APPENDIX A. REVIEW OF BRIDGE PLANS

The plans for 20 different truss bridges were reviewed to help the research team understand the range of designs that might be encountered in the rating process. Eighteen plan sets were submitted by Idaho, Indiana, Minnesota, New York, Pennsylvania, and Tennessee specifically for this project. In addition, the I-275 Bridge in Kentucky and the original I-35W Bridge from Minnesota were included since the FHWA already had these plans available. These bridge plans provide a "snapshot" of highway truss bridges that were designed in the period from 1929 to 1990 in the US.

Figure A1 shows the 20 bridge configurations drawn to the same scale. In general, there are nine deck truss designs, eight through truss designs, one combination deck-through truss, one compression truss-arch suspension bridge, and one combination through-arch suspension bridge. Many of the configurations defy simple classification, but most have their members configured in a Warren truss-type pattern. The truss designs in this sample have a wide variation in size from relatively short, simple span structures to large, multi-span bridges. Five of the trusses were single span with length ranging from 114 to 420 feet. There were two large two-span truss bridges with span lengths of 720 and 725 feet. The majority of the bridges consisted of three or more spans with main span lengths ranging from 120 to 612 feet. In addition, the two compression-arch suspension trusses had the longest main span lengths of 800 and 825 feet.

The angle between members is joint specific for many of these truss designs and is not easy to classify without the context of the overall truss. Some of the trusses have non-parallel chords in many locations which complicates angle definition. A general sense of member angle is available by looking at the truss elevations in Figure A1.

The basic information about each truss is shown inTable A2. The material used to fabricate the gusset plates, when it could be found on the plans, is shown in column 6. The steel grade in the truss gusset plates varied, primarily according to vintage. Carbon steels (36 ksi or lower) were utilized in 11 of the bridges designed between 1929 and 1970. Low alloy steels (50 ksi or lower) of various ASTM grades were utilized for 11 bridges built between 1955 and 1990. High strength, quenched & tempered steel (100 ksi or T1) was utilized in four of the bridges fabricated from 1959 to 1976. This clearly reflects the general transition from grade 36 to grade 50 steel that occurred around 1960 for bridge design. The grade 100 steel saw a window of use in the 60's and 70's for some bridge structures.

Similar to changes in steel materials, the truss designs show the transition from rivets to high strength bolts that occurred around 1960. Sixteen of the bridges built between 1929 and 1965 were designed to utilize rivets to connect the gusset plates. However, in some of these construction plans the designer gave flexibility to the fabricator/erector to substitute A325 bolts for rivets, but it was not possible to determine what was actually used in all cases. Five bridges built between 1959 and 1990 utilized A325 high strength bolts. In general, it appears trusses designed up to the late 1950's were riveted, those designed from the late 1950's to the late

1960’s used either high strength bolts or rivets, and almost all of the bridges built after 1970 used high strength bolts. None of the structures in this sample used A490 bolts. In addition, none of the trusses had welded gusset plates.

With seven exceptions that used one inch diameter fasteners, all of the bridges in this sample used 0.875 inch diameter fasteners. Both rivets and high strength bolts were used in both these diameters. The 0.875 inch fasteners were used for both small and large bridges within the sample, the difference being the number of fasteners in the connection pattern. The fastener diameter does not scale in proportion to the size of bridge. It was difficult to determine the grade of rivet from most of the design drawings. This information was not listed on most of the design plans.

Table A2 shows selected proportion information about the gusset plate connections. The dimensions were scaled off the design drawings and should not be considered exact. The dimensions C_1 and C_2 provide a relative measure of compactness for the gusset plate. Figure A2 shows how these dimensions are defined.

Also scaled off the design drawings was the fastener pattern aspect ratio for the diagonal truss members. The length dimension is along the axis of the member while the width is transverse. As for fastener spacing, this was difficult to accurately determine from the design drawings. Shop drawings were generally not available for most bridges. It appears that three inches is a common baseline for pitch and gage of the fastener patterns. The patterns were adapted as needed to accommodate member shape and geometric compatibility between plates. Edge distance was even harder to discern from the design drawings but it appears all designs meet the minimum limit for a given fastener diameter.

The gusset plate thickness varied between trusses and between connections in a given truss. Figure A3 through A7 show the thickness distribution of gusset plates for each truss using colored circles to represent thickness increments. A few connections are represented by dual-colored circles. This indicates that there are double gusset plates (i.e., a gusset plate with a shingle plate) at that particular location.

The results show that relatively thin gusset plates (0.500 inch or less) are routinely used in many trusses. Plate thickness does not necessarily correlate with the scale of the truss. Some relatively large trusses utilize 3/8 inch gusset plates in some locations. Figure A8 shows a histogram of gusset plate thicknesses from the 20 bridges. This figure shows that approximately 80% of the plates range in thickness from 0.500 to 0.938 inch. However, this distribution counts the aggregate plate thickness and makes no discernment regarding the strength of the plate and whether or not the gusset is built-up from multiple layers of plate. No plates were found thinner than 0.375 inch and the thickest plate was 1.625 inches thick. When connections were multi-layered, it was either with two or three layers and total thickness of all the plies was between 0.875 and 2.063 inches.

Figure A1. Configuration of the 20 bridges from plans submitted by various states. The bridges are drawn to the same scale to illustrate the relative size.

Table A1. Bridge Suite Overview

BRIDGE	YEAR DESIGNED	STATE	TYPE	SPAN ARRANGEMENT (feet)	GUSSET PLATE STEEL GRADE (ksi)	FASTENER TYPE
Kootenai Highway, Moyie River Bridge	1961	ID	Deck Truss	270-378-270	50	7/8” Rivets or 7/8” A325 bolts
I-94 Over Little Calumet River	1990	IL	Through Truss	420	50	7/8” A325
I-474 Over Illinois River	1970	IL	Through Truss	300 – 540 - 300	36 and 50	7/8” A325
SR 56-T Over Salt Fork Creek	1941	IN	Deck Truss	60 – 120 – 60	36	7/8” Rivets
I-64 Over Ohio River	1959	IN	Truss Arch Suspension	800 – 800	50 and 100	1” A325
Bridge Over Ohio River, Mauckport	1964	IN	Through Truss	725 – 725	50 and 100	1” Rivets
Bridge Over Ohio River, Cannelton	1964	IN	Through-Arch Suspension	413 – 825 – 413	50 and 100	7/8” Rivets
I-275 Over Ohio River	1976	KY	Through Truss	720 – 720	50 and 100	1” A325 Bolts
Rt 23 Bridge, St Cloud	1955	MN	Deck Truss	219 – 291 – 219	36 and 50	7/8” Rivets
I-35W Over Mississippi	1965	MN	Deck Truss	266 – 456 – 266	50	1” Rivets
SR 54-13 Over Cattaraugus Creek	1954	NY	Deck Truss	175 – 300 – 175	36	7/8” Rivets
I-80 Over Clarion River	1964	PA	Deck Truss	272 – 612 – 272	36 and 50	1” Rivets
I-40 Over French Broad River	1958	TN	Deck Truss	260 – 312 – 312 – 260	50	7/8” Rivets
SR 56 Over Caney Fork River	1947	TN	Deck Truss	387-384-384-387	36	7/8” Rivets
SR 67 Over Watauga River	1946	TN	Deck Truss	300-492-300	36	1” Rivets
Station 0+09 Over Cumberland River	1934	TN	Deck – Through Truss	145-317-145	33	7/8” Rivets
SR 100 Over Harpeth River	1929	TN	Through Truss	100	30	7/8” Rivets
SR 14 Over I.C.R.R. & Nonconnah Creek	1929	TN	Through Truss	140	30	7/8” Rivets
SR 24 Over Round Lick Creek	1938	TN	Through Truss	114 Simple Span	33	7/8” Rivets
SR 375 – Harrell Bridge	1941	TN	Through Truss	235-282-235	36	7/8” Rivets

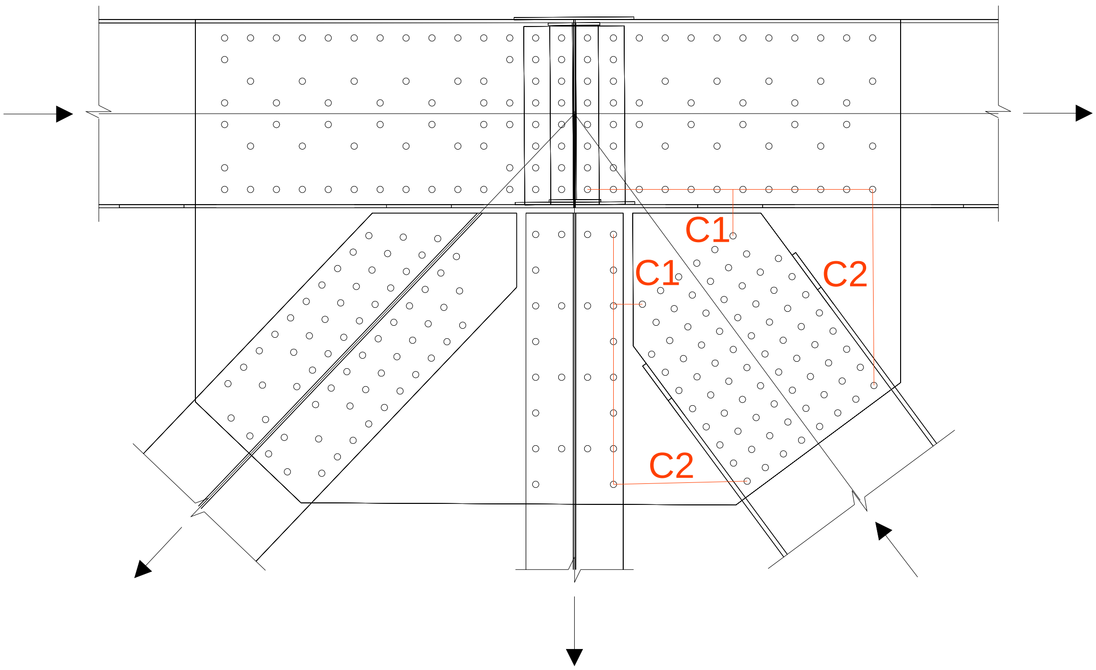

Figure A2. Reference schematic for gusset plate proportions.

Table A2. Gusset Plate Details

BRIDGE	C_1 (inch)		FREE EDGE SLENDERNESS C_2 (inch)		FASTENER PATTERN ASPECT RATIO L/W	
	min	max	min	max	min	max
Kootenai Highway, Moyie River Bridge	4.8	16.8	15.0	39.9	1.0	4.5
I-94 Over Little Calumet River	4.3	23.1	14.4	52.5	0.9	2.8
I-474 Over Illinois River	5.3	37.9	12.8	57.8	0.7	7.2
SR 56-T Over Salt Fork Creek	4.2	5.9	11.3	28.3	1.8	6.3
I-64 Over Ohio River	6.6	23.5	17.2	74.7	0.7	6.4
Bridge Over Ohio River, Mauckport	4.4	14.6	9.9	45.0	0.9	3.6
Bridge Over Ohio River, Cannelton	4.6	25.9	12.4	39.9	1.0	5.5
I-275 Over Ohio River	4.6	14.0	15.7	44.7	1.2	4.6
Rt 23 Bridge, St Cloud	4.7	15.6	13.9	43.3	1.4	5.2
I-35W Over Mississippi	5.6	17.2	10.6	44.1	0.8	2.2
SR 54-13 Over Cattaraugus Creek	5.7	26.9	11.7	40.0	0.9	2.3
I-80 Over Clarion River	6.6	15.6	15.3	49.6	0.9	3.6
I-40 Over French Broad River	6.5	12.6	17.4	35.2	1.2	6.9
SR 56 Over Caney Fork River	5.6	10.4	6.8	26.2	1.0	4.3
SR 67 Over Watauga River	4.7	21.2	11.6	36.7	0.9	3.5
Station 0+09 Over Cumberland River	Information Not Available					
SR 24 Over Round Lick Creek	Information Not Available					
SR 100 Over Harpeth River	4.9	9.5	8.3	23.0	2.0	2.6
SR 14 Over I.C.R.R. & Nonconnah Creek	6.3	11.5	9.0	29.4	1.2	2.8
SR 375 – Harrell Bridge	5.6	11.6	12.5	26.4	1.5	4.1

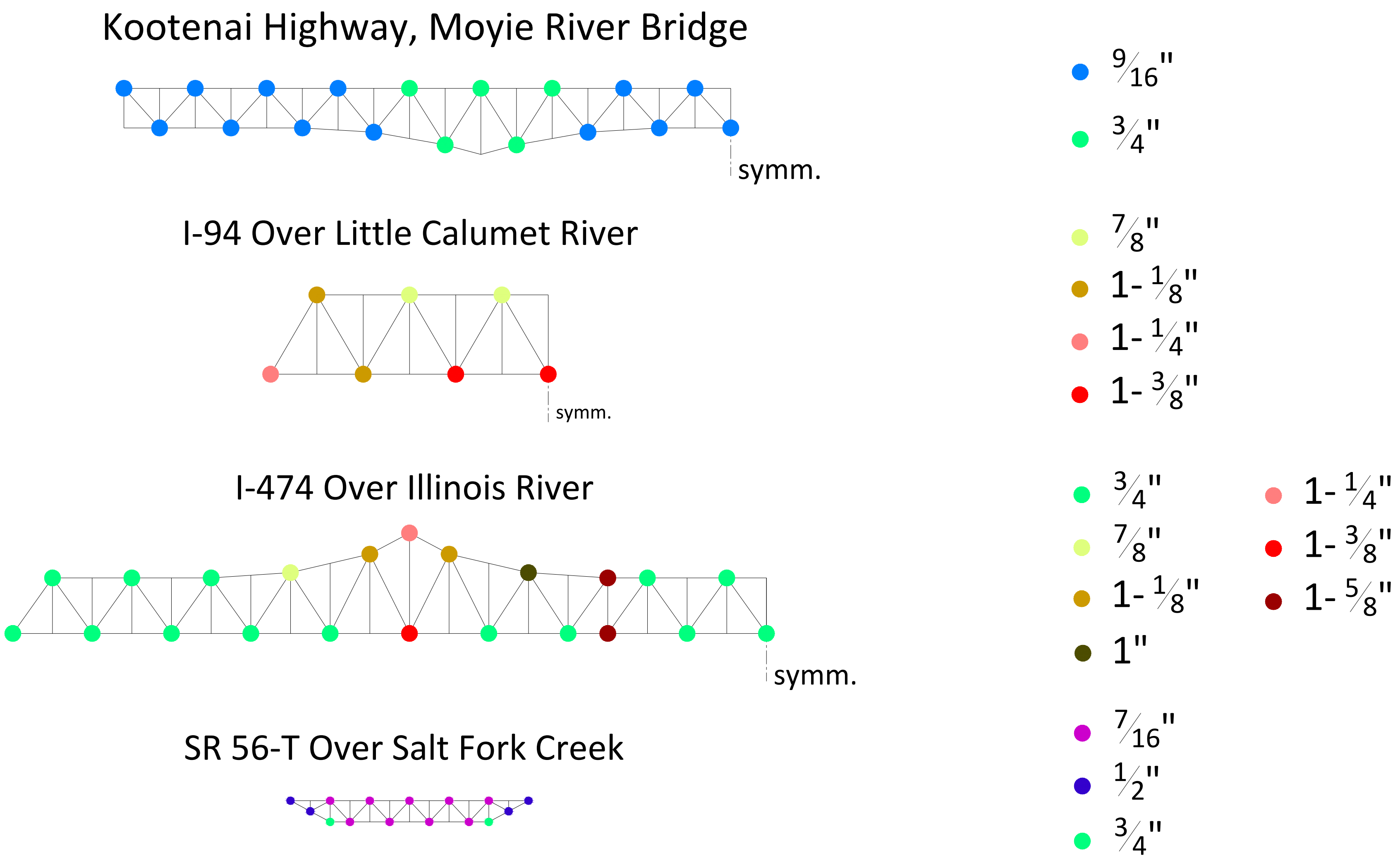

Figure A3. Gusset plate thickness distribution across locations in the truss.

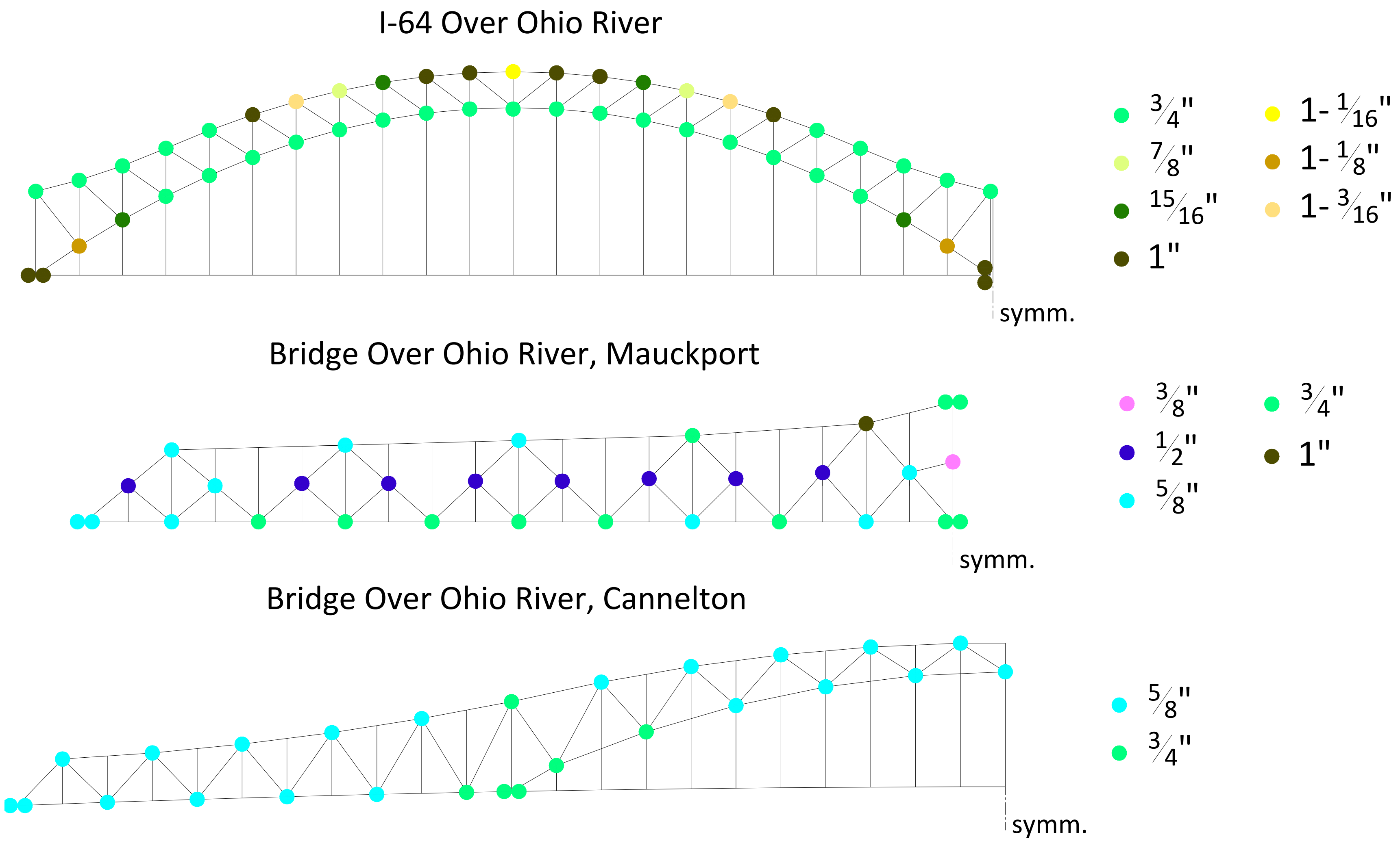

Figure A4. Gusset plate thickness distribution across locations in the truss; continued.

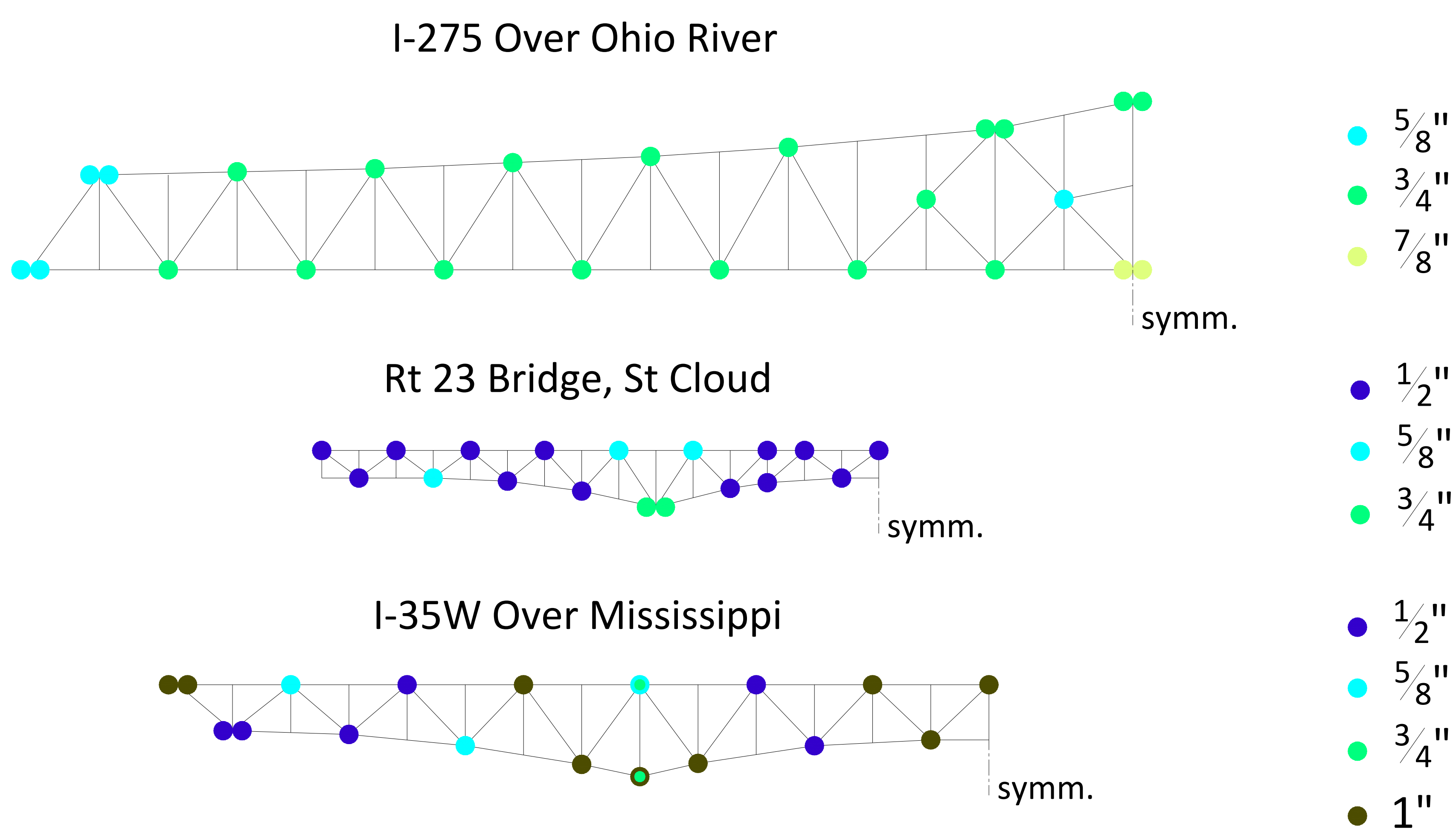

Figure A5. Gusset plate thickness distribution across locations in the truss; continued.

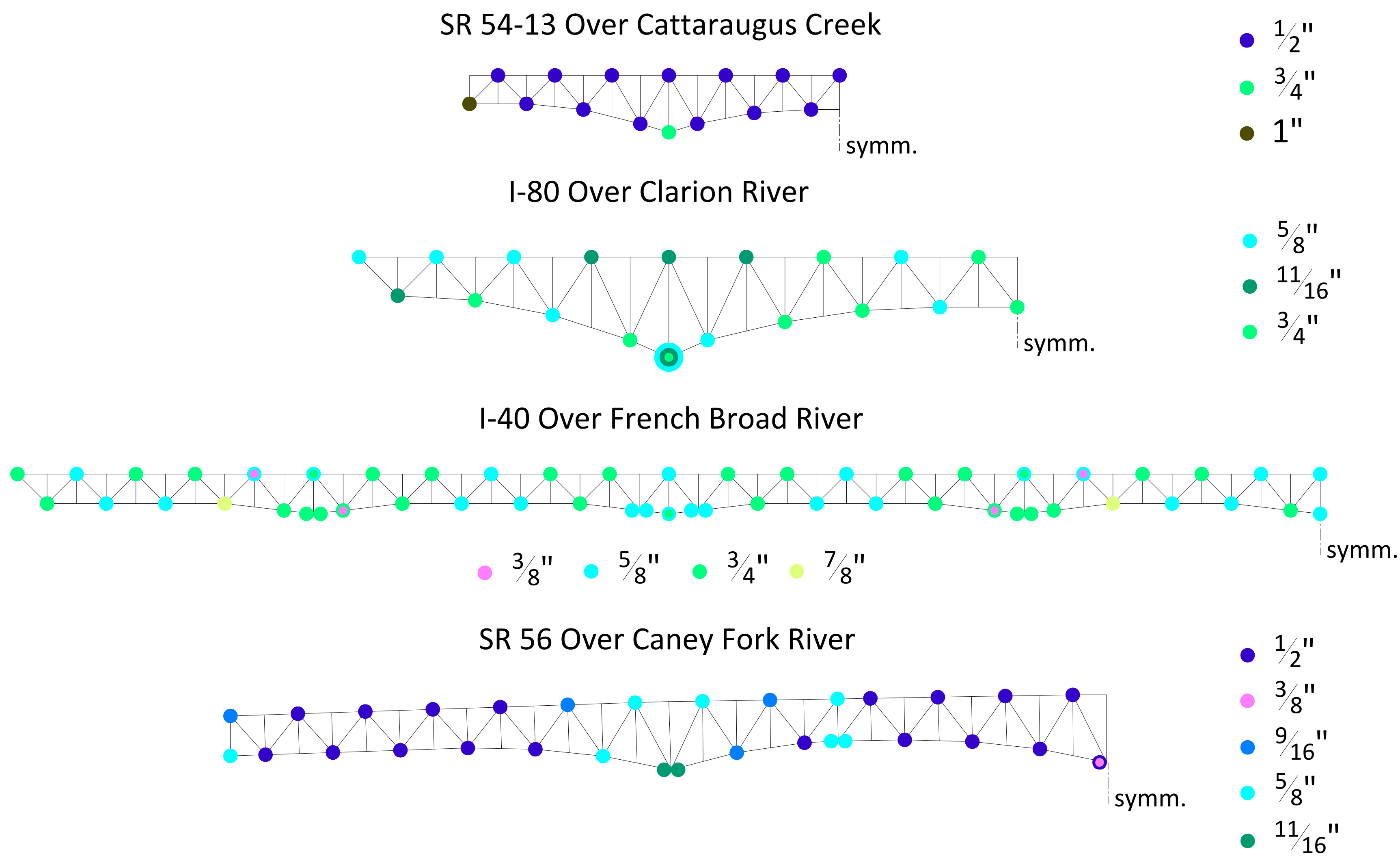

Figure A6. Gusset plate thickness distribution across locations in the truss; continued.

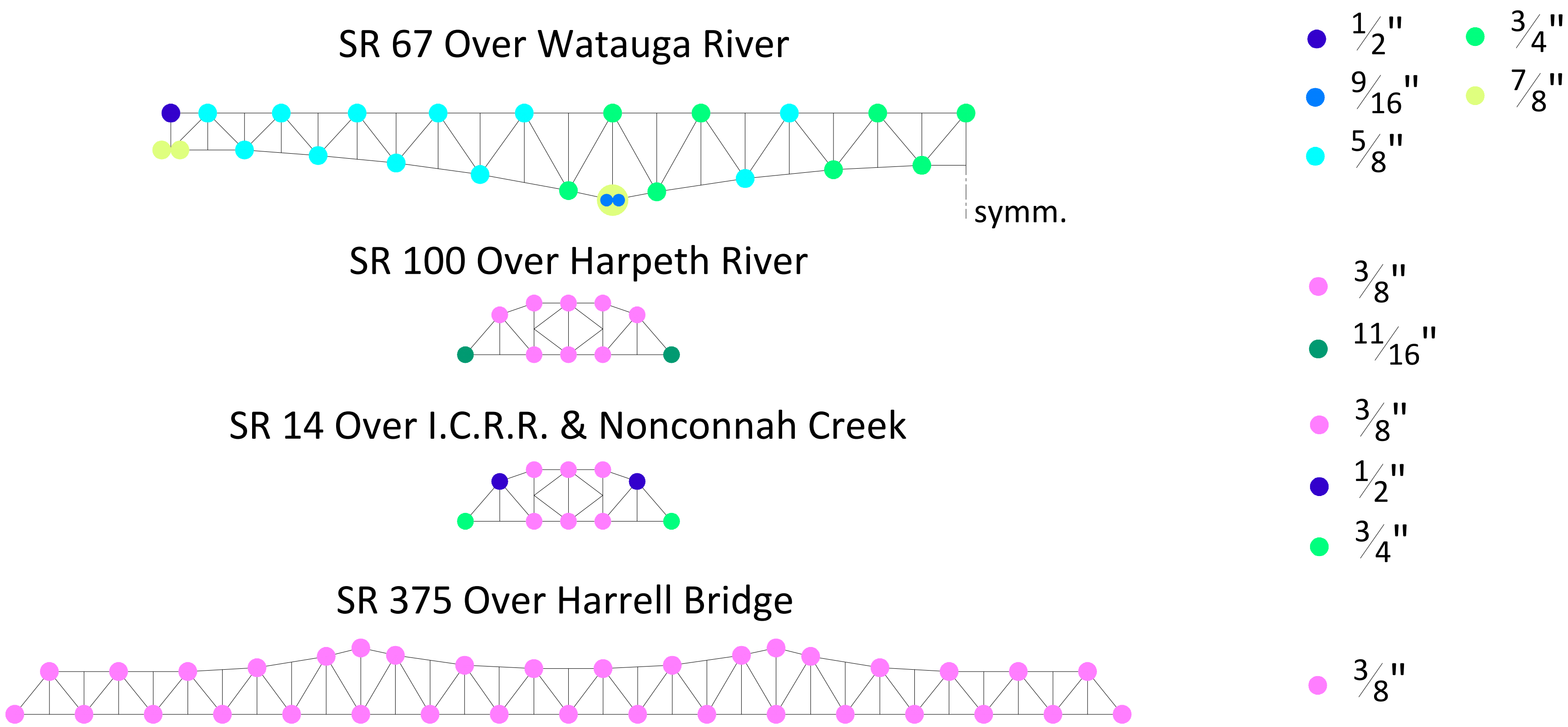

Figure A7. Gusset plate thickness distribution across locations in the truss; continued.

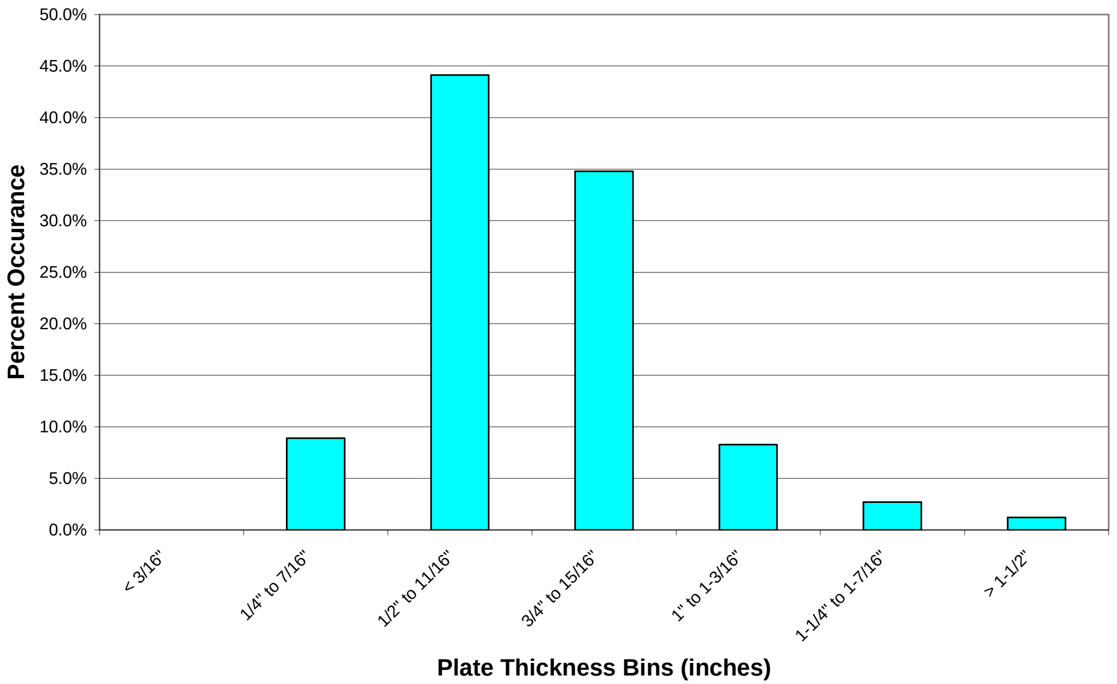

Figure A8. Distribution of gusset plate thicknesses.