate above 1.0 for the operating level of HS20 and the four Ohio Legal Loads.

AS-BUILT / AS-INSPECTED COLUMN CONTROLLING RATING FACTORS							
Section	**Member**	**HS20 Inv**	**HS20 Opr**	**2F1 Opr**	**3F1 Opr**	**4F1 Opr**	**5C1 Opr**
K	North Col K5	0.96	1.60	2.81	2.01	1.91	2.06
	South Col K4	1.00	1.67	3.02	2.14	2.00	2.19
L	North Col L7	1.11	1.86	4.32	2.83	2.43	1.92
	South Col L2	0.80	1.34	3.15	2.06	1.76	1.39
C	North Col C5	1.08	1.79	3.17	2.26	2.14	2.32
	South Col C4	1.13	1.89	3.19	2.27	2.14	2.33

Table 11 – Controlling column rating factors and rating factors below 1.0 for Sections K, L, and C (numbers below 1.0 are red, controlling values are shaded)

Photo 6 – Cracked weld between the seat and south bracket at Column K2 in Section K.

None of the sections exhibited section loss that would affect the primary member ratings. A cracked weld is present at the seat of the south bracket of Floorbeam 2 in Section K **(See Photo 6)**. The crack was caused by pack rust forming between the bracket and seat.

The abandoned connection and seat welds for Stringers 2 through 6 at Floorbeam 4 in Section K are cracked at the floorbeam webs due to the development of pack rust. Pack rust has developed between the tension channel cover plate and the floorbeam top flange directly above Column C7. One of the 4 longitudinal welds at this location is cracked. The cracks are currently contained within the weld material and have not propagated into the base metal.

Isolated fascia stringers in Sections C and K exhibit paint cracking near the top flange at the connection to the cantilevered floorbeam brackets. This may be due to out of plane distortion caused by a connection angle that is not the full height of the web.

The steel floorbeams adjacent to the expansion joints typically exhibit moderate surface rust on the top surfaces of the top and bottom flanges. The bracing members at the east end of Section L under the joint exhibit moderate section loss.

WEST APPROACH – SECTIONS N, P (Volume IV)

Sections N and P form the six lane divided rear approach spans to the main truss spans. Section N is a steel floorbeam/stringer system supported by steel girders, steel columns, and concrete columns **(See Photo)**. Section P is composed of concrete stringers and diaphragms supported by concrete bents. For complete rating calculations see **Volume IV**.

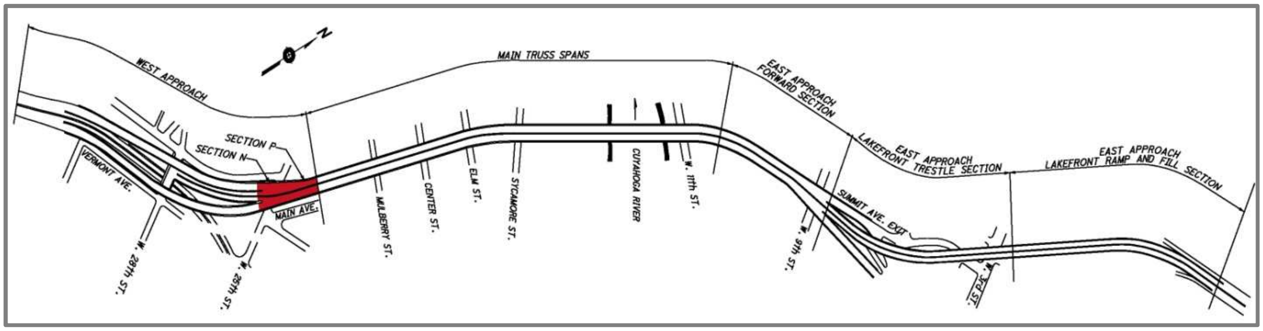


Figure 17 – Location of Sections N and P

Section N

In Section N, the stringers along with select floorbeams and columns were replaced in the 1990 rehabilitation. Since the beam spacing, span length and beam type were similar among the different units, the stringers were rated by creating line girder models in MDX. The fascia stringers were rated along with the three different types of interior stringers: simple span, two span continuous, and three span continuous. The stringers rate above 1.0 for all of the load cases **(See Table 12)**. The interior stringers were typically controlled by moment, while the fascia stringers were typically controlled by shear.

AS-BUILT / AS-INSPECTED STRINGER CONTROLLING RATING FACTORS							
Section	Member	HS20 Inv	HS20 Opr	2F1 Opr	3F1 Opr	4F1 Opr	5C1 Opr
N	Simple Span Int.	1.14	1.91	2.83	2.02	1.91	2.15
	2-Span Int.	1.28	2.13	3.21	2.40	2.26	2.50
	3-Span Int.	1.28	2.14	3.21	2.40	2.26	2.51
	F1-2	1.52	2.53	4.85	3.43	3.18	3.69
	F2-1	1.58	2.63	4.66	3.49	3.28	3.59

Table 12 – Controlling stringer rating factors and rating factors below 1.0 for Section N (numbers below 1.0 are red, controlling values are shaded)

The floorbeam capacities, dead and live load effects, and rating factors were calculated by hand. Four floorbeams have HS20 inventory rating factors that are below 1.0 **(See Table 13)**. All of the floorbeams rate above 1.0 for the operating level of HS20 and the four Ohio Legal Loads. The floorbeams were typically controlled by moment.

AS-BUILT FLOORBEAM CONTROLLING RATING FACTORS							
Section	Member	HS20 Inv	HS20 Opr	2F1 Opr	3F1 Opr	4F1 Opr	5C1 Opr
N	FB 5	0.99	1.65	3.26	2.31	2.07	2.37
	FB 6	0.96	1.60	3.14	2.22	2.00	2.29
	FB 9	0.88	1.46	2.89	2.04	1.83	2.10
	FB 12	1.00	1.67	3.31	2.32	2.08	2.37
	FB13	0.84	1.40	2.79	1.96	1.75	2.00

Table 13 – Controlling floorbeam rating factors and rating factors below 1.0 for Section N (numbers below 1.0 are red, controlling values are shaded)

The girder capacities, dead and live load effects, and rating factors were calculated by hand. The HS20 inventory rating factor for Girder 2 is below 1.0 **(See Table 14)**. All of the girders rate above 1.0 for the operating level of HS20 and the four Ohio Legal Loads. The girders were typically controlled by moment.

AS-BUILT / AS-INSPECTED GIRDER CONTROLLING RATING FACTORS							
Section	Member	HS20 Inv	HS20 Opr	2F1 Opr	3F1 Opr	4F1 Opr	5C1 Opr
N	G1	1.05	1.76	3.74	2.53	2.21	2.12
	G2	0.83	1.38	3.00	1.99	1.74	1.71
	G3	1.05	1.75	3.75	2.20	2.50	1.88

Table 14 – Controlling girder rating factors and rating factors below 1.0 for Section N (numbers below 1.0 are red, controlling values are shaded)

Photo 7 – Typical framing in Section N, stringers supported floorbeams that are framed into girders.

The columns can be divided into three groups: existing steel columns, existing concrete columns, and new steel columns. The new columns were replacements of existing columns in the 1990 rehabilitation. The steel columns were rated by hand and the concrete columns were rated using pcaColumn. All the columns rate above 1.0 for all of the load cases **(See Table 15)**.

AS-BUILT / AS-INSPECTED COLUMN CONTROLLING RATING FACTORS							
Section	Member	HS20 Inv	HS20 Opr	2F1 Opr	3F1 Opr	4F1 Opr	5C1 Opr
N	New Steel	1.65	2.76	5.45	3.85	3.46	3.96
	Ex. Steel	1.05	1.75	3.45	2.44	2.19	2.51
	Ex. Concrete	2.18	3.63	4.37	3.68	3.39	2.72

Table 15 – Controlling column rating factors and rating factors below 1.0 for Section N (numbers below 1.0 are red, controlling values are shaded)

Overall, Section N is in good condition. Isolated floorbeams exhibit areas of pitting up to 1/4" deep. Pack rust is active between the top floorbeam tie plates in several locations. Typically the location of the section loss did not coincide with the section of the floorbeam controlling the rating. Therefore, the as-inspected rating factors of those sections are actually higher than the as-built rating factors at the controlling locations.

AS-INSPECTED FLOORBEAM CONTROLLING RATING FACTORS							
Section	Member	HS20 Inv	HS20 Opr	2F1 Opr	3F1 Opr	4F1 Opr	5C1 Opr
N	FB 5	0.99	1.65	3.26	2.31	2.07	2.37
	FB 6	0.96	1.60	3.14	2.22	2.00	2.29
	FB 9	0.88	1.46	2.89	2.04	1.83	2.10
	FB 12	1.00	1.67	3.31	2.32	2.08	2.37
	FB13	0.84	1.40	2.79	1.96	1.75	2.00

Table 16 – Controlling floorbeam rating factors and rating factors below 1.0 for Section N (numbers below 1.0 are red, controlling values are shaded)

The section loss of Floorbeam 22 resulted in a lower rating, but the as-inspected conditions do not control the rating **(See Table 17)**. Note that Floorbeam 13 does not have section loss, but still controls the rating in the as-built condition.

COMPARISON BETWEEN AS-BUILT AND AS-INSPECTED					
Section	Member	HS20 Inv		HS20 Opr	
		As-Built	As-Inspected	As-Built	As-Inspected
N	FB 13	0.84	0.84	1.40	1.40
	FB 22	1.43	1.20	2.38	2.00

Table 17 – Comparison of as-built and as-inspected rating factors.

Section P

During the 1990 rehabilitation the deck and upper portions of the stringers and floorbeams were removed in Section P. New concrete was added to the top of the floorbeams and stringers and a lightweight concrete deck slab was constructed **(See Figure 18)**. A 3D STAAD frame model was created to determine the force effects on the stringers, floorbeams and columns.

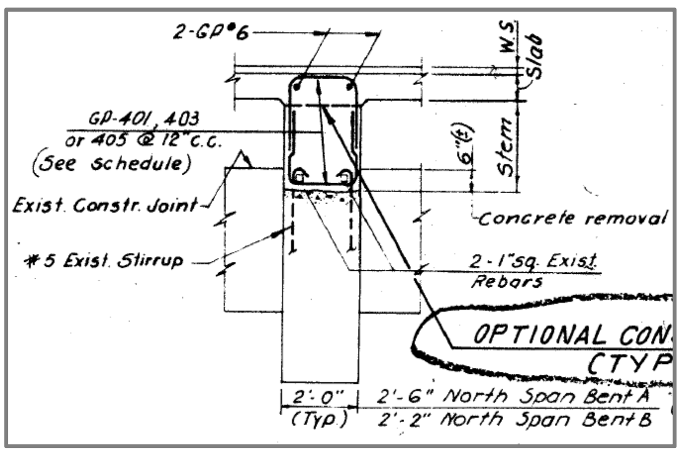


Figure 18 – Typical cross section of a modified stringer in Section P.

The stringer capacities and rating factors were calculated using spreadsheets. The moments and shear forces from the STAAD model were input into the rating spreadsheet. All the stringers rate above 1.0 for all of the load cases **(See Table 18)**. The interior stringers were typically controlled by moment, while the fascia stringers were typically controlled by shear.

AS-BUILT STRINGER CONTROLLING RATING FACTORS							
Section	Member	HS20 Inv	HS20 Opr	2F1 Opr	3F1 Opr	4F1 Opr	5C1 Opr
P	S9, S14	1.15	1.91	3.86	2.64	2.40	2.59
	Fascia	1.36	2.27	3.50	3.61	4.15	3.68

Table 18 – Controlling stringer rating factors and rating factors below 1.0 for Section P (numbers below 1.0 are red, controlling values are shaded)

The floorbeam capacities and rating factors were calculated using spreadsheets. The moments and shear forces from the STAAD model were input into the rating spreadsheet. The floorbeams rate above 1.0 for all load cases **(See Table 19)**. The floorbeam rating factors were controlled by moment.

AS-BUILT / AS-INSPECTED FLOORBEAM CONTROLLING RATING FACTORS							
Section	Member	HS20 Inv	HS20 Opr	2F1 Opr	3F1 Opr	4F1 Opr	5C1 Opr
P	FB 1	1.44	2.41	5.08	3.49	3.14	3.26
	FB 10	1.48	2.48	4.99	3.42	3.07	3.42

Table 19 – Controlling floorbeam rating factors and rating factors below 1.0 for Section P (numbers below 1.0 are red, controlling values are shaded)

The column capacities were calculated by using pcaColumn. The axial forces and moments from the STAAD model were input into pcaColumn and this program was used to rate the columns. All the columns rate above 1.0 for all of the load cases **(See Table 20)**.

AS-BUILT COLUMN CONTROLLING RATING FACTORS							
Section	Member	HS20 Inv	HS20 Opr	2F1 Opr	3F1 Opr	4F1 Opr	5C1 Opr
P	P 16	1.59	2.21	3.05	2.59	2.45	2.61

Table 20 – Controlling floorbeam rating factors and rating factors below 1.0 for Section P (numbers below 1.0 are red, controlling values are shaded)

The reinforced concrete stringers in Section P exhibit isolated heavy spalling and large delaminated areas **(See Photo 8)**. The exposed reinforcement typically exhibits up to 1/16" section loss on all faces of the square bars. Stringer 2 in Span 4 has a broken shear stirrup east of Column 10. Spalls with exposed reinforcement were noted in isolated concrete diaphragms of Section P. The reinforced concrete floorbeams exhibit localized areas of heavy spalling and minor losses to exposed reinforcement. Isolated floorbeams exhibit spalled concrete along the full length of the member. Deterioration is predominantly concentrated adjacent to the joints. The reinforced concrete columns exhibit spalls with exposed reinforcement and one column was noted to have 100% loss of three reinforcing bars.

Photo 8 – Typical stringer spall along the bottom flange with exposed reinforcement in Section P.

Section loss of the stringers results in lower rating factors for Ohio Legal Loads 3F1 and 4F1. Although there is section loss in column P1, the as-built condition of column P16 still controls the rating. The rating factors for the stringers and columns in the as-inspected condition remain above 1.0

AS-INSPECTED STRINGER CONTROLLING RATING FACTORS							
Section	Member	HS20 Inv	HS20 Opr	2F1 Opr	3F1 Opr	4F1 Opr	5C1 Opr
P	S9, S14	1.15	1.91	3.86	2.64	2.40	2.59
	S10, S11	1.25	2.09	3.50	2.46	2.27	2.84
	Fascia	1.36	2.27	3.50	3.61	4.15	3.68

Table 21 – Controlling stringer rating factors and rating factors below 1.0 for Section P (numbers below 1.0 are red, controlling values are shaded)

AS-INSPECTED COLUMN CONTROLLING RATING FACTORS							
Section	Member	HS20 Inv	HS20 Opr	2F1 Opr	3F1 Opr	4F1 Opr	5C1 Opr
P	P 16	1.59	2.21	3.05	2.59	2.45	2.61

Table 22 – Controlling column rating factors and rating factors below 1.0 for Section P (numbers below 1.0 are red, controlling values are shaded)

Although deterioration is present, the as-inspected locations typically do not control the overall rating of the stringers and columns. Stringers 4, 9, and 14, each have section loss that reduces the moment capacity, but since these stringers are controlled by shear, the controlling rating factors do not change. A comparison between the as-built and as-inspected rating factors for HS20 loading is shown in **Table 23**.

COMPARISON BETWEEN AS-BUILT AND AS-INSPECTED					
Section	Member	HS20 Inv		HS20 Opr	
		As-Built	As-Inspected	As-Built	As-Inspected
P	S4	1.46	1.46	2.44	2.44
	S9, S14	1.15	1.15	1.91	1.91
	S10, S11	1.26	1.25	2.11	2.09
	P1	3.37	2.87	4.67	4.01
	P16	1.59	1.59	2.21	2.21

Table 23 – Comparison of as-built and as-inspected rating factors.

MAIN TRUSS (Volume V)

The Main Truss Section consists of a ten span cantilevered modified Pratt deck truss. The truss chord members are comprised of riveted built-up box sections and the truss web members consist of rolled and built-up sections. The truss supports a mixture of riveted built-up and welded floorbeams. Rolled stringers rest on top of interior floorbeams and frame into cantilevers. Stringers are coped over floorbeams at numerous locations to match roadway super-elevations. There are two bend points in the roadway geometry, one in Span 6 and one in Span 10. For complete rating calculations refer to **Volume V**.

Deck and framing elements of the Main Truss Section underwent a major rehabilitation in 1990. During the rehabilitation, the roadway in each direction was widened by approximately 6' with the removal of pedestrian sidewalks. Additionally, stringers were replaced throughout the bridge along with 188 floorbeam cantilevers at select locations and 9 interior floorbeams at expansion joints.

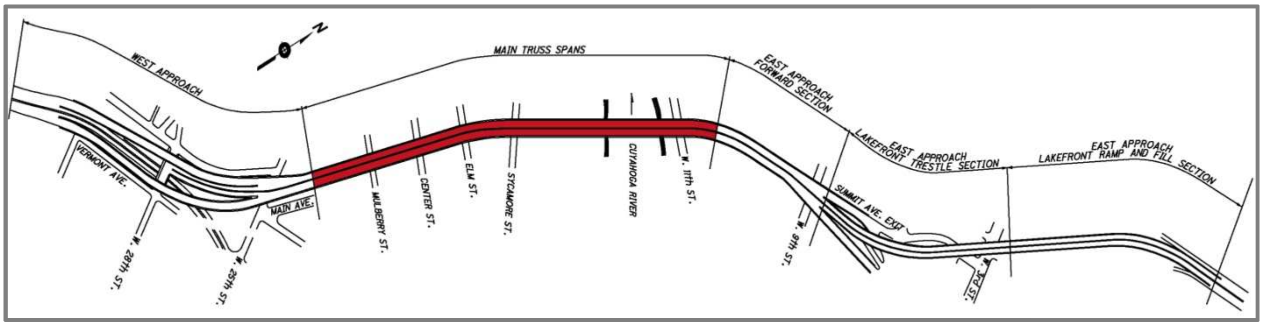


Figure 19 – Location of Main Truss Spans

The Main Truss was analyzed utilizing a series of 3D models in STAAD.Pro. Roadway curvature and superelevation were taken into account with truss geometry. Centrifugal force effects were considered where they increased the controlling force effects on a superstructure component. Inclined supports and member releases were utilized to mimic the bridge supports, truss member connections, links, and zero force members. Force effects were applied to excel spreadsheets to rate both truss members and gusset plates.

Framing members were analyzed utilizing hand calculations, STAAD models, and excel spreadsheets along with dead load forces taken from the Main Truss dead load 3D model.

Dead Loads

The dead load STAAD model consists of truss primary and secondary members, floorbeams and stringers. Calculated average increases (bump-ups) were applied to each member to account for the additional weight of connection, tie, and fill plates. Gusset plate loads were applied at each panel point. Deck and parapet loads were distributed evenly between stringers. Additional point loads were applied to the model to represent the superimposed dead loads of the catwalk, drainage troughs and overhead sign structures.

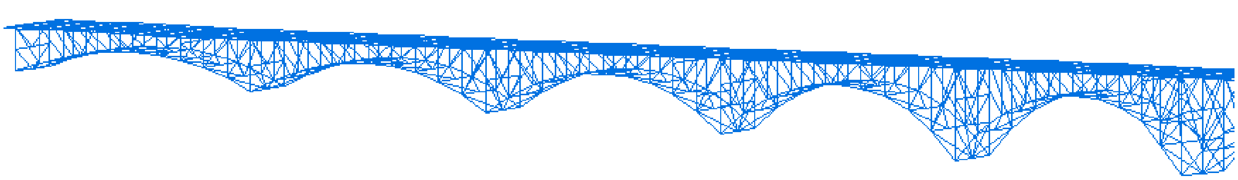


Figure 20 – South Elevation Main Truss STAAD Model Spans 1 through 5.

During the major rehabilitation in 1990, the deck and framing components were replaced with a heavier system. As presented in the original plans, the original deck and framing members weighed approximately 9 kips per linear foot of the bridge. The current cross-section weighs 11.3 kips per linear foot of the bridge, roughly a 15% increase. In order to verify the accuracy of the STAAD model and compare force effects with the original 1936 force sheets, TranSystems substituted the weight of the original deck and framing members into the STAAD model. Comparing results with legible forces from the 1936 original plans (cantilever Span 1 and suspended Span 9), the new truss force effects are typically between 95% and 99% of the original forces for Spans 1 and 9, respectively.

Dead load force effects from 2012 are typically 15% to 20% higher than member forces in the 1996 Load Rating **(see Chart 1)**. Additionally from **Chart 1**, percent differences are well correlated between the north and south truss along the symmetric cross-section portions of the bridge. However, where asymmetric cross-sections exist at roadway bend points, these percentages diverge. At the bend points in Span 6 and Span 10, the deck area supported by the north truss increases whereas the deck area supported by the south truss decreases. This divergence may suggest the 1996 load rating may have been based solely on a symmetric cross section for determining deck and framing dead load effects on each truss.

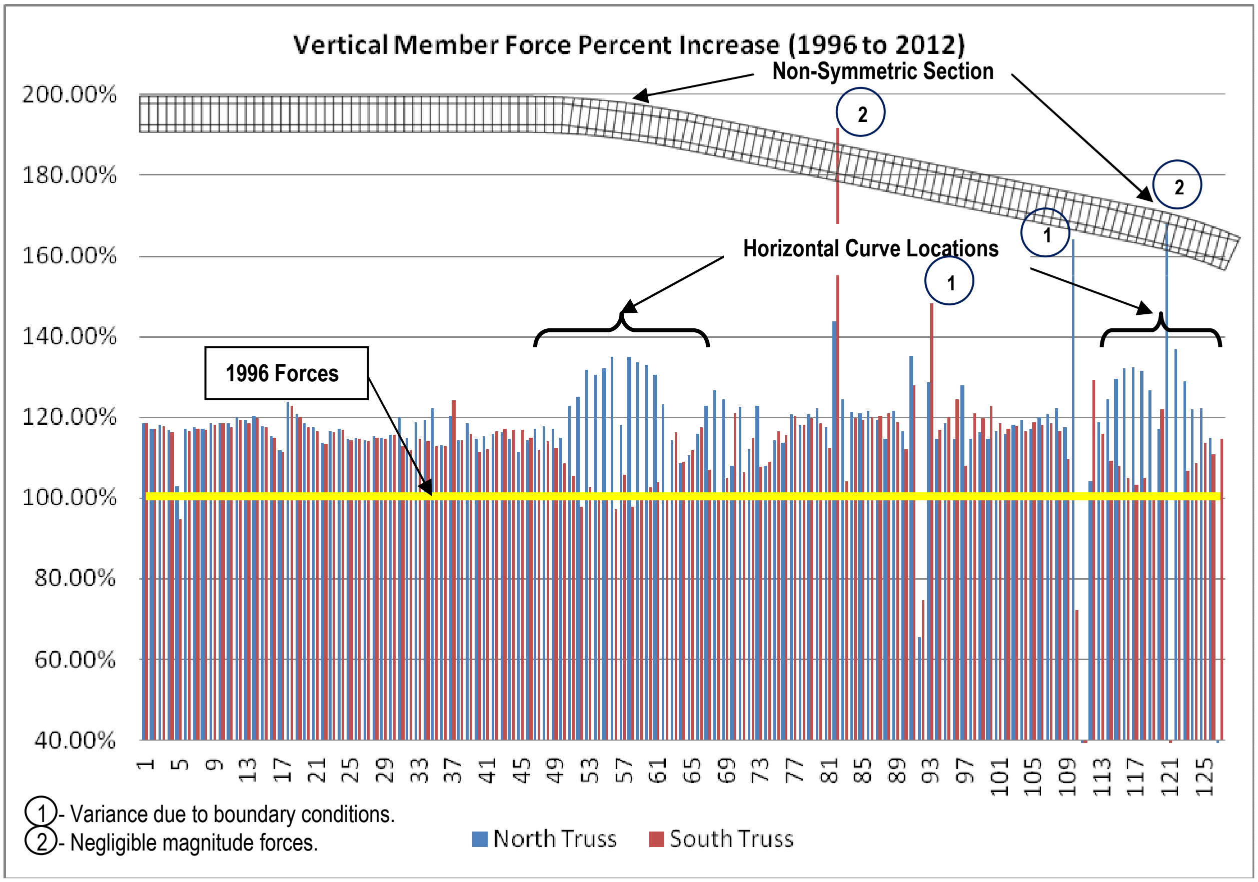


Chart 1 – Variance between 2012 and 1996 vertical member forces. Note divergence of percentages at roadway bend points.

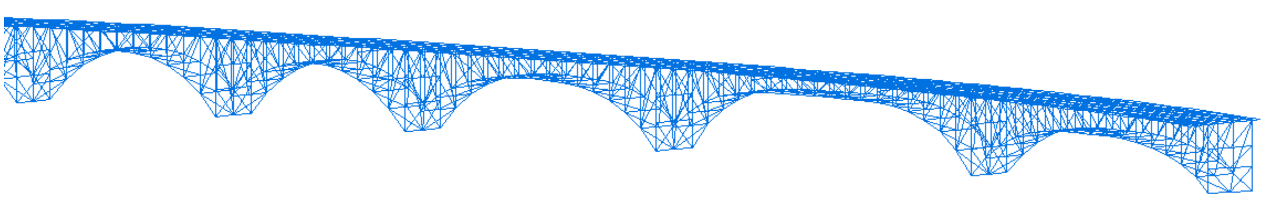


Figure 21 – South Elevation Main Truss STAAD Model Spans 6 through 10.

Live Load

To develop appropriate live load distribution into truss panel points, a floating deck was modeled to separate the loaded deck from the primary truss elements. A "Master-Slave" relationship was defined to link the vertical force in the floating deck with the truss-level framing below **(see Figure 22)**.

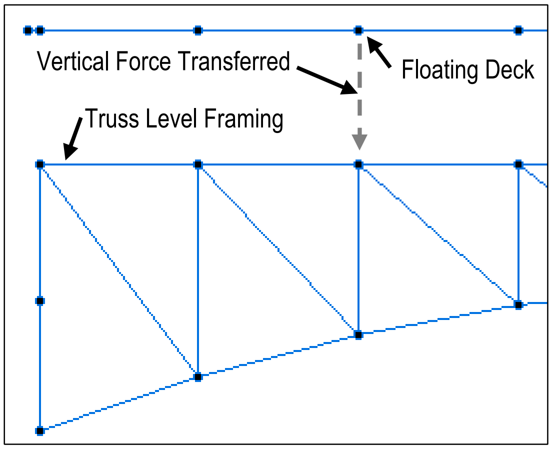


Figure 22: Floating Deck and Truss Elevation

Lane loading was applied to maximize shear as well as positive and negative moment regions throughout the structure. Truck load generations and lane loading followed the horizontal curvature of the structure with impact and centrifugal force increases accounted for in the rating sheets. HS20 and 5C1 truck trains were applied to maximize shear and moment regions in each span utilizing whole trucks.

Analysis Results

Truss Members

Force effects were taken from the STAAD output files and sorted into rating sheets. Impact and centrifugal effects were applied in the forces spreadsheet, with centrifugal force effects only being applied to the north truss. In the as-built condition, all primary truss member operating rating factors are higher than 1.00 with isolated HS20 inventory factors below 1.00 **(see Table 24)**.

AS-BUILT MAIN TRUSS CONTROLLING RATING FACTORS										
Section	Location	Member	HS20 Inv	HS20 Opr	2F1 Opr	3F1 Opr	4F1 Opr	5C1 Opr	HS-20 Truck Train	5C1 Truck Train
South Truss	Lower Chord	L19-L20	1.02	1.71	5.66	3.74	3.21	2.42	1.69	1.87
		L20-L21	1.27	2.11	4.97	3.30	2.85	2.23	1.92	2.11
	Upper Chord	U57-U58	0.72	1.20	3.97	2.60	2.23	1.69	1.33	1.44
	Vertical	U0-L0	0.75	1.25	2.97	1.99	1.74	1.33	1.12	1.25
	Diagonal	U28-L27	1.22	2.03	4.49	3.00	2.62	2.30	1.96	2.31
		U112-L113	0.92	1.53	5.36	3.51	3.02	2.24	1.68	1.76
North Truss	Lower Chord	L61-L62	0.66	1.10	4.46	2.92	2.50	1.84	1.20	1.33
	Upper Chord	U34-U35	1.11	1.86	5.63	3.71	3.20	2.47	2.02	2.23
		U45-U46	1.18	1.97	4.36	2.88	2.50	2.16	1.93	2.14
	Vertical	U0-L0	0.75	1.25	2.97	1.98	1.73	1.33	1.11	1.25
	Diagonal	U47-L46	1.20	2.00	4.43	2.96	2.59	2.27	1.94	2.29
		U52-L53	0.96	1.60	4.65	3.06	2.64	1.99	1.65	1.78

Table 24 – Controlling as-built truss member rating factors (numbers below 1.0 are red, controlling values are shaded)

In the as-inspected condition, 56 (56 of 1010) truss members exhibited more than 10% section loss, 11 locations exhibited between 20% and 30% loss, and 45% loss was noted at one location. Significant losses to the truss members were primarily located adjacent to expansion joints and adjacent to deteriorated drainage troughs. The controlling as-inspected members are diagonal U52-L53 of the north truss **(See Photo 9)** and vertical U0-L0 of both trusses. After section loss reductions to capacity, the truss members rate higher than 1.00 for all Operating conditions with several members rating less than 1.00 for HS20 Inventory **(See Table 25)**.

Photo 9– Member U52-L53 of the north truss with heavy web section loss.

AS-INSPECTED MAIN TRUSS CONTROLLING RATING FACTORS											
Section	Location	Member	HS20 Inv	HS20 Opr	2F1 Opr	3F1 Opr	4F1 Opr	5C1 Opr	HS-20 Truck Train	5C1 Truck Train	Section Loss
South Truss	Lower Chord	L94-L95	0.82	1.37	3.92	2.57	2.21	1.68	1.31	1.47	14.94%
	Upper Chord	U57-U58	0.72	1.20	3.97	2.60	2.23	1.69	1.33	1.44	---
	Vertical	U0-L0	0.75	1.25	2.97	1.99	1.74	1.33	1.12	1.25	---
	Diagonal	U29-L28	0.92	1.54	3.47	2.31	2.01	1.65	1.38	1.64	21.43%
		U112-L113	0.92	1.53	5.36	3.51	3.02	2.24	1.68	1.76	---
North Truss	Lower Chord	L61-L62	0.66	1.10	4.46	2.92	2.50	1.84	1.20	1.33	---
	Upper Chord	U52-U53	1.08	1.80	5.50	3.62	3.10	2.31	1.90	1.99	6.75%
		U66-U67	1.14	1.90	4.28	2.80	2.43	2.00	1.74	2.05	5.30%
	Vertical	U0-L0	0.75	1.25	2.97	1.98	1.73	1.33	1.11	1.25	25.45%
	Diagonal	U52-L53	0.64	1.07	3.00	1.99	1.73	1.33	1.10	1.18	14.88%

Table 25– Controlling as-inspected truss member rating factors (numbers below 1.0 are red, controlling values are shaded)

COMPARISON BETWEEN AS-BUILT AND AS-INSPECTED						
Section	Location	Member	HS20 Inv		HS20 Opr	
			As-Built	As-Inspected	As-Built	As-Inspected
South Truss	Lower Chord	L94-L95	1.28	0.82	2.14	1.37
	Upper Chord	U57-U58	0.72	0.72	1.20	1.20
	Vertical	U0-L0	0.75	0.75	1.25	1.25
	Diagonal	U29-L28	1.52	0.92	2.53	1.54
		U112-L113	0.92	0.92	1.53	1.53
North Truss	Lower Chord	L61-L62	0.66	0.66	1.10	1.10
	Upper Chord	U52-U53	1.21	1.08	2.02	1.80
		U66-U67	1.27	1.14	2.12	1.90
	Vertical	U0-L0	0.75	0.75	1.25	1.25
	Diagonal	U52-L53	0.96	0.64	1.60	1.07

Table 26– Comparison of controlling as-built and as-inspected rating factors.

Pins

The suspended spans in the truss are connected with pins. The verticals have 8" or 9" diameter pins, while the chords are connected with 4" diameter pins. The pin connections were rated for shear in the pin and bearing on the plates. The pins and plates rate above 1.0 for all of the load cases and the bearing condition controlled (See Table 27). The pins exhibited section loss and were rated in the as-inspected condition with reduced capacity, however the bearing of the plates still controls the rating.

AS-BUILT / AS-INSPECTED MAIN TRUSS PINS CONTROLLING RATING FACTORS									
Location	Member	HS20 Inv	HS20 Opr	2F1 Opr	3F1 Opr	4F1 Opr	5C1 Opr	HS-20 Truck Train	5C1 Truck Train
South Truss	L23	1.17	1.95	4.46	2.99	2.63	2.14	1.81	2.10
	L65	1.08	1.80	4.61	3.05	2.62	2.07	1.70	1.95
North Truss	U23	1.16	1.93	4.45	2.99	2.62	2.14	1.81	2.10
	U65	1.06	1.78	4.52	2.99	2.57	2.03	1.67	1.91

Table 27 – Controlling as-built pin rating factors and rating factors below 1.0 (numbers below 1.0 are red, controlling values are shaded)

Framing

The stringers were replaced during the 1990 rehabilitation, along with 188 floorbeam cantilevers and 9 interior floorbeams at expansion joints. Stringers are typically coped over the floorbeam connections (See Figure 23). Initially these coped locations were modeled as continuous. Since no cover plates are present, the moment capacity is significantly reduced. After discussing with the District it was agreed that the stringers were acting as simple spans and the stringers were reanalyzed.

The controlling framing elements rate below 1.00 for HS20 Inventory loading, but above 1.00 for all the Ohio Legal Loads (See Table 28). The stringers are controlled by positive moment, while the floorbeam bracket is controlled by negative moment.

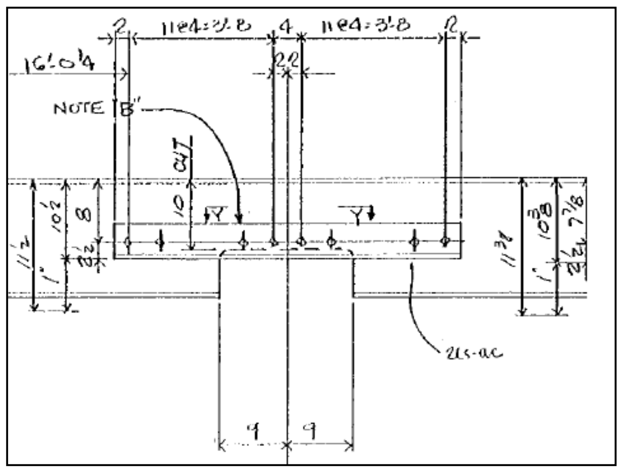


Figure 23– Typical coped stringer detail over floorbeam connection (Unit 3 Span 6 Stringer 14 shown).

AS-BUILT MAIN TRUSS FRAMING CONTROLLING RATING FACTORS							
Item	Member	HS20 Inv	HS20 Opr	2F1 Opr	3F1 Opr	4F1 Opr	5C1 Opr
Stringers	S11-4	0.87	1.46	2.24	1.71	1.52	1.71
Floorbeam Bracket	South Bracket 126	0.71	1.19	2.29	1.54	1.36	1.59
Floorbeam	Floorbeam 118	0.76	1.27	2.46	1.65	1.45	1.70

Table 28– Controlling as-built framing member rating factors (numbers below 1.0 are red, controlling values are shaded)

No significant deficiencies were noted to the main span stringers. However, isolated floorbeams exhibited moderate to advanced section loss near expansion joints. Floorbeam 72 had the lowest rating among the floorbeams with loss, but it is not lower than the as-built condition of Floorbeam 118. The as-built condition of Floorbeam Bracket 126 still controls the overall rating **(See Table 29)**.

AS-INSPECTED MAIN TRUSS FRAMING CONTROLLING RATING FACTORS							
Item	Member	HS20 Inv	HS20 Opr	2F1 Opr	3F1 Opr	4F1 Opr	5C1 Opr
Stringers	S11-4	0.87	1.46	2.24	1.71	1.52	1.71
Floorbeam Bracket	South Bracket 126	0.71	1.19	2.29	1.54	1.36	1.59
Floorbeam	Floorbeam 72	0.85	1.42	2.74	1.84	1.63	1.89
Floorbeam	Floorbeam 118	0.79	1.32	2.55	1.71	1.51	1.76

Table 29– Controlling as-inspected framing member rating factors (numbers below 1.0 are red, controlling values are shaded)

A comparison of the controlling as-built and as-inspected HS20 load rating factors is presented in **Table 30** . Note that only the controlling factors are presented; For all the members that rate below 1.0 or that are reduced due to section loss see **Volume V**.

COMPARISON BETWEEN AS-BUILT AND AS-INSPECTED					
Section	Member	HS20 Inv		HS20 Opr	
		As-Built	As-Inspected	As-Built	As-Inspected
Main Truss	S11-4	0.87	0.87	1.46	1.46
	South Bracket 126	0.71	0.71	1.19	1.19
	FB 72	0.89	0.85	1.49	1.42
	FB 118	0.79	0.79	1.32	1.32

Table 30 – Comparison of as-built and as-inspected rating factors.

EAST APPROACH – FORWARD SECTION (Volume VI)

The western part of the Forward Section consists of a single simply supported Pratt deck truss (Span 11). The Pratt deck truss members consist of rolled wide flange sections, with a similar deck framing system to the main truss span. The eastern part of the Forward Section consists of steel truss bents that support rolled steel floorbeams with rolled steel stringers bearing on top. The steel truss bent members consist of rolled steel sections connected by riveted gusset plates. A lower utility/parking deck exists below the eastbound lanes of this section. For complete rating calculations refer to **Volume VI**.

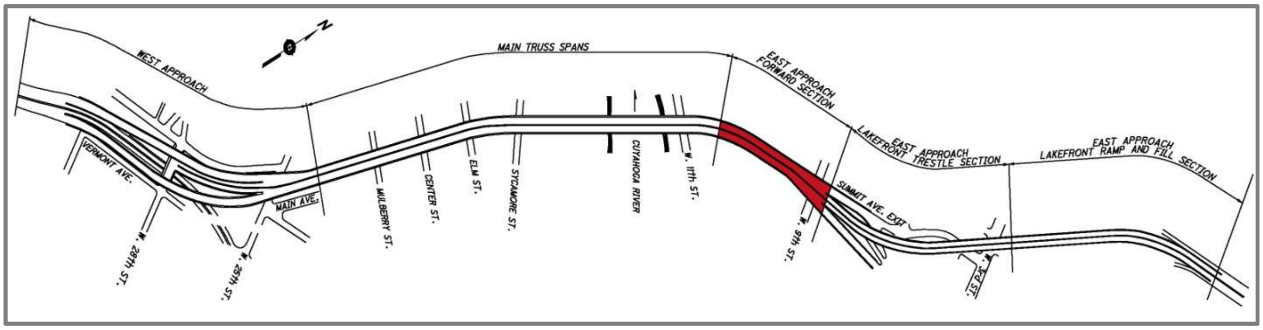


Figure 24 – Location of East Approach – Forward Section

Span 11

During the 1990 rehabilitation all the stringers in Span 11 and select floorbeam brackets were replaced. Similar to other sections, the stringers were coped at the floorbeam locations where the superelevation required it. Retrofits were also performed on isolated floorbeams. The rehabilitation included removal of the pedestrian sidewalk and widening of the roadway in each direction. A 3D STAAD frame model was created to model Span 11 **(See Figure 25)**.

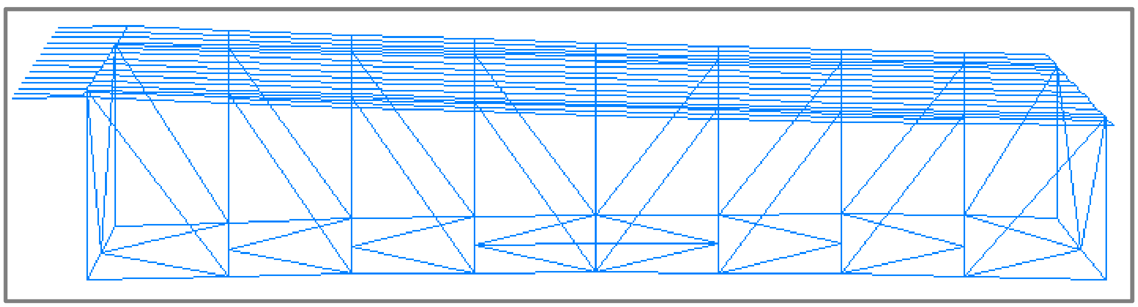


Figure 25 – South Elevation of Span 11 STAAD model

A series of 3D STAAD models were used to determine the dead and live load effects on the truss. The live loads were modeled as moving point loads at the truck axle locations in order to follow the geometry of the roadway. The models, dead loads, and live loads were created in a similar way to the main truss spans. The force effects from the STAAD models and capacities calculated in spreadsheets were input in rating spreadsheets to rate the truss members. The truss members rate above 1.0 for all of the load cases **(See Table 31)**.

AS-BUILT SPAN 11 TRUSS CONTROLLING RATING FACTORS								
Section	Location	Member	HS20 Inv	HS20 Opr	2F1 Opr	3F1 Opr	4F1 Opr	5C1 Opr
South Truss	Upper Chord	U131-U132	1.08	1.80	4.30	2.84	2.48	1.97
	Lower Chord	L131-L132	1.62	2.70	6.38	4.23	3.71	2.88
	Vertical	U131-L131	1.32	2.20	3.88	2.65	2.44	2.74
		U134-L134	1.13	1.88	4.95	3.27	2.87	2.19
	Diagonal	U129-L130	1.22	2.04	4.54	3.03	2.67	2.24
North Truss	Upper Chord	U130-U131	1.15	1.92	4.35	2.87	2.48	1.98
	Lower Chord	L131-L132	1.62	2.69	6.10	4.04	3.48	2.75
		L133-L134	1.62	2.70	6.22	4.10	3.54	2.73
	Vertical	U131-L131	1.18	1.96	3.46	2.36	2.16	2.44
		U133-L133	1.21	2.01	4.60	3.04	2.63	2.08
	Diagonal	U129-L130	1.25	2.09	4.72	3.13	2.72	2.24

Table 31 – Controlling as-built framing member rating factors (numbers below 1.0 are red, controlling values are shaded)

The truss members are in good condition overall. Six truss members (6 of 66) exhibited section loss that was included in the as-inspected analysis. Four of these were less than 5% loss, one was less than 10%, and one was less than 15%. After section loss reductions to capacity the truss members rate higher than 1.00 for all the load cases **(See Table 32)**.

AS-INSPECTED SPAN 11 TRUSS CONTROLLING RATING FACTORS								
Section	Location	Member	HS20 Inv	HS20 Opr	2F1 Opr	3F1 Opr	4F1 Opr	5C1 Opr
South Truss	Upper Chord	U131-U132	1.08	1.80	4.30	2.84	2.48	1.97
	Lower Chord	L131-L132	1.62	2.70	6.38	4.23	3.71	2.88
	Vertical	U131-L131	1.32	2.20	3.88	2.65	2.44	2.74
		U135-L135	1.11	1.84	4.94	3.25	2.84	2.13
	Diagonal	U127-L128	1.14	1.91	4.78	3.18	2.80	2.21
		U129-L130	1.22	2.04	4.54	3.03	2.67	2.24
North Truss	Upper Chord	U130-U131	1.15	1.92	4.35	2.87	2.48	1.98
	Lower Chord	L131-L132	1.62	2.69	6.10	4.04	3.48	2.75
		L133-L134	1.62	2.70	6.22	4.10	3.54	2.73
	Vertical	U131-L131	1.18	1.96	3.46	2.36	2.16	2.44
		U134-L134	1.14	1.90	4.77	3.14	2.71	2.08
	Diagonal	U129-L130	1.25	2.09	4.72	3.13	2.72	2.24

Table 32 – Controlling as-inspected rating factors (numbers below 1.0 are red, controlling values are shaded)

Both the South and North Truss are typically controlled by the as-built condition, however section loss in the North Truss causes the controlling HS20 rating factors to decrease slightly. A comparison of the controlling as-built and as-inspected HS20 load rating factors is presented in **Table 33**. Note that only the controlling factors are presented, for all the members that rate below 1.0 or that are reduced due to section loss see **Volume VI**.

COMPARISON BETWEEN AS-BUILT AND AS-INSPECTED						
Section	Location	Member	HS20 Inv		HS20 Opr	
			As-Built	As-Inspected	As-Built	As-Inspected
South Truss	Upper Chord	U131-U132	1.08	1.08	1.80	1.80
	Lower Chord	L131-L132	1.62	1.62	2.70	2.70
	Vertical	U131-L131	1.32	1.32	2.20	2.20
		U135-L135	1.20	1.11	2.00	1.84
	Diagonal	U127-L128	1.37	1.14	2.28	1.91
		U129-L130	1.22	1.22	2.04	2.04
North Truss	Upper Chord	U130-U131	1.15	1.15	1.92	1.92
	Lower Chord	L131-L132	1.62	1.62	2.69	2.69
		L133-L134	1.62	1.62	2.70	2.70
	Vertical	U131-L131	1.18	1.18	1.96	1.96
		U134-L134	1.18	1.14	1.97	1.90
	Diagonal	U129-L130	1.25	1.25	1.90	2.09

Table 33 – Comparison of as-built and as-inspected rating factors.

The capacities of the stringers and floorbeams were calculated using spreadsheets. The dead load effects on the framing members were taken for the STAAD model. Multiple line models were created in STAAD to determine the live load effects for the floorbeams and full height and coped stringers. The forces and capacities were input in a rating spreadsheet to rate the framing members. The coped stringers were rated as simple spans similar to the main spans. The framing members rate above 1.0 for the operating load cases, but five members rate below 1.0 for HS20 Inventory **(See Table 34)**.

Photo 10 – South elevation of Span 11 (looking east)

AS-BUILT SPAN 11 TRUSS FRAMING CONTROLLING RATING FACTORS							
Section	Member	HS20 Inv	HS20 Opr	2F1 Opr	3F1 Opr	4F1 Opr	5C1 Opr
Stringers	S6-2	0.93	1.56	2.36	1.77	1.59	1.81
	S7-2	0.99	1.66	2.55	1.94	1.72	1.94
	S10-3	0.93	1.56	2.40	1.82	1.62	1.82
	S6-5	1.00	1.68	2.58	1.96	1.74	1.96
Floorbeams	FB 128	0.94	1.56	3.01	2.02	1.79	2.09
	FB 129	0.97	1.62	3.26	2.10	1.86	2.17

Table 34 – Controlling as-built framing member rating factors (numbers below 1.0 are red, controlling values are shaded)

The framing is in very good condtion. One floorbeam required a reduction in capacity due to section loss, however the stringers in the as-built condition still control the overall framing system rating **(See Table 35)**.

AS-INSPECTED SPAN 11 TRUSS FRAMING CONTROLLING RATING FACTORS							
Section	Member	HS20 Inv	HS20 Opr	2F1 Opr	3F1 Opr	4F1 Opr	5C1 Opr
Stringers	S6-2	0.93	1.56	2.36	1.77	1.59	1.81
Floorbeams	FB 128	0.94	1.56	3.01	2.02	1.79	2.09
	FB 135	0.98	1.63	2.85	2.05	1.96	2.11

Table 35 – Controlling as-inspected framing member rating factors (numbers below 1.0 are red, controlling values are shaded)

The framing system is controlled by the as-built condition. Section loss to Floorbeam 135 results in its HS20 Inventory rating factor dropping below 1.0 **(See Table 36)**.

COMPARISON BETWEEN AS-BUILT AND AS-INSPECTED					
Section	Member	HS20 Inv		HS20 Opr	
		As-Built	As-Inspected	As-Built	As-Inspected
Span 11 Truss	S6-2	0.93	0.93	1.56	1.56
	FB 128	0.94	0.94	1.56	1.56
	FB 135	1.08	0.98	1.80	1.63

Table 36 – Comparison of as-built and as-inspected rating factors.

Eastern Part of Forward Section

The eastern part of the East Approach – Forward Section connects Span 11 to the Lakefront Trestle. During the 1990 rehabilitation all the stringers, except three, were replaced in the eastern part of the forward section. The three remaining stringers had new t-shaped stringers placed on top of them **(See Photo 11)**. Three span continuous units were replaced with a two span continuous unit and a simple span unit. Line girder models were created using MDX to deteremine load effects and rate the full depth stringers. Similar to sections in the West Approach and Main Truss Spans, the bottom flange and web of select stringers were coped at floorbeam locations. Select coped stringers were also reinforced with a bolted top cover plate over the floorbeam. Spreadsheets were used to calculate the coped stringer capacitities. The moments and shears from the MDX analysis were input into these spreadsheets to rate the coped stringers. The coped stringers were rated as simple spans similar to the other sections with coped stringers.

Photo 11 – Forward Section showing t-shaped stringer added in rehabilitation on top of existing stringer.

Two stringers had Operating rating factors below 1.0 **(See Table 37)**. Multiple stringers had inventory rating factors below 1.0. The stringers were controlled by positive moment.

AS-BUILT / AS-INSPECTED STRINGER CONTROLLING RATING FACTORS							
Section	Member	HS20 Inv	HS20 Opr	2F1 Opr	3F1 Opr	4F1 Opr	5C1 Opr
East Approach - Forward Section	S3-3 to S11-5	0.76	1.26	2.31	1.57	1.43	1.62
	S12-3	0.70	1.18	2.15	1.46	1.33	1.50
	S13-3	0.70	1.17	2.14	1.45	1.33	1.50
	S3-5 to S11-5	0.76	1.26	2.31	1.57	1.43	1.62
	S12-5	0.70	1.18	2.15	1.46	1.33	1.50
	S13-5	0.72	1.20	1.99	1.36	1.22	1.41
	S6-7 to S13-7	0.74	1.24	2.18	1.49	1.36	1.54
	S14-7	0.78	1.30	1.35	0.92	0.84	0.95
	S15-7	0.98	1.64	1.45	1.00	0.86	1.05
	S1-9 to S15-9	0.71	1.19	2.35	1.58	1.41	1.62

Table 37 – Controlling stringer rating factors and rating factors below 1.0 for eastern part of the Forward Section (numbers below 1.0 are red, controlling values are shaded)

Photo 12 – Lower level deck in the East Approach – Forward Section (looking west)

The East Approach – Forward Section has a lower deck extending from Bent 0 to Bent 7 **(See Photo 12)**. The stringers of the lower deck were analyzed for HS-20 loading only. The controlling stringer, S4, had a rating factor of 0.96. Since the lower deck is presently closed, as-inspected ratings were not calculated for the lower deck although some deterioration was noted in the inspections. The manager of the building adjacent to this section reported that the building periodically experiences vibrations from the bridge.

The majority of the bents are of original construction. The 1990 rehabilitation replaced select floorbeams and one column. The rehabilitation also consisted of adding column reinforcing plates and new knee braces to select columns. Column reinforcing plates and knee braces were assumed to only carry live load effects. Deteriorated columns were also repaired as part of the original rehabilitation. They were assumed to have been repaired to the original capacity since records of the deterioration before the repair were not available and it is no longer visible by inspection.

The bents were analyzed by creating 2D STAAD models. Connection details from the shop drawings were used to determine column end conditions for the STAAD models and capacity calculations. Superstructure dead loads applied to the STAAD model were taken from the MDX stringer models. The bents were loaded with multiple lane configurations to maximize load effects on the floorbeams and columns. For Bents 0 to 7, the lower deck was simultaneously loaded with a 40psf area load. Truck loads applied to the floorbeams in the STAAD models were taken from MDX for bents supporting continuous stringers or from separate STAAD models for bents supporting non-continuous stringers. Bent 0 also supports Truss Span 11 and the reactions from this truss were obtained from the Span 11 STAAD models. Centrifugal force has also been applied to Bents 0, 7, and 8. Members of Bents 0, 7, and 8 are rated for maximum load effects with and without centrifugal force.

The floorbeam capacities were calculated using spreadsheets and the load effects from STAAD were input into the spreadsheets to determine the rating factors. Twelve floorbeams in the as-built condition rate below 1.0 for HS20 inventory **(See Table 38)**. Two floorbeams have HS20 operating rating factors less than 1.0 and one of these floorbeams also rates below 1.0 for the 5C1 Ohio Legal Load. The floorbeam rating factors are controlled by moment.

AS-BUILT FLOORBEAM RATING FACTORS							
Section	Member	HS20 Inv	HS20 Opr	2F1 Opr	3F1 Opr	4F1 Opr	5C1 Opr
East Approach - Forward Section	FB 0	0.82	1.37	2.86	1.94	1.73	1.94
	FB 1	0.65	1.09	2.88	1.92	1.67	1.28
	FB 2	0.78	1.30	2.75	1.84	1.62	1.61
	FB 3	0.51	0.85	1.95	1.28	1.10	0.96
	FB 4	0.69	1.15	2.43	1.63	1.42	1.43
	FB 5	0.73	1.23	2.60	1.74	1.52	1.52
	FB 6	0.59	0.99	2.28	1.49	1.28	1.12
	FB 7	0.69	1.15	2.41	1.62	1.42	1.47
	FB 8	0.97	1.62	3.37	2.27	1.99	2.10
	FB 9	0.71	1.18	2.69	1.77	1.52	1.41
	FB 12	0.64	1.06	2.44	1.61	1.38	1.19
	FB 13	0.82	1.37	2.76	1.87	1.65	1.93

Table 38 – Controlling floorbeam rating factors and rating factors below 1.0 for eastern part of the Forward Section (numbers below 1.0 are red, controlling values are shaded)

The column capacities were calculated using spreadsheets. The load effects from the STAAD models were input into a customized rating spreadsheet where the rating factor was determined by satisfying the combined axial and moment condition equation **(See Figures 15 & 16)**. Eight columns in the as-built condition rate below 1.0 for HS20 Inventory **(See Table 39)**. One column rates below 1.0 for HS20 Operating, but this column and the remaining columns rate above 1.0 for the Ohio Legal Loadings.

AS-BUILT COLUMN RATING FACTORS							
Section	Column	HS20 Inv	HS20 Opr	2F1 Opr	3F1 Opr	4F1 Opr	5C1 Opr
East Approach - Forward Section	100	0.89	1.48	3.35	1.70	1.99	1.52
	100A	0.83	1.38	2.72	1.92	1.72	1.91
	300	0.97	1.62	3.66	2.45	2.11	1.61
	300A	0.86	1.44	2.79	1.98	1.79	1.98
	307	0.90	1.49	3.14	2.10	1.84	1.90
	408	0.74	1.23	2.57	1.73	1.51	1.60
	409	0.59	0.98	2.21	1.53	1.25	1.16
	410	0.73	1.21	2.73	1.71	1.47	1.60
"A" indicates the portion of the column above the lower deck							

Table 39 – Controlling column rating factors and rating factors below 1.0 for eastern part of the Forward Section (numbers below 1.0 are red, controlling values are shaded)

The armor of Joint C, at the east end of the forward section, is vertically misaligned and exhibits plow damage. Bent 14 is located below this joint, therefore the deterioration of the armor and the joint gland are allowing rainwater and salt to drain onto the bent. This is causing advanced section loss of the floorbeam and bent components **(See Photo 13)**. Isolated areas of the web, most notably near the beam ends, exhibit ½" loss and are nearly holed through. Isolated floorbeams exhibit areas of cleaned and painted pitting up to ¼" deep in the bottom half of the beams and adjacent to splices. Several floorbeams that rated above 1.0 in the as-built condition, now rate below 1.0 for HS20 Inventory and Operating due to section loss **(See Table 40)**.

Photo 13 – Typical pitting of the east face of Floorbeam 14 at mid-beam. Note the removal of vertical stiffener legs in this area.

AS-INSPECTED FLOORBEAM RATING FACTORS							
Section	Member	HS20 Inv	HS20 Opr	2F1 Opr	3F1 Opr	4F1 Opr	5C1 Opr
East Approach - Forward Section	FB 0	0.63	1.06	2.20	1.50	1.33	1.49
	FB 1	0.59	0.99	2.61	1.74	1.52	1.16
	FB 2	0.78	1.30	2.75	1.84	1.62	1.61
	FB 3	0.51	0.85	1.95	1.28	1.10	0.96
	FB 4	0.52	0.87	1.90	1.26	1.10	1.10
	FB 5	0.73	1.23	2.60	1.74	1.52	1.52
	FB 6	0.59	0.99	2.28	1.49	1.28	1.12
	FB 7	0.55	0.92	1.94	1.30	1.14	1.18
	FB 8	0.40	0.67	1.41	0.95	0.83	0.88
	FB 9	0.71	1.18	2.69	1.77	1.52	1.41
	FB 12	0.64	1.06	2.44	1.61	1.38	1.19
	FB 13	0.82	1.37	2.76	1.87	1.65	1.93
	FB 14	0.83	1.39	2.43	1.74	1.66	1.78

Table 40 – Controlling floorbeam rating factors and rating factors below 1.0 for eastern part of the Forward Section (numbers below 1.0 are red, controlling values are shaded)

The lower utility deck diaphragms at Bent 4 exhibit distress due to out of plane bending. Pack rust build up at the adjacent joint has caused the diaphragm top flanges to translate differentially, resulting in cracking at the diaphragm upper copes.

Impact damage to the south fascia beam (F2-9) has caused a horizontal misalignment of the beam as well as a distortion to an interior stiffener.

The bent columns exhibit losses typically at the joint locations. The column bearings typically exhibit loss of the stiffeners and anchor bolts. Although several columns have reduced rating factors, the as-built condition still controls for four load cases **(See Table 41)**.

AS-INSPECTED COLUMN RATING FACTORS							
Section	Column	HS20 Inv	HS20 Opr	2F1 Opr	3F1 Opr	4F1 Opr	5C1 Opr
East Approach - Forward Section	100	0.89	1.48	3.35	1.70	1.99	1.52
	100A	0.83	1.38	2.72	1.92	1.72	1.91
	300	0.97	1.62	3.66	2.45	2.11	1.61
	300A	0.86	1.44	2.79	1.98	1.79	1.98
	207	0.86	1.43	2.99	2.01	1.77	1.83
	307	0.90	1.49	3.14	2.10	1.84	1.90
	408	0.74	1.23	2.57	1.73	1.51	1.60
	409	0.59	0.98	2.21	1.53	1.25	1.16
	410	0.73	1.21	2.73	1.71	1.47	1.60
	314	0.63	1.06	1.84	1.32	1.26	1.36
"A" indicates the portion of the column above the lower deck							

Table 41 – Controlling column rating factors and rating factors below 1.0 for eastern part of the Forward Section (numbers below 1.0 are red, controlling values are shaded)

The HS20 Inventory and Operating rating factors are controlled by the as-inspected floorbeams. However, the columns are still controlled by the as-built condition. A comparison between the as-built and as-inspected rating factors is presented in **Table 42**.

COMPARISON BETWEEN AS-BUILT AND AS-INSPECTED					
Section	Member	HS20 Inv		HS20 Opr	
		As-Built	As-Inspected	As-Built	As-Inspected
East Approach - Forward Section	FB 0	0.82	0.63	1.37	1.06
	FB 1	0.65	0.59	1.09	0.99
	FB 2	0.78	0.78	1.30	1.30
	FB 3	0.51	0.51	0.85	0.85
	FB 4	0.69	0.52	1.15	0.87
	FB 5	0.73	0.73	1.23	1.23
	FB 6	0.59	0.59	0.99	0.99
	FB 7	0.69	0.55	1.15	0.92
	FB 8	0.97	0.40	1.62	0.67
	FB 9	0.71	0.71	1.18	1.18
	FB 12	0.64	0.64	1.06	1.06
	FB 13	0.82	0.82	1.37	1.37
	FB 14	1.37	0.83	2.28	1.39
	Col 100	0.89	0.89	1.48	1.48
	Col 100A	0.83	0.83	1.38	1.38
	Col 300	0.97	0.97	1.62	1.62
	Col 300A	0.86	0.86	1.44	1.44
	Col 207	1.20	0.86	1.99	1.43
	Col 307	0.90	0.90	1.49	1.49
	Col 408	0.74	0.74	1.23	1.23
	Col 409	0.59	0.59	0.98	0.98
	Col 410	0.73	0.73	1.21	1.21
	Col 314	1.28	0.63	2.13	1.06

Table 42 – Comparison of as-built and as-inspected rating factors.

EAST APPROACH – LAKEFRONT TRESTLE SECTION (Volume VII)

The Lakefront Trestle superstructure is supported by two lines of longitudinal steel frames composed of riveted built-up beams and columns. Transverse floorbeams frame into the longitudinal frames and support rolled stringers. All of the stringers and select floorbeam cantilever brackets were replaced in the 1990 rehabilitation. During this rehabilitation cover plates were added to isolated locations on the both the north and south girders. For complete rating calculations refer to **Volume VII**.

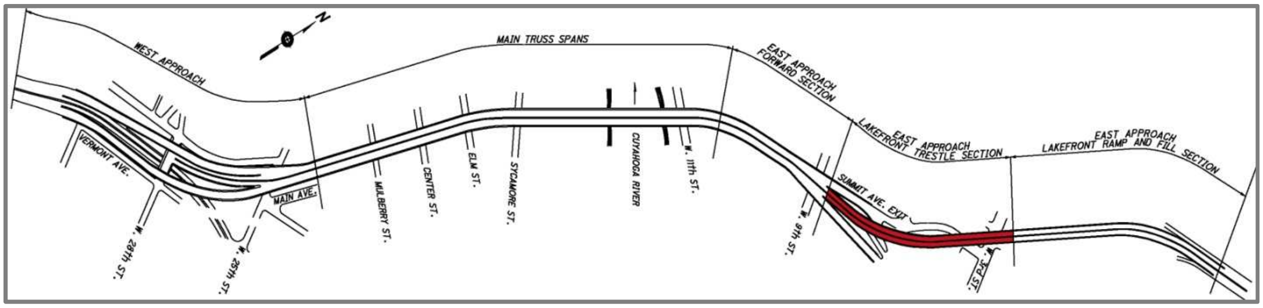


Figure 26 – Location of East Approach – Lakefront Trestle Section

A STAAD model of the entire Lakefront Trestle was created **(See Figure 27)**. The hinged columns were modeled as pinned-pinned while the remaining columns were modeled as fixed-fixed. The self weight was applied along with hand calculated dead loads. The live loads were applied by two different methods. In the tangent roadway portions a live load generation was used. In the curved roadway section moving point loads at the wheel locations were created by using a spreadsheet to locate the loads based on the geometry of the section.

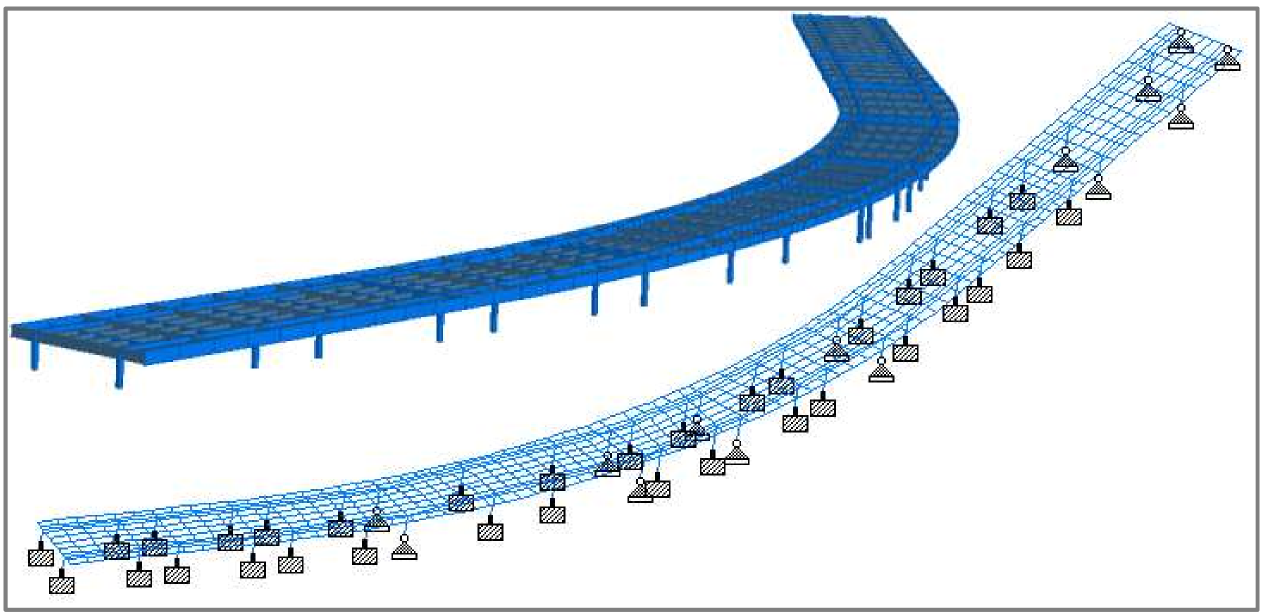


Figure 27 – A 3D rendering and line model of the Lakefront Trestle Section

Multiple stringers were coped at the floorbeam locations similar to the other approach sections. The coped sections were modeled in STAAD. The capacities of the stringers were calculated using spreadsheets. Multiple STAAD models were created to allow different live load scenarios that maximized the load effects on each stringer. The dead and live load force effects were taken from STAAD and input into rating spreadsheets. Twenty three stringers rated below 1.0 for HS20 inventory **(See Table 43)**. The stringers rated above 1.0 for all the operating load cases. The stringers were controlled by positive moment.

AS-BUILT / AS-INSPECTED STRINGER CONTROLLING RATING FACTORS							
Section	Member	HS20 Inv	HS20 Opr	2F1 Opr	3F1 Opr	4F1 Opr	5C1 Opr
East Approach - Lakefront Trestle Section	S2-1	0.95	1.59	2.44	1.70	1.61	1.78
	S3-1	0.91	1.52	2.39	1.66	1.55	1.73
	S4-1	0.89	1.49	2.37	1.64	1.53	1.71
	S5-1	0.92	1.53	2.40	1.67	1.57	1.74
	S6-1	0.96	1.60	2.46	1.72	1.62	1.80
	S4-2	1.00	1.66	2.56	1.86	1.73	1.95
	S1-5	0.81	1.36	2.15	1.46	1.40	1.61
	S2-5	0.74	1.24	1.93	1.35	1.28	1.43
	S3-5	0.98	1.63	2.40	1.72	1.62	1.80
	S4-5	0.95	1.59	2.41	1.71	1.60	1.75
	S5-5	0.97	1.62	2.54	1.76	1.62	1.78
	S6-5	1.00	1.67	2.57	1.83	1.66	1.84
	S7-5	0.95	1.59	2.37	1.71	1.63	1.81
	S3-14	0.99	1.66	2.81	1.88	1.72	1.96
	S7-15	0.94	1.57	3.60	1.77	1.64	1.87
	S5-19	0.99	1.66	2.85	1.92	1.75	2.02
	S6-19	0.99	1.65	2.85	1.92	1.74	2.01
	S7-19	1.00	1.67	2.82	1.89	1.75	1.99
	S7-21	0.88	1.46	2.32	1.59	1.47	1.65
	S6-1 (H)	0.99	1.66	2.48	1.72	1.57	1.73
	S2-4 (H)	0.99	1.65	2.38	1.70	1.53	1.72
	S3-4 to S6-4 (H)	0.99	1.65	2.39	1.71	1.53	1.72

Table 43 – Controlling stringer rating factors and rating factors below 1.0 for Lakefront Trestle Section (numbers below 1.0 are red, controlling values are shaded)

Different loading cases to maximize the positive moment, negative moment and shear force were created in different STAAD models. The capacities of the floorbeams were calculated using spreadsheets and these along with the force effects from the STAAD model were input into a rating spreadsheet. Sixteen floorbeams in the as-built condition rated below 1.0 for HS20 inventory **(See Table 44)**. The floorbeams in the as-built condition rated above 1.0 for the operating level load cases.

AS-BUILT FLOORBEAM CONTROLLING RATING FACTORS							
Section	Member	HS20 Inv	HS20 Opr	2F1 Opr	3F1 Opr	4F1 Opr	5C1 Opr
East Approah - Lakefront Trestle Section	FB A2	0.89	1.49	3.23	2.13	1.85	2.11
	FB B2	0.82	1.37	2.95	1.95	1.69	1.96
	FB C2	0.96	1.60	3.00	2.03	1.83	2.17
	FB C3	0.99	1.66	3.38	2.25	1.99	2.48
	FB C5	1.00	1.66	3.15	2.12	1.90	2.29
	FB C6	0.94	1.58	3.26	2.16	1.90	2.27
	FB C7	0.93	1.56	3.20	2.13	1.85	2.13
	FB C8	0.98	1.64	3.09	2.08	1.86	2.17
	FB D2	0.89	1.49	3.14	2.08	1.81	2.09
	FB F2	0.98	1.64	3.62	2.39	2.06	2.13
	FB G2	0.89	1.48	2.98	1.99	1.75	2.02
	FB G3	0.86	1.44	3.09	2.03	1.78	2.02
	FB G5	0.81	1.36	2.84	1.89	1.65	1.90
	FB H2	0.99	1.65	3.37	2.25	1.97	2.41
	FB H5	0.92	1.54	3.14	2.09	1.84	2.17
	FB H8	0.98	1.64	3.30	2.19	1.93	2.22
	FB H11	0.93	1.56	3.10	2.07	1.81	2.12

Table 44 – Controlling floorbeam rating factors and rating factors below 1.0 for Lakefront Trestle Section (numbers below 1.0 are red, controlling values are shaded)

Multiple STAAD models were created to maximize the loading on the north and the south girders independently. Since the girders are tapered, they were modeled as multiple sections with an average of the height within that section. The capacities for each section were calculated using spreadsheets. These capacities and the force effects from the STAAD model were input into a rating spreadsheet. Both girders rate above 1.0 for all loading cases **(See Table 45)**. The pin and links in the girders were also rated. They were checked for shear, compression, and bearing. The pin and links rated above 1.0 for all load cases **(See Table 46)**.

AS-BUILT / AS-INSPECTED GIRDER CONTROLLING RATING FACTORS							
Section	Member	HS20 Inv	HS20 Opr	2F1 Opr	3F1 Opr	4F1 Opr	5C1 Opr
Lakefront Trestle	North Girder	1.11	1.86	3.95	2.64	2.34	2.06
	South Girder	1.05	1.75	3.65	2.42	2.12	2.18

Table 45 – Controlling girder rating factors and rating factors below 1.0 for Lakefront Trestle Section (numbers below 1.0 are red, controlling values are shaded)

AS-BUILT / AS-INSPECTED PIN & LINK CONTROLLING RATING FACTORS							
Section	Member	HS20 Inv	HS20 Opr	2F1 Opr	3F1 Opr	4F1 Opr	5C1 Opr
Lakefront Trestle	34 North	2.47	4.13	8.68	5.79	5.06	5.76

Table 46 – Controlling pin & link rating factors and rating factors below 1.0 for Lakefront Trestle Section (numbers below 1.0 are red, controlling values are shaded)

The models for the girders also maximize the loads on the columns. The column capacities were calculated using spreadsheets. The properties for the columns of Bents 24 and 25 **(See Figure 28)** were calculated by drawing the section in Microstation and using the "Mass Properties" tool to obtain the desired section properties. The final properties were calculated using a spreadsheet so the properties were about the desired axes. The axial forces and moments were taken from the STAAD model and input into a customized rating sheet. The pinned columns were rated only for axial loads and the remaining columns were rated based upon an axial-moment interaction. The columns rate above 1.0 for all the load cases **(See Table 47)**.

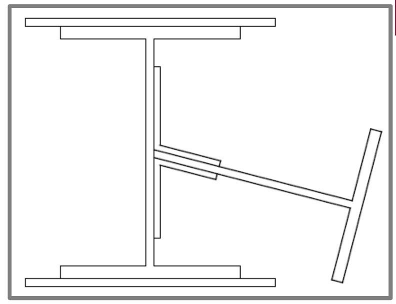


Figure 28 – Typical column cross section for Bents 24 and 25 (East Approach – Lakefront Trestle)

AS-BUILT / AS-INSPECTED COLUMN CONTROLLING RATING FACTORS							
Section	**Member**	**HS20 Inv**	**HS20 Opr**	**2F1 Opr**	**3F1 Opr**	**4F1 Opr**	**5C1 Opr**
Lakefront Trestle	33 South	2.21	3.69	5.07	3.38	2.93	2.26

Table 47 – Controlling column factors and rating factors below 1.0 for Lakefront Trestle Section (numbers below 1.0 are red, controlling values are shaded)

Isolated girders exhibit section loss on the web near the joints and pin and links. Most of these locations have been cleaned and painted, but others exhibit active corrosion and rust. Pack rust is forming between some of the pin plates, however the pin and link assemblies exhibited signs of movement in the most recent inspection. Pack rust between the girder bottom flange cover plates and wind shear plates was noted in the field; in isolated locations the pack rust is causing the connection bolts to be loose **(See Photo 14)**. Typically the as-inspected locations on the girders did not coincide with the critical sections and the as-inspected ratings are above 1.0. The as-built conditions condition controls the girder rating.

Photo 14 – Pack rust between South Girder bottom flange and wind shear plate at Bent 29. Note bolts have backed off nuts.

Isolated floorbeams exhibited section loss. The loss is typically more severe on floorbeams at joint locations. Several floorbeams were noted to have loss on the web and on the flanges. Of the floorbeams that rated below 1.0 in the as-built condition, six had section loss that resulted in lower as-inspected rating factors. One floorbeam that rated above 1.0 in the as-built condition rates below 1.0 in the as-inspected condition **(See Table 48)**.

AS-INSPECTED FLOORBEAM CONTROLLING RATING FACTORS							
Section	Member	HS20 Inv	HS20 Opr	2F1 Opr	3F1 Opr	4F1 Opr	5C1 Opr
East Approach - Lakefront Trestle	FB A2	0.87	1.46	3.16	2.09	1.81	2.06
	FB A5	0.94	1.57	3.05	2.07	1.83	2.09
	FB B2	0.82	1.37	2.95	1.95	1.69	1.96
	FB C2	0.92	1.53	2.87	1.94	1.75	2.08
	FB C3	0.95	1.59	3.24	2.16	1.90	2.38
	FB C5	0.95	1.59	3.01	2.03	1.82	2.19
	FB C6	0.90	1.50	3.10	2.06	1.81	2.16
	FB C7	0.93	1.56	3.20	2.13	1.85	2.13
	FB C8	0.98	1.64	3.09	2.08	1.86	2.17
	FB D2	0.89	1.49	3.14	2.08	1.81	2.09
	FB F2	0.98	1.64	3.62	2.39	2.06	2.13
	FB G2	0.89	1.48	2.98	1.99	1.75	2.02
	FB G3	0.86	1.44	3.09	2.03	1.78	2.02
	FB G5	0.81	1.36	2.84	1.89	1.65	1.90
	FB H2	0.99	1.65	3.37	2.25	1.97	2.41
	FB H5	0.92	1.54	3.14	2.09	1.84	2.17
	FB H8	0.98	1.64	3.30	2.19	1.93	2.22
	FB H11	0.93	1.56	3.10	2.07	1.81	2.12
	FB H12	0.96	1.61	2.93	1.94	1.72	1.98

Table 48 – Controlling floorbeam rating factors and rating factors below 1.0 for Lakefront Trestle Section (numbers below 1.0 are red, controlling values are shaded)

Although deterioration is present, the as-built condition still controls the overall rating of the floorbeams. The floorbeams rate above 1.0 for the operating load cases.

COMPARISON BETWEEN AS-BUILT AND AS-INSPECTED					
Section	Member	HS20 Inv		HS20 Opr	
		As-Built	As-Inspected	As-Built	As-Inspected
East Approach - Lakefront Trestle	FB A2	0.89	0.87	1.49	1.46
	FB A5	1.00	0.94	1.67	1.57
	FB B2	0.82	0.82	1.37	1.37
	FB C2	0.96	0.92	1.60	1.53
	FB C3	0.99	0.95	1.66	1.59
	FB C5	1.00	0.95	1.66	1.59
	FB C6	0.94	0.90	1.58	1.50
	FB C7	0.93	0.93	1.56	1.56
	FB C8	0.98	0.98	1.64	1.64
	FB D2	0.89	0.89	1.49	1.49
	FB F2	0.98	0.98	1.64	1.64
	FB G2	0.89	0.89	1.48	1.48
	FB G3	0.86	0.86	1.44	1.44
	FB G5	0.81	0.81	1.36	1.36
	FB H2	0.99	0.99	1.65	1.65
	FB H5	0.92	0.92	1.54	1.54
	FB H8	0.98	0.98	1.64	1.64
	FB H11	0.93	0.93	1.56	1.56
	FB H12	1.36	0.96	1.79	1.61

Table 49 – Comparison of as-built and as-inspected rating factors.

EAST APPROACH – LAKEFRONT RAMP SECTION (Volume VIII)

The Lakefront Ramp Section (Section I) consists of 3 riveted, built-up haunched plate girders with rolled floorbeams and stringers. The girders are supported by steel encased concrete columns. All of the stringers and select floorbeam brackets were replaced in the 1990 rehabilitation. For complete rating calculations refer to **Volume VIII**.

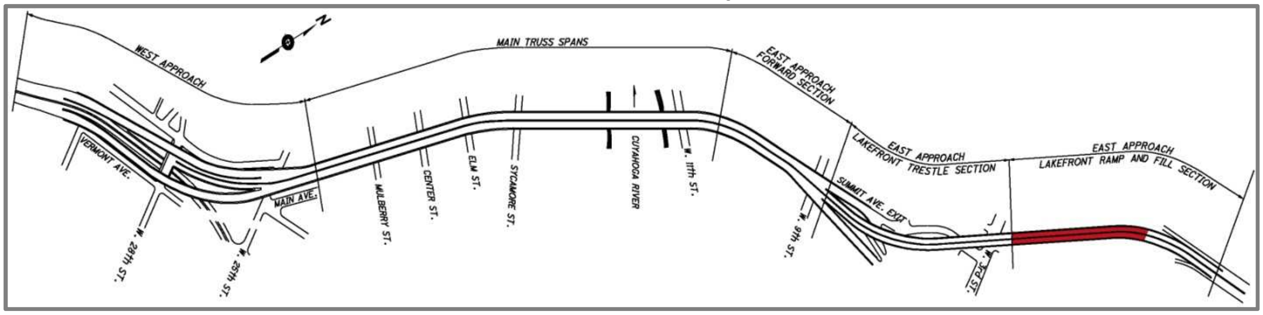


Figure 29 – Location of East Approach – Lakefront Ramp Section

Based upon geometry and section properties, the stringers that would control were selected and rated. The capacities were calculated using spreadsheets. The dead and live load effects on the stringers were calculated with CONSYS. The stringers were rated using spreadsheets and the interior stringers control. The interior stringers typically rate below 1.0 for HS20 Inventory **(See Table 50)**. The stringers rate above 1.0 for all of the Ohio Legal Load operating load cases.

Similar to the stringers, the floorbeams, including the cantilever brackets, were rated based upon which members had the controlling geometry and section properties. The load effects were taken from hand calculations and CONSYS and the capacities were calculated using spreadsheets. The floorbeams rate above 1.0 for all the load cases **(See Table 51)**.

Photo 15 – North elevation of North Girder in the East Approach – Lakefront Ramp Section

AS-BUILT / AS-INSPECTED STRINGER CONTROLLING RATING FACTORS							
Section	Member	HS20 Inv	HS20 Opr	2F1 Opr	3F1 Opr	4F1 Opr	5C1 Opr
Lakefront Ramp Section	Units 12, 15, 16, 17	0.67	1.11	1.80	1.48	1.72	1.48
	Units 13 & 18	0.55	0.91	1.46	1.72	2.08	1.72
	Units 14 & 19	0.54	0.90	1.45	1.70	2.07	1.70

Table 50 – Controlling stringer factors and rating factors below 1.0 for Lakefront Ramp Section (numbers below 1.0 are red, controlling values are shaded)

AS-BUILT / AS-INSPECTED FLOORBEAM CONTROLLING RATING FACTORS							
Section	Member	HS20 Inv	HS20 Opr	2F1 Opr	3F1 Opr	4F1 Opr	5C1 Opr
Lakefront Ramp	FB 99	1.02	1.71	2.83	1.98	2.08	1.96
	FB 112	1.01	1.69	2.89	2.04	2.19	2.01

Table 51 – Controlling floorbeam factors and rating factors below 1.0 for Lakefront Ramp Section (numbers below 1.0 are red, controlling values are shaded)

Spans 2, 3, and 4 of the North and Center Girders and Spans 2 and 4 of the South Girder are greater than 200 feet. Therefore the girders were analyzed with truck train loading for HS20 (inventory and operating) and for Ohio Legal Load 5C1 (Operating). The truck train loadings were performed using 2D STAAD models. The single truck loadings for the other Ohio Legal Loads (2F1, 3F1, and 4F1) were performed using CONSYS. The capacities of the girders were calculated using spreadsheets. The capacities and load output from the analysis software was input into a girder rating spreadsheet. The North and South Girders rate below 1.0 for HS20 Inventory **(See Table 52)**. All three girders rate above 1.0 for the operating load cases.

AS-BUILT GIRDER CONTROLLING RATING FACTORS							
Section	Member	HS20 Inv	HS20 Opr	2F1 Opr	3F1 Opr	4F1 Opr	5C1 Opr
Lakefront Ramp	North Girder	0.83	1.38	5.70	3.79	3.25	2.00
	Center Girder	1.11	1.85	7.00	4.66	4.01	3.15
	South Girder	0.89	1.49	5.39	3.57	3.09	1.88

Table 52 – Controlling girder factors and rating factors below 1.0 for Lakefront Ramp Section (numbers below 1.0 are red, controlling values are shaded)

The columns were treated as short columns that only experience axial loading. The simply supported main girders bear on individual columns. The column capacities and dead loads were calculated using a MathCAD spreadsheet. The live load force effects on the columns were calculated using STAAD and CONSYS. Similar to the girders, truck train loadings were used for HS20 (inventory and operating) and 5C1 (operating), while single truck loadings were used for the 2F1, 3F1, and 4F1 vehicles. The columns rate above 1.0 for all load cases **(See Table 53)**.

AS-BUILT / AS-INSPECTED COLUMN CONTROLLING RATING FACTORS							
Section	Member	HS20 Inv	HS20 Opr	2F1 Opr	3F1 Opr	4F1 Opr	5C1 Opr
Lakefront Ramp	Pier 38	13.14	21.95	284.13	185.32	157.90	28.10

Table 53 – Controlling column factors and rating factors below 1.0 for Lakefront Ramp Section (numbers below 1.0 are red, controlling values are shaded)

Most of the conditions noted in the field inspections did not affect the rating because the location of loss typically was not located at the critical sections. The south cantilevered bracket at Floorbeam 1 exhibits heavy pitting on the bottom flange and web. The floorbeams in the Lakefront Ramp section typically exhibit minor pitting with isolated floorbeams having advanced section loss. The floorbeams in the as-inspected condition all rate higher than the as-built conditions.

The access road from West 3rd Street to the Route 2 Eastbound on-ramp runs below Unit 18 of the Lakefront Ramp. The south girder exhibits impact damage at this location with missing rivet heads **(See Photo 16)**. Just west of Pier 38, the south girder exhibits a 2.5 in^2 area of 100% section loss in the web. Similar to the Lakefront Trestle, isolated locations along the girders were noted to have pack rust between the cover plates. Although no section loss was noted, the girder ends at Pier 37 exhibit active rust. The as-built condition of the North Girder controls all the loading cases except for the 5C1 Ohio Legal Load which is controlled by the as-inspected condition of the South Girder **(See Table 54)**.

Photo 16 – Impact to the South Girder in the Lakefront Ramp. Note scraping and rivet heads sheared off.

AS-INSPECTED GIRDER CONTROLLING RATING FACTORS							
Section	Member	HS20 Inv	HS20 Opr	2F1 Opr	3F1 Opr	4F1 Opr	5C1 Opr
Lakefront Ramp	North Girder	0.83	1.38	5.70	3.79	3.25	2.00
	Center Girder	1.11	1.85	7.00	4.66	4.01	3.15
	South Girder	0.88	1.46	7.22	4.82	4.16	1.84

Table 54 – Controlling girder rating factors and rating factors below 1.0 for Lakefront Ramp Section (numbers below 1.0 are red, controlling values are shaded)

The as-inspected condition of the South Girder results in a slightly lower rating factor than the as-built condition. The section loss on the North Girder does not occur at the critical section, so the as-built and as-inspected controlling rating factors are the same.

COMPARISON BETWEEN AS-BUILT AND AS-INSPECTED					
Section	Member	HS20 Inv		HS20 Opr	
		As-Built	As-Inspected	As-Built	As-Inspected
Lakefront Ramp	North Girder	0.83	0.83	1.38	1.38
	Center Girder	1.11	1.11	1.85	1.85
	South Girder	0.89	0.88	1.49	1.46

Table 55 – Comparison of as-built and as-inspected rating factors.

GUSSET PLATES – MAIN TRUSS SPANS AND SPAN 11 (Volume IX)

TranSystems performed a gusset plate load rating for the Main Truss and Span 11 gusset plates in 2010. The analysis was based upon the 2009 Special In-Depth inspection of the gusset plates. Truss axial forces were taken from the 1996 "Main Avenue Bridge Analysis and Rating" submitted by Richland Engineering. As part of the 2012 Load Rating Analysis, TranSystems updated the 2010 Gusset Plate Load Rating Analysis with truss axial forces taken from the 3D STAAD models. For a detailed explanation of assumptions and methodology in the 2010 load rating report, refer to the "Gusset Plate Load Rating Report" submitted on April 14, 2011.

The Load Factor Rating was performed using a modified version of the 2009 Rating Excel spreadsheet provided by the ODOT Office of Structural Engineering that is based upon the FHWA Load Rating Guidance and Examples for Bolted and Riveted Gusset Plates in Truss Bridges (FHWA-IF-09-014). Modifications allow the vertical members to be non-perpendicular to the chord and as-inspected losses columns were added to allow for individual losses for Tensile, Whitmore, and Shear regions for each gusset plate.

Modifications from the 2010 gusset plate load rating are as follows:

1. Plate dimensions for the North Truss gusset plates at L126, U113, U115 and U123 were adjusted based upon field measurements. These dimensions had previously been assumed as equal to the South Truss due to missing original shop drawings.
2. Where floorbeams were replaced during the 1990 rehabilitation, high strength bolts replaced rivets in the rating sheet. 188 gusset plates were affected.
3. HS20 and 5C1 Truck Trains were analyzed during the 2012 Load Rating. These loading conditions were not considered during either the 1996 or 2010 load ratings.

Seven gusset plates rate less than 1.00 for Ohio Legal Loads after applying revised loads to the gusset plate rating spreadsheets, whereas all plates rated higher than 1.00 in the 2010 load rating (See Table 56). These seven gusset plates are controlled by connector capacity. There are 323 of 544 gusset plates which rate below 1.00 for HS20 Inventory and 21 plates with HS20 Operating rating factors less than 1.00.

AS-BUILT GUSSET PLATE CONTROLLING RATING FACTORS									
Truss	Panel Point	HS20 Inv	HS20 Opr	2F1 Opr	3F1 Opr	4F1 Opr	5C1 Opr	HS-20 Truck Train	5C1 Truck Train
North	U110	0.26	0.43	1.49	0.97	0.84	0.61	0.45	0.49
	U127	0.28	0.47	1.18	0.77	0.67	0.51	N/A	N/A
	U135	0.42	0.70	1.80	1.18	1.02	0.76	N/A	N/A
South	U110	0.36	0.60	1.99	1.30	1.11	0.82	0.61	0.66
	U127	0.34	0.56	1.46	0.97	0.85	0.61	N/A	N/A
	U128	0.29	0.48	1.21	0.80	0.71	0.56	N/A	N/A
	U135	0.34	0.57	1.49	0.98	0.86	0.66	N/A	N/A

Table 56 – Controlling gusset plate as-built rating factors and plates with Ohio Legal Loads less than 1.0 (numbers below 1.0 are red, controlling values are shaded).

The existing rivet yield strength based on the ASTM steel type (per original shop drawings, See Figure 30) is 28 ksi. Replacing rivets with high strength bolts will increase the rivet yield strength to 43.75 ksi.

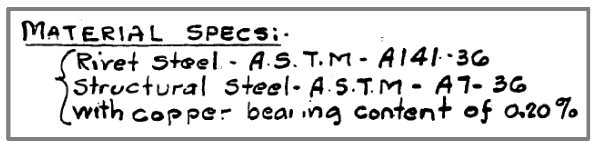


Figure 30 – Material specifications from original truss shop drawings

The North Truss and South Truss have 90 plates and 92 plates respectively that do not meet the free edge stiffness requirements of AASHTO 10.16.13.3. The free edge stiffness is dependent upon the ratio of the unstiffened length of the plate to the plate thickness. It is an indication of the possibility of localized buckling of the plate.

As-Inspected conditions for each gusset plate include Pocket UT data taken during the 2009 Special In-Depth Gusset Plate Inspection as well as conditions noted during the 2011 In-Depth Rehabilitation Level Inspection. Rating factors controlled by rivet capacity do not change between the As-Built and As-Inspected condition due to no measurable section loss being found on the shaft of rivets. Table 57 identifies the controlling As-Inspected gusset plates and all plates with Ohio Legal Load rating factors less than 1.00. There are 323 of 544 gusset plates which rate below 1.00 for HS20 Inventory and 22 plates with HS20 Operating rating factors less than 1.00.

AS-INSPECTED GUSSET PLATE CONTROLLING RATING FACTORS									
Truss	Panel Point	HS20 Inv	HS20 Opr	2F1 Opr	3F1 Opr	4F1 Opr	5C1 Opr	HS-20 Truck Train	5C1 Truck Train
North	U110	0.26	0.43	1.49	0.97	0.84	0.61	0.45	0.49
	U127	0.28	0.47	1.18	0.77	0.67	0.51	N/A	N/A
	U135	0.42	0.70	1.80	1.18	1.02	0.76	N/A	N/A
	L59	0.45	0.76	2.23	1.47	1.26	0.95	0.78	0.86
South	U110	0.36	0.60	1.99	1.30	1.11	0.82	0.61	0.66
	U127	0.34	0.56	1.46	0.97	0.85	0.61	N/A	N/A
	U128	0.29	0.48	1.21	0.80	0.71	0.56	N/A	N/A
	U135	0.34	0.57	1.49	0.98	0.86	0.66	N/A	N/A

Table 57 – Controlling gusset plate as-inspected rating factors and plates with Ohio Legal Loads less than 1.0 (numbers below 1.0 are red, controlling values are shaded).

Panel Point L59 of the North Truss exhibits a 5C1 Rating Factor of 0.95 due to 15% section loss of both gusset plates along the bottom chord under the vertical member (See Chart 2). This section loss negatively affects the capacity of the gusset plates for local compression buckling under Whitmore Effective Width. Gusset plate L59 exhibits an Ohio Legal Load rating factor within the 5% allowance for not requiring a bridge posting.

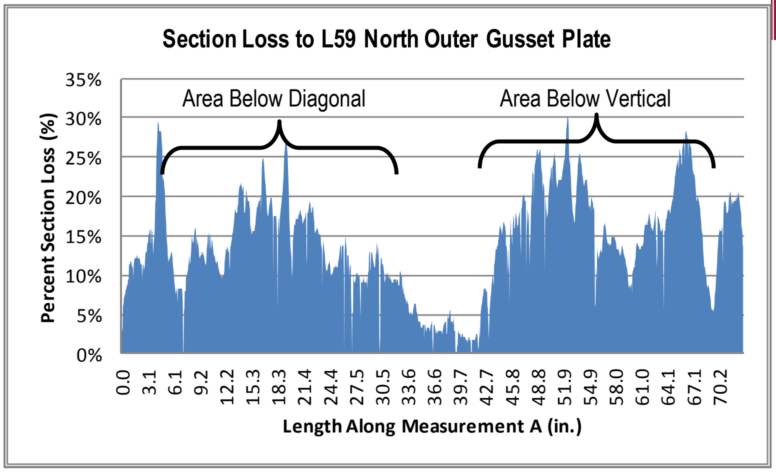


Chart 2 – Section loss to L59 North Outer Gusset Plate along intersection with bottom chord.

COMPARISON WITH 2010 LOAD RATING RESULTS

Increases in dead loads, as discussed in the **Main Truss – Volume V** section, have negatively impacted both As-Built and As-Inspected rating factors throughout the structure **(See Table 58)**. Seven (7) gusset plates rate below 0.95 for Ohio Legal Loads in the 2012 analysis, requiring posting of the bridge. Bridge posting was not necessary with the 2010 results as no Ohio Legal Load rating factors were less than 0.95. In the 2010 analysis, there were no As-Inspected conditions that caused Ohio Legal Loads to rate less than 1.00, compared to one (1) in the 2012 rating with a rating factor of 0.95 for 5C1 (within the allowable 5% to not require bridge posting).

	Year-to-Year Comparison As-Inspected Condition	
	2010 (with 1996 Forces)	2012 (with 3D STAAD Forces)
Ohio Legal Load RF < 0.95 (Requires Posting)	0	7
Lowest Ohio Legal Load RF	0.98	0.51
0.95 < Ohio Legal Load RF < 1.00 (No Posting Required)	1	1
HS-20 (Inventory) RF < 1.00	138	323
HS-20 (Operating) RF < 1.00	8	22
Lowest HS-20 (Operating) RF	0.77	0.43

Table 58 – Variations between 2010 Load Rating Analysis based on 2D STAAD Model Forces and 2012 Load Rating Analysis based on 3D STAAD Model Forces.

FATIGUE SUMMARY

The ODOT bridge design manual requires the finite remaining life to be calculated based upon the BDM and AASHTO's *Guide Specification for Fatigue Evaluation of Existing Steel Bridges*, 1990 and all Interims. The finite remaining life (Y_f) is calculated by multiplying the fatigue life based on future volume (Y_N) by a factor. The factor is dependent upon the present age (Y_P) of the bridge and fatigue life based upon past volumes of traffic (Y_1). The remaining life will be the shortest when both Y_N and Y_1 are minimized. The fatigue life is most dependent upon the stress range experienced by the member (S_r), the fatigue category detail (K), and the reliability factor (R_S) **(See Figure 31)**.

$$Y_f = Y_N\left[1-\frac{Y_P}{Y_1}\right] \qquad Y_N = \frac{fK\times 10^6}{T_N C\left(R_S S_r \frac{W_N}{W}\right)^3} \qquad Y_1 = \frac{fK\times 10^6}{T_P C\left(R_S S_r \frac{W_P}{W}\right)^3}$$

Figure 31 – Finite remaining life equations per AASHTO's *Guide Specification for Fatigue Evaluation of Existing Steel Bridges*, 1990

There are two types of life that can be calculated: mean life and safe life. The remaining "mean life" is a lifespan that will most accurately predict the number of remaining years. The remaining "safe life" is a very conservative calculation for the number of years remaining for a particular member. The degree of safety for "safe life" is so high that AASHTO's *Guide Specification for Fatigue Evaluation of Existing Steel Bridges*, 1990 states "…the probability that the actual remaining life will exceed the remaining safe life is 97.7 percent for redundant members and 99.9 percent for nonredundant members." The stringers in each section were treated as redundant members, while the floorbeams and girders (since there are three or less) were treated as non-redundant members.

The stress range was produced by using a single HS-15 truck (fatigue truck) **(See Figure 32)**. An impact of 15% was used per the BDM. The average daily truck volume (T_P) was calculated by multiplying the fraction of trucks in the outer lane (F_L) by the actual average daily truck volume (ADT). The fraction, F_L, is taken from the AASHTO Guide Specifications and is based upon the number of lanes and 2-way traffic. The ADT was taken from the 2010 traffic count data on ODOT's website.

	Load Designation	Load Configuration	Gross Weight
AASHTO	HS15-44	6 k — 14' — 24 k — 30' — 24 k	27 Tons

Figure 32 – Fatigue Truck Configuration

The details on the bridge ranged from Category B to Category E **(See Figure 33)**. Base metal Category A details were not analyzed.

TYPICAL FATIGUE DETAILS		
Category	**Detail Description**	**Example**
B	Bolted connections	Coped Stringers with bolted angles
		Bolted cover plates
C	Stiffener welded to flanges	Intermediated transverse stiffener welded to a stringer
D	Riveted connections	Built-up girders and floorbeams with rivets
		Floorbeams with riveted stiffeners
E	Partial length welded cover plate	Welded plate on cantilever brackets in Sections C and K

Figure 33 – Typical fatigue categories and details.

Six sections of the bridge were calculated to have no remaining fatigue life **(See Table 59)**. The controlling member for each section is a non-redundant member. This is expected because the fatigue life based on past volume (Y_1) and the fatigue life based upon future volume (Y_N) are reduced by a factor of 4.9 compared to a redundant member. The stringers, including coped stringers, are based on continuous analysis.

Location		Detail	Category	Finite Remaining Fatigue Life
West Approach	Section K	Floorbeam welded cover plate	E	-7 years
	Section L	Riveted floorbeam stiffener	D	-23 years
	Section C	Floorbeam welded cover plate	E	-6 years
	Section N	Riveted floorbeam bracket	D	70 years
Main Truss Spans	Framing	Riveted floorbeam bracket	D	105 years
	Truss	Riveted built-up diagonal	D	51 years
East Approach	Forward Section (Span 11)	Riveted floorbeam bracket	D	51 years
	Forward Section (Eastern Part)	Riveted floorbeam splice	D	-12 years
	Lakefront Trestle	Riveted floorbeam with section loss	D	-29 years
	Lakefront Ramp	Riveted floorbeam bracket	D	-30 years

Table 59 – Fatigue Summary showing remaining life in years.

CONCLUSIONS

Based on the results of the structural analysis and the 2011 In-Depth Inspection Report, TranSystems has concluded that the *General Appraisal & Operational Status,* of CUY-2-1441 should be downgraded to **4P – Poor – Posted for load-carrying capacity restriction**. *Please note that at the date of this final report, the bridge has been posted to restrict Ohio Legal Truck Loads.*

Bridge load rating calculations provide a basis for determining the safe load capacity of a bridge. Load ratings require engineering evaluation in determining a rating value that is applicable to maintaining the safe use of the bridge and arriving at posting and permit decisions. A rating factor of less than 1.00 indicates that the structure does not have sufficient capacity to carry the specified loading. TranSystems performed a structural analysis and load rating on the as-built structure and the as-inspected structure in order to reflect changed conditions in the superstructure.

Based upon the rating analysis, two gusset plates in the North Truss (U110 and U127) were determined to control the overall rating of the structure. The gusset plate ratings are typically controlled by the rivet connector capacity. The controlling rating factors along with tonnages are presented in **Table 60**. The ratings of the primary structural elements were generally governed by as-built conditions, although select members' ratings were reduced due to section loss.

Controlling Rating Factors					
Load		Gusset Plate	Rating Factor	Tonnage	Equivalent
HS20	Inventory	U110	0.26	9	HS5.2
	Operating	U110	0.43	15	HS8.6
Ohio Legal Loads (operating)	2F1	U127	1.18	17	49%
	3F1	U127	0.77	17	
	4F1	U127	0.67	18	
	5C1	U127	0.51	20	
	5C1 Truck Train	U110	0.49	19	

Table 60 – Overall controlling rating factors

Per Section 918.3 of the *2004 ODOT Bridge Design Manual (October 2011 Interim)*, when a rating factor is less than 1.00 the bridge shall be posted if it cannot immediately be strengthened to produce a calculated rating factor greater than 1.00. The safe posting loads for the bridge are calculated by dividing the truck weight by a constant and then multiplying by a reduced rating factor. The safe posting load is then rounded to the nearest ton. The tonnage on Bridge CUY-2-1441 is recommended to be restricted by posting the bridge as follows:

Ohio Legal Truck	Ohio Legal Truck (Tons)	Safe Posting Load (Tons)
2F1	15	15
3F1	23	15
4F1	27	14
5C1	40	11

The restriction on loading should remain in place until repairs are made that will raise the rating factors for all members above 1.0 for the Ohio Legal Loads.

RECOMMENDATIONS

The recommendations presented in this report are intended to provide a short and long term rehabilitation plan to ensure the CUY-2-1441 – Main Avenue Bridge has an extended service life and to maintain a safe load capacity for the traveling public. These recommendations are based on the results of the load rating analysis, the *2011 In-Depth Physical Condition Report* submitted March 2012, and discussion held with ODOT personnel on May 29, 2012 at District 12.

We present our recommendations for CUY-2-1441 in the following three phases:

Phase 1 - Priority Work:	Work which should be performed as soon as possible to address deficiencies which affect the capacity of the structure and require the posting of the bridge.
Phase 2 - Rehabilitation:	Recommendations for large-scale deficiencies which are extensive in nature and require engineering analysis.
Phase 3 - Bridge Painting & Joint Replacement:	Continue the long term maintenance program of providing a protective paint system and replacing the joints to prevent deterioration of the structural components of the bridge.

Phase 1 - Priority Repairs

The Phase 1 – Priority Repair items are the bridge elements that were found to be structurally deficient due to the insufficient safe load capacity of the members. Twelve (12) members are not adequate to carry the Ohio Legal Truck Loads and therefore govern the recommended load restriction for the bridge.

TranSystems recommends these members be rehabilitated to provide a capacity of 110% or greater for the Ohio Legal Loads (Rating Factor = 1.1) based on the following four repair Items:

Item 1: At the seven (7) locations where the gusset plates are overstressed due to rivet capacity limitations, TranSystems recommends the rivet groupings for the truss member chords be replaced with high strength bolts. A table identifying these plates **(Table C1)** along with a schematic elevation **(Figure C1)** can be found in **Appendix C**

Item 2: For the one (1) location where the gusset plate is overstressed due to local compression buckling, it is recommended to strengthen the gusset plates with additional structural steel plates. A table identifying this plate **(Table C1)** along with a schematic elevation **(Figure C1)** can be found in **Appendix C**.

Item 3: Stringers S14-7 and S15-7 in the East Approach-Forward Section are recommended to be strengthened to raise their rating factors above 1.1 for the Ohio Legal Loads. Both stringers are being overstressed in the positive moment region at the midspan of the beam **(Appendix C Table C2)**. TranSystems recommends a partial length positive moment cover plate should be bolted to the bottom flange of each beam.

Item 4: Floorbeams 3 and 8, in the Forward Section, have a rating factor below 1.0 in the negative moment region for the Ohio Legal Loads **(Appendix C Table C2)**. TranSystems recommends strengthening these members in the negative moment region by bolting cover plates to the undersides of the top flanges over the column locations.

Phase 1 - Construction Cost Estimate					
*retrofit will raise Ohio Truck Legal Load rating factors to 1.1 or greater					
Item	Location	Description of Work	Number of Retrofits	Cost per Retrofit	Estimated Total Cost
1	Truss	Gusset Plates - replace select rivets with high strength bolts*	7 panel pts	$26,000.00	$182,000.00
2	Truss	Gusset Plates - strengthen gusset plate*	1 panel pts	$206,500.00	$206,500.00
3	Forward Section	Stringer - add positive moment cover plate*	2 each	$10,000.00	$20,000.00
4	Forward Section	Floorbeams - add negative moment cover plates*	2 each	$27,500.00	$55,000.00
5	Truss & Fwd Sec	Zone painting in repair areas	484 SF	$29.50	$14,500.00
6	General	Maintaining Traffic	1 lump	$15,000.00	$15,000.00
7	General	Mobilization	1 lump	$50,000.00	$50,000.00
Phase 1 Total					$543,000.00

Phase 2 – Rehabilitation Repairs

The Phase 2 - Rehabilitation Repairs are intended to repair structural deficiencies and to address maintenance items that affect the long term service life of the bridge. The deficiencies may include structural members exhibiting advanced section loss, but do not restrict the load posting of the bridge. The maintenance repairs do not affect the capacity of the structure; however, they are necessary to prevent further deterioration of the bridge components or to improve the serviceability of the bridge. All structural repairs are recommended to increase the members capacity to 110% or greater for the Ohio Legal Loads.

Item 1: The apartment building on the southeast corner of West 10th Street and Main Avenue borders the south side of the East Approach – Forward Section of the bridge **(See Photo 17)**. An access driveway and sidewalk adjoin the lower utility deck of the Forward Section **(See Photo 18)**. At the eastern end of the access driveway there is a small gap (1/2") between the south fascia stringer top flange and edge of the driveway. Just west of this is a section along the joint covered by pieces of lumber. The remaining length consists of a rigid joint material on top of the fasica stringer flange. The joint is connected to the edge of the concrete sidewalk. The sidewalk and driveway appear to be completely supported by the apartment building. The vibration of the building may be reduced by removing the joint material between the lower deck and sidewalk and by ensuring there is a gap between the stringer flanges and driveway/sidewalk.

Photo 17 – On Main Avenue, looking up and east at apartment building and lower deck of Forward Section.

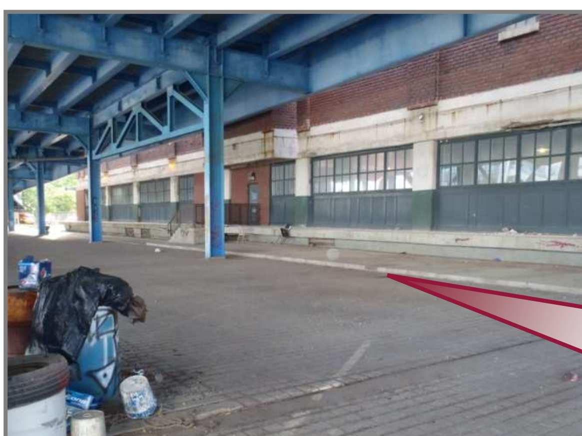
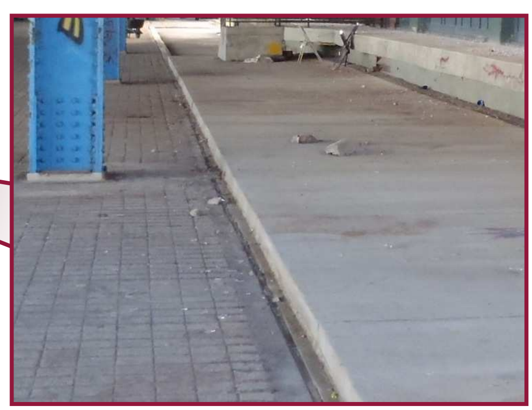


Photo 18 – Looking south from lower deck at apartment building and lower deck.



Item 2: The drainage system throughout the entire structure is generally in poor condition. The open trough drainage system on the truss spans allows water to spill onto adjacent truss members. Leaking joints, misaligned/broken pipes, and clogged pipes throughout all the sections are contributing to advanced section loss to members in those areas. It is recommended that the deteriorated members and open trough drainage components be replaced with a closed drainage system. Since complete joint replacement is not practical for this phase the joints should be sealed with Wabo HSeal or EMSeal.

Item 3: Four impact attenuators at different locations on the bridge exhibit damage and should be replaced.

Item 4: Isolated truss chords have internal diaphragms with severe losses that should be replaced.

Item 5: The windlock assemblies exhibit advanced section loss and should be repaired.

Items 6: The north cantilever bracket at Floorbeam 96 in the main truss spans exhibits a 3 1/8" long crack in the web initiating at a vertical stiffener weld. It is recommended to grind out the top of the weld at this location and drill crack arrest holes into the web of the bracket to prevent further propagation of the crack.

Item 7-9: Several truss members, gusset plates, and floorbeams that rate above 110% for Ohio Legal Loads in the truss spans still exhibit advanced section loss and are located in areas where future corrosion is imminent. A description of the loss and the controlling Ohio Legal Load rating factors can be found in **Appendix C Tables C3-C5**. It is recommended that these members be retrofitted in a similar manner to those being rehabilitated in Phase 1 to raise the rating factors by adding structural steel or replacing rivets.

Item 10: The south girder in the Lakefront Ramp has several rivets sheared off due to collision damage. It is recommended to remove the damaged rivets and replace them with high strength bolts

Item 11: A stringer in the Forward Section has also sustained impact damage. It is recommended to heat straighten this stringer and replace the distorted vertical web stiffener

Item 12-14: Similar to the truss spans, the approach spans have floorbeams and columns that exhibit advanced losses, but rate above 110% for Ohio Legal Loads **(Appendix C Table C6)**. TranSystems recommends retrofitting these with flange cover plates and additional web plates where necessary.

Items 15: Isolated panel points exhibit bowing of the gusset plates. It is recommended that plates bowed more than 1/8" be stiffened. The recommended retrofit is to bolt a structural steel angle along the free edge.

Item 16: Although Section P rates satisfactorily there are large spalls on the concrete beams and columns throughout the section. These spalls should be repaired with structural concrete

Items 17-20: The concrete frames in Section B', D, J', and M also exhibit large areas of spalling. Multiple areas expose the steel reinforcement which is beginning to corrode. These spalls should be repaired with structural concrete.

Items 21-22: Several secondary members of the truss that make up the lateral and sway bracing exhibit advanced section loss. These members should be repaired.

Item 23: It is recommended to remove the fatigue prone details on the structure. All the steel sections have isolated tack welds on various members. The welds should be removed by grinding. Isolated main truss tension members have flame cut holes in the bottom perforated cover plates. Steel within the heat affected zone should be removed and ground smooth. The estimate for this item assumes that tack welds and flame cut holes within a 50' length of the bridge can be retrofitted in one hour. With the overall length of the bridge being 6500' and adding in contingency time, 18 days were estimated for the completion of this item.

Item 24: As noted earlier in the report, there is a cracked weld due to pack rust on the south cantilever bracket of Floorbeam 2 in Section K. The pack rust at this location should be removed and the weld should be repaired.

Item 25: It is recommended to remove and patch the spalling concrete on the parapets throughout the structure. It especially important to repair the areas that are over sidewalks and roadways.

Item 26: The navigation lights for the Cuyahoga River Channel under Span 9 of the Main truss are not functioning properly. The fixtures and conduits should be replaced.

Items 27-39: There are many minor deficiencies in the steel sections that should be repaired such as missing anchor bolts, small areas of advanced section loss in the bracing, and missing anchor bolt nuts.

Items 40-50: The substructure units typically exhibit delaminated and spalled areas. Many spalled locations expose the steel reinforcement. These deteriorated areas should be patched.

Phase 2 - Construction Cost Estimate

Legend: AB=As-Built AI=As-Inspected RF=Rating Factor

Item	Location	Description of Work	Number of Retrofits	Cost per Retrofit	Estimated Total Cost
1	Forward Section	Retrofit joint between building and lower deck	1 lump	$120,000.00	$120,000.00
2	Entire Bridge	Retrofit drainage system and seal joints	1 lump	$1,900,000.00	$1,900,000.00
3	Entire Bridge	Replace damaged impact attenuators	4 each	$35,000.00	$140,000.00
4	Truss	Replace truss internal diaphragms with advanced section loss	20 each	$2,500.00	$50,000.00
5	Truss	Repair windlock assembly with advanced section loss	2 each	$11,100.00	$22,200.00
6	Truss	Repair crack in floorbeam bracket web	1 each	$7,500.00	$7,500.00
7	Truss	Retrofit gusset plates with advanced section loss (AI RF > 1.1)	29 plates	$21,000.00	$609,000.00
8	Truss	Retrofit truss members with advanced section loss (AI RF > 1.1)	41 each	$21,600.00	$885,600.00
9	Truss	Retrofit floorbeams with advanced section loss (AI RF > 1.1)	3 each	$4,900.00	$14,700.00
10	Lakefront Ramp	Repair sheared rivets on south girder	18 each	$600.00	$10,800.00
11	Forward Section	Repair collision damage to stringer	1 each	$2,700.00	$2,700.00
12	Forward Section	Retrofit floorbeams with advanced section loss (AI RF > 1.1)	2 each	$3,700.00	$7,400.00
13	Forward Section	Retrofit columns with advanced section loss (AI RF > 1.1)	1 each	$3,700.00	$3,700.00
14	Lakefront Trestle	Retrofit floorbeams with advanced section loss (AI RF > 1.1)	1 each	$3,700.00	$3,700.00
15	Truss	Gusset Plates - stiffen edges	25 plates	$1,800.00	$45,000.00
15	Section P	Repair concrete spalls on beams & columns	680 SF	$75.00	$51,000.00
16	Section B'	Repair concrete spalls on frames	78 SF	$75.00	$5,850.00
17	Section D	Repair concrete spalls on frames	399 SF	$75.00	$29,925.00
18	Section J'	Repair concrete spalls on frames	23 SF	$75.00	$1,725.00
19	Section M	Repair concrete spalls on frames	202 SF	$75.00	$15,150.00
20	Truss	Repair sway bracing with advanced section loss	14 each	$2,500.00	$35,000.00
21	Truss	Repair lower lateral bracing with advanced section loss	21 each	$2,500.00	$52,500.00
22	Steel Spans	Remove fatigue prone details	1 lump	$48,300.00	$48,300.00
23	Section K	Repair cracked cantilever seat weld	1 each	$2,200.00	$2,200.00
24	Entire Bridge	Repair concrete spalls in parapets	100 SF	$75.00	$7,500.00
		Subtotal			**$4,071,450.00**

Phase 2 -Construction Cost Estimate (Continued)					
Legend: AB=As-Built AI=As-Inspected RF=Rating Factor					
Item	Location	Description of Work	Number of	Cost per	Estimated Total
25	Truss	Repair the navigation lighting system at channel crossing	1 lump	$25,000.00	$25,000.00
26	Section L	Repair broken connection bolts between girder and column	2 each	$600.00	$1,200.00
27	Section N	Add anchor bolt nuts for girder	4 each	$400.00	$1,600.00
28	Lakefront Ramp	Add anchor bolts for girder at pier	3 each	$800.00	$2,400.00
29	Section N	Add anchor bolts for girder at concrete column	4 each	$800.00	$3,200.00
30	Truss	Reset shims under stringer bearing	1 each	$15,500.00	$15,500.00
31	Forward Section	Shim floating stringers at bearing	3 each	$15,500.00	$46,500.00
32	Lakefront Trestle	Shim floating stringers at bearing	1 each	$15,500.00	$15,500.00
33	Lakefront Trestle	Repair broken/loose keeper bolts in girder at link assemblies	4 locations	$1,800.00	$7,200.00
34	Section K	Replace missing connection bolt between girder and column	1 each	$600.00	$600.00
35	Forward Section	Replace missing bolt on stringer	1 each	$600.00	$600.00
36	Lakefront Ramp	Repair small holes in webs of girders & floorbeams	2 each	$1,500.00	$3,000.00
37	Lakefront Ramp	Repair lateral bracing with advanced section loss	3 each	$1,500.00	$4,500.00
38	Section K	Remove old stringer seats with cracked welds on floorbeams	4 each	$1,100.00	$4,400.00
39	Truss	Repair concrete spalls on piers	537 SF	$75.00	$40,275.00
40	Lakefront Ramp	Repair concrete spalls on abutment and pedestals	83 SF	$75.00	$6,225.00
41	Forward Section	Repair concrete spalls on column pedestals	33 SF	$75.00	$2,475.00
42	Lakefront Trestle	Repair concrete spalls on column pedestals	34 SF	$75.00	$2,550.00
43	Truss	Repair access hatches on piers	2 each	$1,100.00	$2,200.00
44	Section L	Repair concrete spalls on curtain walls	10 SF	$75.00	$750.00
45	Section N	Repair concrete spalls on curtain walls	5 SF	$75.00	$375.00
46	Section B'	Repair concrete spalls on curtain walls	120 SF	$75.00	$9,000.00
47	Section D	Repair concrete spalls on curtain walls	260 SF	$75.00	$19,500.00
48	Section M	Repair concrete spalls on curtain walls	30 SF	$75.00	$2,250.00
49	Forward Section	Repair concrete spalls on ramp curtain walls	270 SF	$75.00	$20,250.00
50	General	Zone painting in repair areas	29900 SF	$25.00	$747,500.00
51	General	Field Office	1 lump	$24,000.00	$24,000.00
52	General	Mobilization	1 lump	$1,000,000.00	$1,000,000.00
53	General	Maintenance of Traffic	1 lump	$400,000.00	$400,000.00
Subtotal					$2,408,550.00
Phase 2 Total					$6,480,000.00

Phase 3 – Bridge Painting

The Phase 3 – Bridge Painting is recommended to continue the long term maintenance program of providing a protective paint system to prevent deterioration of the structural components of the bridge. In 2007, a new protective coating system of the truss spans was completed. The steel approach spans were painted in 1984. The paint system in the steel approach spans has many deficiencies including: chalking paint, peeling paint, and active surface rust. Isolated locations, especially near joints, exhibit heavy rust. Isolated paint failures due to inadequate thickness or coverage, exposure to sunlight, road salt, or other environmental factors were noted throughout the structure. The structure is not uniformly coated, utilizing multiple paint systems and/or painting at different times, producing vastly different coating conditions even in localized areas. There are widespread areas exhibiting paint failures throughout the Lakefront Trestle section. Isolated difficult access areas were noted to have no coating system. TranSystems recommends painting all the steel approach span sections to stop corrosion and prevent future deterioration.

The joints are typically leaking with isolated torn glands and damaged joint armor. The joints should be replaced to allow the optimal performance of the replaced drainage system and to prevent future deterioration of the structural components of the bridge. TranSystems recommends replacing the strip seal joints and modular joints completely and replacing the seals in the compression joints and stress relief joints.

Phase 3 - Construction Cost Estimate					
Item	Location	Description of Work	Number of Retrofits	Cost per Retrofit	Estimated Total Cost
1	Approach Spans	Surface preparation of existing structural steel	746000 SF	$8.00	$5,968,000.00
2	Approach Spans	Field painting of existing structural steel, prime coat	746000 SF	$8.00	$5,968,000.00
3	Approach Spans	Field painting structural steel, intermediate coat	783300 SF	$5.00	$3,916,500.00
4	Approach Spans	Field painting structural steel, finish coat	783300 SF	$5.00	$3,916,500.00
5	Entire Bridge	Replace compression seals in compression joints	550 FT	$11.00	$6,050.00
6	Entire Bridge	Replace strip seal joints	450 FT	$368.00	$165,600.00
7	Entire Bridge	Replace modular joints	650 FT	$818.00	$531,700.00
8	Entire Bridge	Replace seal in stress relief joints	750 FT	$6.00	$4,500.00
9	General	Field Office	1 lump	$18,000.00	$18,000.00
10	General	Mobilization	1 lump	$500,000.00	$500,000.00
11	General	Maintenance of Traffic	1 lump	$1,000,000.00	$1,000,000.00
Phase 3 Total					$21,994,850.00

Appendix A
Section Site Plans

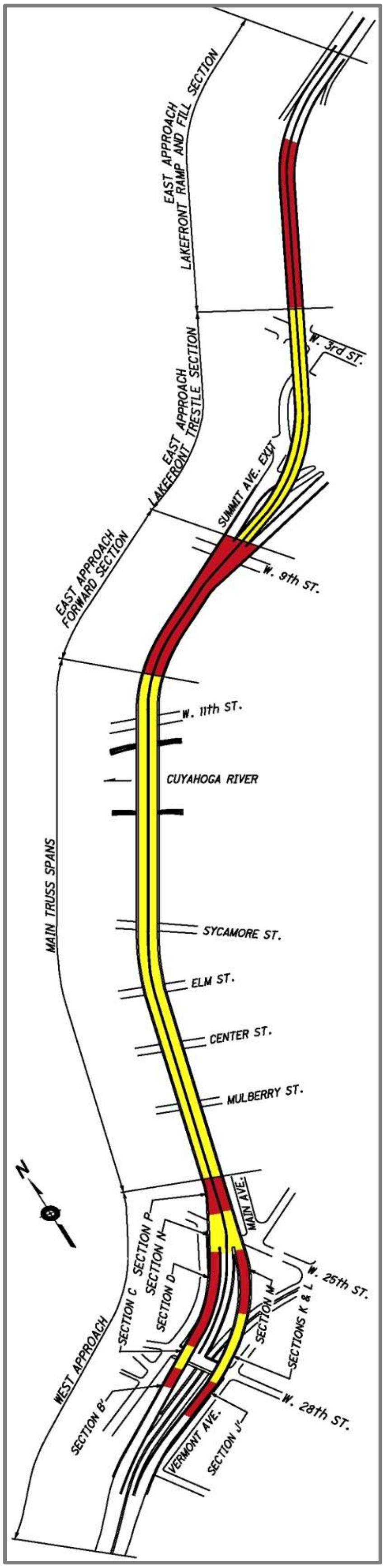


Figure A1 – Overall Site Plan

Overall Site Plan and Bridge Narrative

The Main Avenue Bridge is divided into twelve sections as shown in **Figure A1**.

West Approach

The West Approach section consists of similar east and west bound structures, each carrying three lanes of traffic from West 29th Street to 250' east of West 25th Street. These structures merge into one structure near West 25th Street. The West Approach section consists of four main structure types: Transverse rigid reinforced concrete frames supporting a concrete deck slab (Sections B', D, J', and M); reinforced concrete stringers, diaphragms, floorbeams, and columns (Section P); longitudinal rigid steel frames supporting floorbeams and stringers (Sections C, K, and L); and a steel floorbeam/stringer system supported by steel girders, steel columns, and concrete columns (Section N). The various steel sections consist of rolled beams, welded plate girders, and riveted built-up plate girders.

Main Truss

Starting at the termination of the West Approach Section, the Main Truss Spans carry six lanes of traffic over the east and west banks of the flats to near West 10th Street. The Main Truss Spans section consists of a 10 span cantilevered modified Pratt deck truss. The cantilevered deck truss chord members are composed of riveted built-up box sections that support a mixture of riveted built-up floorbeams and welded floorbeams. Rolled stringers rest on top of the floorbeams, and frame into the floorbeam cantilevers. Truss web members consist of rolled sections.

East Approach – Forward Section

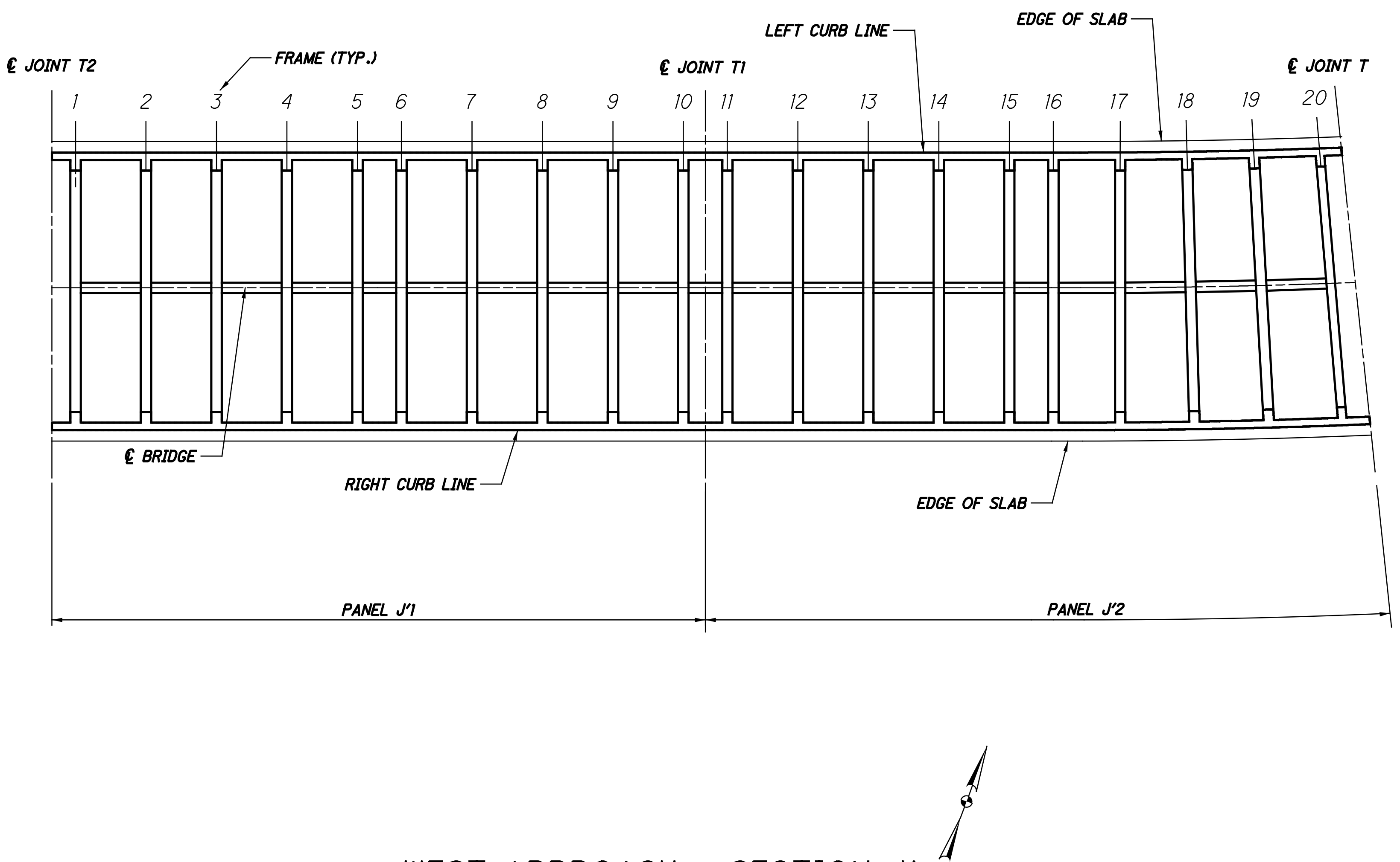
The Forward Section carries the six lanes of traffic from the Main Span at West 10th Street, at the base of the Flats from the Cuyahoga River Valley up to West 9th Street. The western part of the section consists of a single simply supported Pratt deck truss (Span 11). The Pratt deck truss members consist of rolled wide flange sections, with a similar deck framing system to the main truss span. The eastern part of the Forward Section consists of steel truss bents that support rolled steel floorbeams with rolled steel stringers bearing on top. The steel truss bent members consist of rolled steel sections connected by riveted gusset plates. A lower utility/parking deck exists below the eastbound lanes of this section at the north end.

East Approach – Lakefront Trestle

This section starts at West 9th Street and continues to West 3rd Street carrying four lanes of traffic. The Lakefront Trestle superstructure carries four lanes of traffic and is supported by two lines of longitudinal rigid steel frames composed of riveted built-up beams and columns. Transverse floorbeams frame into the longitudinal frames and support rolled stringers.

East Approach – Lakefront Ramp

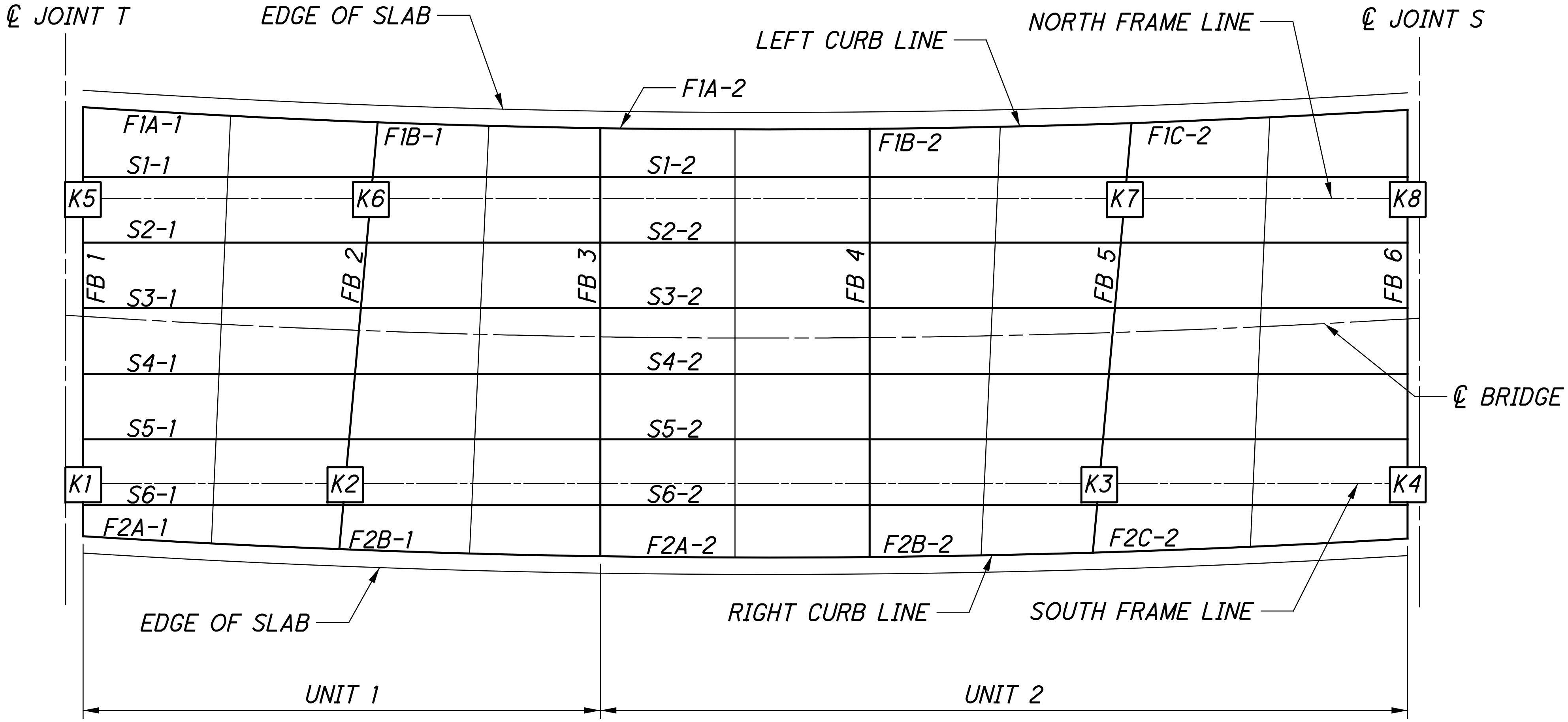
The Lakefront Ramp carries four lanes of traffic, beginning at West 3rd Street, continuing over the RTA and the Norfolk Southern/CSX railroad tracks, and terminating at the southeast entrance to Cleveland Browns Stadium. The superstructure consists of 3 riveted, built-up plate girders with rolled floorbeams and stringers.



WEST APPROACH - SECTION J'

MAIN AVENUE BRIDGE
CUY-2-1441

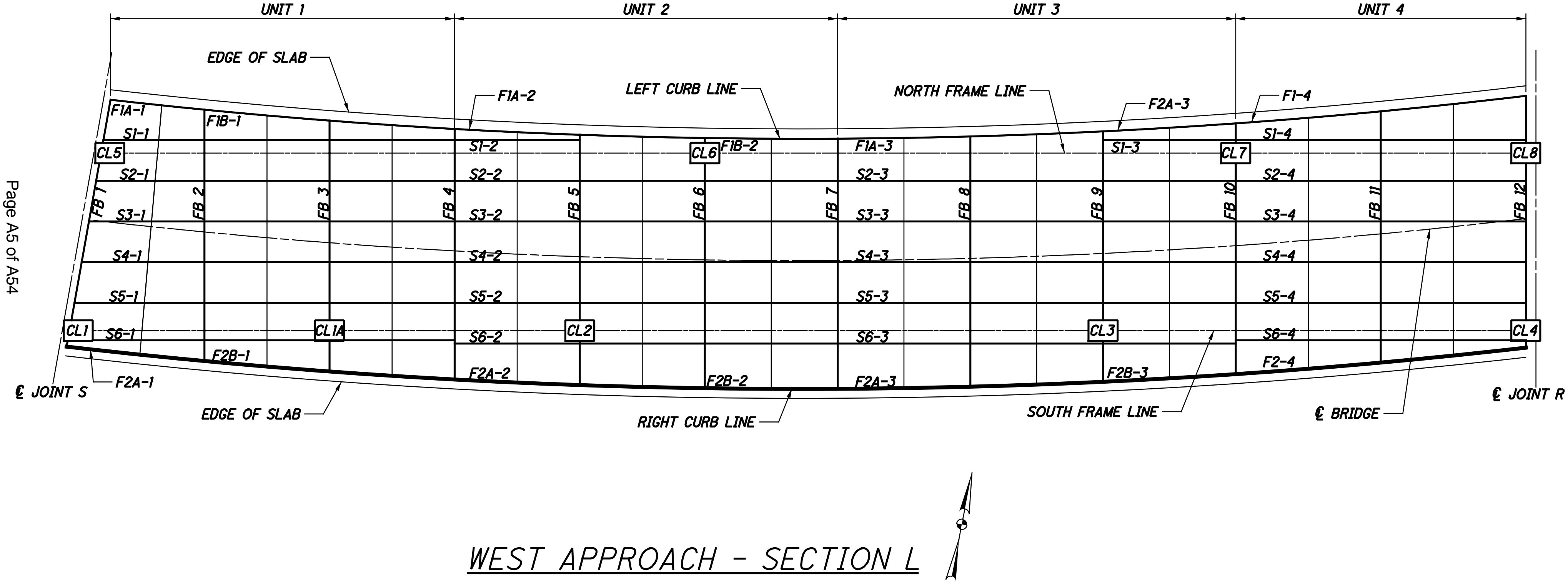
TranSystems



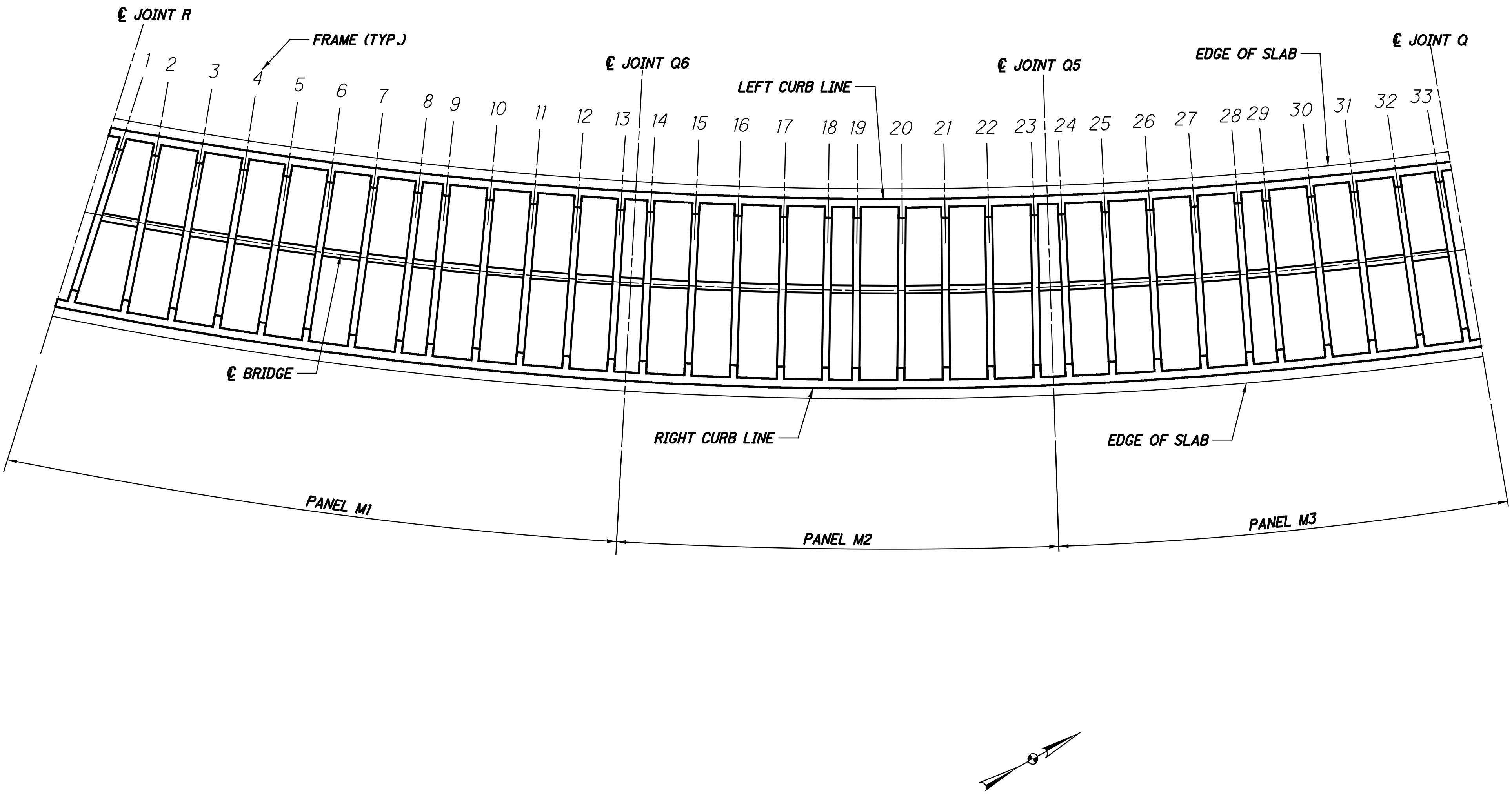
WEST APPROACH - SECTION K

MAIN AVENUE BRIDGE
CUY-2-1441

TranSystems



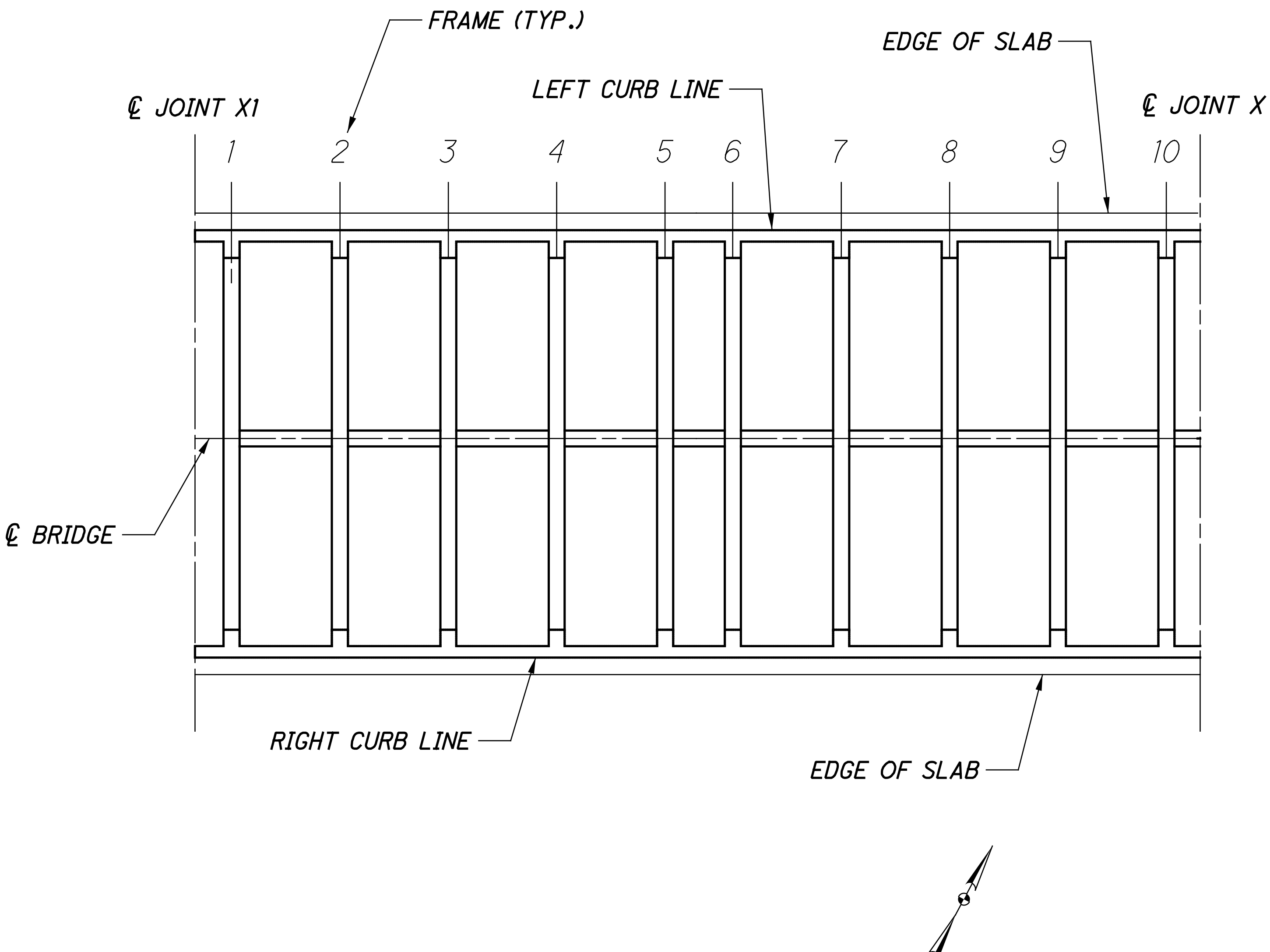
WEST APPROACH - SECTION L



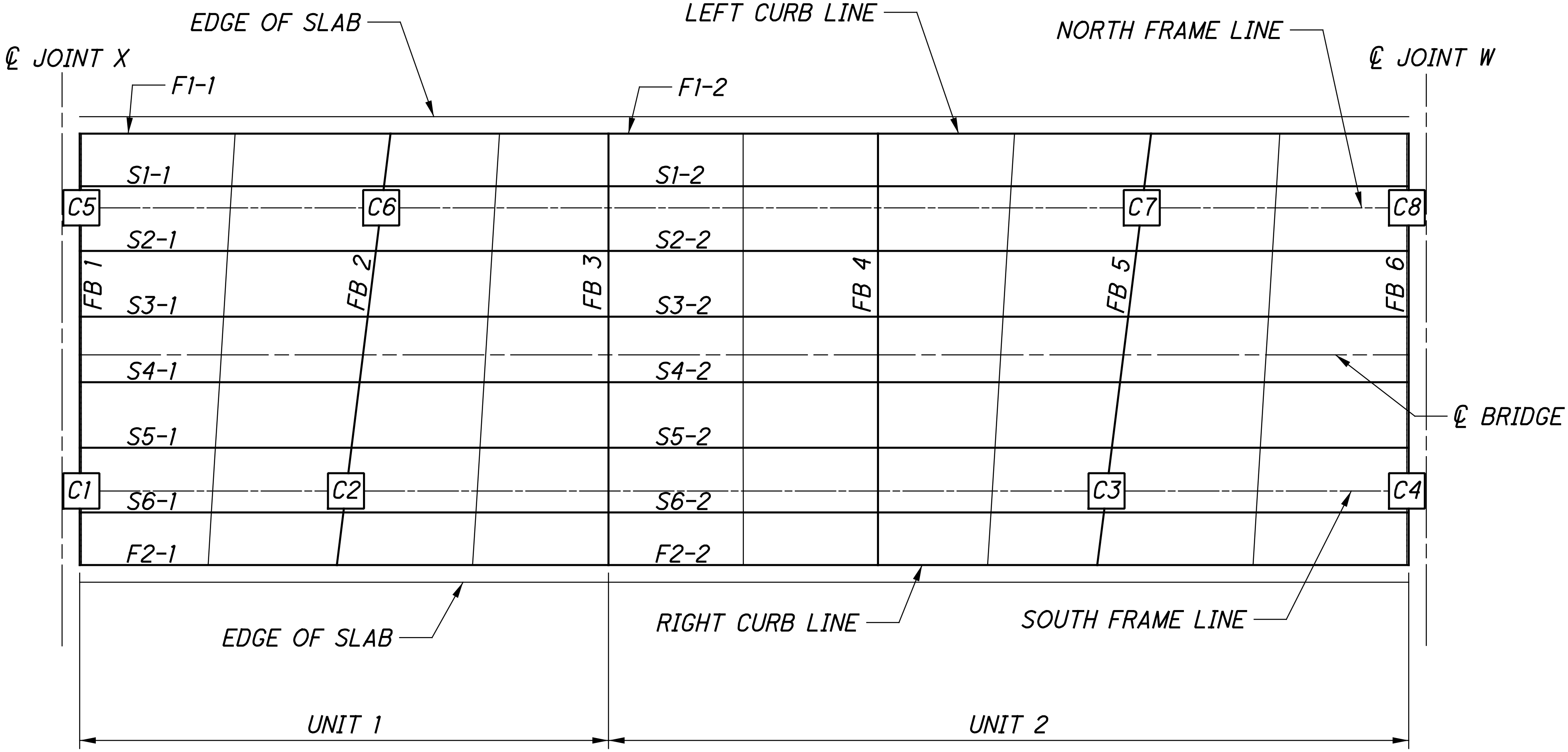
WEST APPROACH - SECTION M

MAIN AVENUE BRIDGE
CUY-2-1441

TranSystems



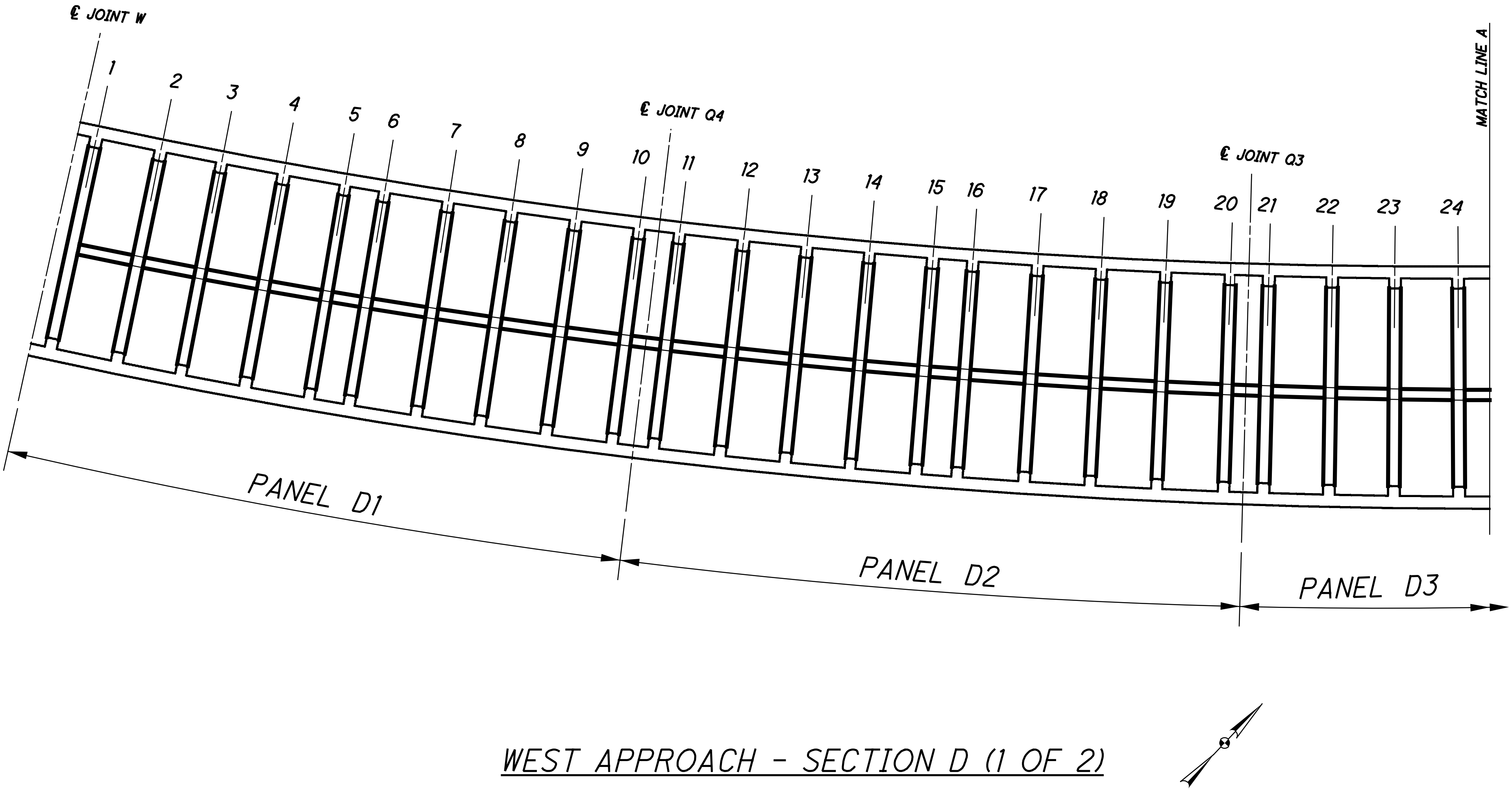
WEST APPROACH - SECTION B'



WEST APPROACH - SECTION C

MAIN AVENUE BRIDGE
CUY-2-1441

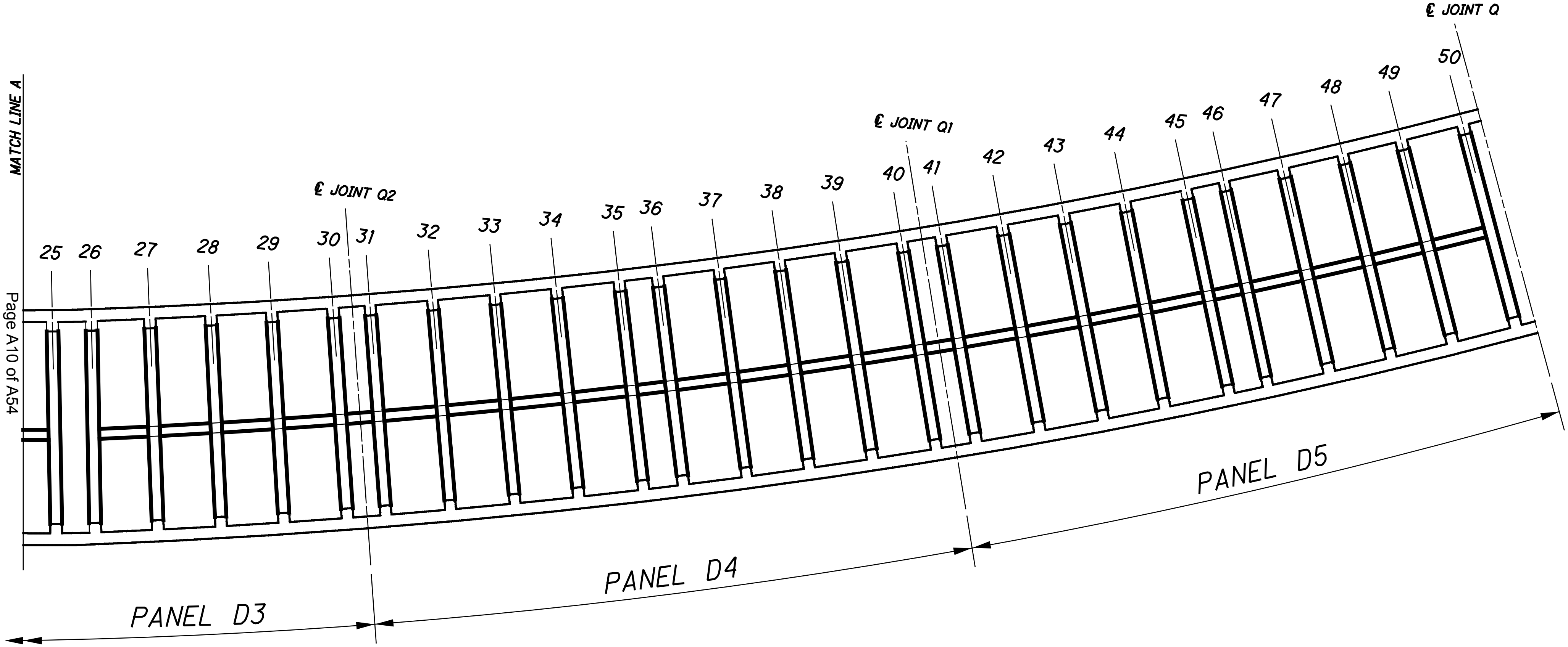
TranSystems



WEST APPROACH - SECTION D (1 OF 2)

MAIN AVENUE BRIDGE
CUY-2-1441

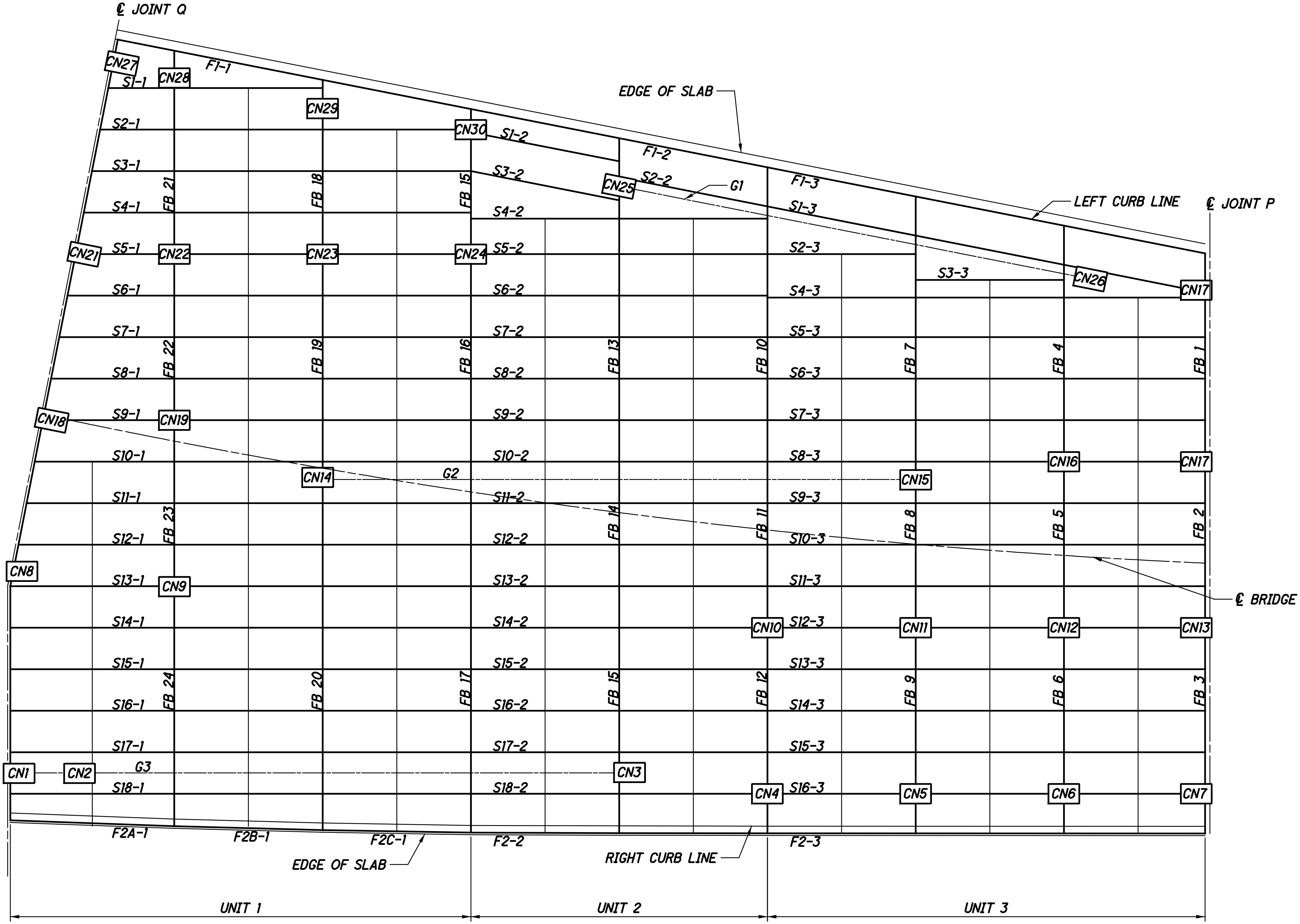
TranSystems



WEST APPROACH - SECTION D (2 OF 2)

MAIN AVENUE BRIDGE
CUY-2-1441

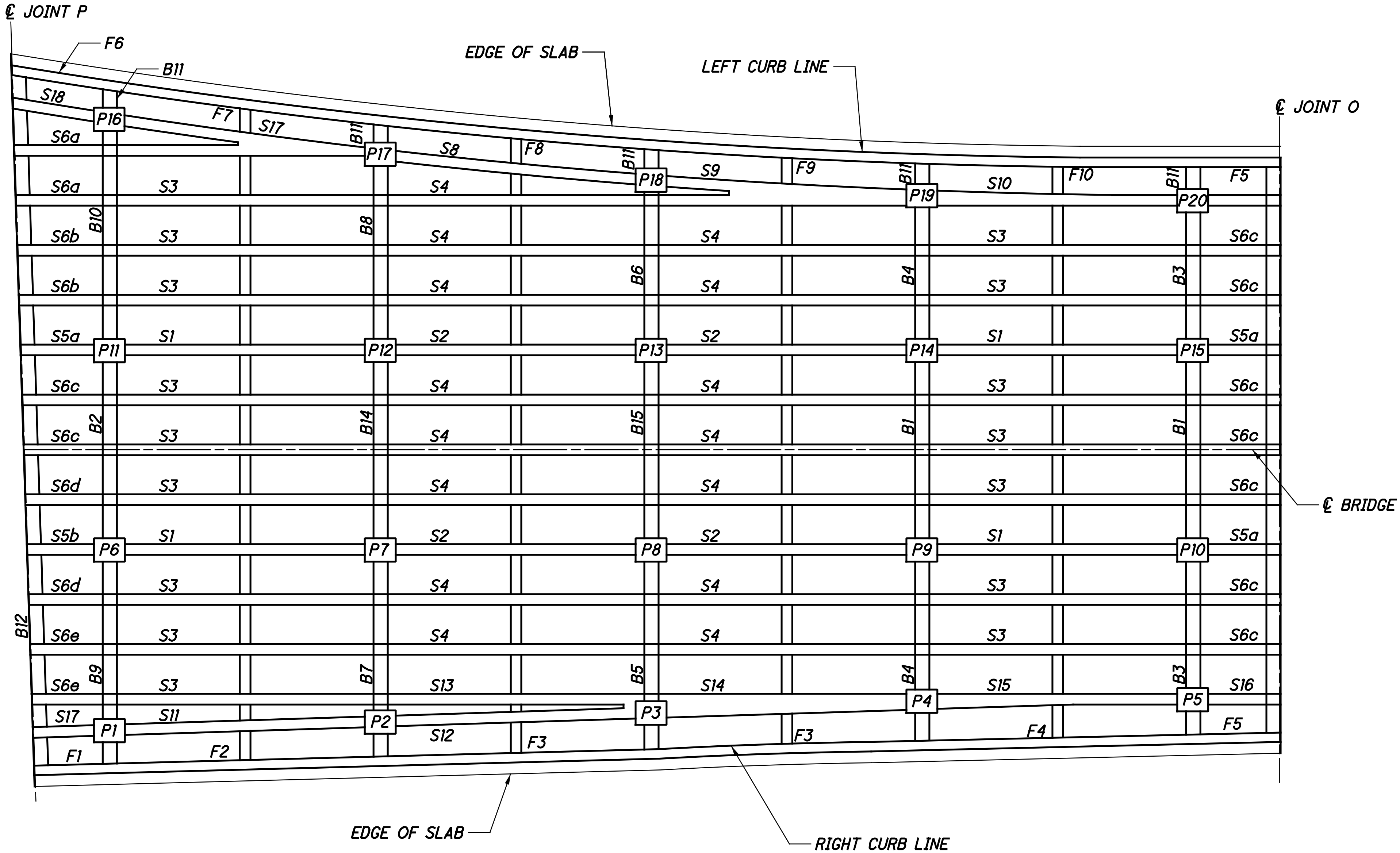
TranSystems



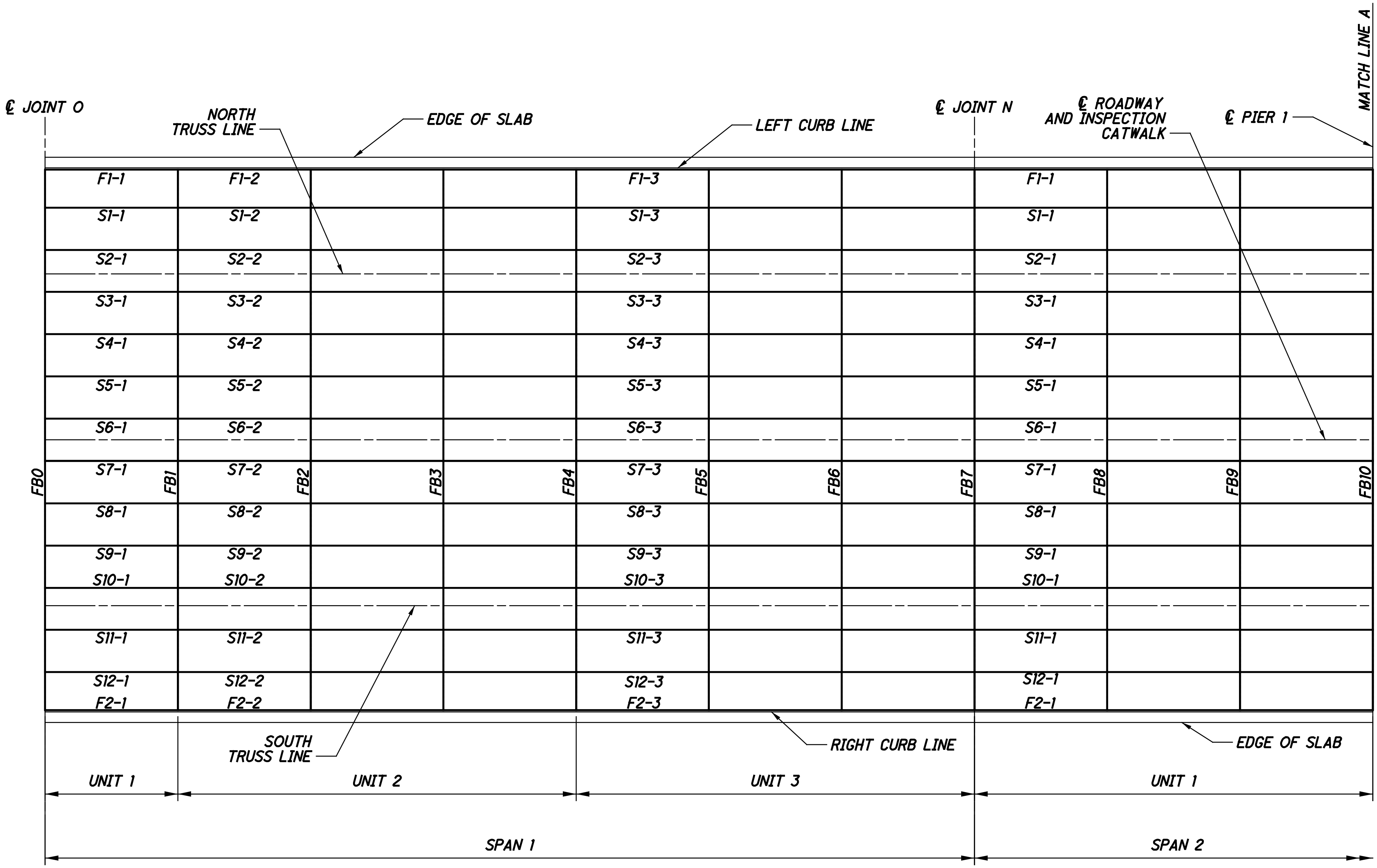
WEST APPROACH - SECTION N

MAIN AVENUE BRIDGE
CUY-2-1441

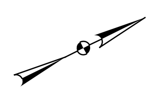
TranSystems

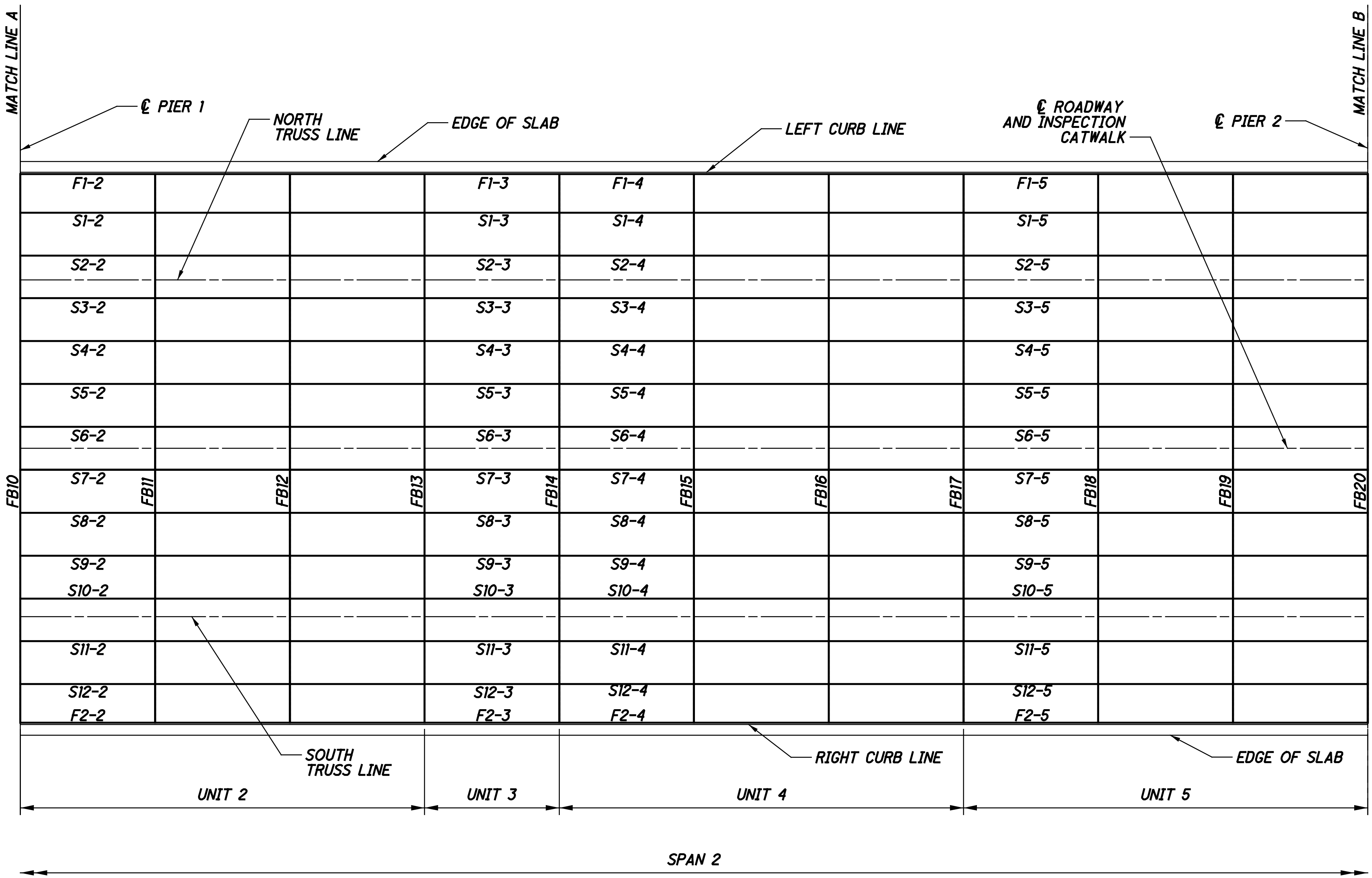


WEST APPROACH - SECTION P



MAIN TRUSS SPANS (1 OF 13)

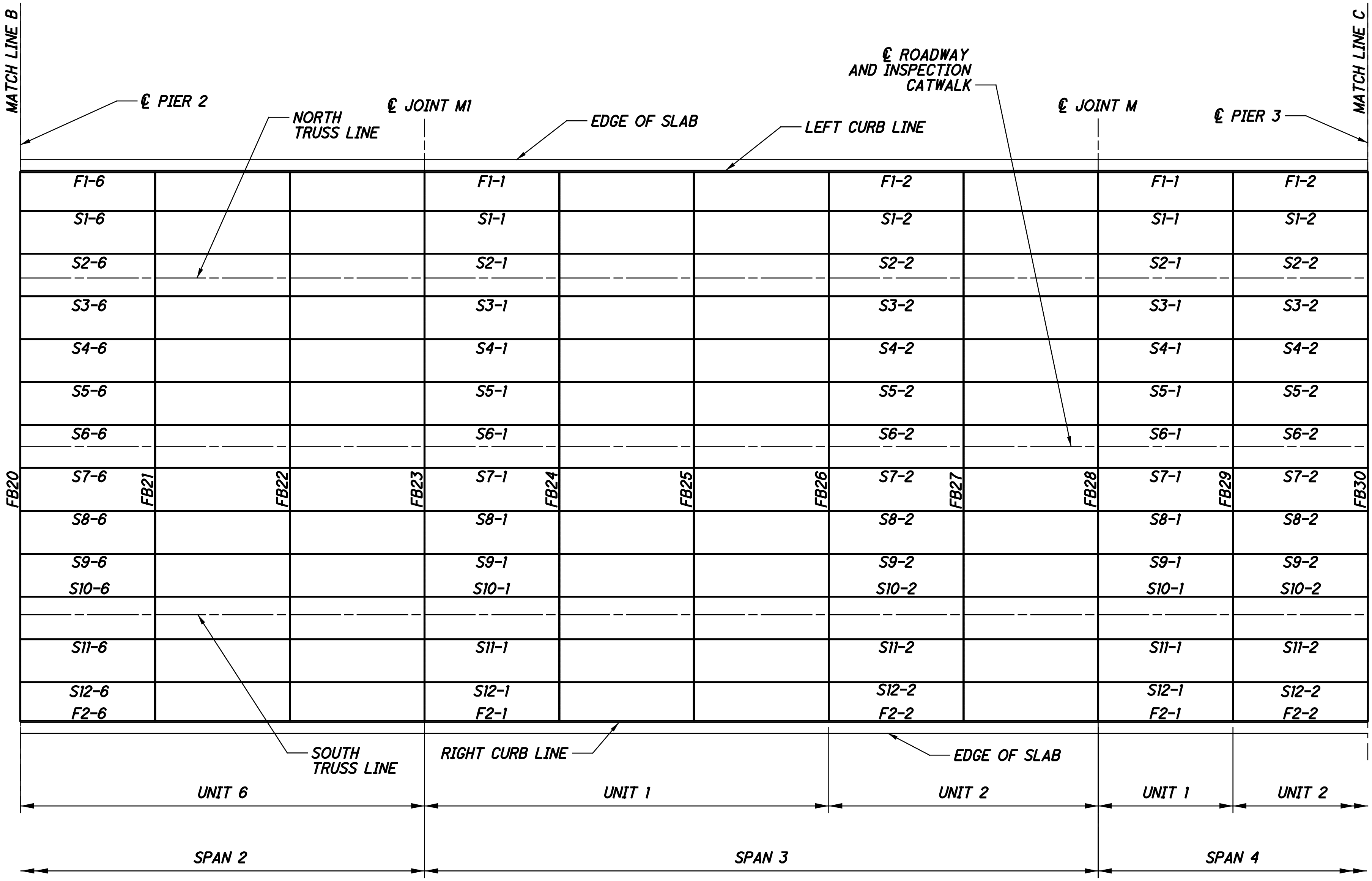




MAIN TRUSS SPANS (2 OF 13)

MAIN AVENUE BRIDGE
CUY-2-1441

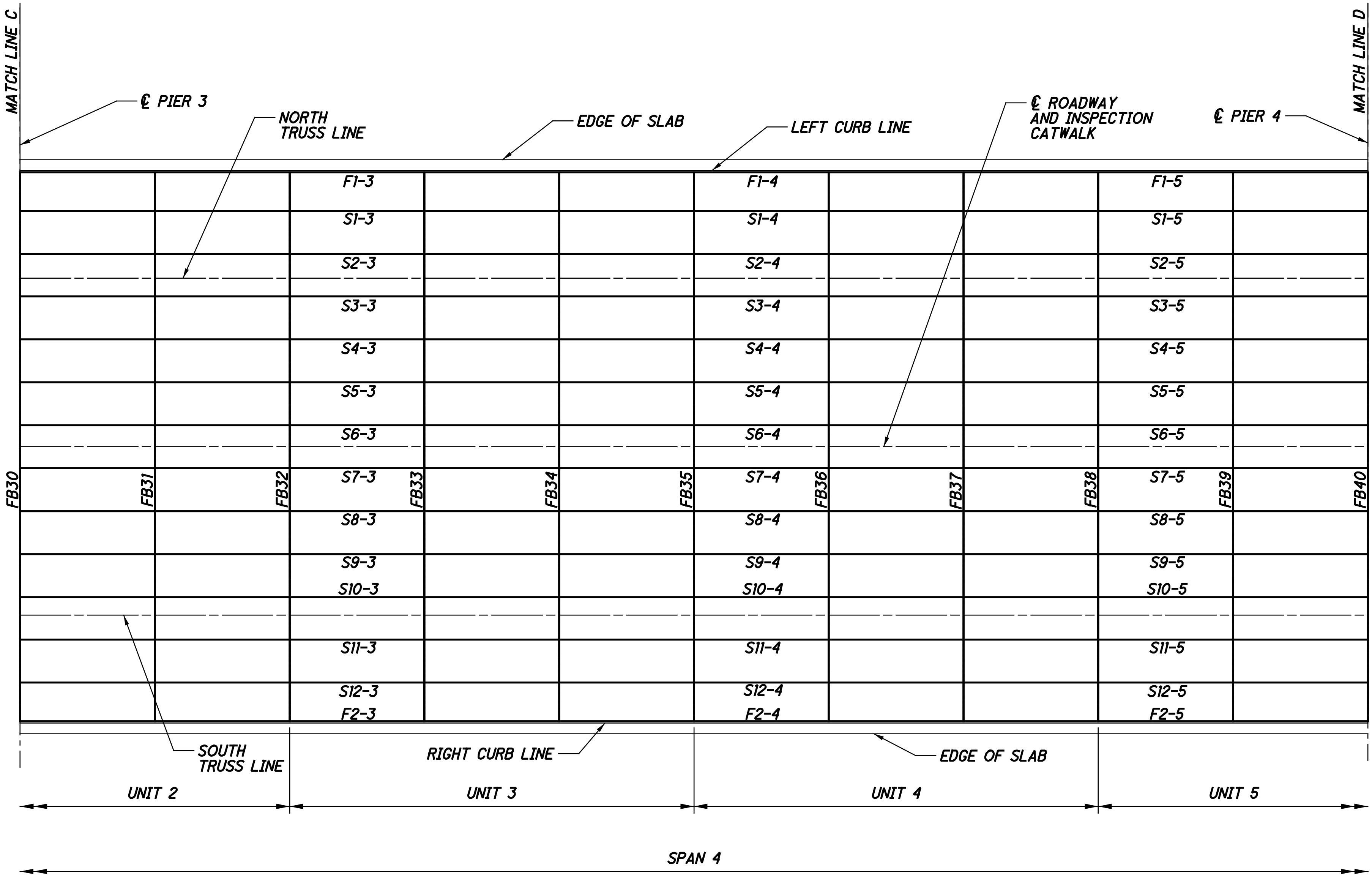
TranSystems



MAIN TRUSS SPANS (3 OF 13)

MAIN AVENUE BRIDGE
CUY-2-1441

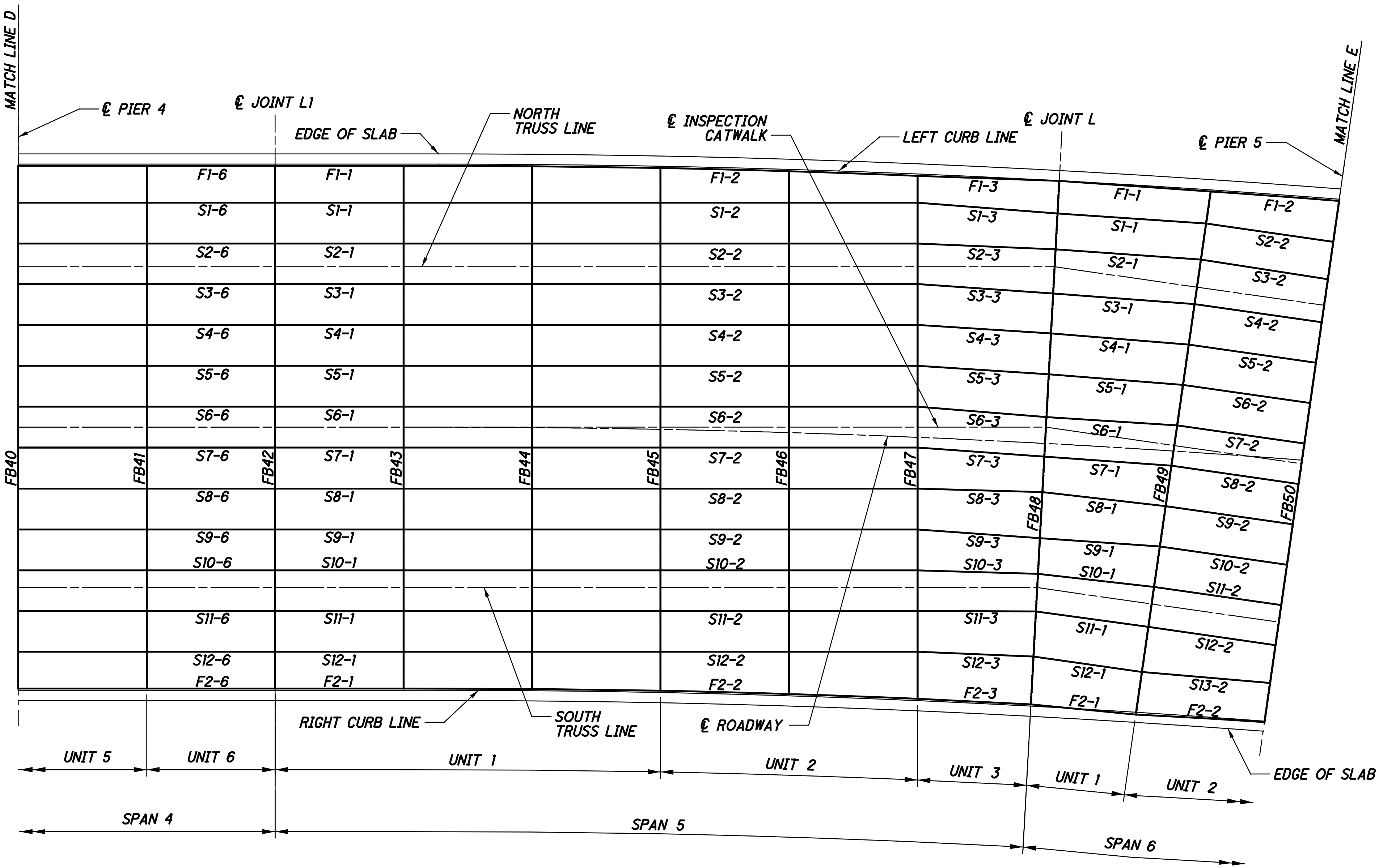
TranSystems



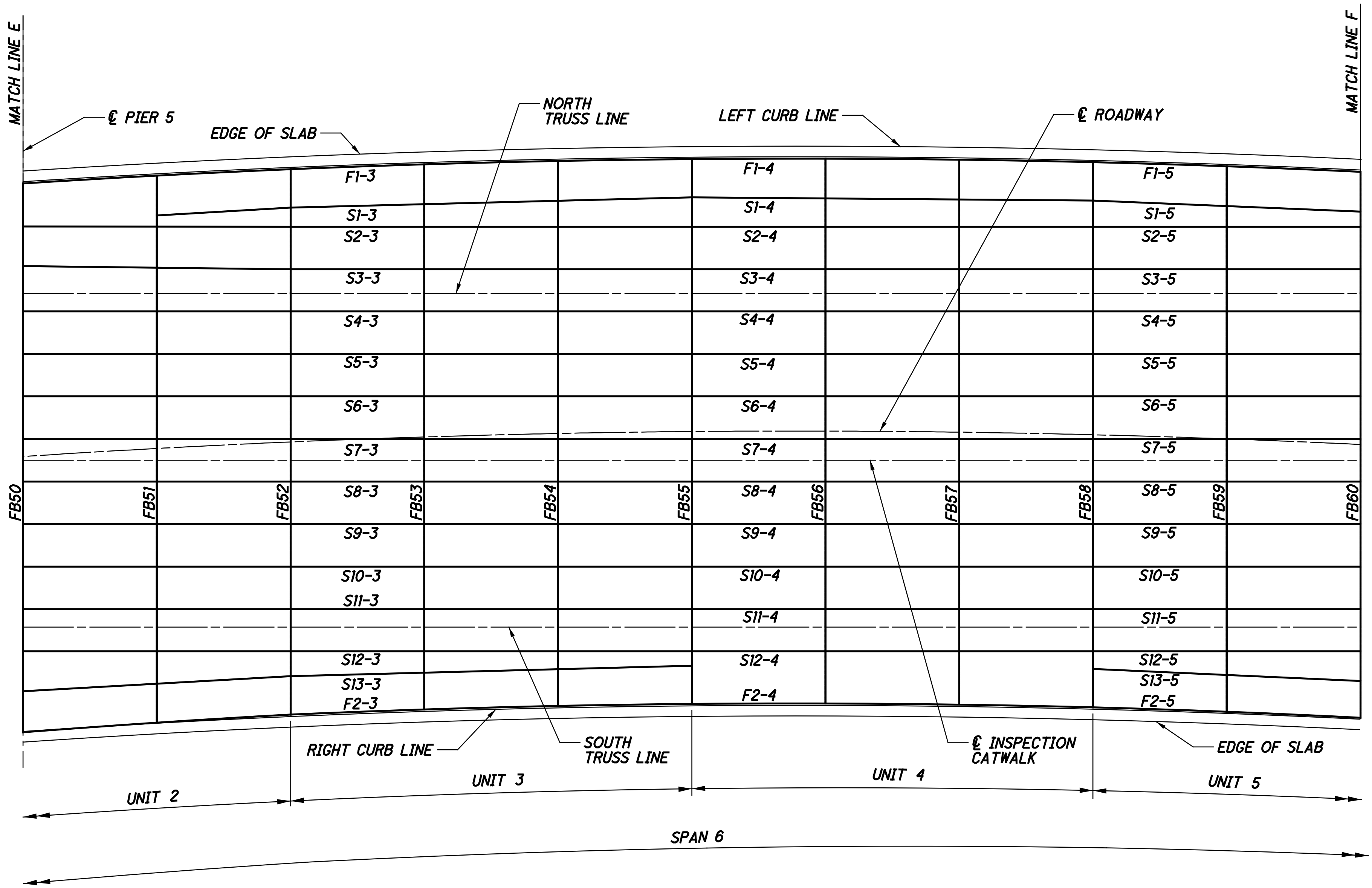
MAIN TRUSS SPANS (4 OF 13)

MAIN AVENUE BRIDGE
CUY-2-1441

TranSystems



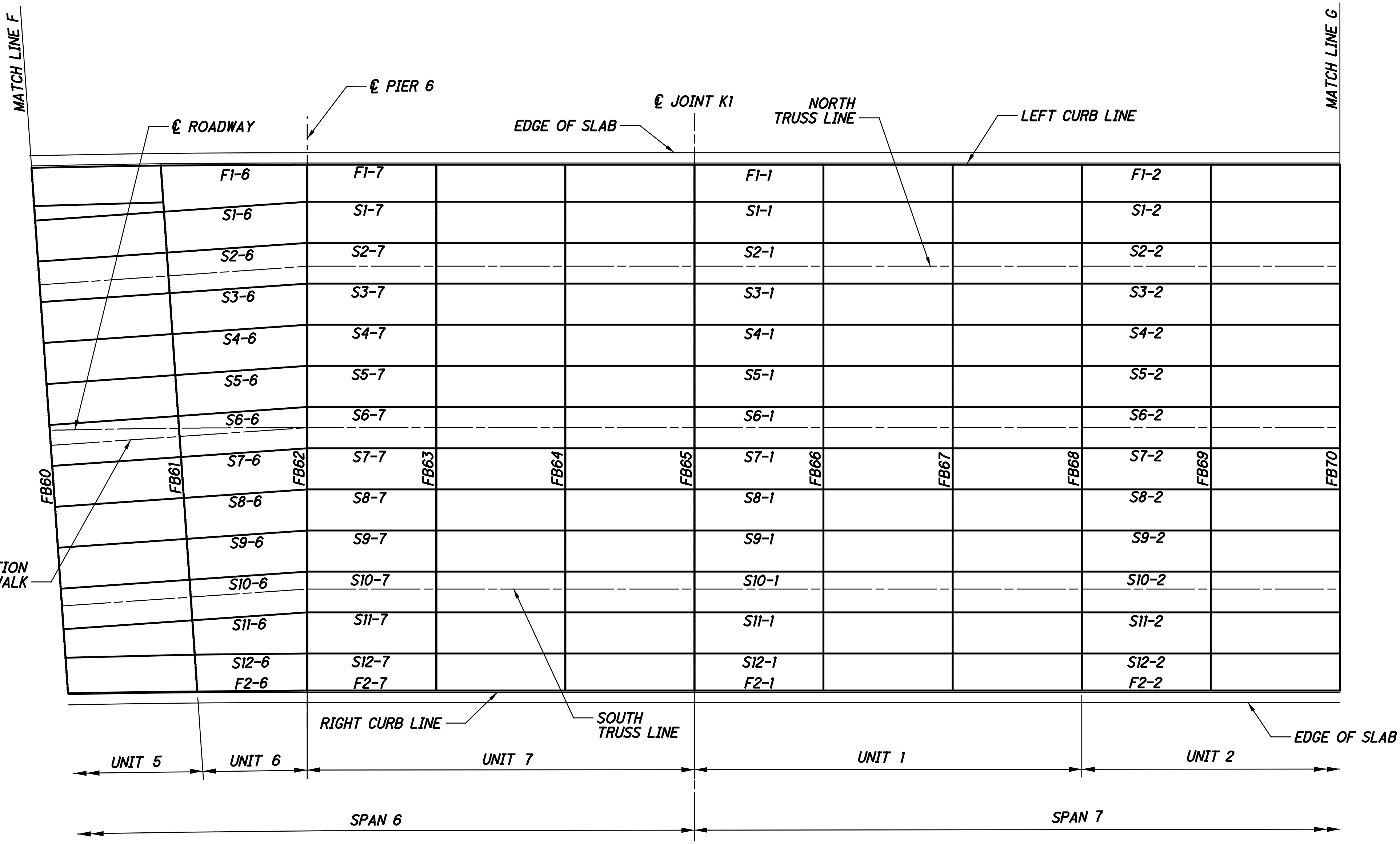
MAIN TRUSS SPANS (5 OF 13)



MAIN TRUSS SPANS (6 OF 13)

MAIN AVENUE BRIDGE
CUY-2-1441

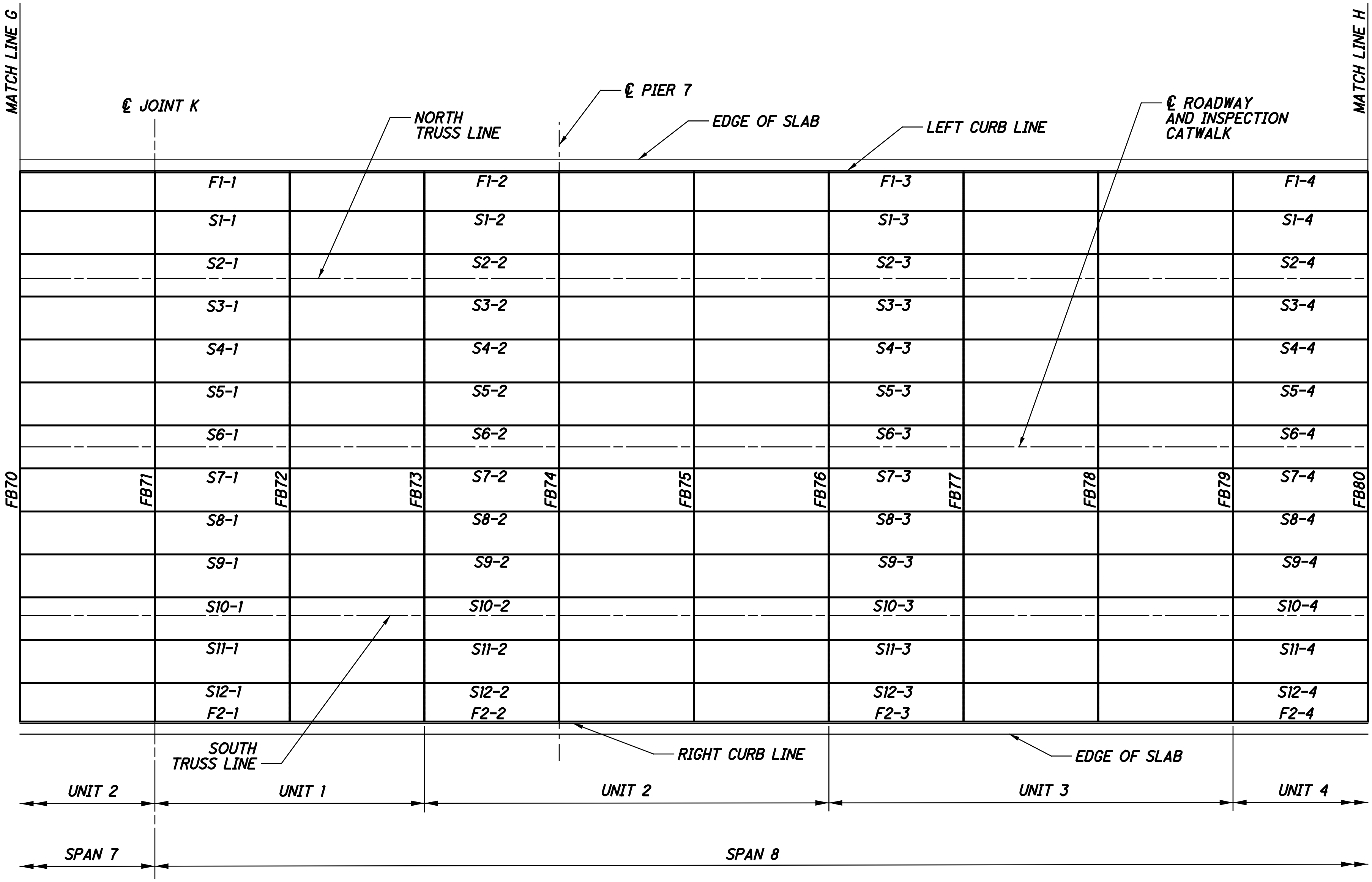
TranSystems



MAIN TRUSS SPANS (7 OF 13)

MAIN AVENUE BRIDGE
CUY-2-1441

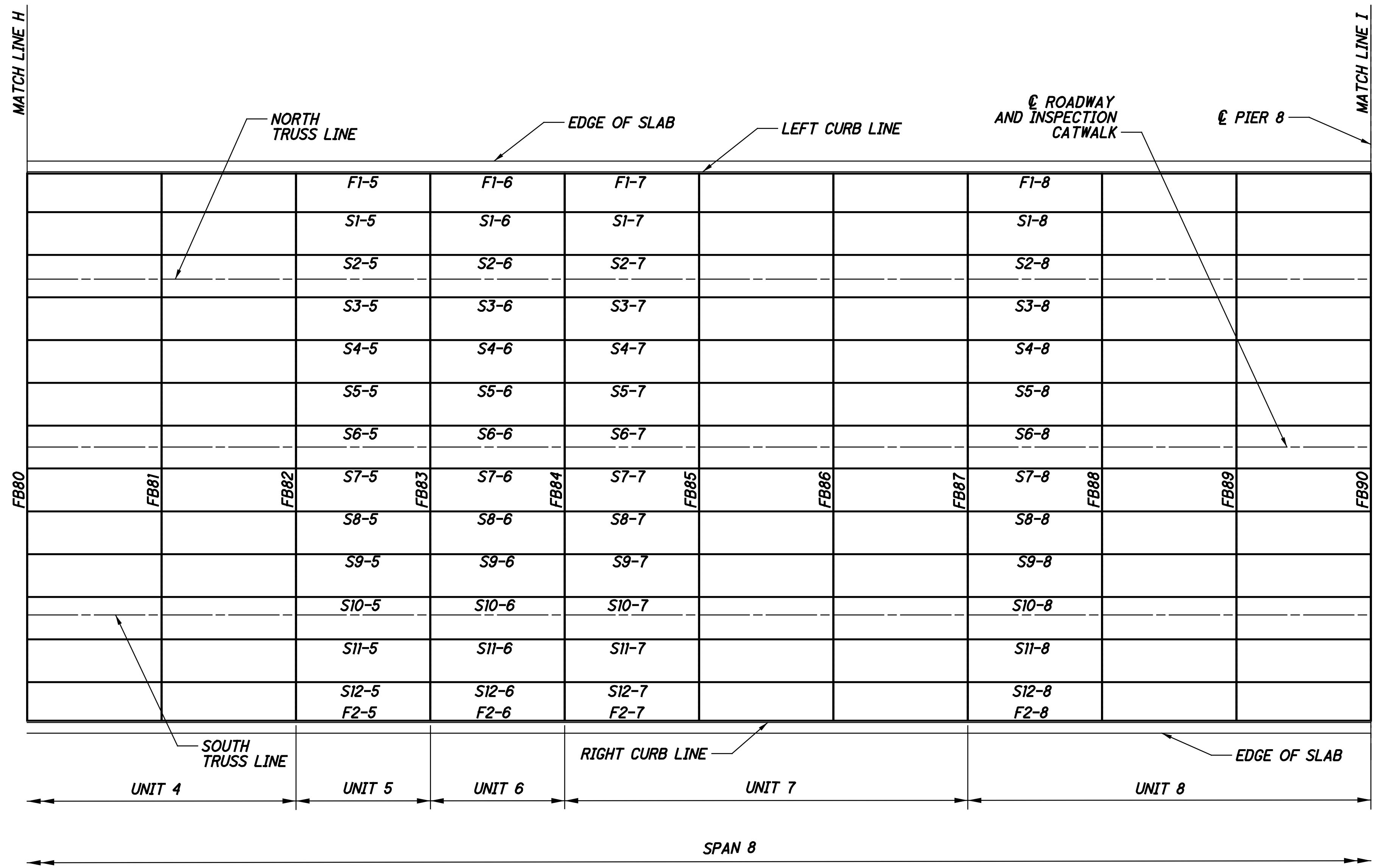
TranSystems



MAIN TRUSS SPANS (8 OF 13)

MAIN AVENUE BRIDGE
CUY-2-1441

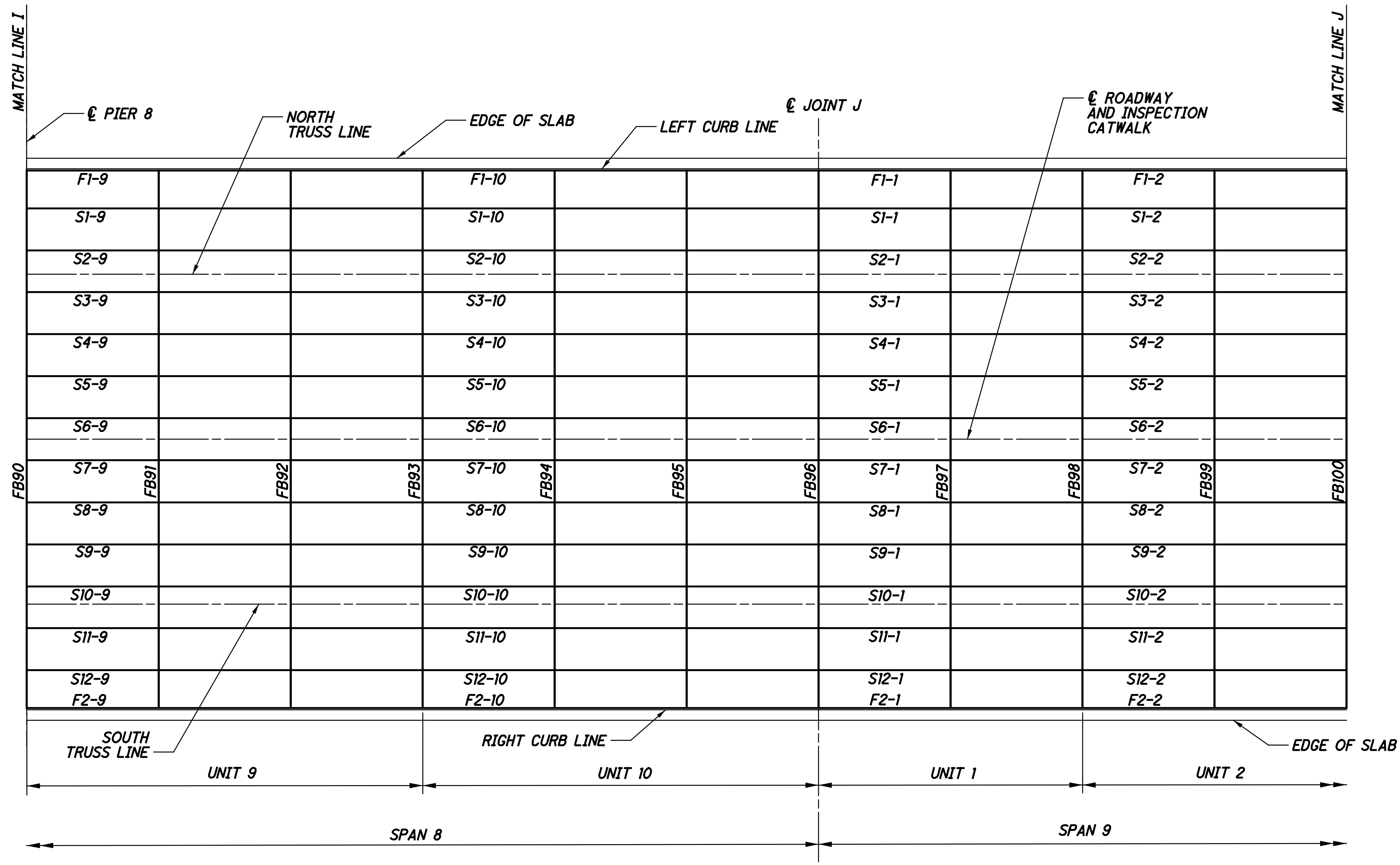
TranSystems



MAIN TRUSS SPANS (9 OF 13)

MAIN AVENUE BRIDGE
CUY-2-1441

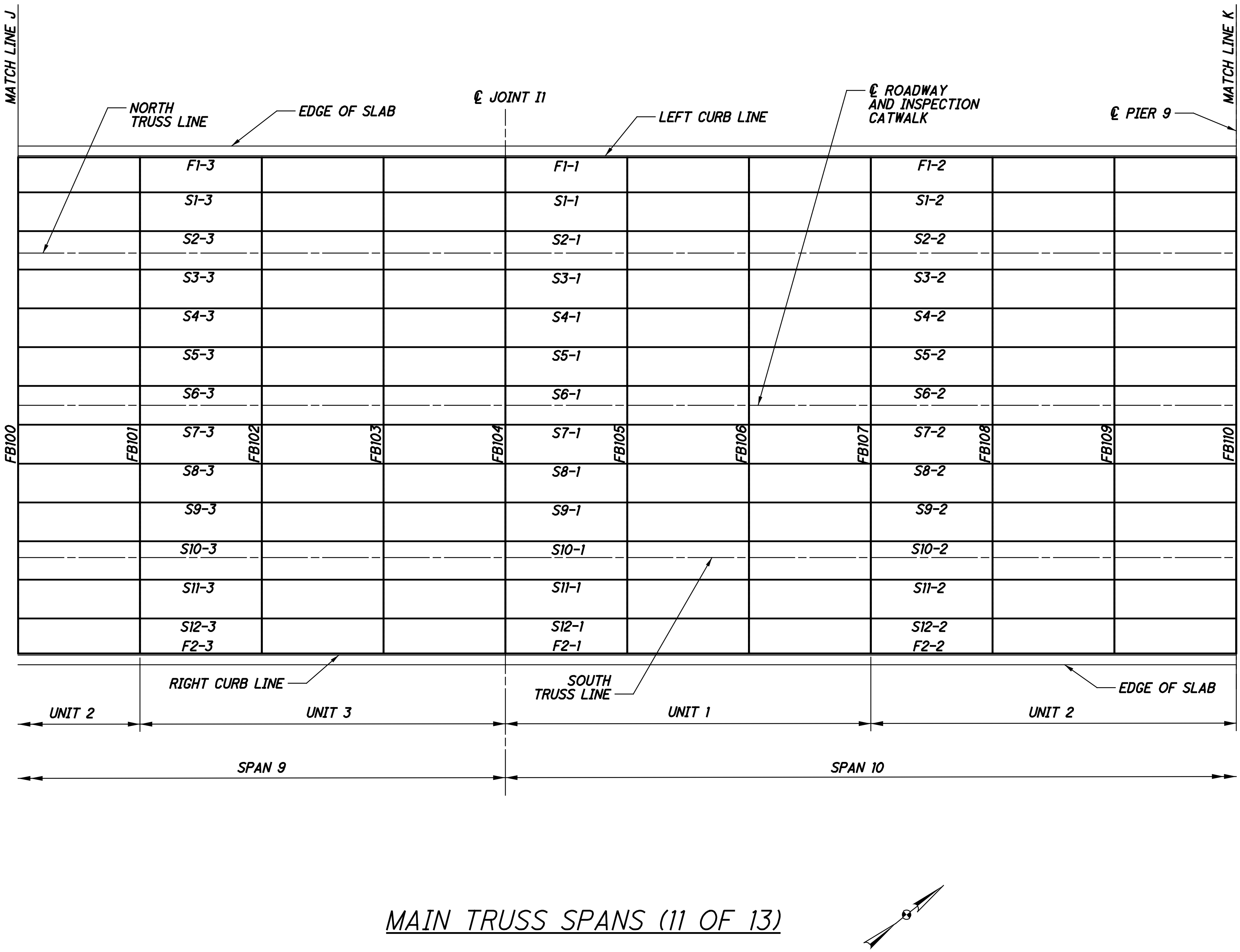
TranSystems



MAIN TRUSS SPANS (10 OF 13)

MAIN AVENUE BRIDGE
CUY-2-1441

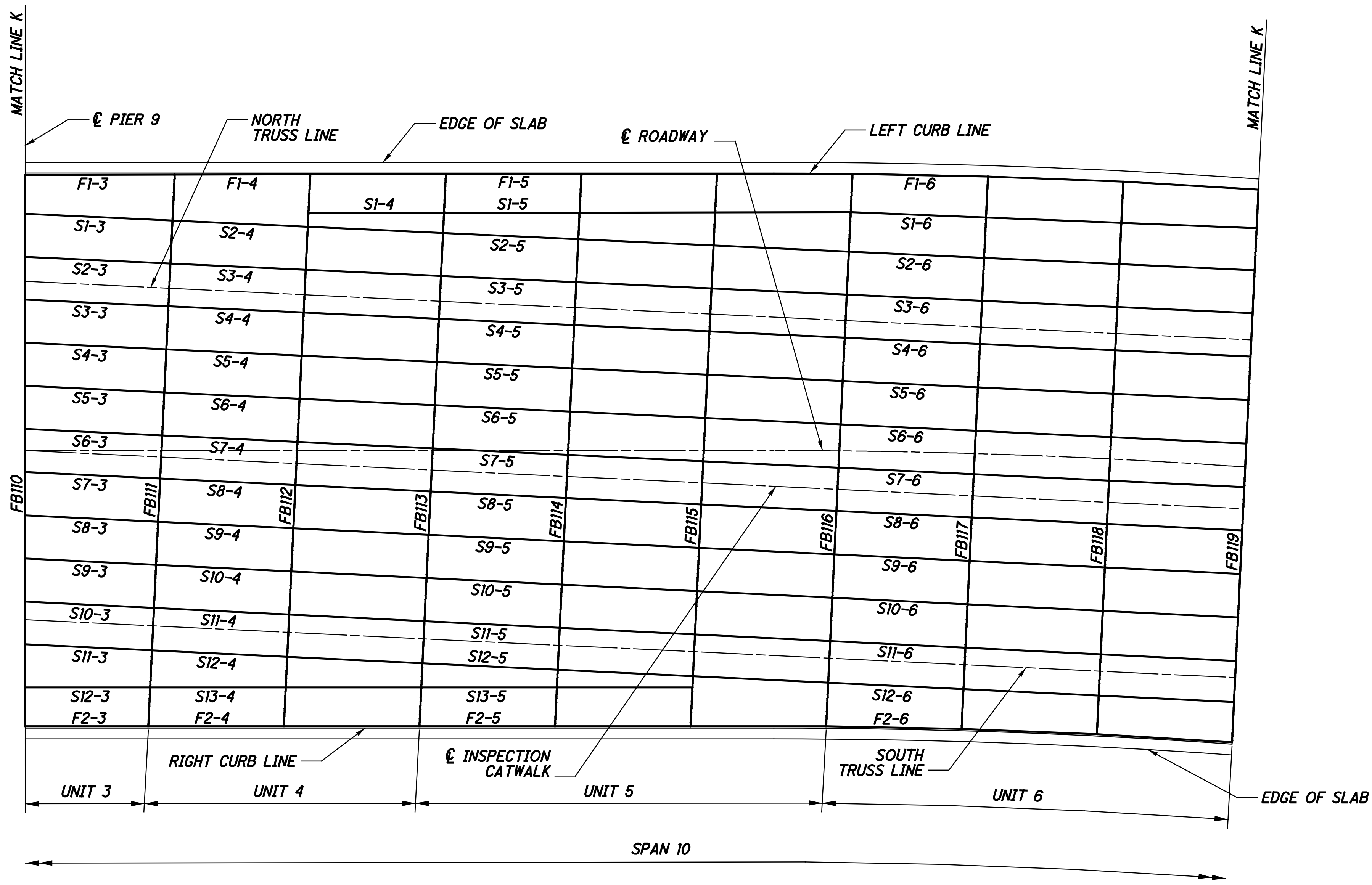
TranSystems



MAIN TRUSS SPANS (11 OF 13)

MAIN AVENUE BRIDGE
CUY-2-1441

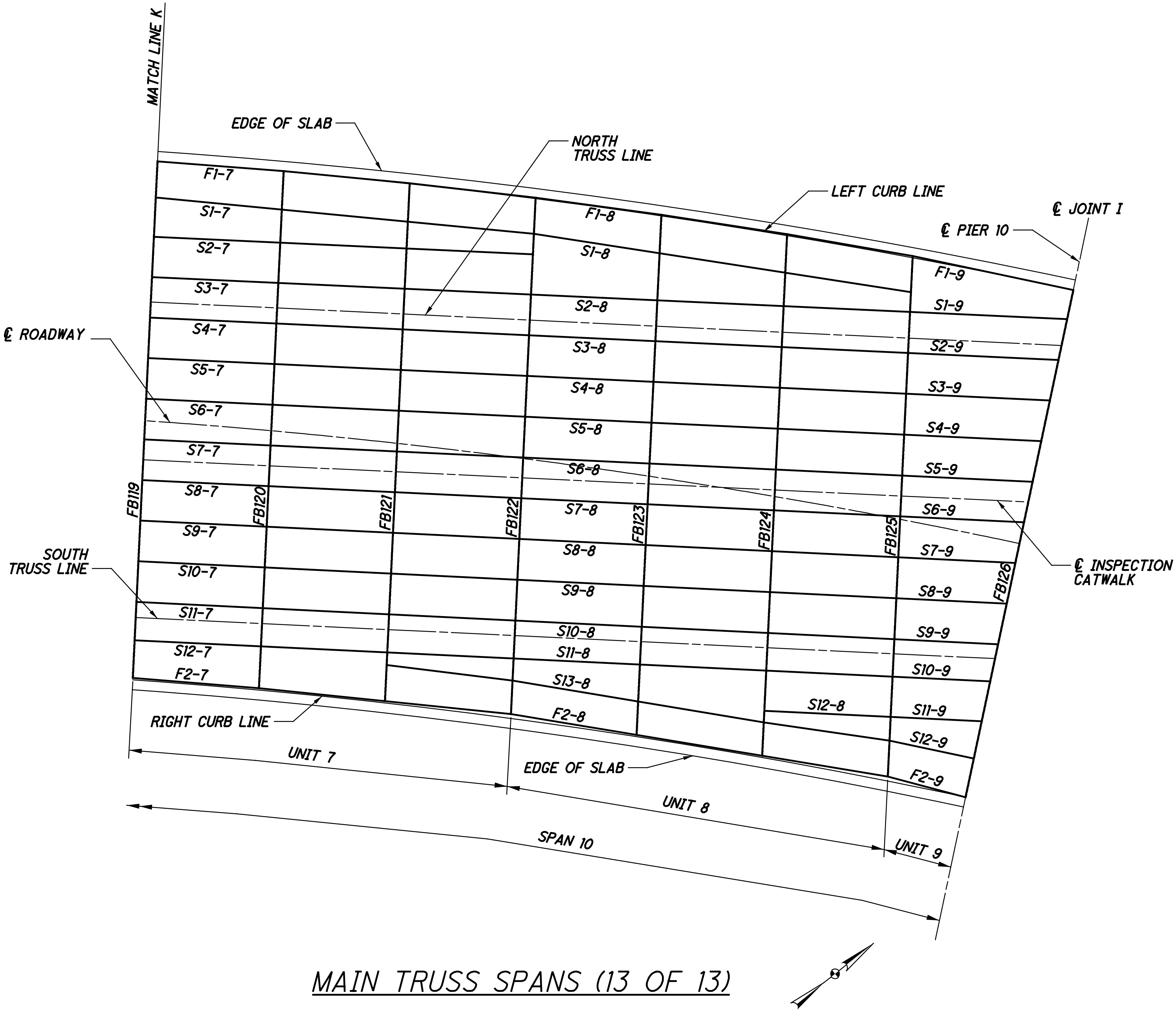
TranSystems



MAIN TRUSS SPANS (12 OF 13)

MAIN AVENUE BRIDGE
CUY-2-1441

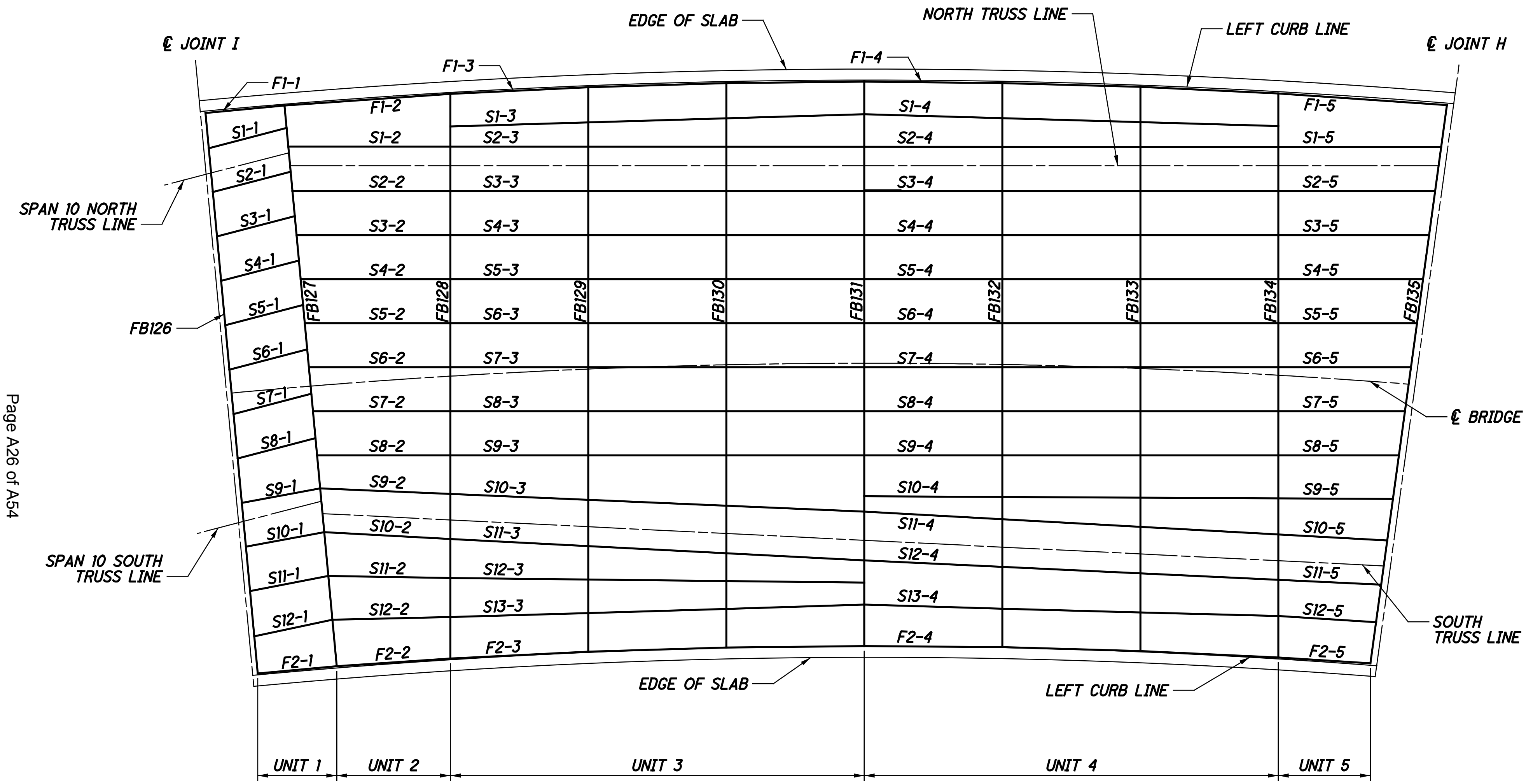
TranSystems

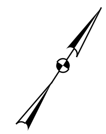


MAIN TRUSS SPANS (13 OF 13)

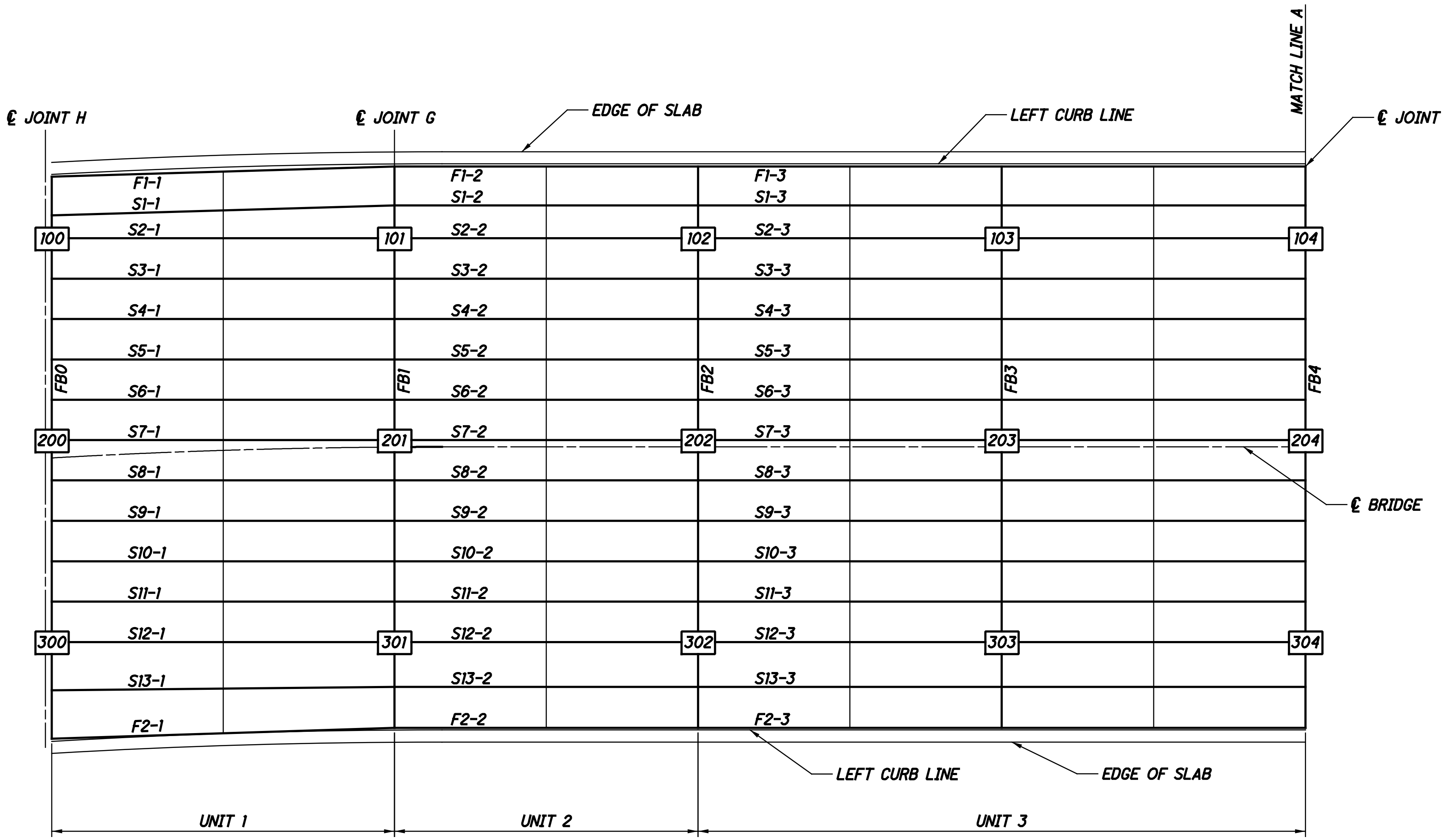
MAIN AVENUE BRIDGE
CUY-2-1441

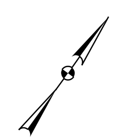
TranSystems





EAST APPROACH - FORWARD SECTION - SPAN 11

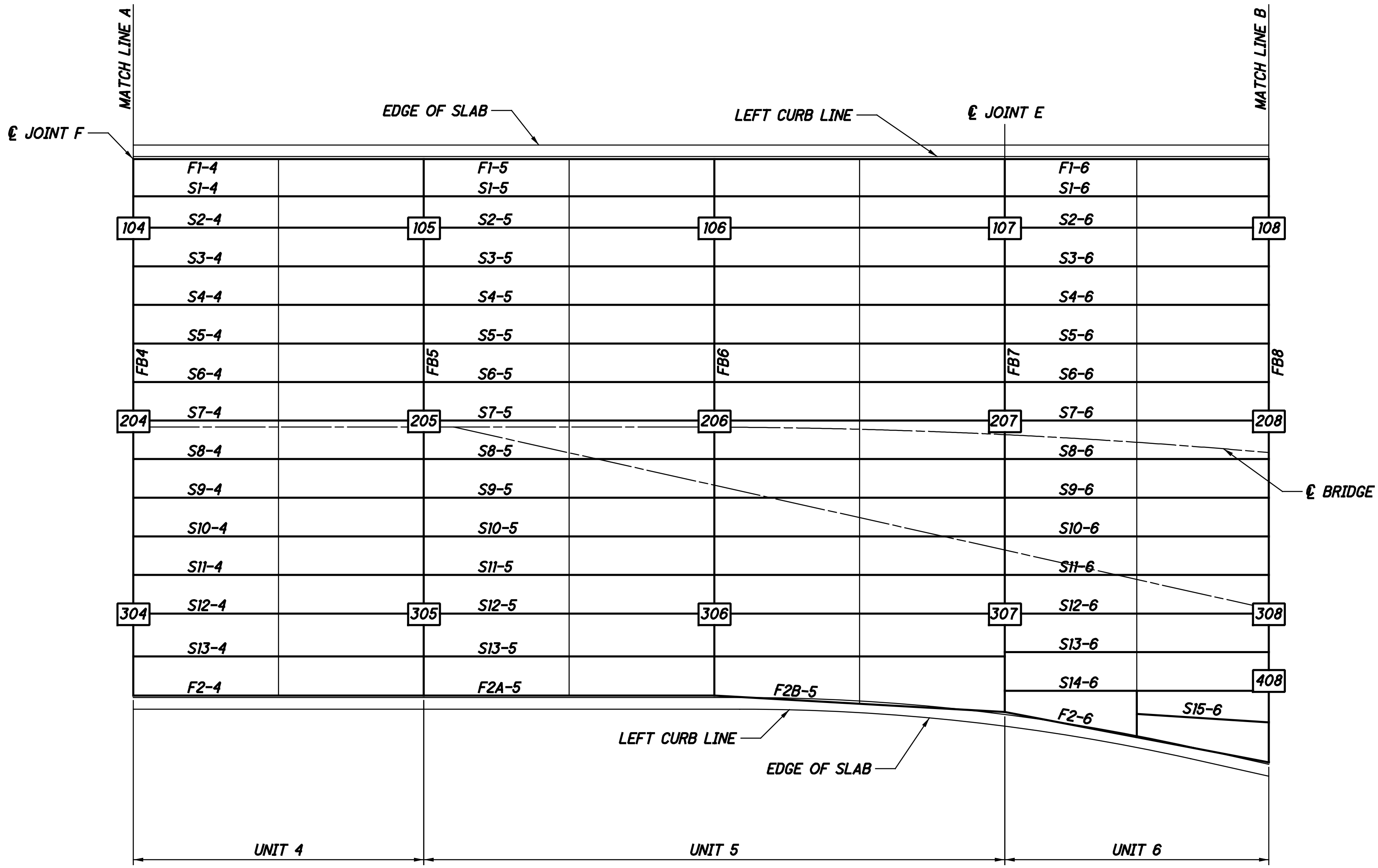




EAST APPROACH - FORWARD SECTION (1 OF 3)

MAIN AVENUE BRIDGE
CUY-2-1441

TranSystems



EAST APPROACH - FORWARD SECTION (2 OF 3)

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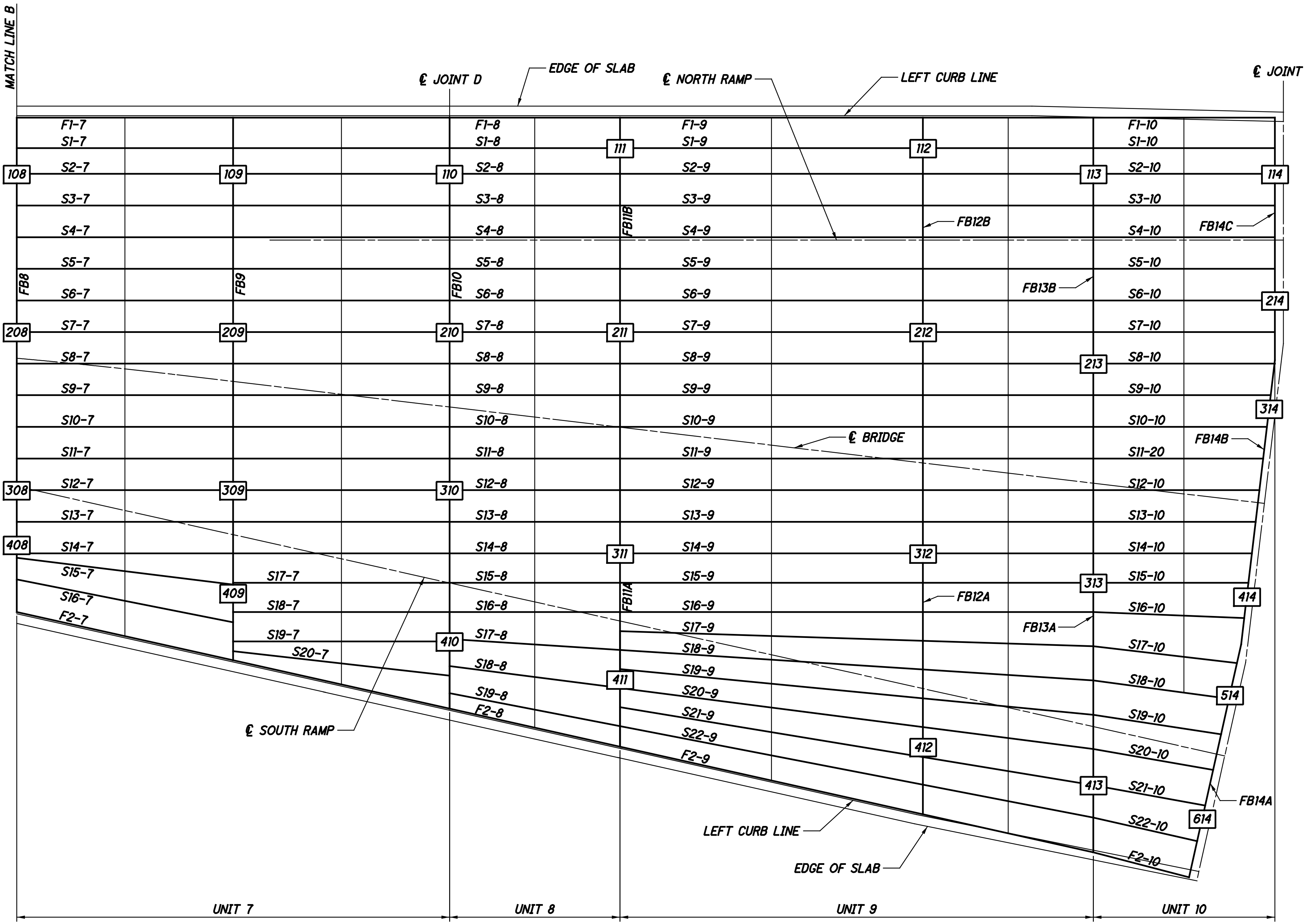
MAIN AVENUE BRIDGE
CUY-2-1441

TranSystems



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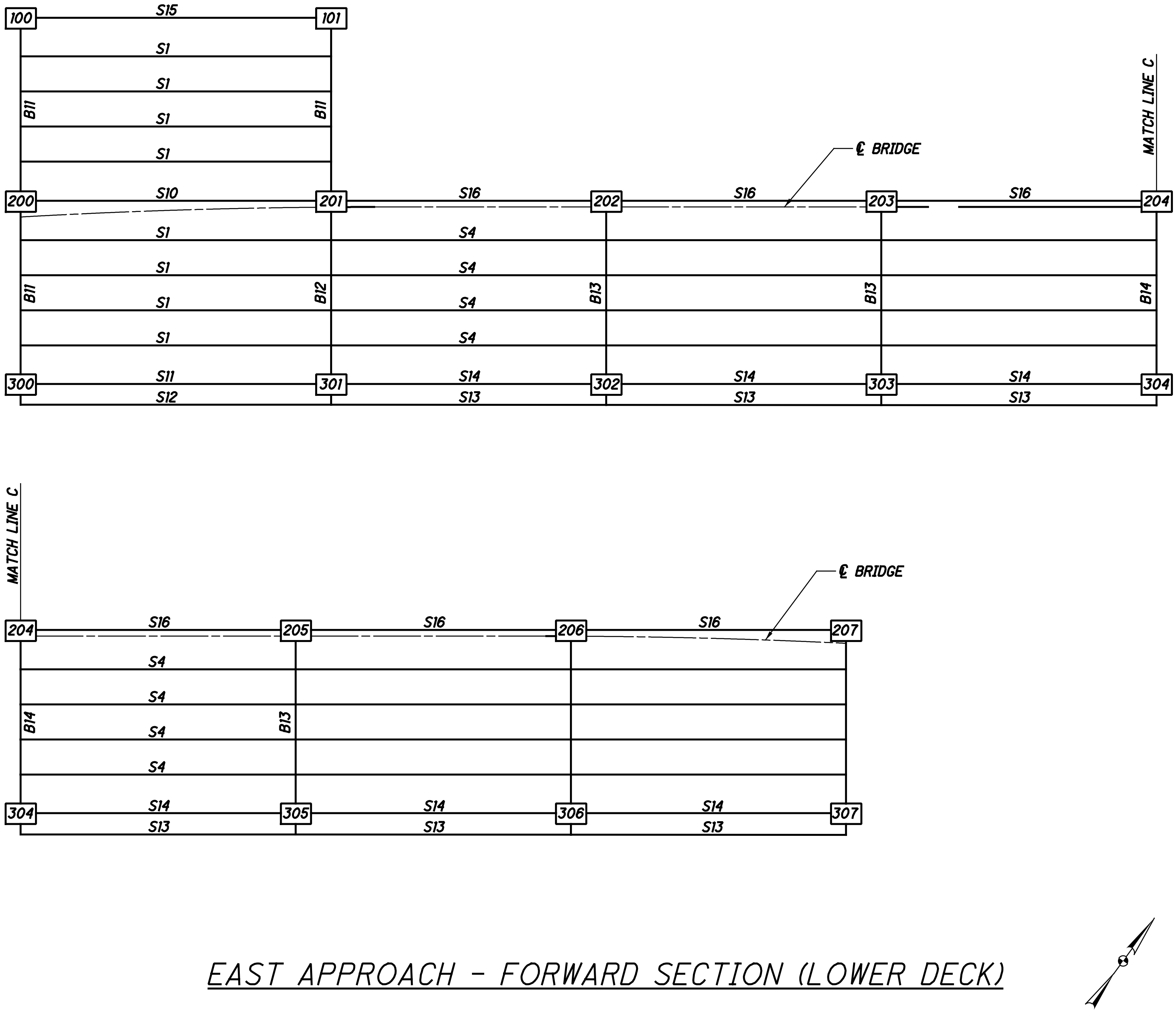
EAST APPROACH - FORWARD SECTION (3 OF 3)

MAIN AVENUE BRIDGE
CUY-2-1441

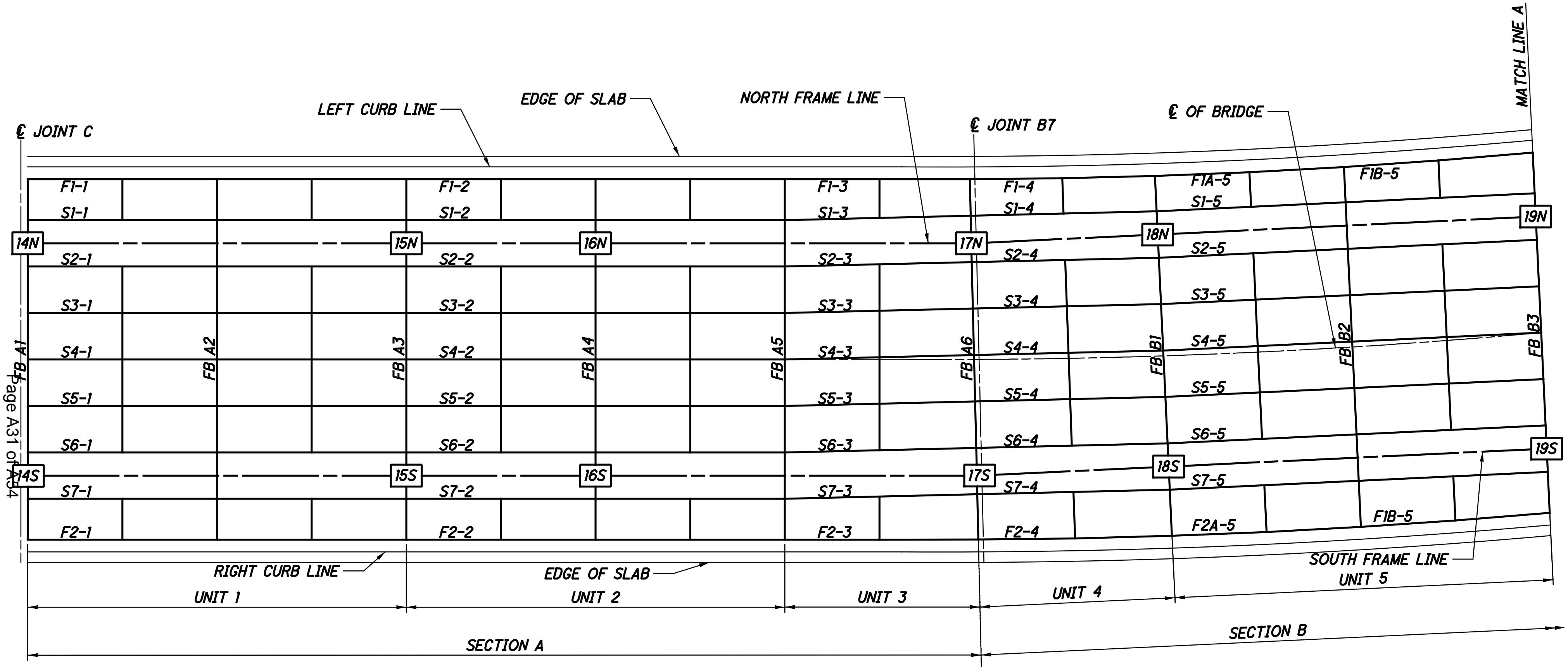
TranSystems



EAST APPROACH - FORWARD SECTION (LOWER DECK)

MAIN AVENUE BRIDGE
CUY-2-1441

TranSystems



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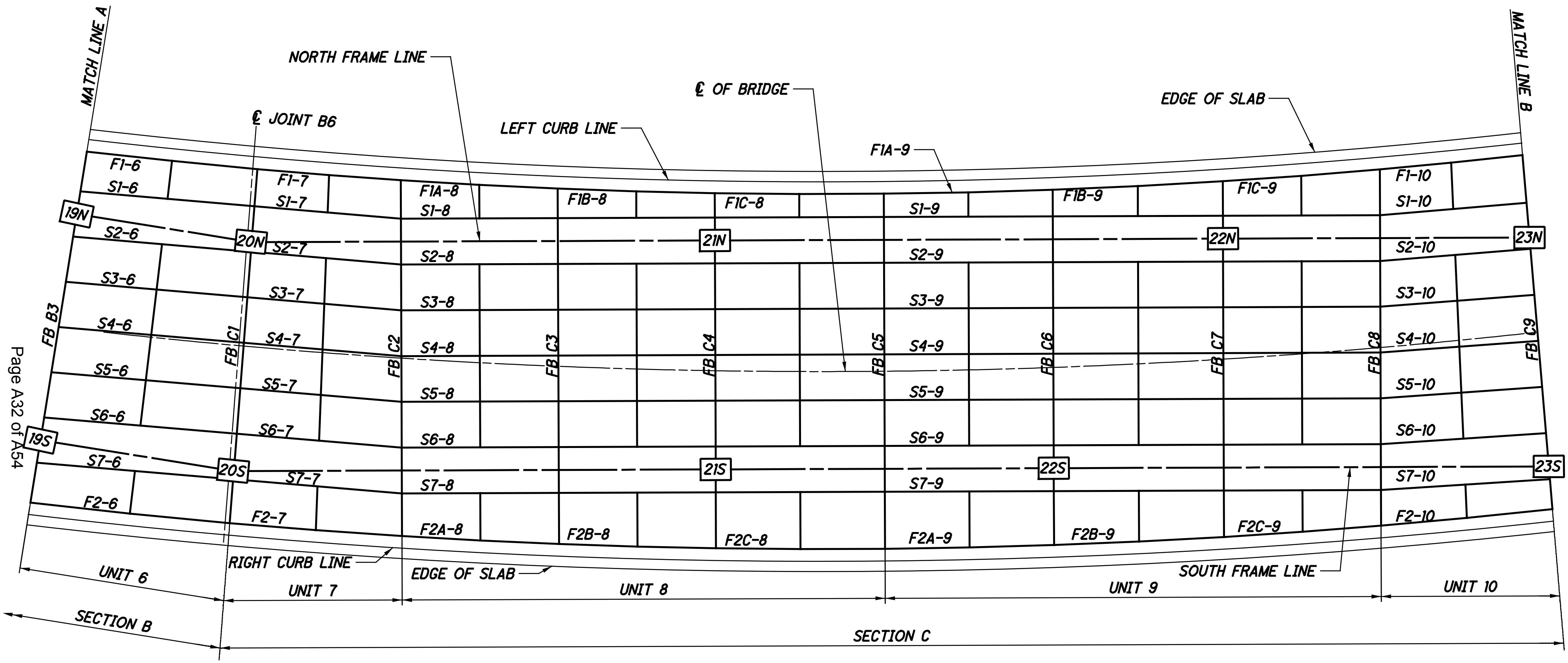
EAST APPROACH - LAKEFRONT TRESTLE (1 OF 6)

MAIN AVENUE BRIDGE
CUY-2-1441

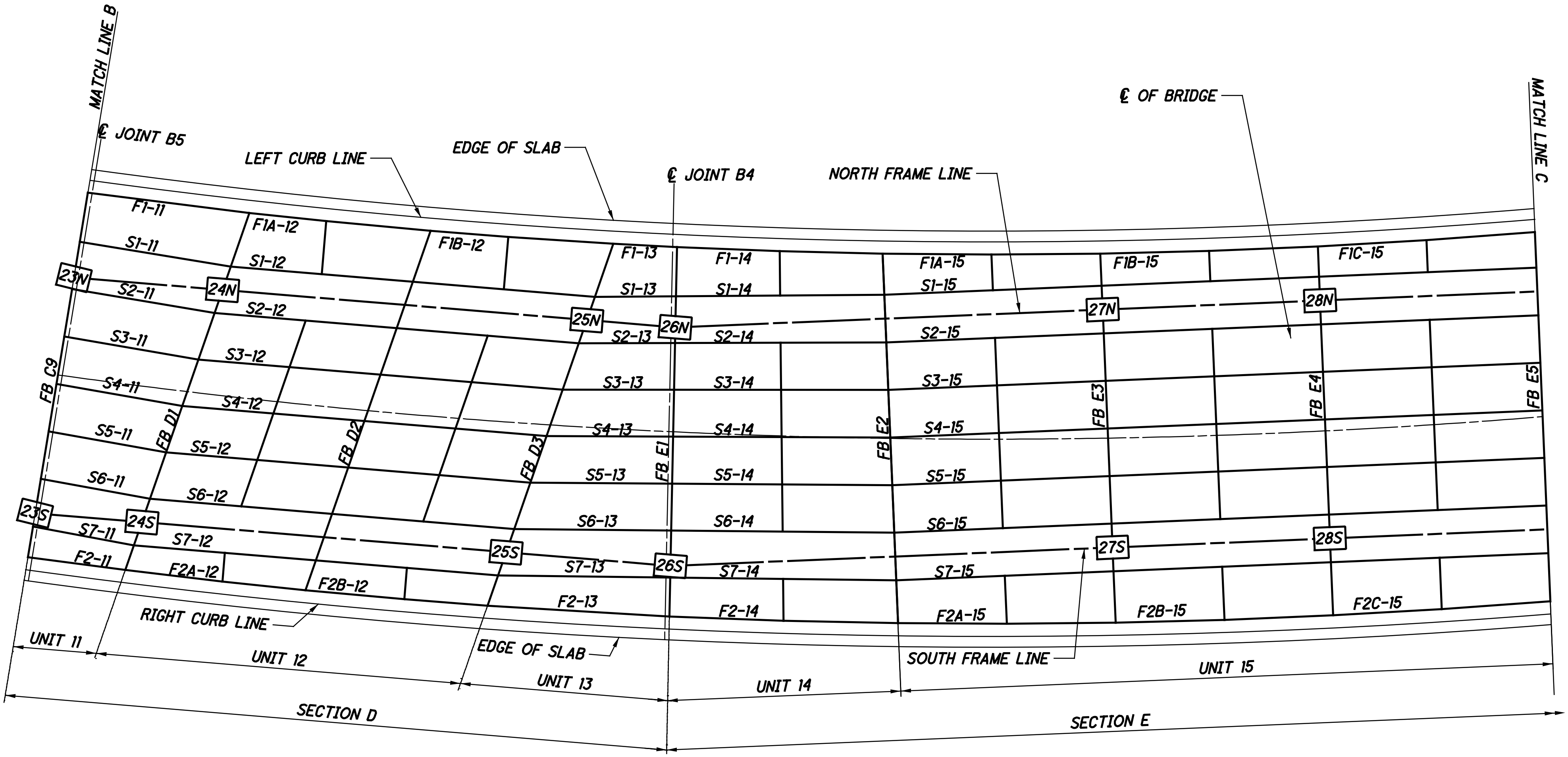
TranSystems



EAST APPROACH - LAKEFRONT TRESTLE (2 OF 6)

MAIN AVENUE BRIDGE
CUY-2-1441

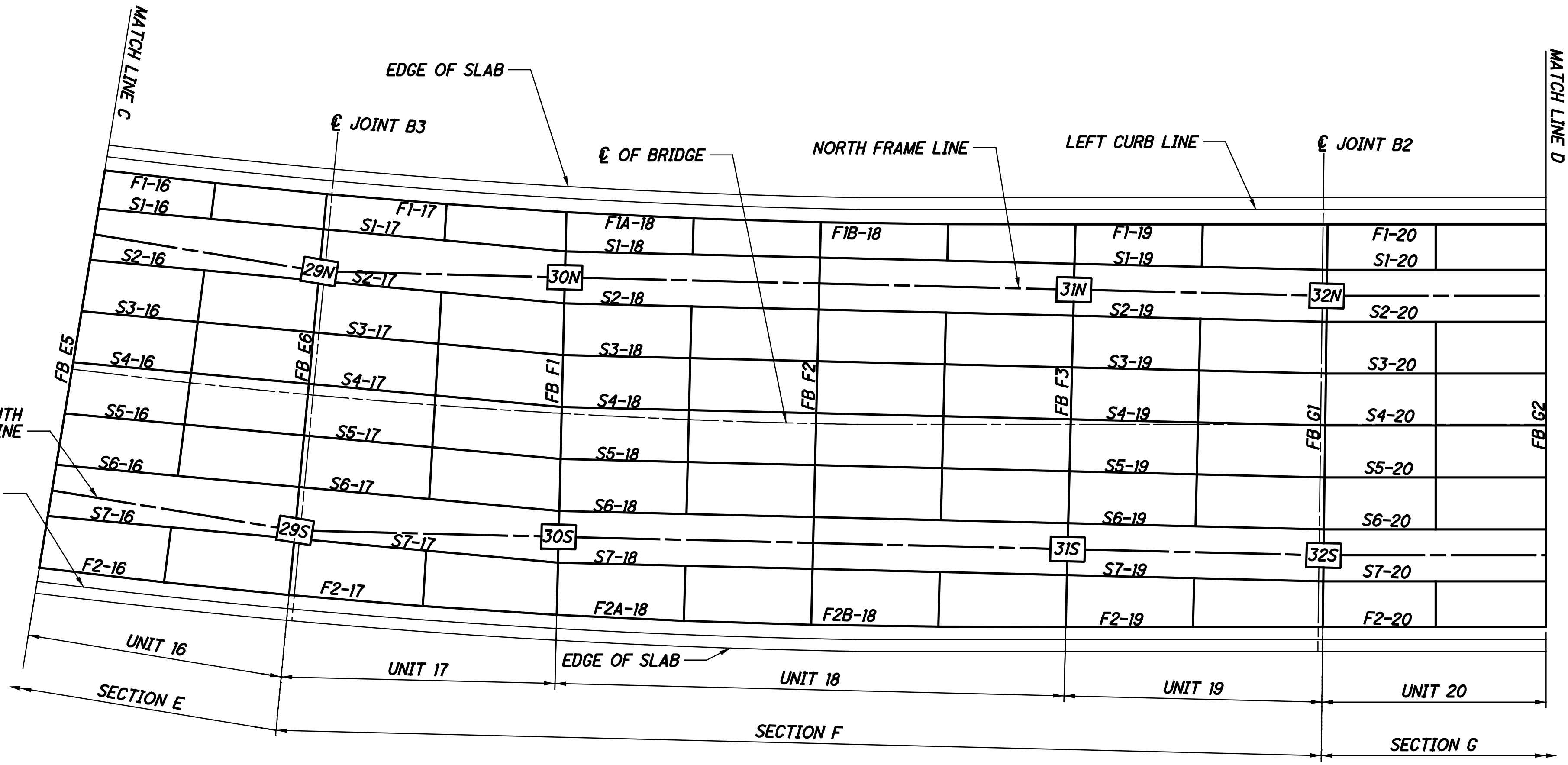
TranSystems



EAST APPROACH - LAKEFRONT TRESTLE (3 OF 6)

MAIN AVENUE BRIDGE
CUY-2-1441

TranSystems



EAST APPROACH - LAKEFRONT TRESTLE (4 OF 6)

MAIN AVENUE BRIDGE
CUY-2-1441

TranSystems

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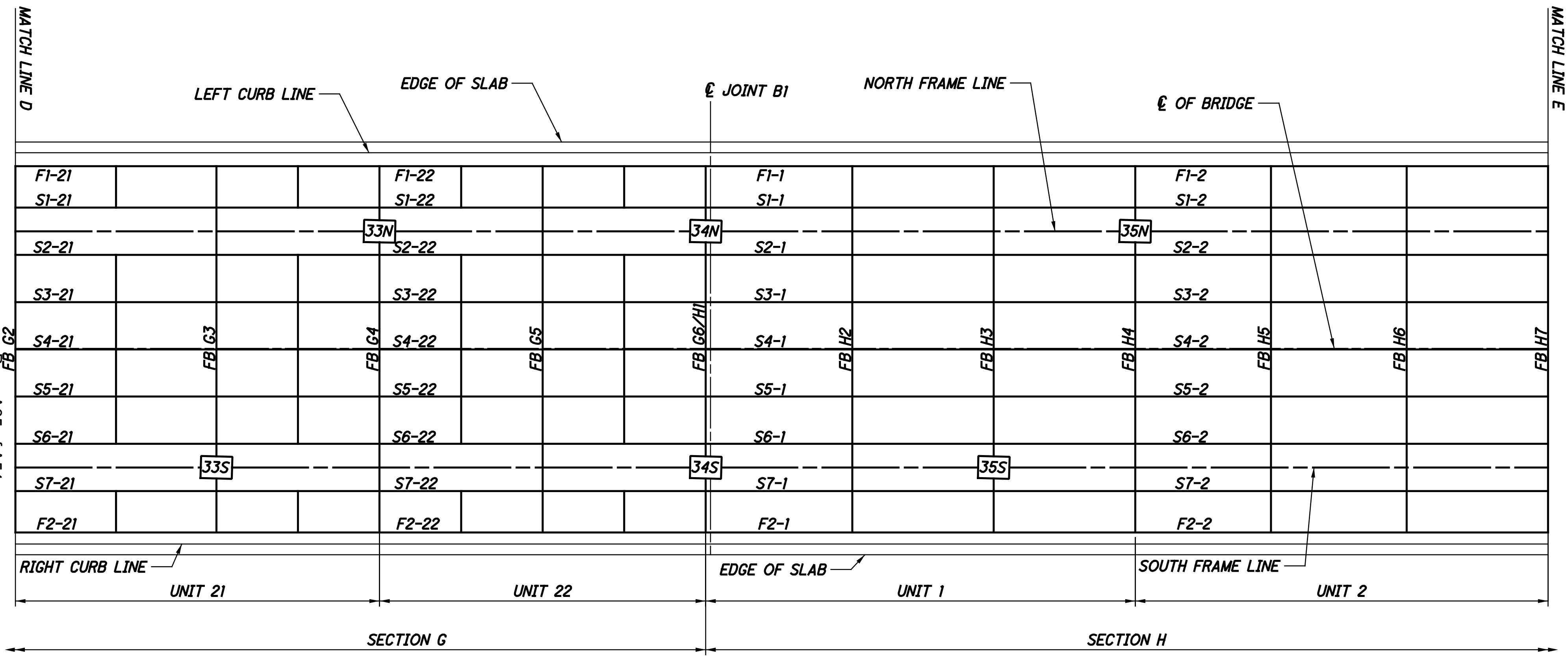

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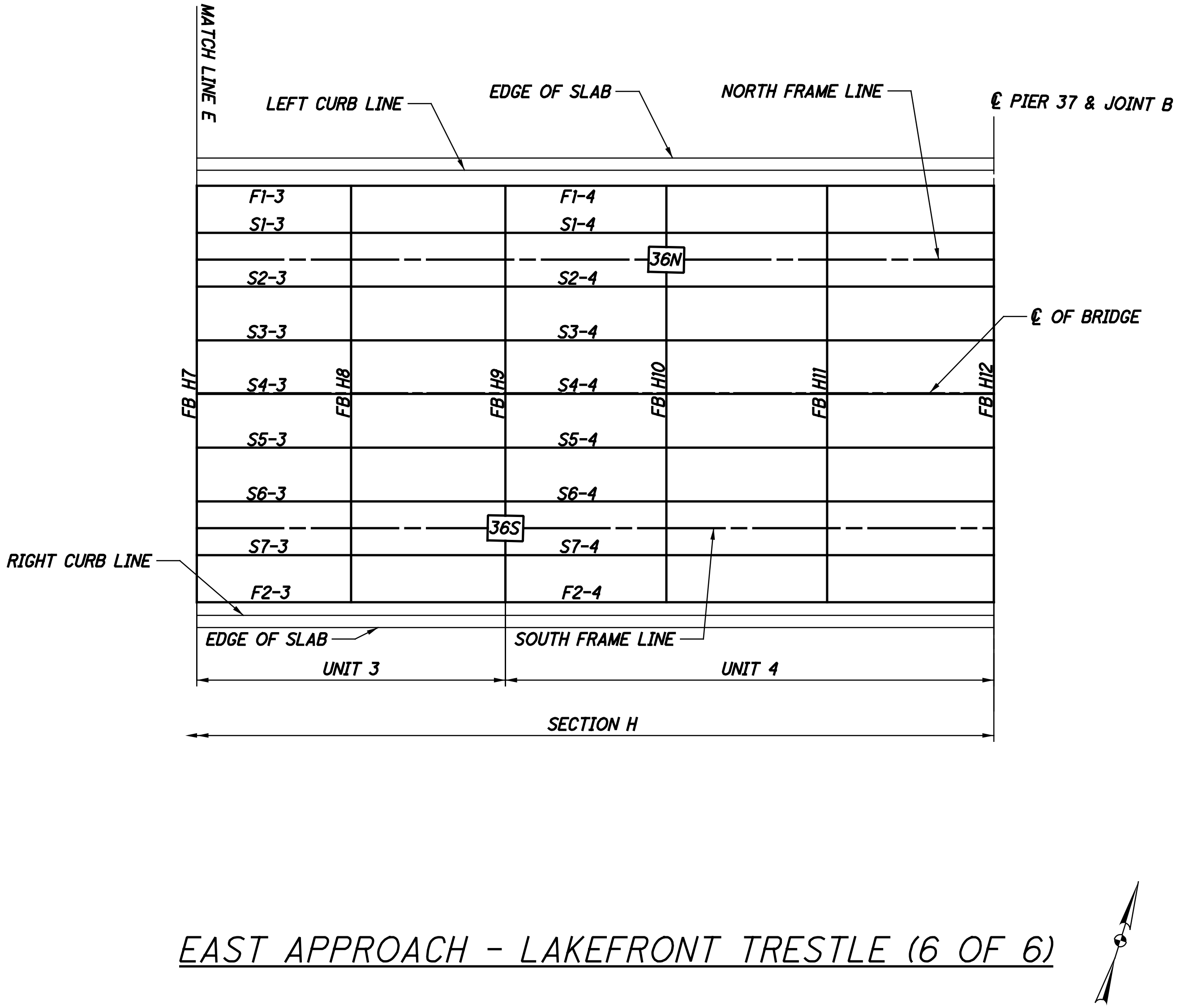
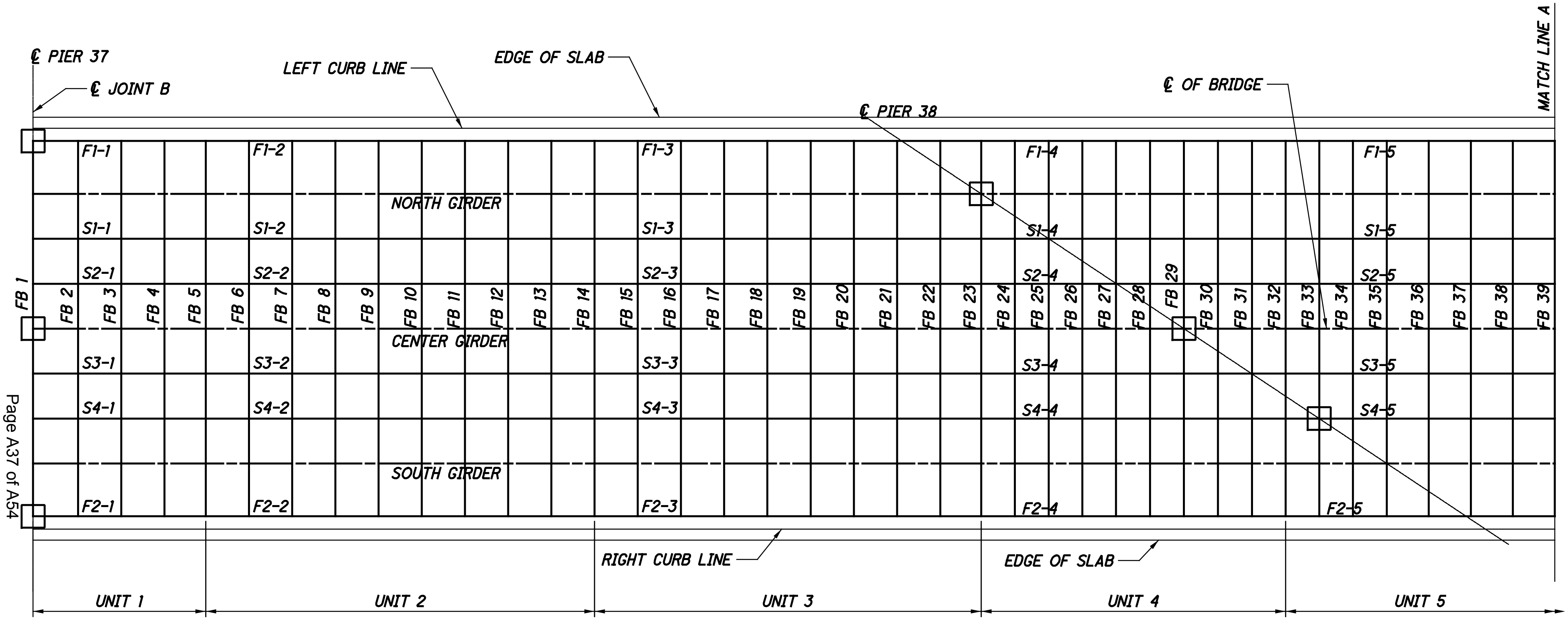
EAST APPROACH - LAKEFRONT TRESTLE (5 OF 6)

MAIN AVENUE BRIDGE
CUY-2-1441

TranSystems



EAST APPROACH - LAKEFRONT TRESTLE (6 OF 6)



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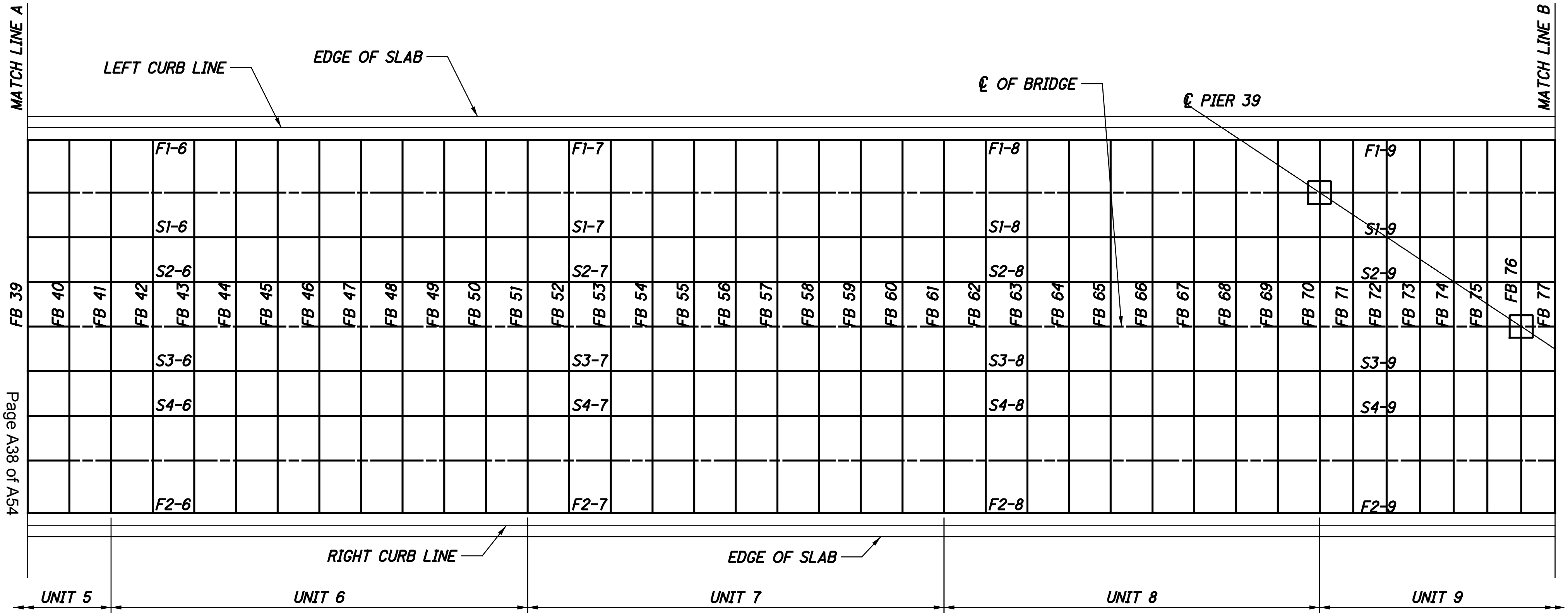
EAST APPROACH - LAKEFRONT RAMP (1 OF 4)

MAIN AVENUE BRIDGE
CUY-2-1441

TranSystems



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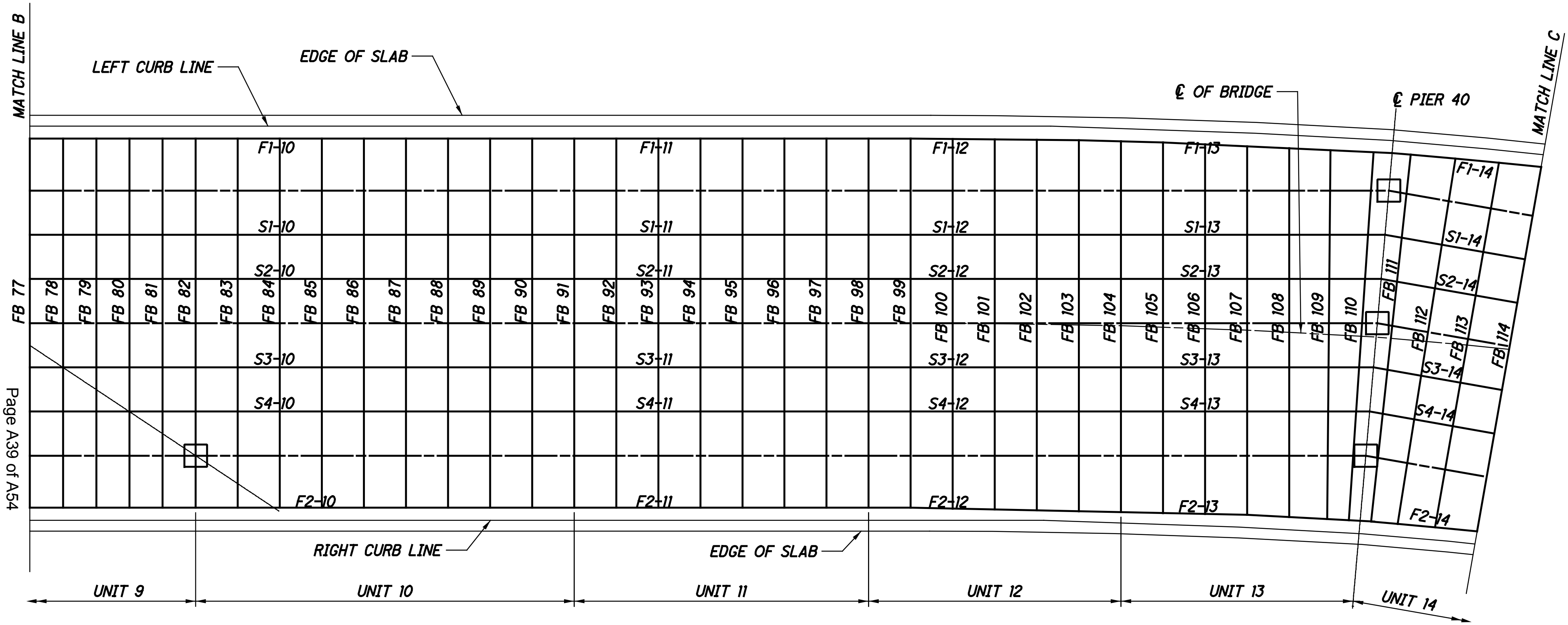
EAST APPROACH - LAKEFRONT RAMP (2 OF 4)

MAIN AVENUE BRIDGE
CUY-2-1441

TranSystems



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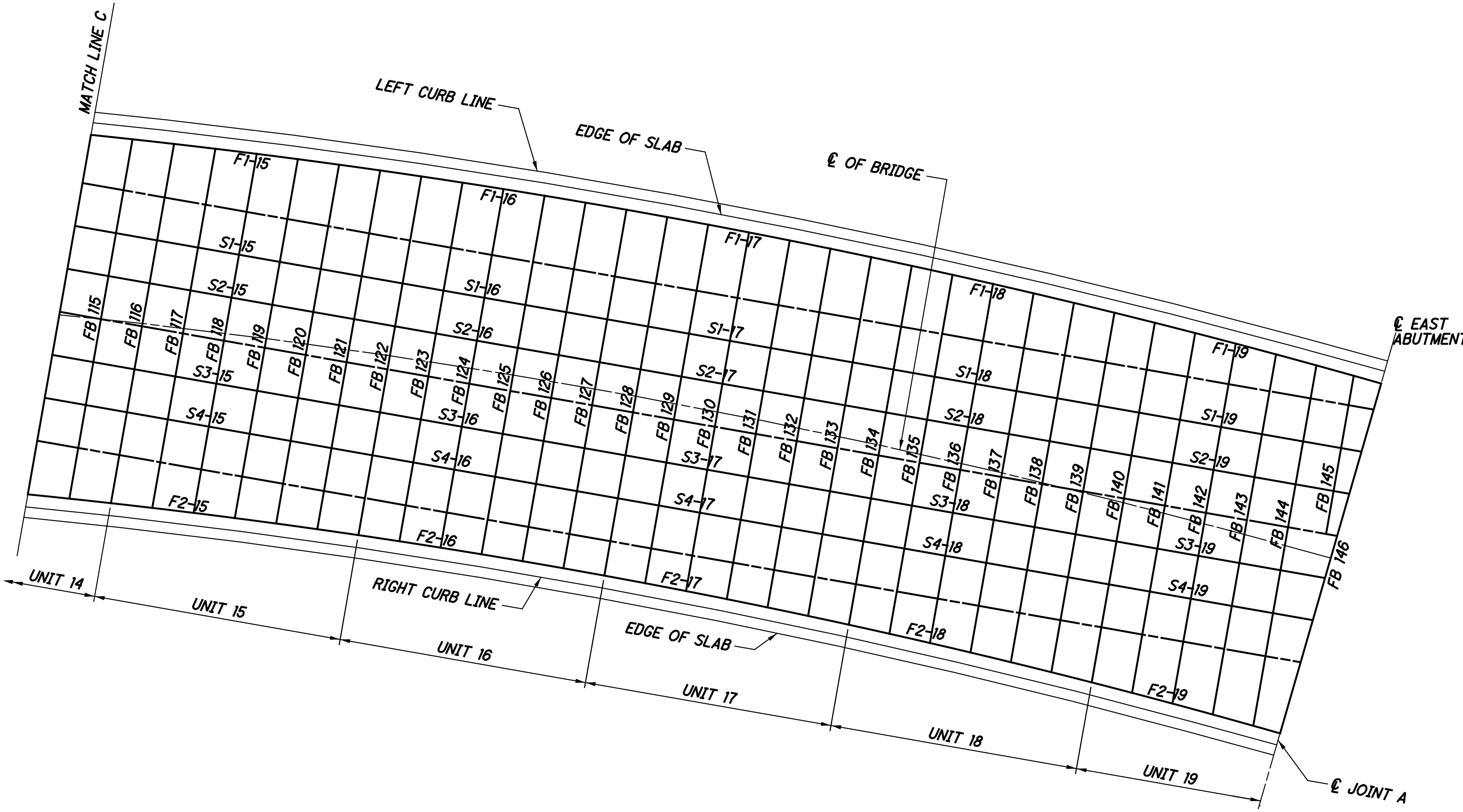
EAST APPROACH - LAKEFRONT RAMP (3 OF 4)

MAIN AVENUE BRIDGE
CUY-2-1441

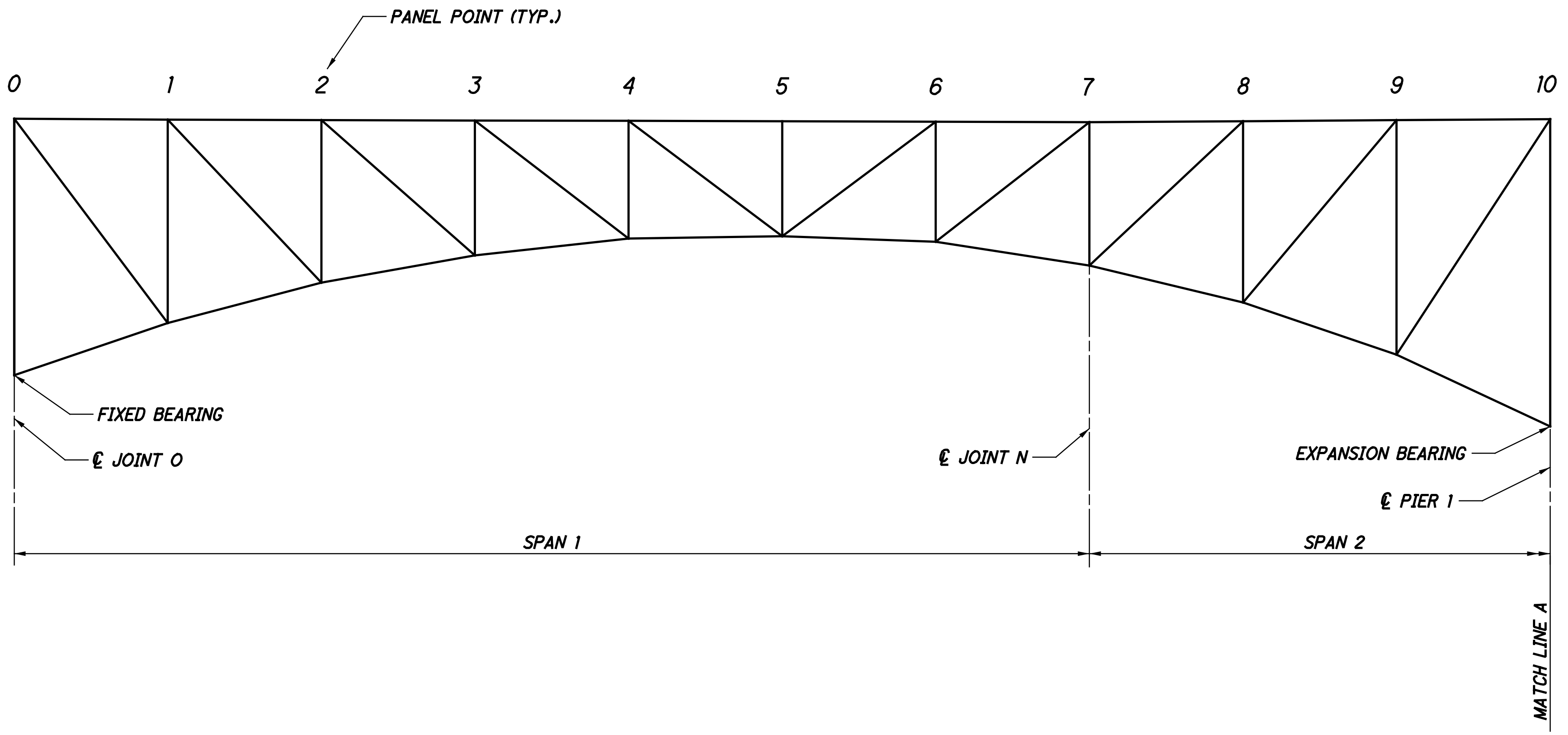
TranSystems



EAST APPROACH - LAKEFRONT RAMP (4 OF 4)

MAIN AVENUE BRIDGE
CUY-2-1441

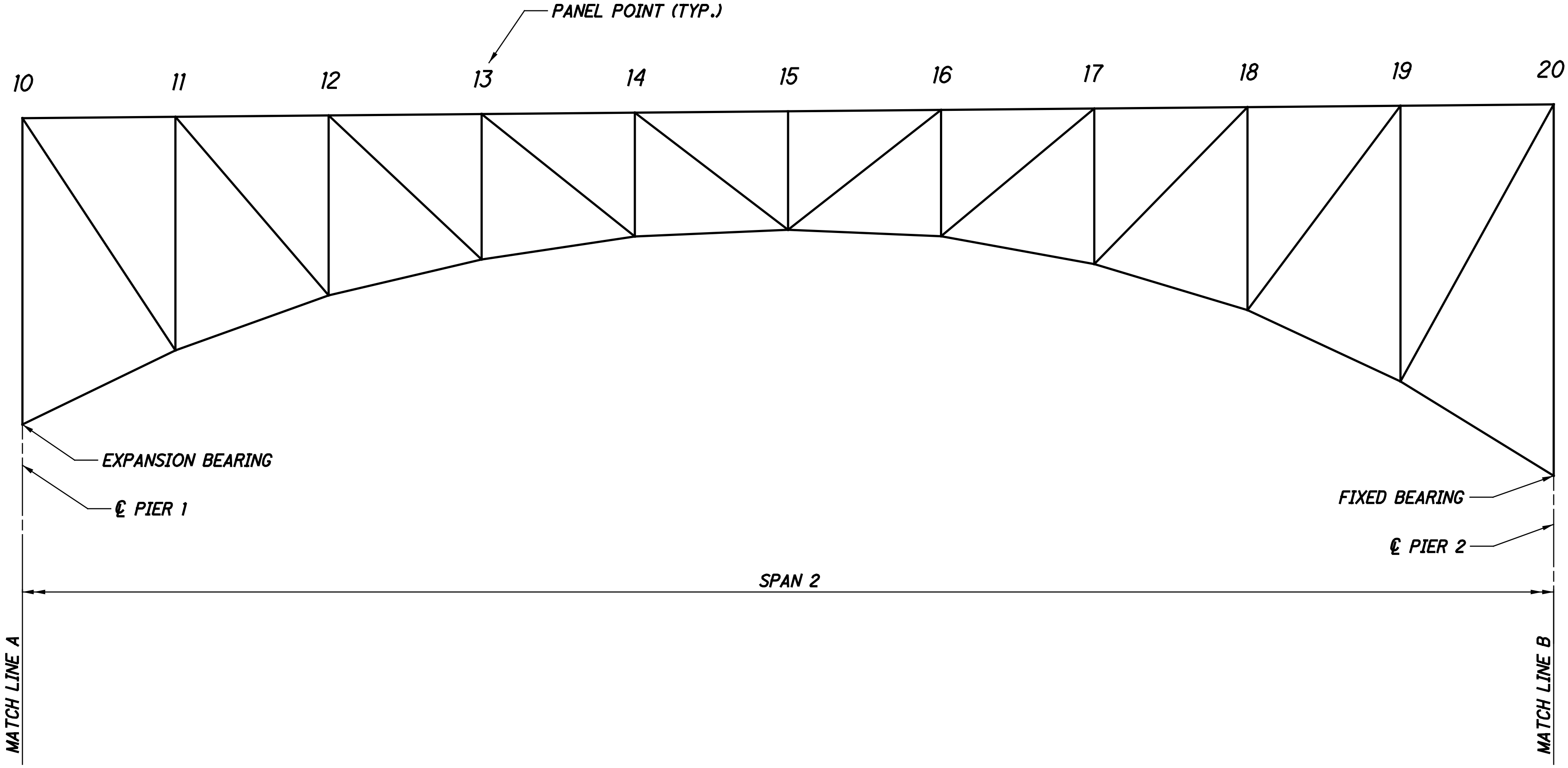
TranSystems



MAIN TRUSS SPANS (1 OF 13)
(SOUTH ELEVATION)

MAIN AVENUE BRIDGE
CUY-2-1441

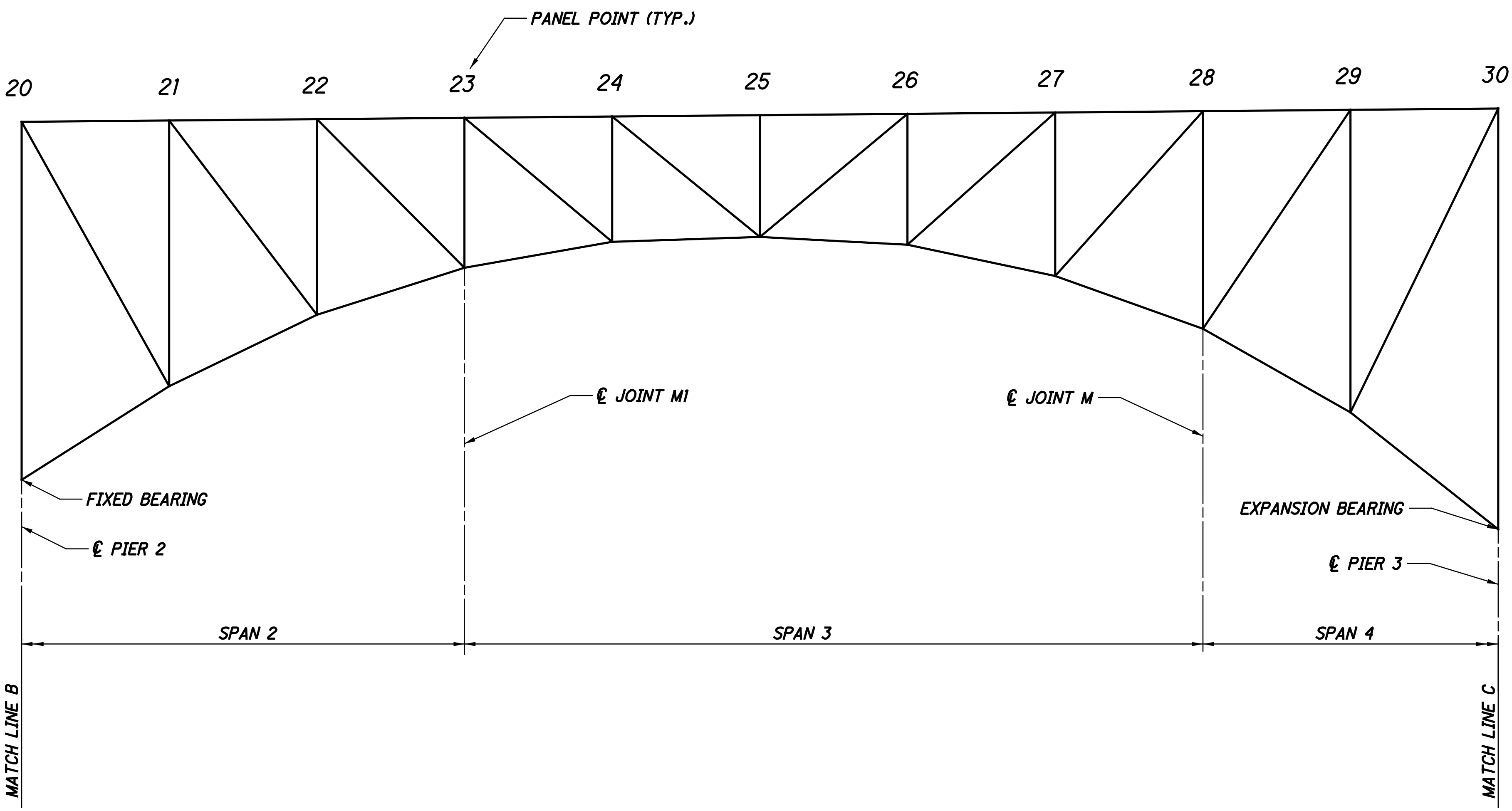
TranSystems



MAIN TRUSS SPANS (2 OF 13)
(SOUTH ELEVATION)

MAIN AVENUE BRIDGE
CUY-2-1441

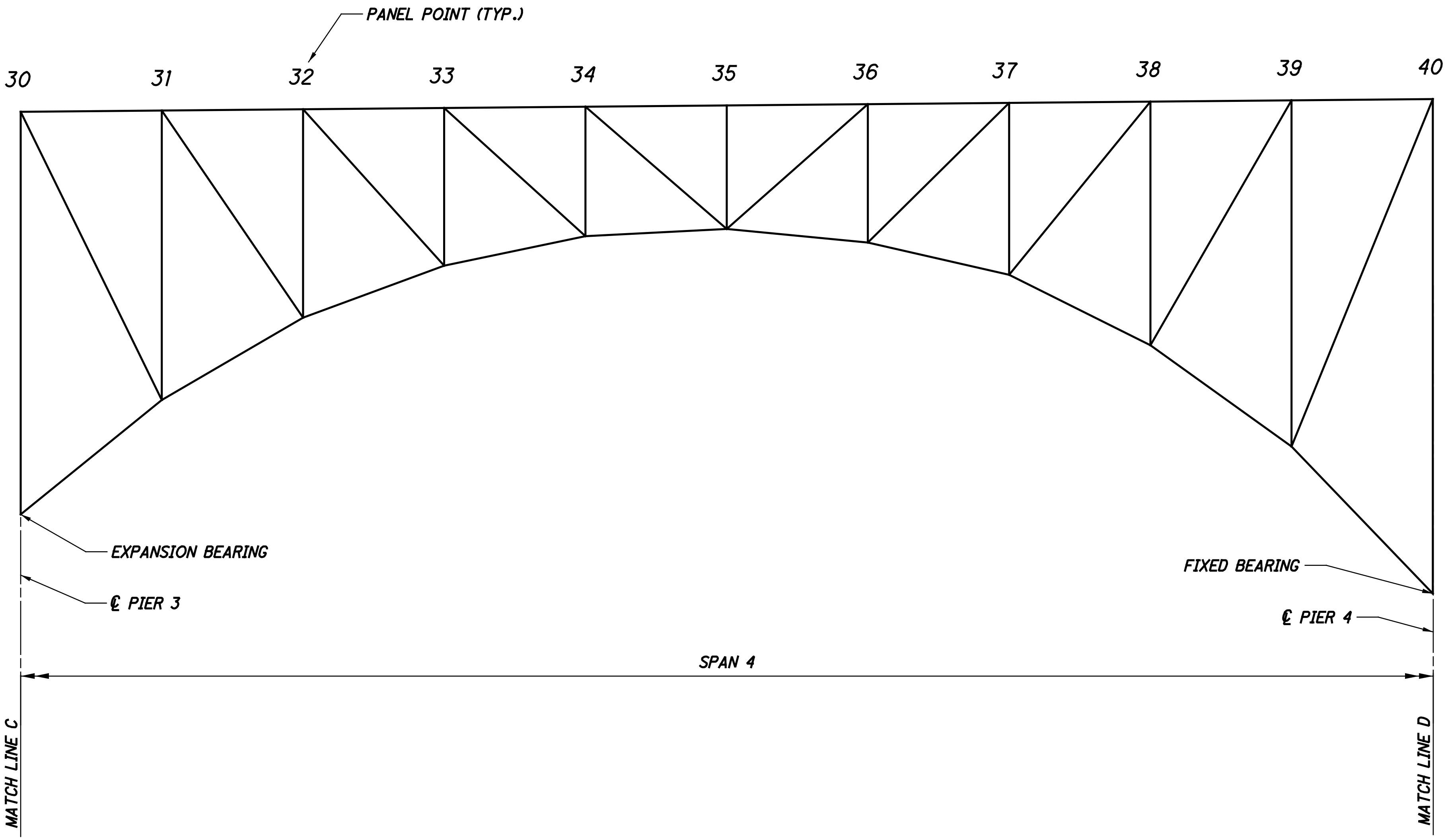
TranSystems



MAIN TRUSS SPANS (3 OF 13)
(SOUTH ELEVATION)

MAIN AVENUE BRIDGE
CUY-2-1441

TranSystems

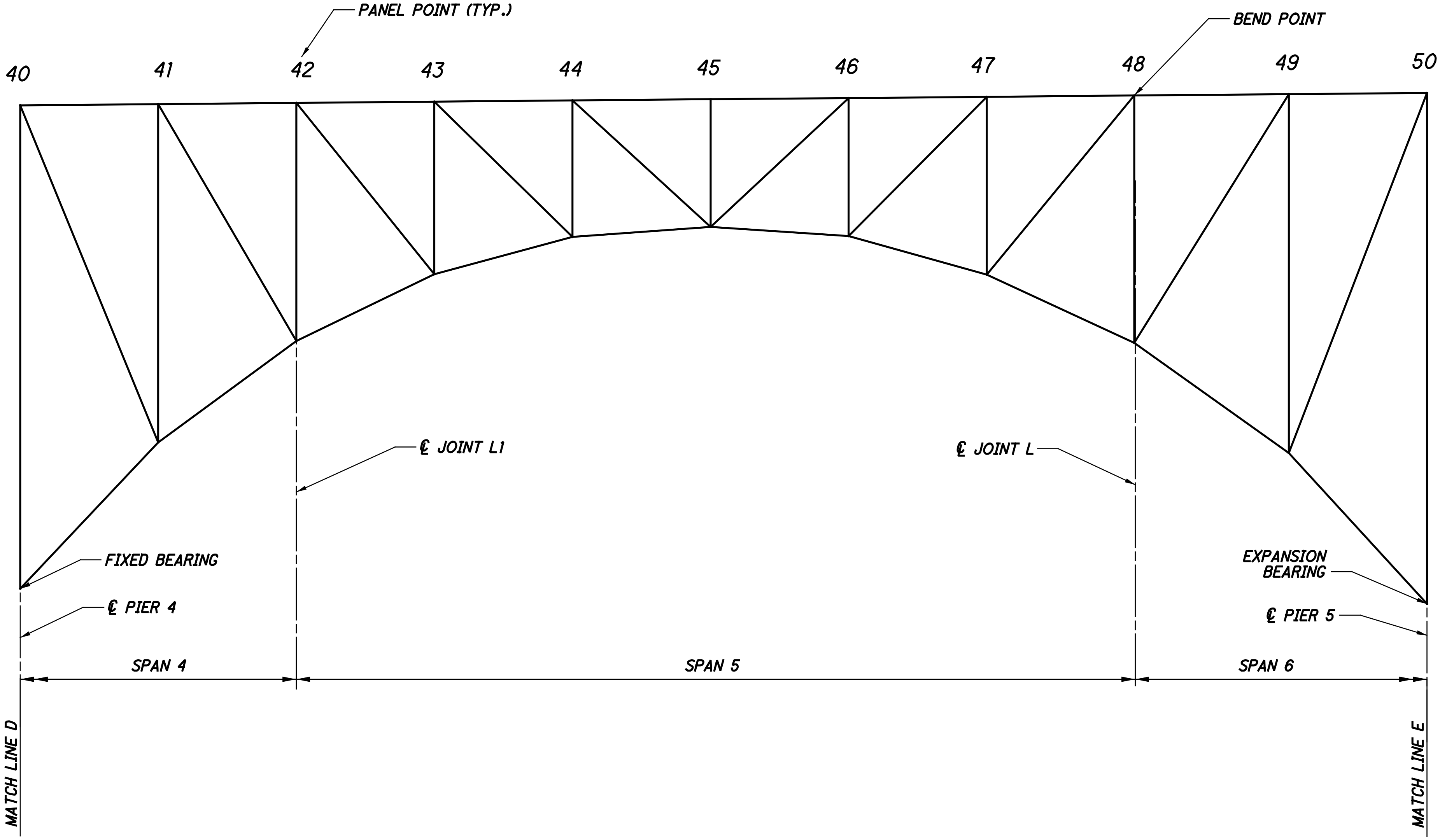


<u>MAIN TRUSS SPANS (4 OF 13)</u>

(SOUTH ELEVATION)

MAIN AVENUE BRIDGE
CUY-2-1441

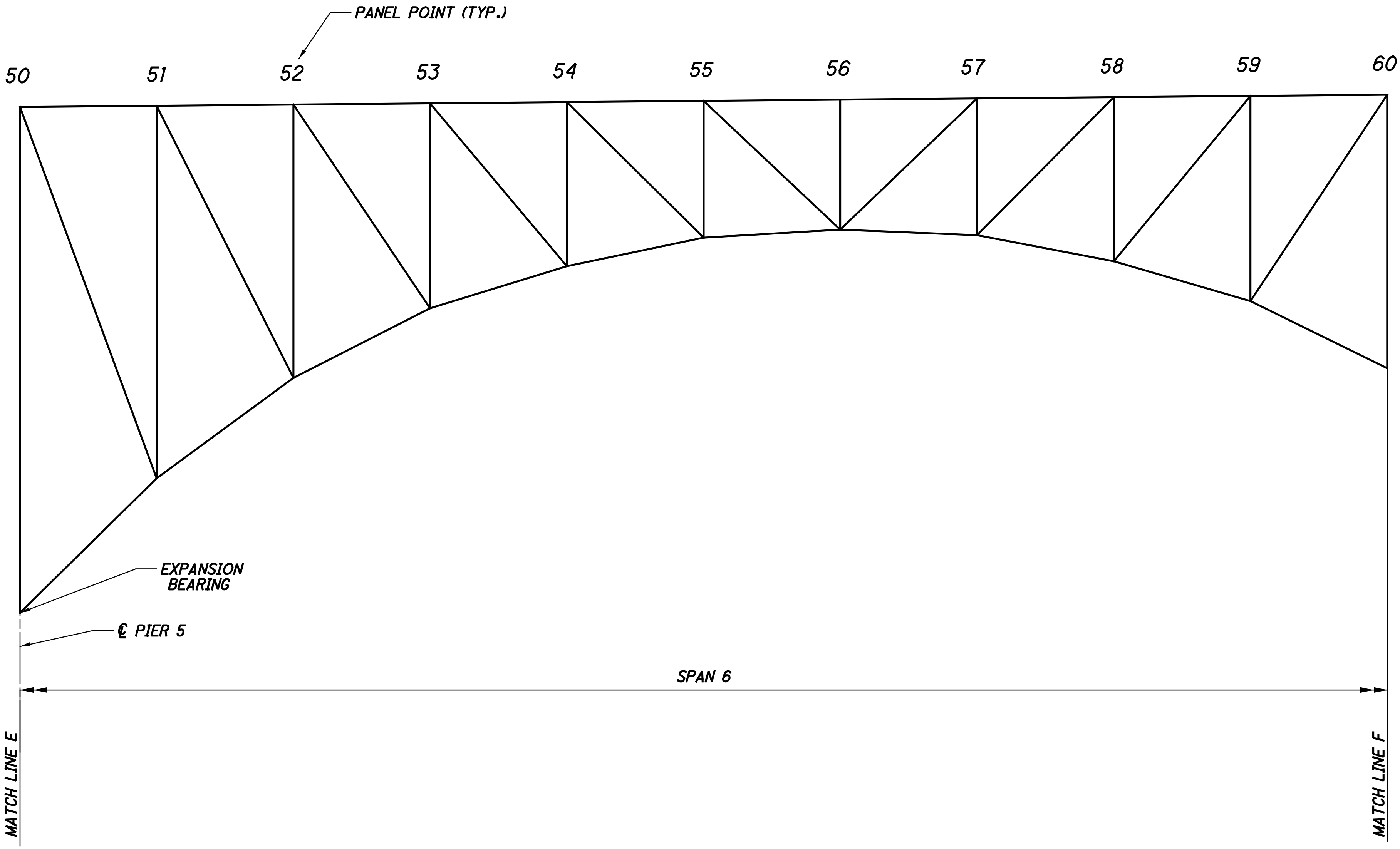
TranSystems



MAIN TRUSS SPANS (5 OF 13)
(SOUTH ELEVATION)

MAIN AVENUE BRIDGE
CUY-2-1441

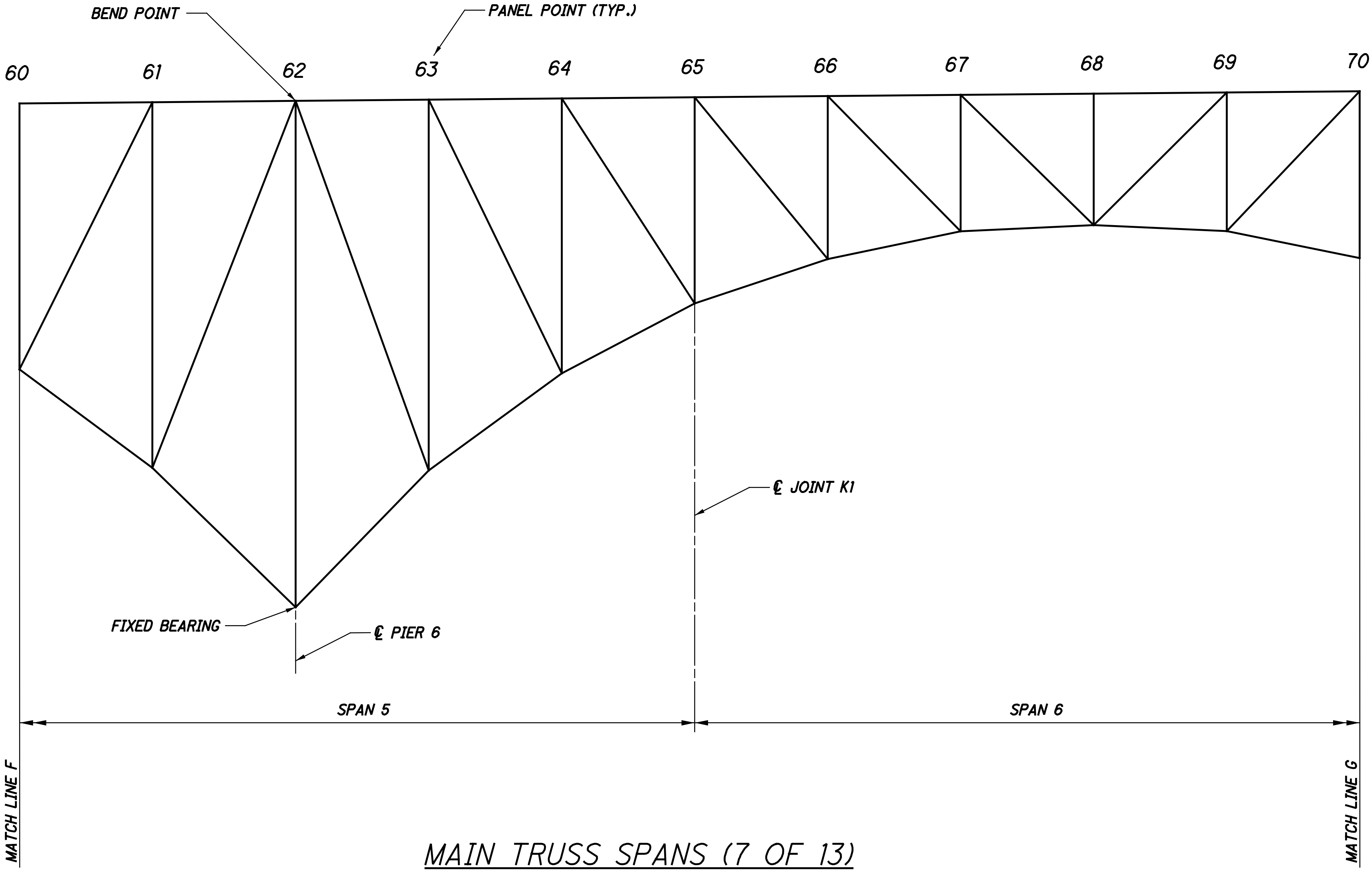
TranSystems



MAIN TRUSS SPANS (6 OF 13)
(SOUTH ELEVATION)

MAIN AVENUE BRIDGE
CUY-2-1441

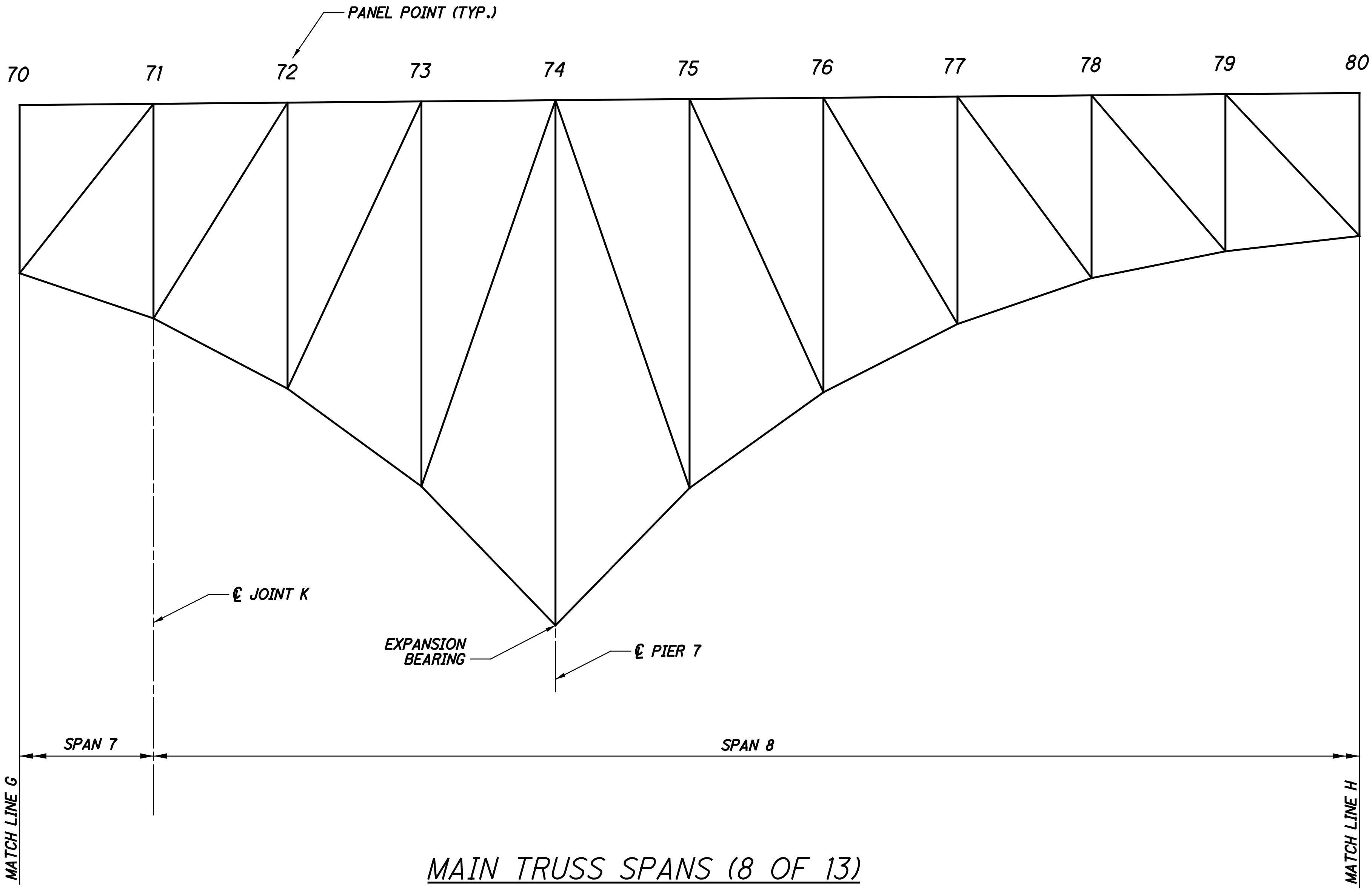
TranSystems



MAIN TRUSS SPANS (7 OF 13)
(SOUTH ELEVATION)

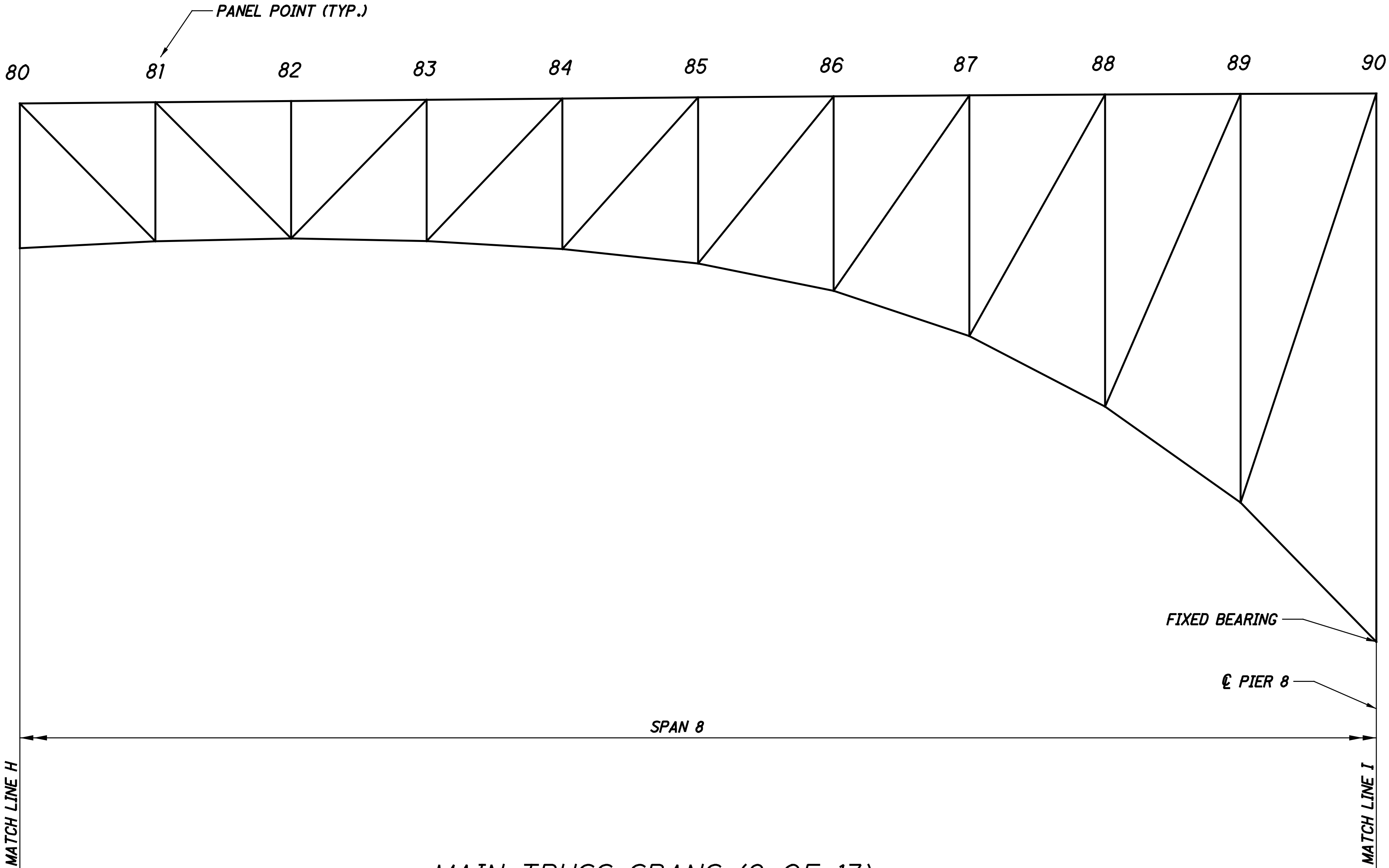
MAIN AVENUE BRIDGE
CUY-2-1441

TranSystems



MAIN TRUSS SPANS (8 OF 13)
(SOUTH ELEVATION)

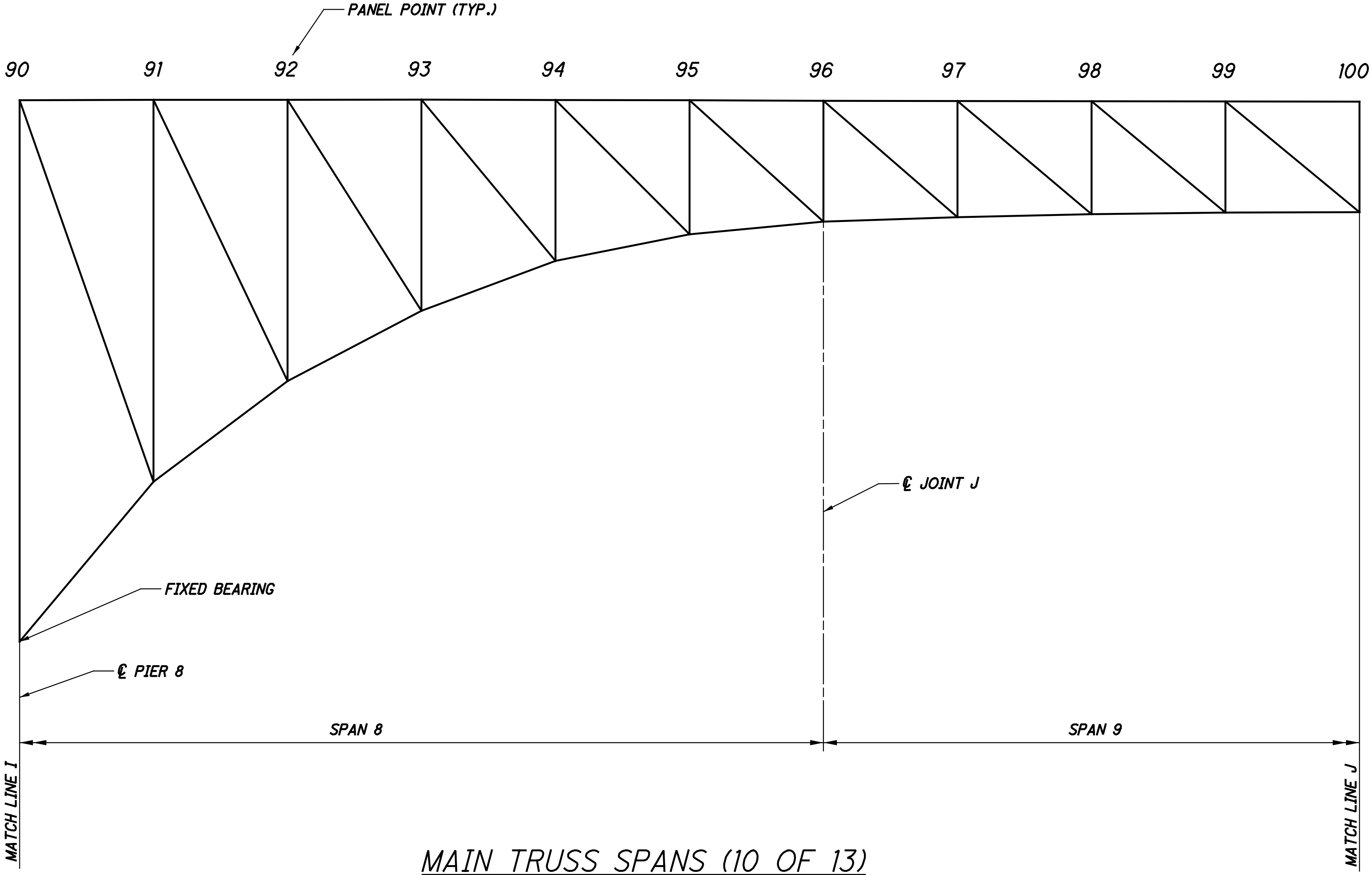
MAIN AVENUE BRIDGE
CUY-2-1441
TranSystems



MAIN TRUSS SPANS (9 OF 13)
(SOUTH ELEVATION)

MAIN AVENUE BRIDGE
CUY-2-1441

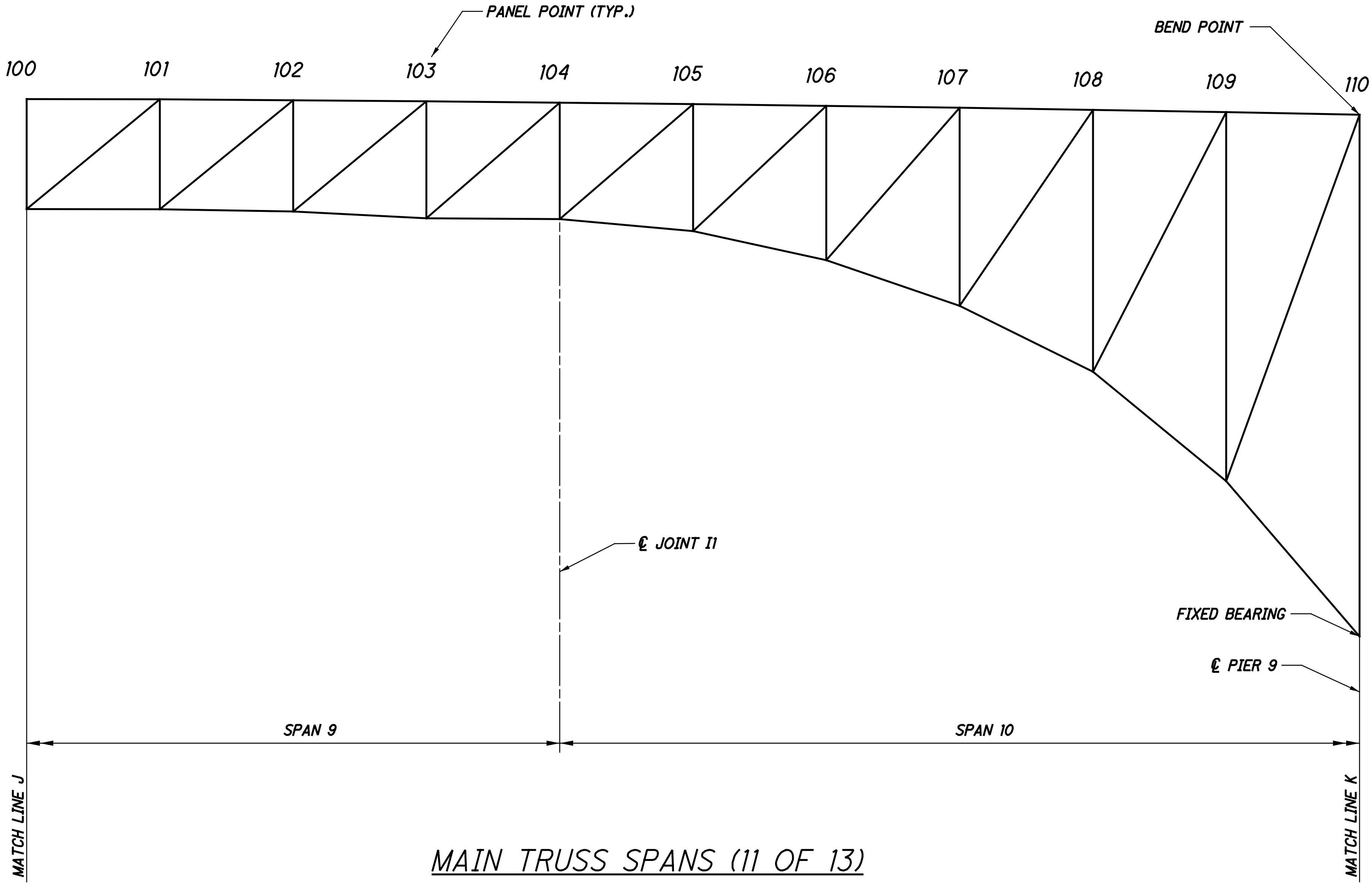
TranSystems



MAIN TRUSS SPANS (10 OF 13)
(SOUTH ELEVATION)

MAIN AVENUE BRIDGE
CUY-2-1441

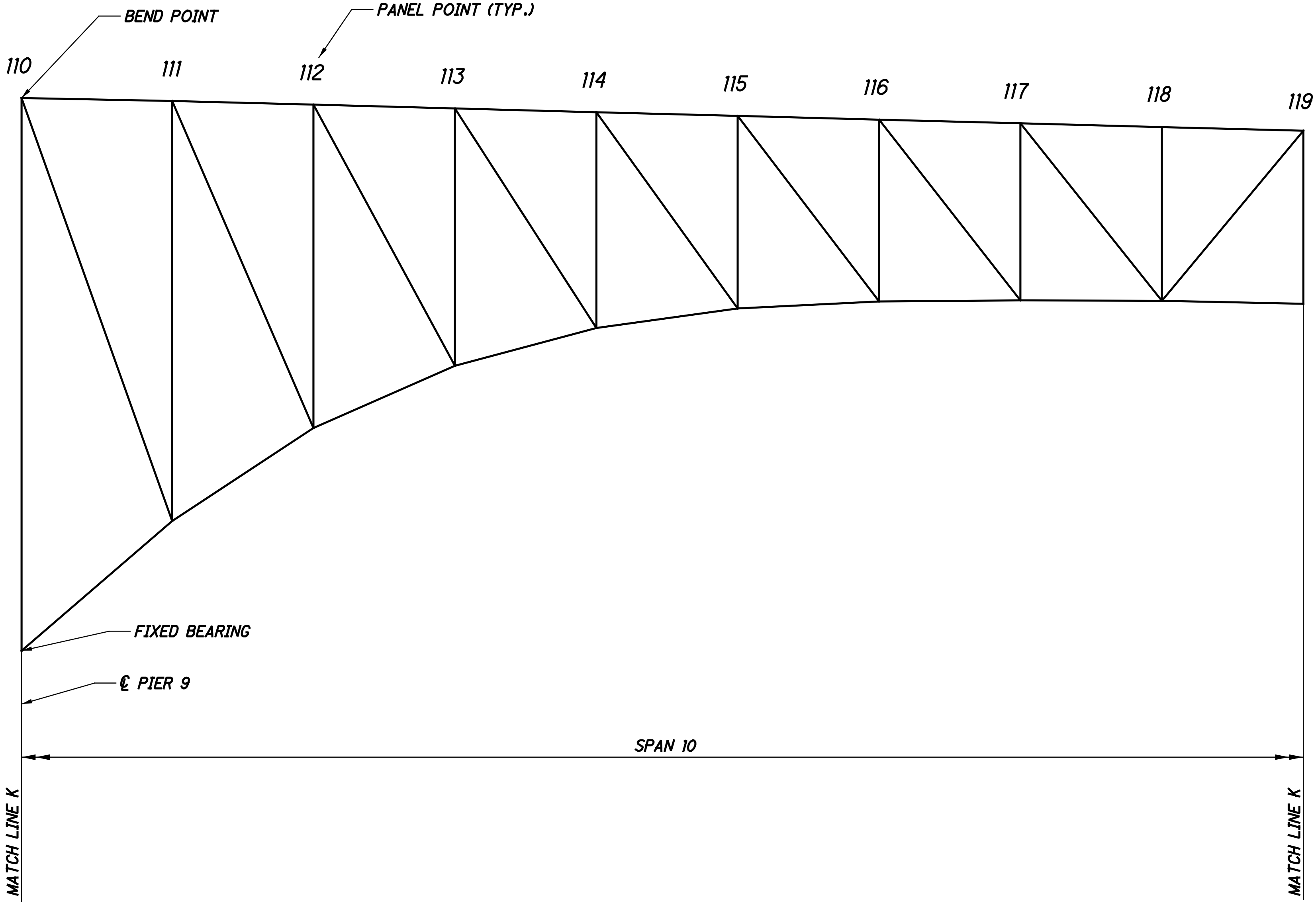
TranSystems



MAIN TRUSS SPANS (11 OF 13)
(SOUTH ELEVATION)

MAIN AVENUE BRIDGE
CUY-2-1441

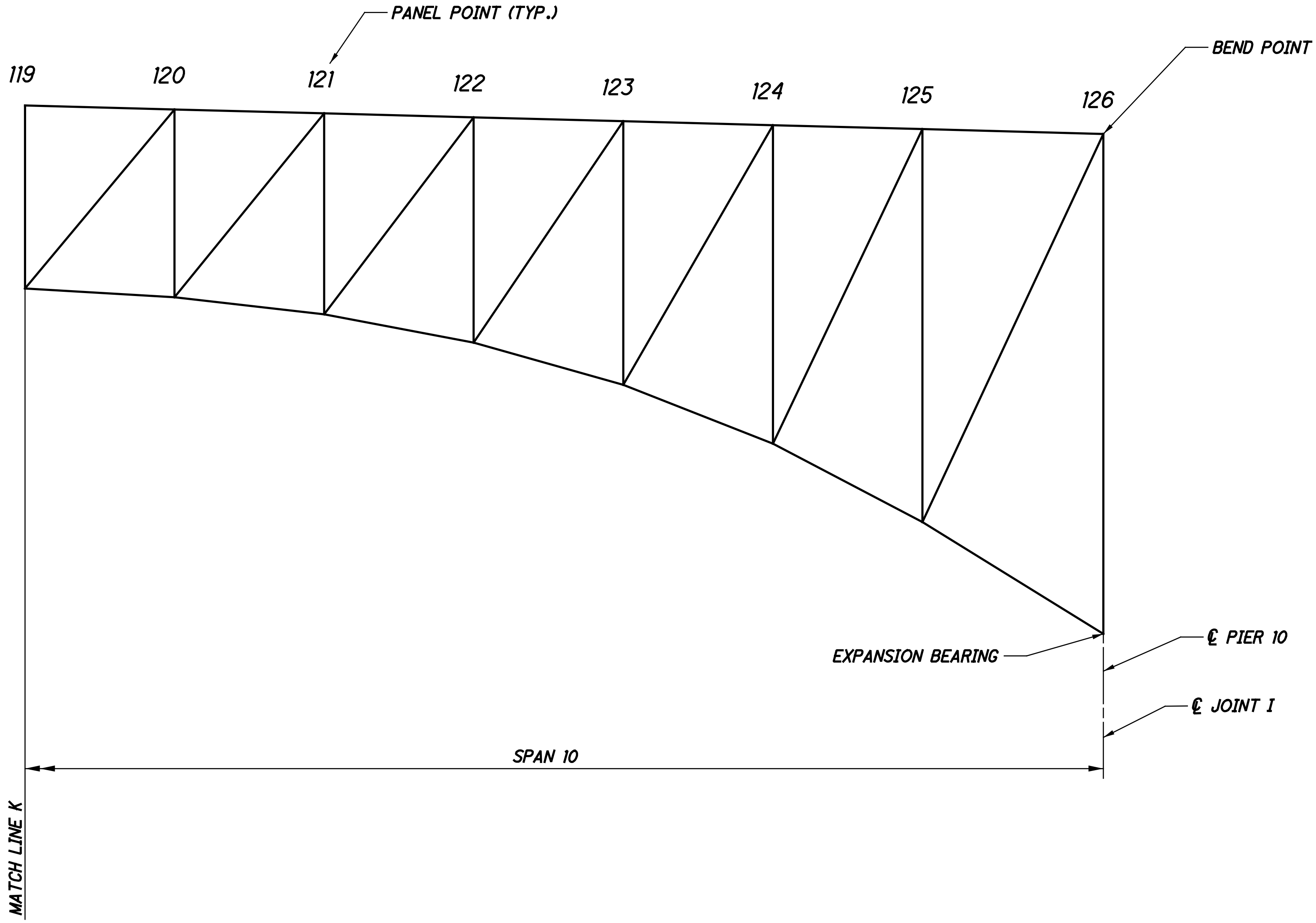
TranSystems



MAIN TRUSS SPANS (12 OF 13)
(SOUTH ELEVATION)

MAIN AVENUE BRIDGE
CUY-2-1441

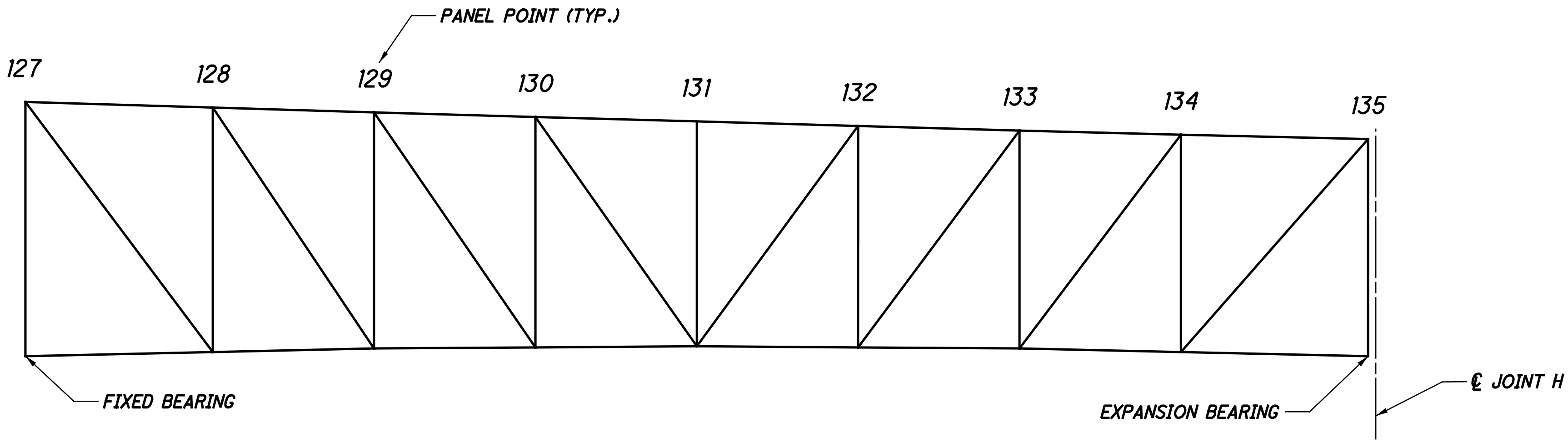
TranSystems



MAIN TRUSS SPANS (13 OF 13)
(SOUTH ELEVATION)

MAIN AVENUE BRIDGE
CUY-2-1441

TranSystems



EAST APPROACH - FORWARD SECTION - SPAN 11
(SOUTH ELEVATION)

MAIN AVENUE BRIDGE
CUY-2-1441

TranSystems

Appendix B
BR-100 Form
Summary forms for each section

BRIDGE LOAD RATING SUMMARY REPORT

CUY-2-1441

WEST APPROACH - SECTION J'

SFN	BRIDGE NUMBER	DISTRICT
1800035	CUY-2-1441	12
ORIGINAL CONSTRUCTION YEAR	**REHABILITATION YEAR**	**OVERALL STRUCTURE LENGTH (FT)**
1938 - 1940	1991 - 1992	6580
FEATURE INTERSECTED:	NUMEROUS LOCAL STREETS, RTA RAILROAD TRACKS AND THE CUYAHOGA RIVER	
SPECIAL ASSUMPTIONS & COMMENTS		
RATING & ANALYSIS OPTION:		
LOAD RATING PURPOSE:	LOAD RATING FOR FUTURE REHABILITATION RECOMMENDATIONS	
RATING SOFTWARE:	STAAD, CONSYS	
BASIS OF ANALYSIS:	EXISTING PLANS AND FIELD MEASUREMENTS	
METHOD OF ANALYSIS:	LOAD FACTOR	
DESIGN LOADING (ORIGINAL):	H20-33	
STRUCTURE RATING SUMMARY		
LOADING & RATING TYPE	**RATING FACTOR - RF (ROUNDED TO 2 DECIMAL POINTS**	**RATING LOAD**
INVENTORY CURRENT DESIGN	1.02	HS20.4
OPERATING CURRENT DESIGN	1.70	
OHIO LEGAL - 2F1	2.25	**OHIO LEGAL LOADS OVERALL MINIMUM RATING FACTOR**
OHIO LEGAL - 3F1	1.94	1.94
OHIO LEGAL - 4F1	1.96	**OHIO LEGAL LOADS OVERALL CONTROLLING TRUCK**
OHIO LEGAL - 5C1	1.94	3F1 & 5C1
RATED BY, PE#	**REVIEWED BY, PE#**	**REPORT DATE**
Matthew Johnson, PE	Jason Kemnitz, PE	6/22/2012
AGENCY/FIRM	**PHONE NUMBER**	**EMAIL**
TranSystems	216-861-1780	ctguion@transystems.com

BRIDGE LOAD RATING SUMMARY REPORT

CUY-2-1441

WEST APPROACH - SECTION K

SFN	BRIDGE NUMBER	DISTRICT
1800035	CUY-2-1441	12
ORIGINAL CONSTRUCTION YEAR	**REHABILITATION YEAR**	**OVERALL STRUCTURE LENGTH (FT)**
1938 - 1940	1991 - 1992	6580
FEATURE INTERSECTED:	NUMEROUS LOCAL STREETS, RTA RAILROAD TRACKS AND THE CUYAHOGA RIVER	
SPECIAL ASSUMPTIONS & COMMENTS		
RATING & ANALYSIS OPTION:		
LOAD RATING PURPOSE:	LOAD RATING FOR FUTURE REHABILITATION RECOMMENDATIONS	
RATING SOFTWARE:	STAAD, MDX	
BASIS OF ANALYSIS:	EXISTING PLANS AND FIELD MEASUREMENTS	
METHOD OF ANALYSIS:	LOAD FACTOR	
DESIGN LOADING (ORIGINAL):	H20-33	
STRUCTURE RATING SUMMARY		
LOADING & RATING TYPE	**RATING FACTOR - RF (ROUNDED TO 2 DECIMAL POINTS**	**RATING LOAD**
INVENTORY CURRENT DESIGN	0.85	HS17.0
OPERATING CURRENT DESIGN	1.42	
OHIO LEGAL - 2F1	2.25	**OHIO LEGAL LOADS OVERALL MINIMUM RATING FACTOR**
OHIO LEGAL - 3F1	1.71	1.61
OHIO LEGAL - 4F1	1.61	**OHIO LEGAL LOADS OVERALL CONTROLLING TRUCK**
OHIO LEGAL - 5C1	1.77	4F1
RATED BY, PE#	**REVIEWED BY, PE#**	**REPORT DATE**
Donald Cartwright, EIT	Carolyn Guion, PE 75189	6/22/2012
AGENCY/FIRM	**PHONE NUMBER**	**EMAIL**
TranSystems	216-861-1780	ctguion@transystems.com

BRIDGE LOAD RATING SUMMARY REPORT

CUY-2-1441

WEST APPROACH - SECTION L

SFN	BRIDGE NUMBER	DISTRICT
1800035	CUY-2-1441	12
ORIGINAL CONSTRUCTION YEAR	**REHABILITATION YEAR**	**OVERALL STRUCTURE LENGTH (FT)**
1938 - 1940	1991 - 1992	6580
FEATURE INTERSECTED:	NUMEROUS LOCAL STREETS, RTA RAILROAD TRACKS AND THE CUYAHOGA RIVER	
SPECIAL ASSUMPTIONS & COMMENTS		
RATING & ANALYSIS OPTION:		
LOAD RATING PURPOSE:	LOAD RATING FOR FUTURE REHABILITATION RECOMMENDATIONS	
RATING SOFTWARE:	STAAD, MDX	
BASIS OF ANALYSIS:	EXISTING PLANS AND FIELD MEASUREMENTS	
METHOD OF ANALYSIS:	LOAD FACTOR	
DESIGN LOADING (ORIGINAL):	H20-33	
STRUCTURE RATING SUMMARY		
LOADING & RATING TYPE	**RATING FACTOR - RF (ROUNDED TO 2 DECIMAL POINTS**	**RATING LOAD**
INVENTORY CURRENT DESIGN	0.69	HS13.8
OPERATING CURRENT DESIGN	1.16	
OHIO LEGAL - 2F1	2.25	**OHIO LEGAL LOADS OVERALL MINIMUM RATING FACTOR**
OHIO LEGAL - 3F1	1.51	1.34
OHIO LEGAL - 4F1	1.34	**OHIO LEGAL LOADS OVERALL CONTROLLING TRUCK**
OHIO LEGAL - 5C1	1.39	4F1
RATED BY, PE#	**REVIEWED BY, PE#**	**REPORT DATE**
Donald Cartwright, EIT	Carolyn Guion, PE 75189	6/22/2012
AGENCY/FIRM	**PHONE NUMBER**	**EMAIL**
TranSystems	216-861-1780	ctguion@transystems.com

BRIDGE LOAD RATING SUMMARY REPORT

CUY-2-1441

WEST APPROACH - SECTION M

SFN	BRIDGE NUMBER	DISTRICT
1800035	CUY-2-1441	12
ORIGINAL CONSTRUCTION YEAR	**REHABILITATION YEAR**	**OVERALL STRUCTURE LENGTH (FT)**
1938 - 1940	1991 - 1992	6580
FEATURE INTERSECTED:	NUMEROUS LOCAL STREETS, RTA RAILROAD TRACKS AND THE CUYAHOGA RIVER	
SPECIAL ASSUMPTIONS & COMMENTS		
RATING & ANALYSIS OPTION:		
LOAD RATING PURPOSE:	LOAD RATING FOR FUTURE REHABILITATION RECOMMENDATIONS	
RATING SOFTWARE:	STAAD, CONSYS	
BASIS OF ANALYSIS:	EXISTING PLANS AND FIELD MEASUREMENTS	
METHOD OF ANALYSIS:	LOAD FACTOR	
DESIGN LOADING (ORIGINAL):	H20-33	
	STRUCTURE RATING SUMMARY	
LOADING & RATING TYPE	**RATING FACTOR - RF (ROUNDED TO 2 DECIMAL POINTS**	**RATING LOAD**
INVENTORY CURRENT DESIGN	1.00	HS20.0
OPERATING CURRENT DESIGN	1.66	
OHIO LEGAL - 2F1	2.45	**OHIO LEGAL LOADS OVERALL MINIMUM RATING FACTOR**
OHIO LEGAL - 3F1	1.90	1.9
OHIO LEGAL - 4F1	1.95	**OHIO LEGAL LOADS OVERALL CONTROLLING TRUCK**
OHIO LEGAL - 5C1	1.92	3F1
RATED BY, PE#	**REVIEWED BY, PE#**	**REPORT DATE**
Matthew Johnson, PE	Jason Kemnitz, PE	6/22/2012
AGENCY/FIRM	**PHONE NUMBER**	**EMAIL**
TranSystems	216-861-1780	ctguion@transystems.com

BRIDGE LOAD RATING SUMMARY REPORT

CUY-2-1441

WEST APPROACH - SECTION B'

SFN	BRIDGE NUMBER	DISTRICT
1800035	CUY-2-1441	12
ORIGINAL CONSTRUCTION YEAR	**REHABILITATION YEAR**	**OVERALL STRUCTURE LENGTH (FT)**
1938 - 1940	1991 - 1992	6580
FEATURE INTERSECTED:	NUMEROUS LOCAL STREETS, RTA RAILROAD TRACKS AND THE CUYAHOGA RIVER	
SPECIAL ASSUMPTIONS & COMMENTS		
RATING & ANALYSIS OPTION:		
LOAD RATING PURPOSE:	LOAD RATING FOR FUTURE REHABILITATION RECOMMENDATIONS	
RATING SOFTWARE:	STAAD, CONSYS	
BASIS OF ANALYSIS:	EXISTING PLANS AND FIELD MEASUREMENTS	
METHOD OF ANALYSIS:	LOAD FACTOR	
DESIGN LOADING (ORIGINAL):	H20-33	
STRUCTURE RATING SUMMARY		
LOADING & RATING TYPE	**RATING FACTOR - RF (ROUNDED TO 2 DECIMAL POINTS**	**RATING LOAD**
INVENTORY CURRENT DESIGN	1.07	HS21.4
OPERATING CURRENT DESIGN	1.78	
OHIO LEGAL - 2F1	2.62	**OHIO LEGAL LOADS OVERALL MINIMUM RATING FACTOR**
OHIO LEGAL - 3F1	2.03	1.9
OHIO LEGAL - 4F1	1.90	**OHIO LEGAL LOADS OVERALL CONTROLLING TRUCK**
OHIO LEGAL - 5C1	2.03	4F1
RATED BY, PE#	**REVIEWED BY, PE#**	**REPORT DATE**
Matthew Johnson, PE	Jason Kemnitz, PE	6/22/2012
AGENCY/FIRM	**PHONE NUMBER**	**EMAIL**
TranSystems	216-861-1780	ctguion@transystems.com

BRIDGE LOAD RATING SUMMARY REPORT

CUY-2-1441

WEST APPROACH - SECTION C

SFN	BRIDGE NUMBER	DISTRICT
1800035	CUY-2-1441	12
ORIGINAL CONSTRUCTION YEAR	**REHABILITATION YEAR**	**OVERALL STRUCTURE LENGTH (FT)**
1938 - 1940	1991 - 1992	6580
FEATURE INTERSECTED:	NUMEROUS LOCAL STREETS, RTA RAILROAD TRACKS AND THE CUYAHOGA RIVER	
SPECIAL ASSUMPTIONS & COMMENTS		
RATING & ANALYSIS OPTION:		
LOAD RATING PURPOSE:	LOAD RATING FOR FUTURE REHABILITATION RECOMMENDATIONS	
RATING SOFTWARE:	STAAD, MDX	
BASIS OF ANALYSIS:	EXISTING PLANS AND FIELD MEASUREMENTS	
METHOD OF ANALYSIS:	LOAD FACTOR	
DESIGN LOADING (ORIGINAL):	H20-33	
STRUCTURE RATING SUMMARY		
LOADING & RATING TYPE	**RATING FACTOR - RF (ROUNDED TO 2 DECIMAL POINTS**	**RATING LOAD**
INVENTORY CURRENT DESIGN	0.73	HS14.6
OPERATING CURRENT DESIGN	1.22	
OHIO LEGAL - 2F1	2.04	**OHIO LEGAL LOADS OVERALL MINIMUM RATING FACTOR**
OHIO LEGAL - 3F1	1.43	1.35
OHIO LEGAL - 4F1	1.35	**OHIO LEGAL LOADS OVERALL CONTROLLING TRUCK**
OHIO LEGAL - 5C1	1.47	4F1
RATED BY, PE#	**REVIEWED BY, PE#**	**REPORT DATE**
Donald Cartwright, EIT	Carolyn Guion, PE 75189	6/22/2012
AGENCY/FIRM	**PHONE NUMBER**	**EMAIL**
TranSystems	216-861-1780	ctguion@transystems.com

BRIDGE LOAD RATING SUMMARY REPORT

CUY-2-1441

WEST APPROACH - SECTION D

SFN	BRIDGE NUMBER	DISTRICT
1800035	CUY-2-1441	12
ORIGINAL CONSTRUCTION YEAR	**REHABILITATION YEAR**	**OVERALL STRUCTURE LENGTH (FT)**
1938 - 1940	1991 - 1992	6580
FEATURE INTERSECTED:	NUMEROUS LOCAL STREETS, RTA RAILROAD TRACKS AND THE CUYAHOGA RIVER	
SPECIAL ASSUMPTIONS & COMMENTS		
RATING & ANALYSIS OPTION:		
LOAD RATING PURPOSE:	LOAD RATING FOR FUTURE REHABILITATION RECOMMENDATIONS	
RATING SOFTWARE:	STAAD, CONSYS	
BASIS OF ANALYSIS:	EXISTING PLANS AND FIELD MEASUREMENTS	
METHOD OF ANALYSIS:	LOAD FACTOR	
DESIGN LOADING (ORIGINAL):	H20-33	
STRUCTURE RATING SUMMARY		
LOADING & RATING TYPE	**RATING FACTOR - RF (ROUNDED TO 2 DECIMAL POINTS**	**RATING LOAD**
INVENTORY CURRENT DESIGN	1.07	HS21.4
OPERATING CURRENT DESIGN	1.78	
OHIO LEGAL - 2F1	2.64	**OHIO LEGAL LOADS OVERALL MINIMUM RATING FACTOR**
OHIO LEGAL - 3F1	2.04	1.97
OHIO LEGAL - 4F1	1.97	**OHIO LEGAL LOADS OVERALL CONTROLLING TRUCK**
OHIO LEGAL - 5C1	1.97	4F1 & 5C1
RATED BY, PE#	**REVIEWED BY, PE#**	**REPORT DATE**
Matthew Johnson, PE	Jason Kemnitz, PE	6/22/2012
AGENCY/FIRM	**PHONE NUMBER**	**EMAIL**
TranSystems	216-861-1780	ctguion@transystems.com

BRIDGE LOAD RATING SUMMARY REPORT

CUY-2-1441

WEST APPROACH - SECTION N

SFN	BRIDGE NUMBER	DISTRICT
1800035	CUY-2-1441	12
ORIGINAL CONSTRUCTION YEAR	**REHABILITATION YEAR**	**OVERALL STRUCTURE LENGTH (FT)**
1938 - 1940	1991 - 1992	6580
FEATURE INTERSECTED:	NUMEROUS LOCAL STREETS, RTA RAILROAD TRACKS AND THE CUYAHOGA RIVER	
SPECIAL ASSUMPTIONS & COMMENTS		
RATING & ANALYSIS OPTION:		
LOAD RATING PURPOSE:	LOAD RATING FOR FUTURE REHABILITATION RECOMMENDATIONS	
RATING SOFTWARE:	STAAD, PCA COLUMN, MDX	
BASIS OF ANALYSIS:	EXISTING PLANS AND FIELD MEASUREMENTS	
METHOD OF ANALYSIS:	LOAD FACTOR	
DESIGN LOADING (ORIGINAL):	H20-33	
	STRUCTURE RATING SUMMARY	
LOADING & RATING TYPE	**RATING FACTOR - RF (ROUNDED TO 2 DECIMAL POINTS**	**RATING LOAD**
INVENTORY CURRENT DESIGN	0.83	HS16.6
OPERATING CURRENT DESIGN	1.38	
OHIO LEGAL - 2F1	2.79	**OHIO LEGAL LOADS OVERALL MINIMUM RATING FACTOR**
OHIO LEGAL - 3F1	1.96	1.71
OHIO LEGAL - 4F1	1.74	**OHIO LEGAL LOADS OVERALL CONTROLLING TRUCK**
OHIO LEGAL - 5C1	1.71	5C1
RATED BY, PE#	**REVIEWED BY, PE#**	**REPORT DATE**
George Dai, PE 73577	Donald Pawlowski, EIT	6/22/2012
AGENCY/FIRM	**PHONE NUMBER**	**EMAIL**
TranSystems	216-861-1780	ctguion@transystems.com

BRIDGE LOAD RATING SUMMARY REPORT

CUY-2-1441

WEST APPROACH - SECTION P

SFN	BRIDGE NUMBER	DISTRICT
1800035	CUY-2-1441	12
ORIGINAL CONSTRUCTION YEAR	**REHABILITATION YEAR**	**OVERALL STRUCTURE LENGTH (FT)**
1938 - 1940	1991 - 1992	6580
FEATURE INTERSECTED:	NUMEROUS LOCAL STREETS, RTA RAILROAD TRACKS AND THE CUYAHOGA RIVER	
SPECIAL ASSUMPTIONS & COMMENTS		
RATING & ANALYSIS OPTION:		
LOAD RATING PURPOSE:	LOAD RATING FOR FUTURE REHABILITATION RECOMMENDATIONS	
RATING SOFTWARE:	STAAD, PCA COLUMN	
BASIS OF ANALYSIS:	EXISTING PLANS AND FIELD MEASUREMENTS	
METHOD OF ANALYSIS:	LOAD FACTOR	
DESIGN LOADING (ORIGINAL):	H20-33	
	STRUCTURE RATING SUMMARY	
LOADING & RATING TYPE	**RATING FACTOR - RF (ROUNDED TO 2 DECIMAL POINTS**	**RATING LOAD**
INVENTORY CURRENT DESIGN	1.15	HS23.0
OPERATING CURRENT DESIGN	1.91	
OHIO LEGAL - 2F1	3.05	**OHIO LEGAL LOADS OVERALL MINIMUM RATING FACTOR**
OHIO LEGAL - 3F1	2.46	2.27
OHIO LEGAL - 4F1	2.27	**OHIO LEGAL LOADS OVERALL CONTROLLING TRUCK**
OHIO LEGAL - 5C1	2.59	4F1
RATED BY, PE#	**REVIEWED BY, PE#**	**REPORT DATE**
George Dai, PE 73577	Donald Pawlowski, EIT	6/22/2012
AGENCY/FIRM	**PHONE NUMBER**	**EMAIL**
TranSystems	216-861-1780	ctguion@transystems.com

BRIDGE LOAD RATING SUMMARY REPORT

CUY-2-1441

MAIN TRUSS

SFN	BRIDGE NUMBER	DISTRICT
1800035	CUY-2-1441	12
ORIGINAL CONSTRUCTION YEAR	**REHABILITATION YEAR**	**OVERALL STRUCTURE LENGTH (FT)**
1938 - 1940	1991 - 1992	6580
FEATURE INTERSECTED:	NUMEROUS LOCAL STREETS, RTA RAILROAD TRACKS AND THE CUYAHOGA RIVER	
SPECIAL ASSUMPTIONS & COMMENTS		
RATING & ANALYSIS OPTION:		
LOAD RATING PURPOSE:	LOAD RATING FOR FUTURE REHABILITATION RECOMMENDATIONS	
RATING SOFTWARE:	STAAD	
BASIS OF ANALYSIS:	EXISTING PLANS AND FIELD MEASUREMENTS	
METHOD OF ANALYSIS:	LOAD FACTOR	
DESIGN LOADING (ORIGINAL):	H20-33	
	STRUCTURE RATING SUMMARY	
LOADING & RATING TYPE	**RATING FACTOR - RF (ROUNDED TO 2 DECIMAL POINTS**	**RATING LOAD**
INVENTORY CURRENT DESIGN	0.26	HS5.2
OPERATING CURRENT DESIGN	0.43	
OHIO LEGAL - 2F1	1.49	**OHIO LEGAL LOADS OVERALL MINIMUM RATING FACTOR**
OHIO LEGAL - 3F1	0.97	0.49
OHIO LEGAL - 4F1	0.84	**OHIO LEGAL LOADS OVERALL CONTROLLING TRUCK**
OHIO LEGAL - 5C1	0.49	4F1
RATED BY, PE#	**REVIEWED BY, PE#**	**REPORT DATE**
Anthony Koloze, PE 76258	Carolyn Guion, PE 75189	6/22/2012
AGENCY/FIRM	**PHONE NUMBER**	**EMAIL**
TranSystems	216-861-1780	ctguion@transystems.com

BRIDGE LOAD RATING SUMMARY REPORT

CUY-2-1441

EAST APPROACH - FORWARD SECTION

SFN	BRIDGE NUMBER	DISTRICT
1800035	CUY-2-1441	12
ORIGINAL CONSTRUCTION YEAR	**REHABILITATION YEAR**	**OVERALL STRUCTURE LENGTH (FT)**
1938 - 1940	1991 - 1992	6580
FEATURE INTERSECTED:	NUMEROUS LOCAL STREETS, RTA RAILROAD TRACKS AND THE CUYAHOGA RIVER	
SPECIAL ASSUMPTIONS & COMMENTS		
RATING & ANALYSIS OPTION:		
LOAD RATING PURPOSE:	LOAD RATING FOR FUTURE REHABILITATION RECOMMENDATIONS	
RATING SOFTWARE:	STAAD, MDX	
BASIS OF ANALYSIS:	EXISTING PLANS AND FIELD MEASUREMENTS	
METHOD OF ANALYSIS:	LOAD FACTOR	
DESIGN LOADING (ORIGINAL):	H20-33	
	STRUCTURE RATING SUMMARY	
LOADING & RATING TYPE	**RATING FACTOR - RF (ROUNDED TO 2 DECIMAL POINTS**	**RATING LOAD**
INVENTORY CURRENT DESIGN	0.28	HS5.6
OPERATING CURRENT DESIGN	0.47	
OHIO LEGAL - 2F1	1.18	**OHIO LEGAL LOADS OVERALL MINIMUM RATING FACTOR**
OHIO LEGAL - 3F1	0.77	0.51
OHIO LEGAL - 4F1	0.67	**OHIO LEGAL LOADS OVERALL CONTROLLING TRUCK**
OHIO LEGAL - 5C1	0.51	4F1 & 5C1
RATED BY, PE#	**REVIEWED BY, PE#**	**REPORT DATE**
Patrick Plews, PE 71422	Anthony Koloze, PE 76258	6/22/2012
AGENCY/FIRM	**PHONE NUMBER**	**EMAIL**
TranSystems	216-861-1780	ctguion@transystems.com

BRIDGE LOAD RATING SUMMARY REPORT

CUY-2-1441

EAST APPROACH - LAKEFRONT TRESTLE

SFN	BRIDGE NUMBER	DISTRICT
1800035	CUY-2-1441	12
ORIGINAL CONSTRUCTION YEAR	**REHABILITATION YEAR**	**OVERALL STRUCTURE LENGTH (FT)**
1938 - 1940	1991 - 1992	6580
FEATURE INTERSECTED:	NUMEROUS LOCAL STREETS, RTA RAILROAD TRACKS AND THE CUYAHOGA RIVER	
SPECIAL ASSUMPTIONS & COMMENTS		
RATING & ANALYSIS OPTION:		
LOAD RATING PURPOSE:	LOAD RATING FOR FUTURE REHABILITATION RECOMMENDATIONS	
RATING SOFTWARE:	STAAD	
BASIS OF ANALYSIS:	EXISTING PLANS AND FIELD MEASUREMENTS	
METHOD OF ANALYSIS:	LOAD FACTOR	
DESIGN LOADING (ORIGINAL):	H20-33	

STRUCTURE RATING SUMMARY

LOADING & RATING TYPE	RATING FACTOR - RF (ROUNDED TO 2 DECIMAL POINTS	RATING LOAD
INVENTORY CURRENT DESIGN	0.74	HS14.8
OPERATING CURRENT DESIGN	1.24	
OHIO LEGAL - 2F1	1.93	**OHIO LEGAL LOADS OVERALL MINIMUM RATING FACTOR**
OHIO LEGAL - 3F1	1.35	1.28
OHIO LEGAL - 4F1	1.28	**OHIO LEGAL LOADS OVERALL CONTROLLING TRUCK**
OHIO LEGAL - 5C1	1.43	4F1

RATED BY, PE#	REVIEWED BY, PE#	REPORT DATE
George Dai, PE 73577	Carolyn Guion, PE 75189	6/22/2012
AGENCY/FIRM	**PHONE NUMBER**	**EMAIL**
TranSystems	216-861-1780	ctguion@transystems.com

BRIDGE LOAD RATING SUMMARY REPORT

CUY-2-1441

EAST APPROACH - LAKEFRONT RAMP

SFN	BRIDGE NUMBER	DISTRICT
1800035	CUY-2-1441	12
ORIGINAL CONSTRUCTION YEAR	**REHABILITATION YEAR**	**OVERALL STRUCTURE LENGTH (FT)**
1938 - 1940	1991 - 1992	6580
FEATURE INTERSECTED:	NUMEROUS LOCAL STREETS, RTA RAILROAD TRACKS AND THE CUYAHOGA RIVER	
SPECIAL ASSUMPTIONS & COMMENTS		
RATING & ANALYSIS OPTION:		
LOAD RATING PURPOSE:	LOAD RATING FOR FUTURE REHABILITATION RECOMMENDATIONS	
RATING SOFTWARE:	STAAD, CONSYS, MATHCAD	
BASIS OF ANALYSIS:	EXISTING PLANS AND FIELD MEASUREMENTS	
METHOD OF ANALYSIS:	LOAD FACTOR	
DESIGN LOADING (ORIGINAL):	H20-33	
	STRUCTURE RATING SUMMARY	
LOADING & RATING TYPE	**RATING FACTOR - RF (ROUNDED TO 2 DECIMAL POINTS**	**RATING LOAD**
INVENTORY CURRENT DESIGN	0.54	HS10.8
OPERATING CURRENT DESIGN	0.90	
OHIO LEGAL - 2F1	1.45	**OHIO LEGAL LOADS OVERALL MINIMUM RATING FACTOR**
OHIO LEGAL - 3F1	1.48	1.45
OHIO LEGAL - 4F1	1.72	**OHIO LEGAL LOADS OVERALL CONTROLLING TRUCK**
OHIO LEGAL - 5C1	1.48	3F1 & 5C1
RATED BY, PE#	**REVIEWED BY, PE#**	**REPORT DATE**
David Hoff, PE	Rodolfo Hutchinson, EIT	6/22/2012
AGENCY/FIRM	**PHONE NUMBER**	**EMAIL**
TranSystems	216-861-1780	ctguion@transystems.com

Appendix C
Supplement Tables for Recommendation Table

TABLE C1
MAIN AVENUE BRIDGE GUSSET PLATES
Rating less than or equal to 1.10 for one or more Ohio Legal Loads

Truss	Panel Point	Location & Mode	As-Built Condition				As-Inspected Condition			
			2F1	3F1	4F1	5C1	2F1	3F1	4F1	5C1
North	L59	Local Compression Buckling (Whitmore Effective Width Under Vertical Member)				0.95				
North	U110	Connector Capacity (U110-U111)		0.97	0.84	0.61				
North	U127	Connector Capacity (U127-L128) & (U127-L127)		0.77	0.67	0.51				
North	U135	Connector Capacity (U135-L135)			1.02	0.76				
South	U110	Connector Capacity (U110-U111)				0.82				
South	U127	Connector Capacity (U127-L127)		0.97	0.85	0.61				
South	U128	Connector Capacity (U128-L128)		0.80	0.71	0.56				
South	U135	Connector Capacity (U135-L134)		0.98	0.86	0.66				

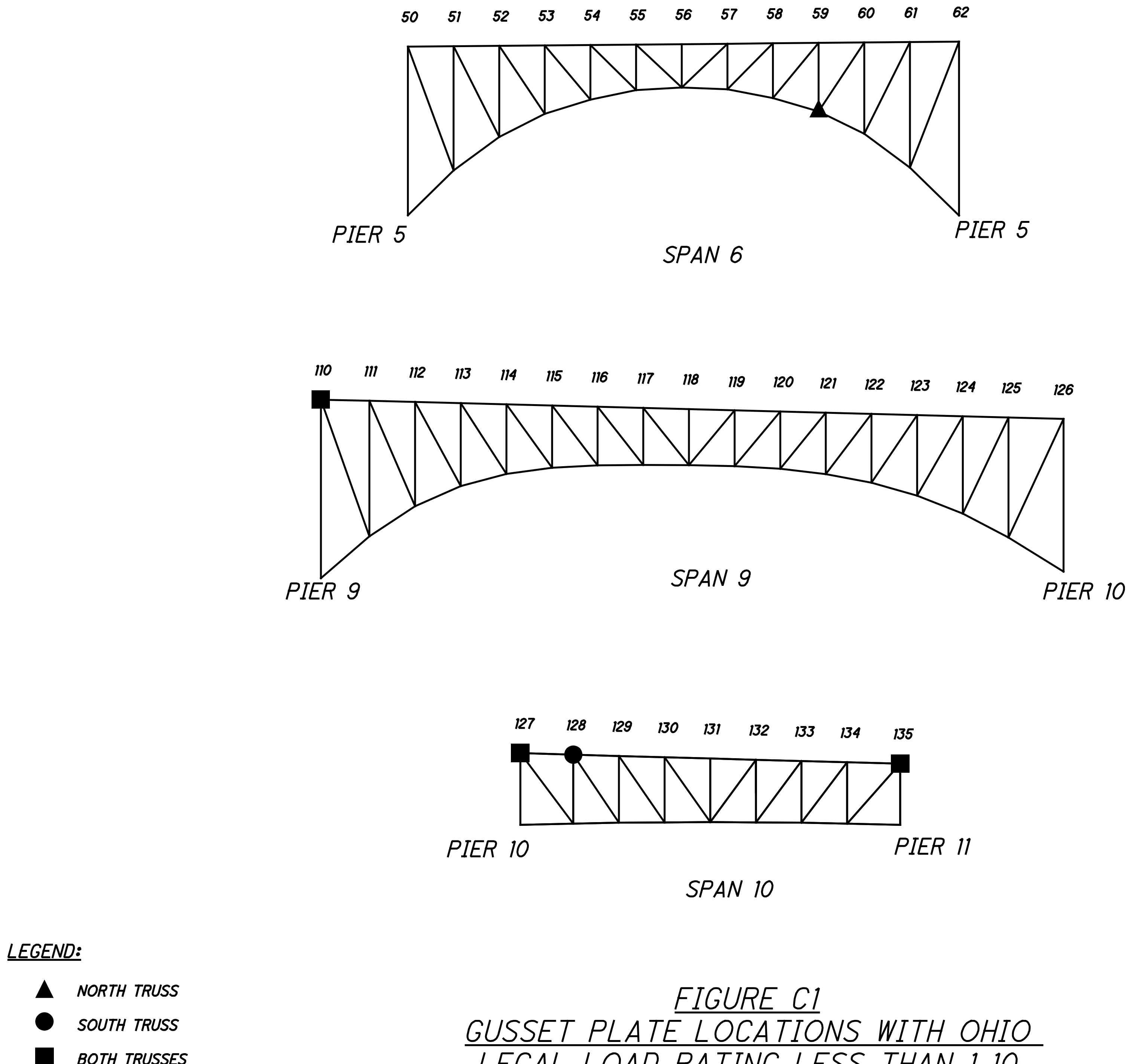


FIGURE C1
GUSSET PLATE LOCATIONS WITH OHIO LEGAL LOAD RATING LESS THAN 1.10
(TRUSS SOUTH ELEVATION)

MAIN AVENUE BRIDGE
CUY-2-1441
TranSystems

TABLE C2
MAIN AVENUE BRIDGE APPROACH SPANS

Rating less than or equal to 1.10 for one or more Ohio Legal Loads

Section	Location & Mode	As-Built Condition				As-Inspected Condition				
		2F1	3F1	4F1	5C1	% Capacity Loss	2F1	3F1	4F1	5C1
Fwd Sec	FB 8, negative moment @ Column 108					40%	1.41	0.95	0.83	0.88
Fwd Sec	S14-7, positive moment @ midspan	1.35	0.92	0.84	0.96					
Fwd Sec	S15-7, positive moment @ midspan	1.45	1.00	0.86	1.05					
Fwd Sec	FB 3, negative moment @ column 303		1.28	1.10	0.96					

TABLE C3 MAIN AVENUE BRIDGE GUSSET PLATES					
Gusset Plates with Advanced Section Loss (Ohio Legal Loads RF > 1.10)					
Truss	**Panel Point**	**Plate**	**Plate ID**	**Loss Description**	**Notes**
North	L93	North	822NLO	21% loss over 56" of Measurement A	39% loss over 19" of Measurement A peaking at 60% loss
North	L94	North	823NLO	16% loss over 64" of Measurement A	29% loss over 23" of Measurement A peaking at 50% loss
North	L68	North	703NLO	22% loss over 80" of Measurement A	37% loss over 18" of Measurement A peaking at 60% loss
North	U71	South	706NUI	41% loss over 18" of Measurement D	Peaking at 70% loss
North	U71	North	706NUO	22% loss over 58" of Measurement C	37% loss over 16" of Measurement C with a 2" diameter hole
North	L33	North	405NLO	21% loss over 15" of Measurement A	Peaking at 31% loss
North	L36	South	408NLI	17% loss over 72" of Measurement A	31% loss over 9" of Measurement A peaking at 54% loss
North	L36	North	408NLO	21% loss over 72" of Measurement A / 36% over 16" of G	67% loss over 6" of Measurement G with 2.5" diameter hole
North	L12	North	205NLO	24% loss over 54" of Measurement A / 36% over 15" of F	Peaking at 81% loss along Measurement F
North	L13	South	206NLI	25% loss over 61" of Measurement A / 44% over 18" of F	46% loss over 17" of Measurement A peaking at 76% loss / 67% loss over 6" of Measurement F peaking at 82% loss
North	L13	North	206NLO	16% loss over 63" of Measurement A	38% loss over 6" of Measurement A peaking at 53% loss
North	L15	North	208NLO	15% loss over 77" of Measurement A	26% loss over 19" of Measurement A peaking at 47% loss
North	L16	North	209NLO	31% loss over 5" of Measurement B	Peaking at 43% loss
North	U18	South	211NUI	27% loss over 30" of Measurement A	40% loss over 18" of Measurement A peaking at 63% loss
North	L21	North	214NLO	28% loss over 21" of Measurement A	Peaking at 43% loss
North	L2	South	102NLI	27% loss over 9" of Measurement A	Peaking at 37% loss
North	L5	South	105NLI	30% loss over 7" of Measurement B	Peaking at 44% loss
North	U6	North	106NUO	32% loss over 12" of Measurement C	Peaking at 45% loss
North	U6	South	106NUI	29% loss over 9" of Measurement D	Peaking at 41% loss
South	L106	South	1002SLO	20% loss over 71" of Measurement A	Peaking at 46% loss
South	L71	South	800SLO	19% loss over 45" of Measurement B / 31% over 9" of C	
South	L84	North	813SLI	23% loss over 49" of Measurement A	46% loss over 13" of Measurement A with a 1/2" diameter hole
South	L85	South	814SLO	24% loss over 13" of Measurement A	
South	L52	South	604SLO	19% loss over 47" of Measurement B	29% loss over 24" of Measurement B peaking at 49% loss
South	L57	North	609SLI	22% loss over 34" of Measurement A	1" diameter hole along A
South	L43	North	501SLI	16% loss over 25" of Measurement A	49% loss over 3" of Measurement A peaking at 55% loss
South	L1	North	101SLI	30% loss over 21" of Measurement B	
South	L1	South	101SLO	35% loss over 15" of Measurement A	
South	L2	North	102SLI	24% loss over 28" of Measurement A	

* Indicates member where loss was not modeled, so As-Built (AB) rating shown

** Indicates zero force member where loss was not modeled because no rating factors were calculated

TABLE C4
MAIN AVENUE BRIDGE TRUSS SPANS
Truss Members with Advanced Section Loss (Ohio Legal Loads RF > 1.1)

Location	As-Inspected Condition		Rating Factor (only controlling shown)				
	Deficiency Description	% Capacity Loss	2F1	3F1	4F1	5C1	5C1T
U48-U49 North	Widespread heavy loss (ZERO FORCE MEMBER)	44.49%					
L96-L97 South	1/8" pitting throughout both web plates, 1/4" pitting to top cover plate with 1" wide hole (ZERO FORCE MEMBER)	29.70%					
L28-L29 North	Top cover plate with 5/16" pitting and web plate 3/16" pitting	27.85%				4.52	4.55
U49-L48 South	1/4" pitting on web and inside faces of flanges	25.19%					1.84
U29-L28 North	1/4" pitting on web and 2" on interior flange faces	25.91%					1.64
U7-U8 North	1/8" remaining on both web faces for 2/3 of member height (ZERO FORCE MEMBER)	23.72%					
U29-L28 South		21.43%				1.65	1.64
U72-L71 South	1/4" pitting for full width of web (essentially bottom half of member) and 3" high on flange	21.29%					1.79
L28-L29 South	Pitting up to 1/4" throughout all exterior plates with isolated hole in one web PL **(D-Meter readings taken)**	18.20%				5.44	
L103-L104 South	Web pitting 1/4" for full height of section (ZERO FORCE MEMBER)	16.51%					
L41-L42 North	Isolated 1/8" to 3/16" pitting throughout member components, 2" holed through section in top cover plate with up to 1/8" pitting	16.97%					5.27
U22-U23 North	1/16" remaining on bottom flange angle outstanding leg for first 3 feet, 1/8" remaining on bottom cover plate for first 5 feet with isolated hole adjacent to perforation	17.02%				14.99	
U23-U24 North	1/16" pitting throughout member with 1/8" remaining on bottom cover plate and flange outstanding legs for first 5 feet	19.93%				2.41	
U32-L33 South	1/4" pitting on cover plates with 1/16" isolated pitting in other locations	18.61%					1.96
U49-L48 North	1/4" pitting by full height on top of web	16.12%					1.92
L7-L8 South	3/8" pitting 4" high on web plate, 1/16" pitting on rest of web plate exterior faces and top cover plate, 1/16" pitting to bottom flange angles	11.75%					2.74
U53-U54 South	5/16" pitting x 3" on web plate with 1/8" x half height at interface with gusset plate, and 1" pack rust between top flange angles and web plates	4.14%					2.41
L54-L55 South	5/16" pitting x full width of top cover PL with 3" diameter hole	8.89%					3.00
L62-L63 South	2 popped rivets due to pack rust along south line of lower chord rivets	1.69%					2.44
L63-L64 South	1/16" remaining on bottom cover plate, 1/8" pitting on lower halves of web plates	11.86%					2.47
L71-L72 South	1/4" pitting on web plate with isolated 3/8" loss, 1/16" remaining on bottom cover plate with isolated holed through sections	11.22%					5.81
L73-L74 South	3/4" pack rust below top cover plate, 1 1/4 pack rust between top cover palte and flange angles (caulked), popped rivet along bottom rivet line on north web plate	3.15%					2.70
U71-L71 South	Two section cuts: 1) 5/16" pitting x full width of cover plate for 1' of member, 2) 1/8" pitting x full width with localized 1/2" deep pitting nearly holed through (below JOINT)	11.63%					2.41

* Indicates member where loss was not modeled, so As-Built (AB) rating shown

** Indicates zero force member where loss was not modeled because no rating factors were calculated

TABLE C4 MAIN AVENUE BRIDGE TRUSS SPANS							
Truss Members with Advanced Section Loss (Ohio Legal Loads RF > 1.1)							
Location	**As-Inspected Condition**		**Rating Factor (only controlling shown)**				
	Deficiency Description	% Capacity Loss	2F1	3F1	4F1	5C1	5C1T
L79-L80 South	Top cover plate with 1/4" pitting x full width in multiple locations, small areas (3" to 5" diameter) with up to 5/16" pitting, small location adjacent to interior gusset plate with 1/4" deep pitting for 1/4 height of the web	5.56%					3.12
U80-L80 South	3/16" remaining on south cover plate for full width at L80 south fill plate	6.03%					4.32
L108-L109 South	5/16" x 2" pitting on north web plate with isolated 1/8" on top cover plate	1.18%					2.31
L17-L18 North	Top cover plate with pitting up to 1/4" and up to 100% section loss 2" wide, 1/16" pitting on north web plate	5.91%					2.51
L18-L19 North	1/4" pitting x full width of web plate	11.43%					1.67
U22-L22 North	1/4" pitting and 3/16" pitting on cover paltes for full width	12.69%					1.79
U23-L23 North	Up to 1/4" pitting on north exterior flange with 1/16" pitting for full width of web	6.68%					1.86
L48-L49 North	bottom cover plate paper thin with holes throughout on lower 1/3 of member (<1/16" remaining), diaphragm west of L49 North with severe loss	7.12%					5.83
L49-L50 North	Bottom cover plate 1/16" remaining with holes throughout full length of member, plate bowed up 1 1/4" at L49. Top cover plate bowed down 1/2" with 1/8" pitting for 1/2 width. Rivet popped out due to 3/4" pack rust in top cover plate 8' east of L49.	*					3.12
U57-L57 North	1/4" pitting x full width along fill plate	9.26%					1.59
U59-L58 North	1/4" pitting with isolated 5/16" on web	6.47%					1.93
L62-L63 North	2 popped rivets due to pack rust in north line of rivets 1' from L62	3.06%					2.26
L63-L64 North	5/16" pitting to bottom cover plate and isolated 1/8" web pitting	12.65%					2.13
U65-L65 North	5/16" pitting x full width of web with 1/8" pitting on cover plate	11.96%					1.88
L65-L66 North	5" diameter hole in bottom flange with 100% section loss in angle adjacent to diaphragm (ZERO FORCE MEMBER)	**					
L79-L80 North	1/4" pitting x full width with isolated 3/8" in top cover plate for full length of member	5.74%					3.08
U83-L83 North	1/4" pitting on north cover plate, 1/16" remaining on south cover plate with 100% section loss along edges 2" wide each, 1/8" pitting on web with isolated 1/4" pitting on inside flange faces	14.82%					1.78
L96-L97 North	Perforated plate with 100% section loss isolated throughout with paper thin section west of pin, top cover plate similar beyond pin. 1/4" gap between gusset plates and member at pin (ZERO FORCE MEMBER).	**					

* Indicates member where loss was not modeled, so As-Built (AB) rating shown

** Indicates zero force member where loss was not modeled because no rating factors were calculated

TABLE C5 MAIN AVENUE BRIDGE TRUSS SPANS						
Framing Members with Advanced Section Loss (Ohio Legal Loads RF > 1.1)						
Location	**As-Inspected Condition**		**Rating Factor**			
	Deficiency Description	% Capacity Loss	2F1	3F1	4F1	5C1
FB 135 (joint)	4" dia holes in numerous stiffeners, 1/2" remaining on east bottom flange, 1/16" pitting on E face of web, bottom flange rivet heads with up to 50% loss at north end	7.30%	2.85	2.05	1.96	2.11
FB 79	1/4" pitting on top flange and web, isolated 100% loss of web stiffeners	24.81%	3.50	2.35	2.07	2.42
FB 121 North Bracket	3/16" pitting in web with 1" diameter hole	0.25%	4.06	2.67	2.36	2.76

TABLE C6
MAIN AVENUE BRIDGE APPROACH SPANS

Members with Advanced Section Loss (Ohio Legal Loads RF > 1.1)

Location	As-Inspected Condition		Rating Factors			
	Deficiency Description	% Capacity Loss	2F1	3F1	4F1	5C1
Forward Section FB 4 (joint)	1/4" pitting on the flanges typical, with isolated locations of up to 11/16"loss	43%	1.90	1.26	1.10	1.10
Forward Section FB 14 (joint)	Heavy section loss of web and web stiffeners with isolated areas of 100% loss and heavy loss to flanges (joint), isolated transverse stiffeners exhibiting distortion up to 1/2"	42%	2.43	1.74	1.66	1.78
Forward Section Column 314 (joint)	1/8" pitting throughout typical with isolated locations of up to 11/16" loss	50%	1.84	1.32	1.26	1.36
Lakefront Trestle FB H12 (joint)	5/8" pitting on the flanges, very isolated	27%	2.93	1.94	1.72	1.98