CHAPTER 1 – LG GIRDER

TABLE OF CONTENTS

1.1─LG GIRDER PRELIMINARY DESIGN CHARTS 1
1.1.1─Design Assumptions 1
1.1.2─LG Girder Dimensions, Section Properties, and Strand Templates 3
1.1.3─Flexural Design - Maximum Estimated Span Length Charts 5
1.1.3.1─Moderate Corrosive Condition, f'_c = 8.5 ksi, f'_{ci} = 6.5 ksi 5
1.1.3.2─Moderate Corrosive Condition, f'_c = 10.0 ksi, f'_{ci} = 7.5 ksi 6
1.1.3.3─Severe Corrosive Condition, f'_c = 8.5 ksi, f'_{ci} = 6.5 ksi 7
1.1.3.4─Severe Corrosive Condition, f'_c = 10.0 ksi, f'_{ci} = 7.5 ksi 8
1.1.4─Shear Design Charts 9
1.1.4.1─LG-25, Grade 60 Steel 9
1.1.4.2─LG-25, Grade 75 WWR 10
1.1.4.3─LG-36, Grade 60 Steel 11
1.1.4.4─LG-36, Grade 75 WWR 12
1.1.4.5─LG-45, Grade 60 Steel 13
1.1.4.6─LG-45, Grade 75 WWR 14
1.1.4.7─LG-54, Grade 60 Steel 15
1.1.4.8─LG-54, Grade 75 WWR 16
1.1.4.9─LG-63, Grade 60 Steel 17
1.1.4.10─LG-63, Grade 75 WWR 18
1.1.4.11─LG-72, Grade 60 Steel 19
1.1.4.12─LG-72, Grade 75 WWR 20
1.1.4.13─LG-78, Grade 60 Steel 21
1.1.4.14─LG-78, Grade 75 WWR 22
1.2─LG GIRDER BEARING DESIGN CHART 23
1.2.1─Bearing Design Assumptions and Requirements 23
1.2.2─Development of Bearing Design Chart 26
1.2.3─Application of Bearing Design Chart 29
1.2.4─Bearing Design Examples 30
1.2.4.1─Example 1: Simple Span 30
Case 1: Girder slope SL = 0.5% 30

Case 2: Girder slope SL = 3.0% 33
1.2.4.2—Example 2: Continuous Deck Span 33
Case 1: Girder slope SL = 0.5% 34
Case 2: Girder slope SL = 3.0% 38
1.3—LG GIRDER STANDARD PLANS AND DESIGN AIDS 39
1.3.1—LG Girder Standard Plans 39
1.3.1.1—Common Details 40
1.3.1.2—Specific Details 40
1.3.2—LG Girder Design Aids 40
1.3.2.1—Girder Data Table and Camber Data Table 41
1.3.2.2—Strand Patterns and Strand Pattern Data Table 41
1.3.2.3—Non-Standard Steel-Reinforced Elastomeric Bearing Data Table 41
1.3.2.4—Typical Simple Spans Made Continuous Deck Unit with Link Slabs 42
1.3.2.5—Diaphragms 42
1.3.2.6—Seismic Shear Key 42
1.3.3—Typical Organization of LG Girder Project Plan Set 55
APPENDIX A—SUMMARY OF REACTIONS AND END ROTATIONS 58
APPENDIX B—BEARING DESIGN CHART DEVELOPMENT EXAMPLE (STANDARD PAD B-1) 62

LIST OF TABLES

Table 1.2.1-1: LADOTD Standard Steel-Reinforced Elastomeric Bearings 25
Table 1.3.1-1: LG Girder Standard Plans 39
Table 1.3.2-1: LG Girder Design Aids 41
Table 1.3.3-1: Typical Organization of LG Girder Project Plan Set 55
Table A-1: Girder Reactions and End Rotations for LG Girders (8.5 ksi Concrete) 58
Table A-2: Girder Reactions and End Rotations for LG Girders (10.0 ksi Concrete) 60

LIST OF FIGURES

LG-36-78 Strand Template 4
LG-25 Strand Template 4a
Figure 1.2.2-1: Flowchart for Developing Bearing Design Chart 27
Figure 1.2.2-2: Bearing Design Chart 28

Figure 1.2.3-1: Flowchart to Use the Bearing Design Chart 29
Figure 1.2.4.1-1: Bridge Profile for Design Example 1 30
Figure 1.2.4.1-2: Bearing Design Chart - Example 1 32
Figure 1.2.3.2-1: Bridge Profile for Design Example 2 33
Figure 1.2.4.2-2: Bearing Design Chart - Example 2 37
Figure 1.3.2-1: Girder Data Table and Camber Data Table 43
Figure 1.3.2-2: Strand Pattern and Strand Pattern Data Table 44
Figure 1.3.2-3: Non-Standard Steel-Reinforced Elastomeric Bearings Data Table 45
Figure 1.3.2-4: Typical Simple Span Made Continuous Deck Unit with Link Slab 46
Figure 1.3.2-4: Typical Simple Span Made Continuous Unit with Link Slab 47
Figure 1.3.2-5: Diaphragms 48
Figure 1.3.2-5: Diaphragms 49
Figure 1.3.2-5: Diaphragms 50
Figure 1.3.2-6: Seismic Shear Key 51
Figure 1.3.2-6: Seismic Shear Key 52
Figure 1.3.2-6: Seismic Shear Key 53
Figure 1.3.2-6: Seismic Shear Key 54
Figure 1.3.3-1: Example LG Girder Project 57
Figure B-1: Dead Load and Live Load Reactions 65

1.1─LG GIRDER PRELIMINARY DESIGN CHARTS

LG girder preliminary design charts are developed based on design assumptions listed in 1.1.1. Two types of design charts, maximum span length and shear design charts, are developed for each girder type (LG-25 to LG-78) considering various beam spacings, two concrete strengths (f'_c = 8.5 ksi and f'_c = 10 ksi), and two corrosive conditions (moderate and severe). These design charts provide efficient tools to aid design and QC/QA efforts. However, the EOR is ultimately responsible for the final design of LG girders.

1.1.1─Design Assumptions

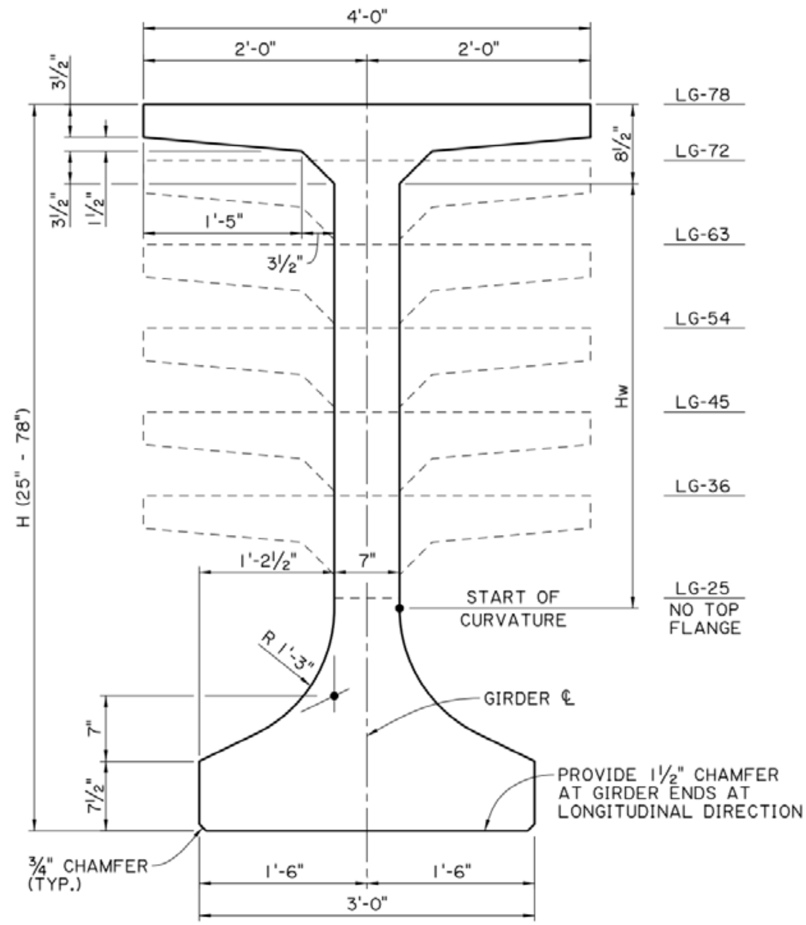
Design Specifications	*AASHTO LRFD Bridge Design Specifications*, 7th Edition with 2016 interim revisions and BDEM unless noted otherwise.
Girder Concrete	f'_c = 8.5 ksi, f'_{ci} = 6.5 ksi, density for dead load = 155 lb/ft^3, density for modulus of elasticity = 148.5 lb/ft^3 f'_c = 10 ksi, f'_{ci} = 7.5 ksi, density for dead load = 155 lb/ft^3, density for modulus of elasticity = 150 lb/ft^3
Deck Concrete	f'_c = 4 ksi, density for dead load = 150 lb/ft^3, density for modulus of elasticity = 145 lb/ft^3
Minimum Concrete Cover	Bottom flange: 2". Top flange and girder web: 1.5"
Prestressing Strands	Grade 270, Low relaxation, 0.6" diameter, harped at 0.4L from the beam ends (except for LG-25), no debonding, initial prestressing steel stress = 202.5 ksi (0.75 f_{pu}). Harping is not allowed for LG-25. Note: LG36 to LG78 design tables are developed based on strands harped at 0.4L from beam ends. However, tie down points could vary. Refer to BDEM PART II, Volume 1 D5.11.4.3 for additional provisions.
Steel Reinforcement	Grade 60 rebar, f_y = 60 ksi Grade 75 WWR, f_y = 75 ksi (shear reinforcement only)
Live Load	LADV-11
Dead Load	- Future wearing surface = 25 psf - SIP form = 10 psf - Railing weight = 520 lb/ft each (assume 42 in. F type, total two railings). The railing weight is equally distributed over all beams. - Include intermediate diaphragm for spans greater than 120 ft (BDEM has since revised this requirement. See current policy for Intermediate Diaphragms in Part II, Volume 1, Chapter 5)
Deck Thickness	8.5" total deck thickness with 0.5" sacrificial thickness
Gutter Line	1'-8" from the edge of deck (assume 42 in. F type barrier)

(*continued on next page)*

Design Assumptions - Continued

Haunch Thickness	- 2" at center of support for spans ≤ 90 ft, and 0.5" at midspan - 3" at center of support for spans from 90 to 120 ft, and 0.5" at midspan - 4" at center of support for spans ≥ 120 ft, and 0.5" at midspan Average haunch weight is considered in the analysis. Haunch thickness is ignored in the calculation of section properties.
Interior Girder Spacing	Varies from 6 - 12 feet
Exterior Girder Capacity	Non-composite section capacity of exterior girders shall not be less than that of interior girders to allow for future widening.
Overhang Length, L	2'-3" ≤ L ≤ ½ Interior girder spacing
Splitting Resistance at Girder End	Based on f_s = 20 ksi, A_s = total area of vertical reinforcement distributed within h/4 or 12 in., whichever is greater, from the girder ends.
Tensile Stress Limits at Service Limit State	$0.19\sqrt{f_c'}$ (ksi) or $6\sqrt{f_c'}$ (psi) for Moderate Corrosive Condition $0.0948\sqrt{f_c'}$ (ksi) or $3\sqrt{f_c'}$ (psi) for Severe Corrosive Condition
Tensile Stress Limit at Transfer	$0.0948\sqrt{f_{ci}'}$ (ksi) or $3\sqrt{f_{ci}'}$ (psi) $\leqslant$ 0.2 ksi Except in areas with bonded reinforcement (reinforcing bars or prestressing steel) sufficient to resist the tensile force in the concrete computed assuming an uncracked section, where reinforcement is proportioned using a stress of $0.5f_y$, not to exceed 30 ksi, stress limit = $0.24\sqrt{f_{ci}'}$ (ksi) or $7.5\sqrt{f_{ci}'}$ (psi).
Prestress Losses	Use gross section and include elastic gains.
Camber and Deflection	Use PCI Multiplier method.
Shear Analysis	The shear reinforcement is designed to satisfy both the shear strength and interface shear. The general method is used in calculating the shear resistance. For interface shear, the concrete surface is assumed to be intentionally roughened with c = 0.24 ksi and μ = 1.0.
Girder Stability	Refer to *D5.14.1.2* for girder stability requirements.
Bridge Layout	Bridge model with 6 girders is studied for the determination of estimated maximum span length and simple span girders are used.
Bridge Skew	The maximum estimated span length and shear design charts were developed based on bridges without skew. These charts may still be applicable for most skew conditions, however the EOR shall check the skew correction factors for moment and shear.
Reinforcement in End Zone	Reinforcement in end zone has been standardized for each girder type and shown in LG girder Standard Plans.

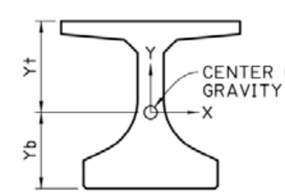
1.1.2─LG Girder Dimensions, Section Properties, and Strand Templates

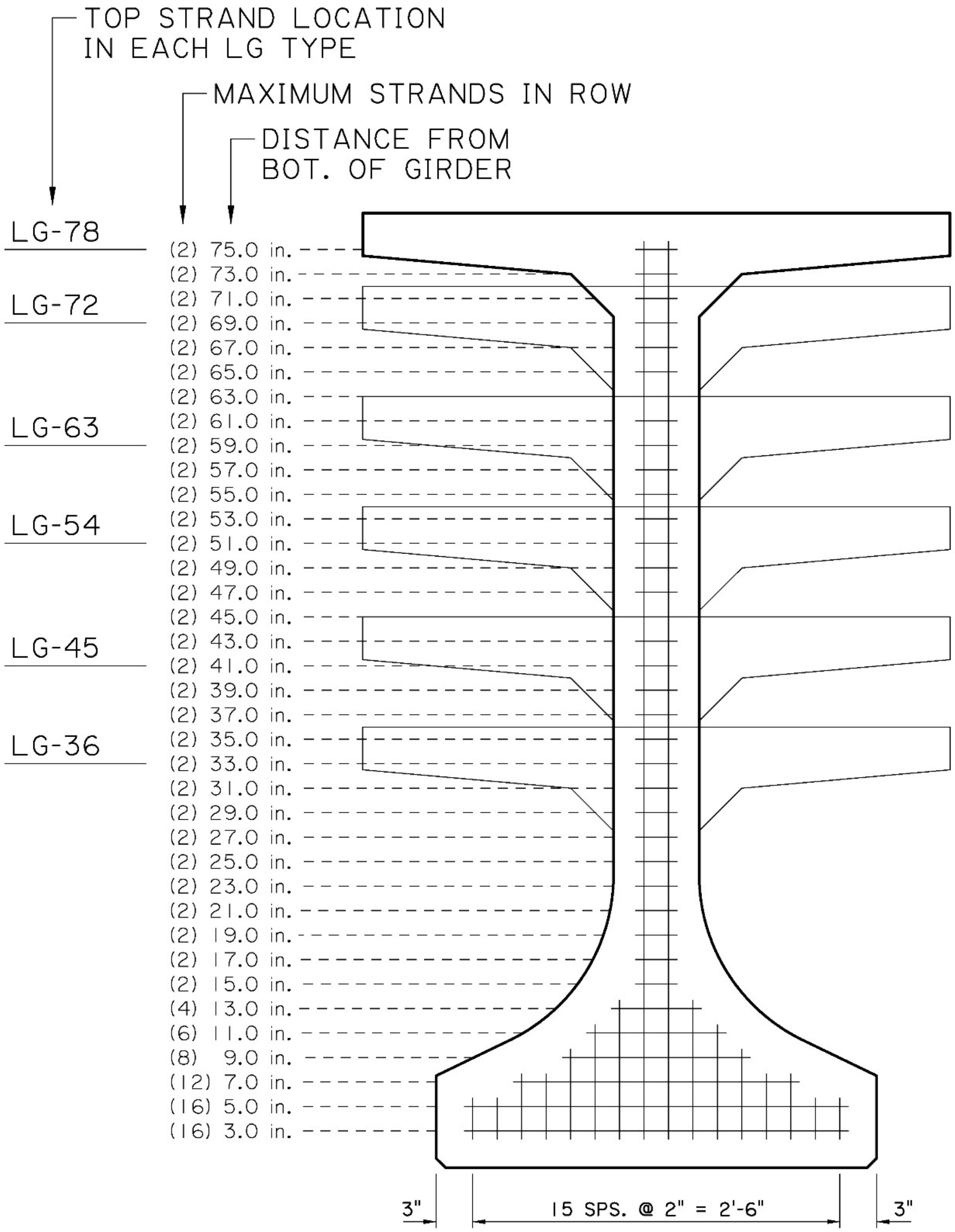


LG DIMENSIONS

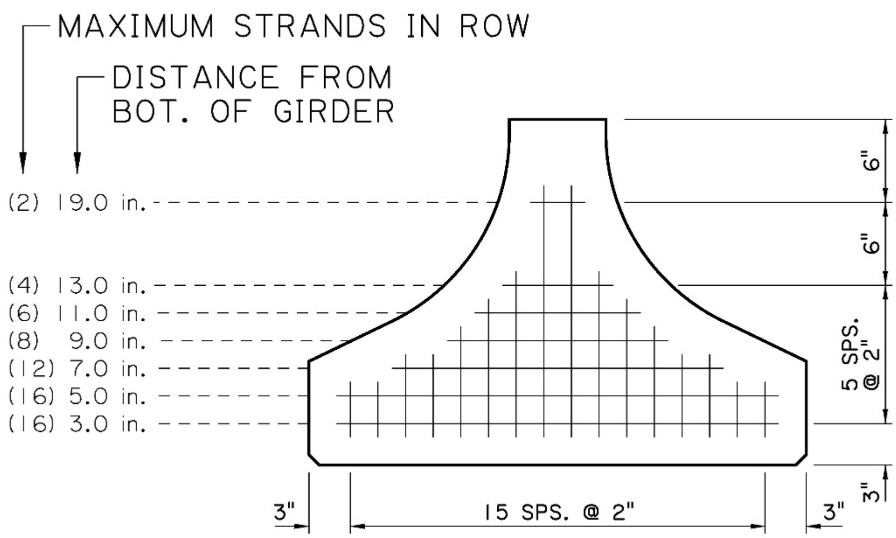
GIRDER DIMENSIONS AND SECTION PROPERTIES										
GIRDER TYPE	H	Hw	Yt	Yb	AREA	Ix	Iy	St	Sb	WEIGHT
	(in.)	(in.)	(in.)	(in.)	(in.^{2})	(in.^{4})	(in.^{4})	(in.^{3})	(in.^{3})	(plf)
LG-25	25	1.08	16.46	8.54	524	19,944	38,636	1,212	2,335	564
LG-36	36	3.58	19.28	16.72	792	125,051	76,182	6,486	7,479	853
LG-45	45	12.58	24.51	20.49	855	222,491	76,439	9,078	10,859	920
LG-54	54	21.58	29.64	24.36	918	353,786	76,696	11,936	14,523	988
LG-63	63	30.58	34.69	28.31	981	521,638	76,954	15,037	18,426	1,056
LG-72	72	39.58	39.67	32.33	1,044	728,715	77,211	18,369	22,540	1,124
LG-78	78	45.58	42.96	35.04	1,086	889,863	77,382	20,714	25,396	1,169

NOTES:
1. UNIT WEIGHT USED IN CALCULATING GIRDER WEIGHT = 155 PCF.
2. GIRDER PROPERTIES CALCULATED BASED ON SIX SIGNIFICANT DIGITS AND FOUR DECIMAL PLACES.
3. Yt AND Yb ARE THE DISTANCE FROM THE CENTER OF GRAVITY OF THE GROSS SECTION TO THE EXTREME TOP FIBER AND EXTREME BOTTOM FIBER, RESPECTIVELY.
4. THE LISTED HEIGHT OF WEB (Hw) IS APPROXIMATE AND HAS BEEN ROUNDED TO THE SECOND DECIMAL PLACE.





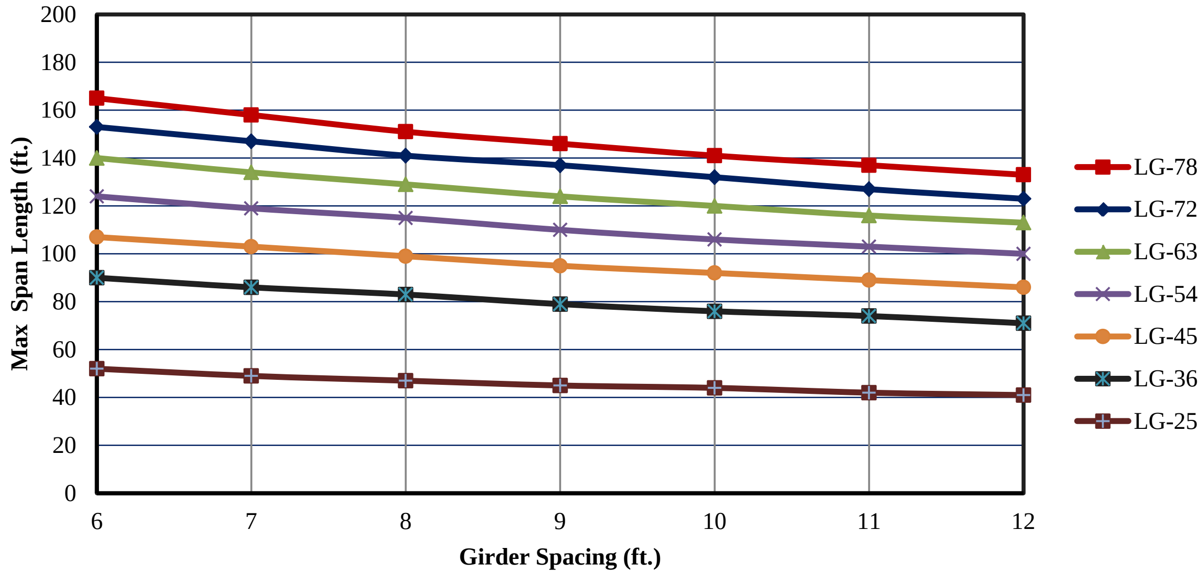
LG-36-78 Strand Template



LG-25 Strand Template

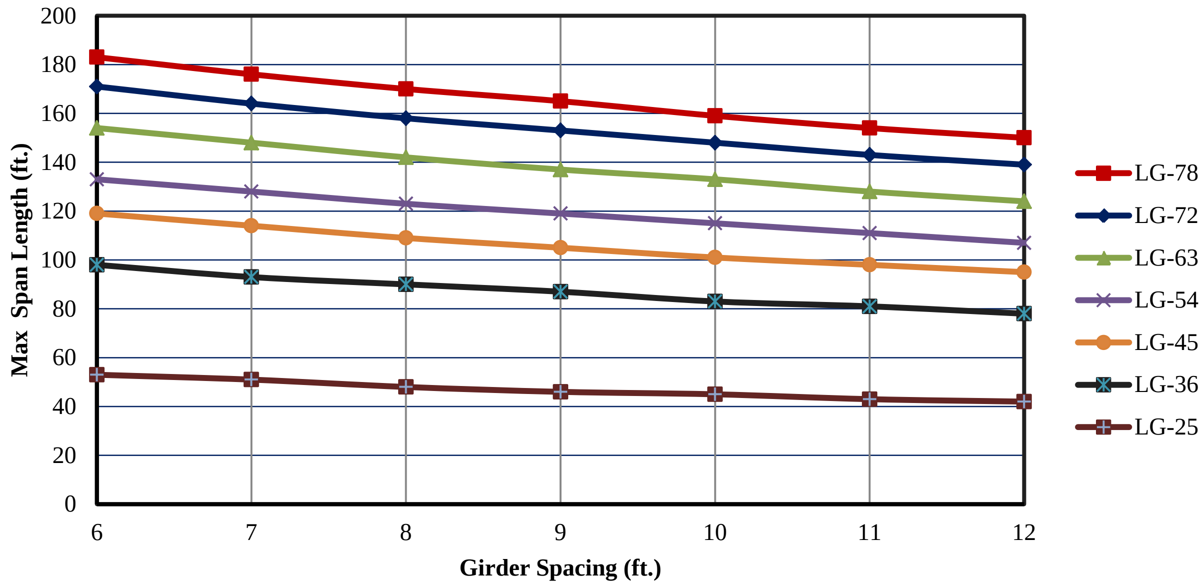
1.1.3─Flexural Design - Maximum Estimated Span Length Charts

1.1.3.1─Moderate Corrosive Condition, f'_c = 8.5 ksi, f'_{ci} = 6.5 ksi



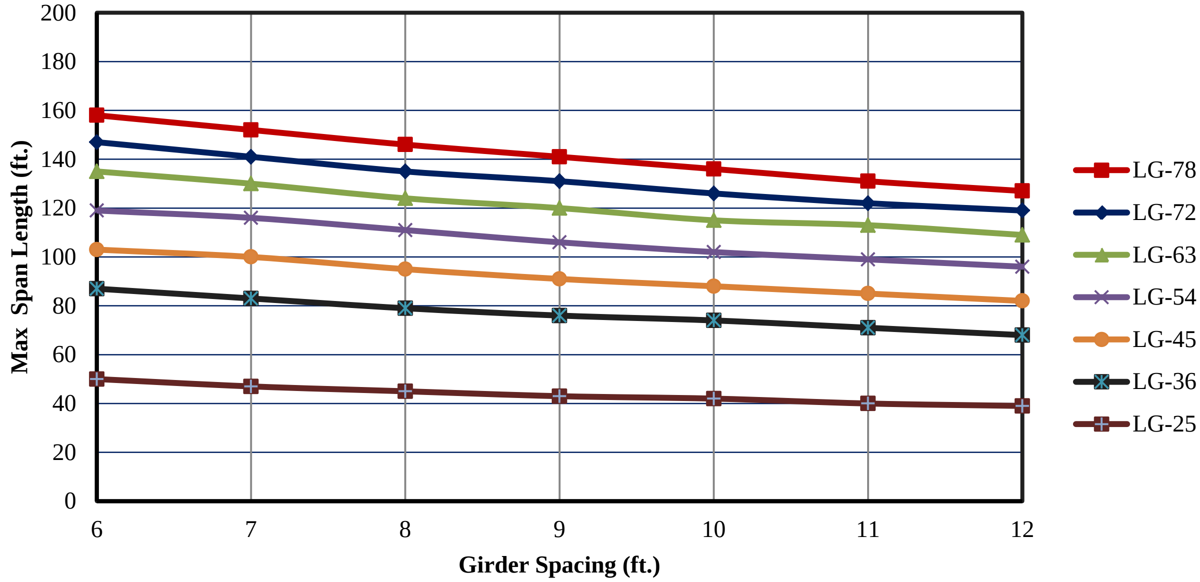
	Beam Spacing (ft.)	6	7	8	9	10	11	12
LG-78	Max. Number of Strands	58	58	58	58	58	58	58
	Max. Span Length (ft.)	165	158	151	146	141	137	133
	R.F. (Service III, Inv.)	1.00	1.01	1.03	1.01	1.01	1.01	1.01
	Maximum Overhang Length	3'-0"	3'-3"	3'-6"	3'-9"	4'-1"	4'-5"	4'-9"
LG-72	Max. Number of Strands	54	54	54	54	54	54	54
	Max. Span Length (ft.)	153	147	141	137	132	127	123
	R.F. (Service III, Inv.)	1.02	1.01	1.01	1.01	1.01	1.01	1.01
	Maximum Overhang Length	3'-0"	3'-4"	3'-6"	3'-8"	4'-0"	4'-5"	4'-9"
LG-63	Max. Number of Strands	52	52	52	52	52	52	52
	Max. Span Length (ft.)	140	134	129	124	120	116	113
	R.F. (Service III, Inv.)	1.02	1.02	1.01	1.01	1.02	1.02	1.02
	Maximum Overhang Length	3'-0"	3'-3"	3'-5"	3'-8"	3'-11"	4'-5"	4'-7"
LG-54	Max. Number of Strands	48	48	48	48	48	48	48
	Max. Span Length (ft.)	124	119	115	110	106	103	100
	R.F. (Service III, Inv.)	1.00	1.04	1.01	1.00	1.01	1.01	1.01
	Maximum Overhang Length	3'-0"	3'-3"	3'-4"	3'-8"	4'-0"	4'-3"	4'-6"
LG-45	Max. Number of Strands	44	44	44	44	44	44	44
	Max. Span Length (ft.)	107	103	99	95	92	89	86
	R.F. (Service III, Inv.)	1.05	1.01	1.01	1.01	1.01	1.01	1.01
	Maximum Overhang Length	3'-0"	3'-4"	3'-4"	3'-7"	3'-10"	4'-2"	4'-6"
LG-36	Max. Number of Strands	40	40	40	40	40	40	40
	Max. Span Length (ft.)	90	86	83	79	76	74	71
	R.F. (Service III, Inv.)	1.01	1.01	1.01	1.03	1.01	1.01	1.03
	Maximum Overhang Length	3'-0"	3'-4"	3'-4"	3'-7"	3'-11"	4'-2"	4'-5"
LG-25	Max. Number of Strands	32	32	32	32	32	32	32
	Max. Span Length (ft.)	51	49	48	46	45	43	42
	R.F. (Service III, Inv.)	1.26	1.22	1.12	1.12	1.05	1.10	1.06
	Maximum Overhang Length	3'-0"	3'-0"	3'-0"	3'-0"	3'-0"	3'-0"	3'-0"

1.1.3.2─Moderate Corrosive Condition, f'_c = 10.0 ksi, f'_{ci} = 7.5 ksi



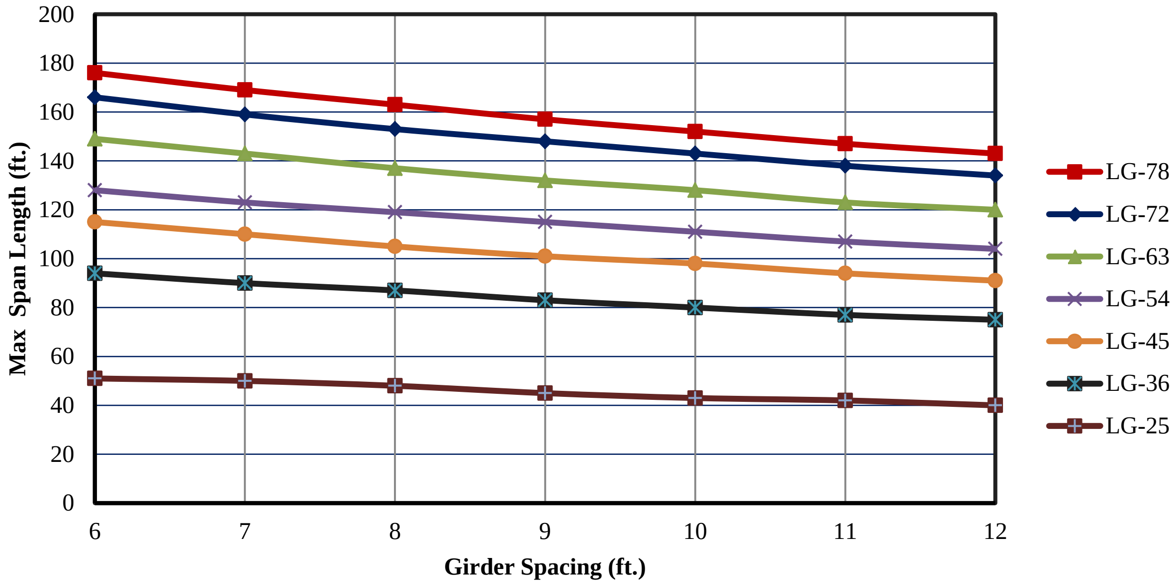
	Beam Spacing (ft.)	6	7	8	9	10	11	12
LG-78	Max. Number of Strands	76	76	76	76	76	76	76
	Max. Span Length (ft.)	183	176	170	165	159	154	150
	R.F. (Service III, Inv.)	1.03	1.03	1.03	1.01	1.01	1.01	1.02
	Maximum Overhang Length	3'-0"	3'-3"	3'-4"	3'-6"	3'-10"	4'-3"	4'-6"
LG-72	Max. Number of Strands	70	70	70	70	70	70	70
	Max. Span Length (ft.)	171	164	158	153	148	143	139
	R.F. (Service III, Inv.)	1.03	1.03	1.03	1.03	1.01	1.02	1.02
	Maximum Overhang Length	3'-0"	3'-3"	3'-4"	3'-6"	3'-9"	4'-3"	4'-9"
LG-63	Max. Number of Strands	64	64	64	64	64	64	64
	Max. Span Length (ft.)	154	148	142	137	133	128	124
	R.F. (Service III, Inv.)	1.02	1.01	1.02	1.01	1.02	1.01	1.01
	Maximum Overhang Length	3'-0"	3'-3"	3'-4"	3'-7"	3'-10"	4'-3"	4'-9"
LG-54	Max. Number of Strands	56	56	56	56	56	56	56
	Max. Span Length (ft.)	133	128	123	119	115	111	107
	R.F. (Service III, Inv.)	1.03	1.02	1.00	1.00	1.02	1.00	1.03
	Maximum Overhang Length	3'-0"	3'-3"	3'-5"	3'-6"	3'-9"	4'-3"	4'-6"
LG-45	Max. Number of Strands	54	54	54	54	54	54	54
	Max. Span Length (ft.)	119	114	109	105	101	98	95
	R.F. (Service III, Inv.)	1.01	1.00	1.01	1.01	1.01	1.00	1.00
	Maximum Overhang Length	3'-0"	3'-3"	3'-4"	3'-6"	3'-10"	4'-2"	4'-8"
LG-36	Max. Number of Strands	48	48	48	48	48	48	48
	Max. Span Length (ft.)	98	93	90	87	83	81	78
	R.F. (Service III, Inv.)	1.01	1.01	1.01	1.00	1.03	1.00	1.02
	Maximum Overhang Length	3'-0"	3'-3"	3'-3"	3'-5"	3'-9"	4'-1"	4'-4"
LG-25	Max. Number of Strands	36	36	36	36	36	36	36
	Max. Span Length (ft.)	55	53	51	50	48	46	45
	R.F. (Service III, Inv.)	1.21	1.16	1.13	1.05	1.06	1.09	1.04
	Maximum Overhang Length	3'-0"	3'-0"	3'-0"	3'-0"	3'-0"	3'-0"	3'-0"

1.1.3.3─Severe Corrosive Condition, $f'_c = 8.5$ ksi, $f'_{ci} = 6.5$ ksi



	Beam Spacing (ft.)	6	7	8	9	10	11	12
LG-78	Max. Number of Strands	58	58	58	58	58	58	58
	Max. Span Length (ft.)	158	152	146	141	136	131	127
	R.F. (Service III, Inv.)	1.03	1.01	1.02	1.00	1.03	1.02	1.02
	Maximum Overhang Length	3'-0"	3'-4"	3'-5"	3'-9"	4'-1"	4'-6"	4'-10"
LG-72	Max. Number of Strands	54	54	54	54	54	54	54
	Max. Span Length (ft.)	147	141	135	131	126	122	119
	R.F. (Service III, Inv.)	1.02	1.01	1.03	1.00	1.02	1.00	1.02
	Maximum Overhang Length	3'-0"	3'-3"	3'-6"	3'-8"	4'-0"	4'-6"	4'-8"
LG-63	Max. Number of Strands	52	52	52	52	52	52	52
	Max. Span Length (ft.)	135	130	124	120	115	113	109
	R.F. (Service III, Inv.)	1.02	1.01	1.01	1.01	1.05	1.00	1.02
	Maximum Overhang Length	3'-0"	3'-3"	3'-5"	3'-7"	3'-11"	4'-4"	4'-6"
LG-54	Max. Number of Strands	48	48	48	48	48	48	48
	Max. Span Length (ft.)	119	116	111	106	102	99	96
	R.F. (Service III, Inv.)	1.05	1.01	1.00	1.02	1.03	1.01	1.01
	Maximum Overhang Length	3'-0"	3'-3"	3'-5"	3'-7"	3'-9"	4'-3"	4'-6"
LG-45	Max. Number of Strands	44	44	44	44	44	44	44
	Max. Span Length (ft.)	103	100	95	91	88	85	82
	R.F. (Service III, Inv.)	1.04	1.03	1.01	1.04	1.01	1.00	1.01
	Maximum Overhang Length	3'-0"	3'-4"	3'-5"	3'-7"	3'-11"	4'-4"	4'-7"
LG-36	Max. Number of Strands	40	40	40	40	40	40	40
	Max. Span Length (ft.)	87	83	79	76	74	71	68
	R.F. (Service III, Inv.)	1.00	1.00	1.03	1.02	1.00	1.00	1.02
	Maximum Overhang Length	3'-0"	3'-3"	3'-4"	3'-7"	3'-9"	4'-3"	4'-4"
LG-25	Max. Number of Strands	32	32	32	32	32	32	32
	Max. Span Length (ft.)	51	49	47	45	43	42	40
	R.F. (Service III, Inv.)	1.07	1.03	1.02	1.04	1.07	1.02	1.07
	Maximum Overhang Length	3'-0"	3'-0"	3'-0"	3'-0"	3'-0"	3'-0"	3'-0"

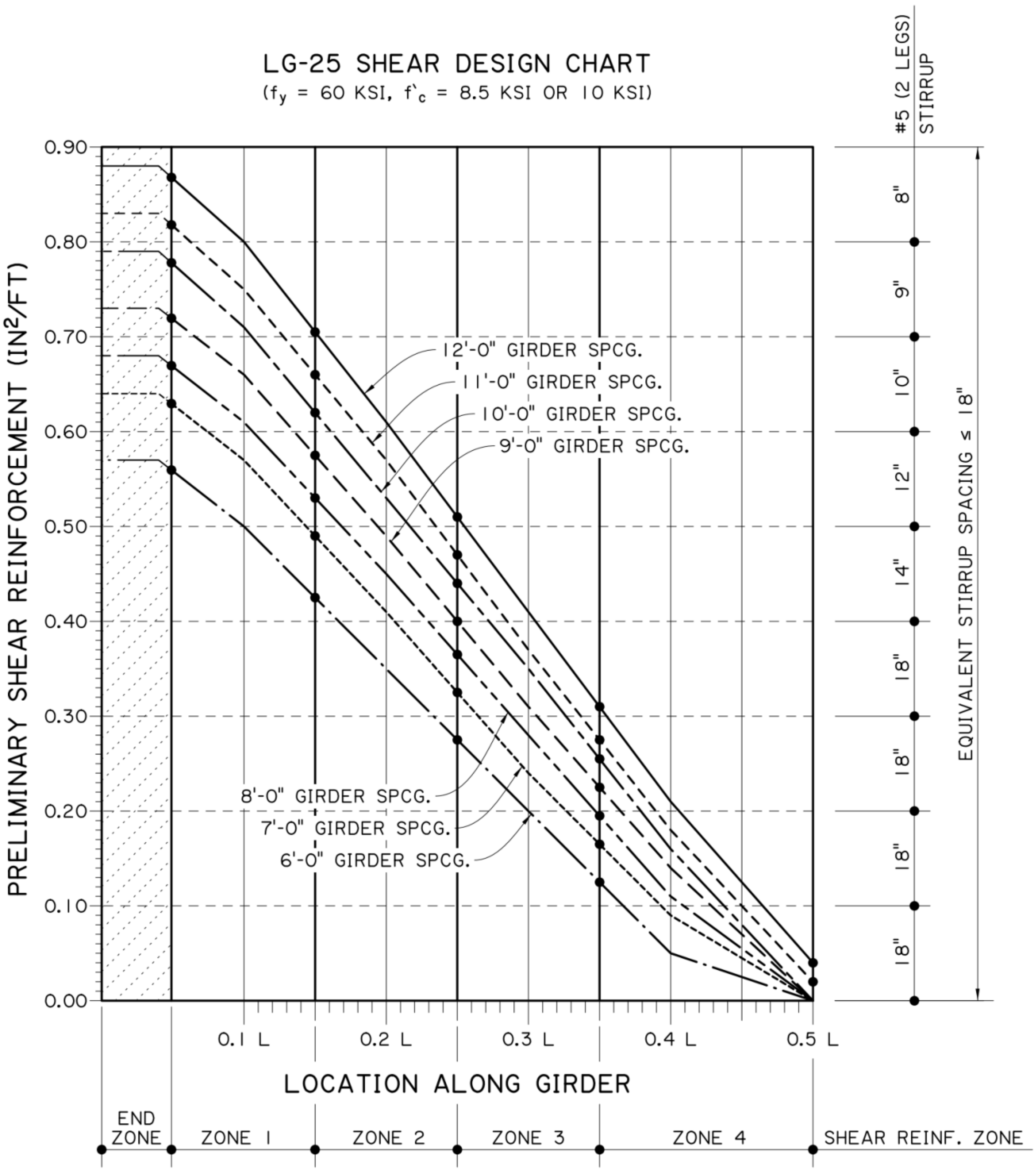
1.1.3.4─Severe Corrosive Condition, $f'_c = 10.0$ ksi, $f'_{ci} = 7.5$ ksi



	Beam Spacing (ft.)	6	7	8	9	10	11	12
LG-78	Max. Number of Strands	74	74	74	74	74	74	74
	Max. Span Length (ft.)	176	169	163	157	152	147	143
	R.F. (Service III, Inv.)	1.02	1.02	1.01	1.02	1.02	1.03	1.02
	Maximum Overhang Length	3'-0"	3'-3"	3'-4"	3'-6"	3'-10"	4'-3"	4'-6"
LG-72	Max. Number of Strands	70	70	70	70	70	70	70
	Max. Span Length (ft.)	166	159	153	148	143	138	134
	R.F. (Service III, Inv.)	1.00	1.01	1.01	1.00	1.00	1.02	1.02
	Maximum Overhang Length	3'-0"	3'-3"	3'-4"	3'-6"	3'-9"	4'-3"	4'-8"
LG-63	Max. Number of Strands	64	64	64	64	64	64	64
	Max. Span Length (ft.)	149	143	137	132	128	123	120
	R.F. (Service III, Inv.)	1.01	1.00	1.02	1.02	1.02	1.03	1.01
	Maximum Overhang Length	3'-0"	3'-3"	3'-4"	3'-6"	3'-9"	4'-3"	4'-6"
LG-54	Max. Number of Strands	56	56	56	56	56	56	56
	Max. Span Length (ft.)	128	123	119	115	111	107	104
	R.F. (Service III, Inv.)	1.03	1.01	1.01	1.01	1.01	1.01	1.01
	Maximum Overhang Length	3'-0"	3'-4"	3'-5"	3'-6"	3'-10"	4'-3"	4'-6"
LG-45	Max. Number of Strands	54	54	54	54	54	54	54
	Max. Span Length (ft.)	115	110	105	101	98	94	91
	R.F. (Service III, Inv.)	1.00	1.00	1.02	1.02	1.00	1.01	1.01
	Maximum Overhang Length	3'-0"	3'-3"	3'-4"	3'-6"	3'-1	4'-3"	4'-7"
LG-36	Max. Number of Strands	48	48	48	48	48	48	48
	Max. Span Length (ft.)	94	90	87	83	80	77	75
	R.F. (Service III, Inv.)	1.03	1.00	1.00	1.03	1.03	1.02	1.02
	Maximum Overhang Length	3'-0"	3'-4"	3'-4"	3'-6"	3'-9"	4'-3"	4'-4"
LG-25	Max. Number of Strands	36	36	36	36	36	36	36
	Max. Span Length (ft.)	54	52	50	48	46	45	43
	R.F. (Service III, Inv.)	1.10	1.06	1.04	1.04	1.06	1.01	1.06
	Maximum Overhang Length	3'-0"	3'-0"	3'-0"	3'-0"	3'-0"	3'-0"	3'-0"

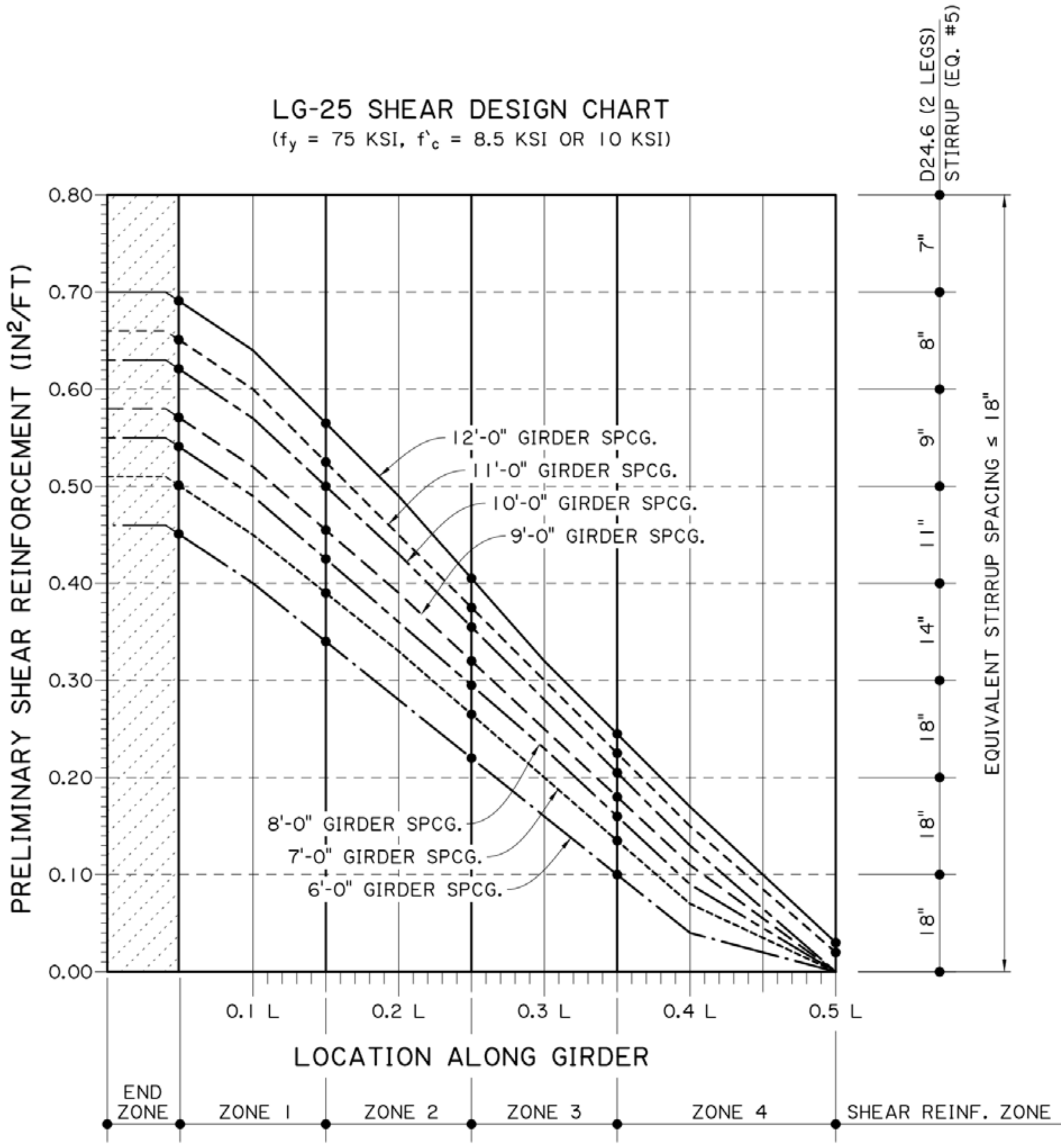
1.1.4─Shear Design Charts

1.1.4.1─LG-25, Grade 60 Steel



NOTES:
1. “L” IS THE GIRDER LENGTH FROM CENTER OF BEARING TO CENTER OF BEARING.
2. THE REQUIRED SHEAR REINFORCEMENT IN THIS CHART IS BASED ON THE MAXIUM ESTIMATED SPAN LENGTHS IN SECTIONS 1.1.3.1 AND 1.1.3.2. FOR LG-25 ONLY ADD ADDITIONAL AMOUNT OF REINFORCEMENT EQUAL TO THOSE SHOWN IN THE DESIGN CHART TO SATISFY INTERFACE SHEAR REQUIREMENT (TOP OF LG-25 WEB TO DECK).
3. END ZONE IS DEFINED AS THE DISTANCE FROM END OF GIRDER TO THE BEGINNING OF ZONE I AND THIS DISTANCE IS TYPICALLY AROUND 1.5 TIMES GIRDER DEPTH “H”. SEE LG GIRDER STANDARD PLANS FOR THE END ZONE DIMENSION AND REINFORCEMENT.

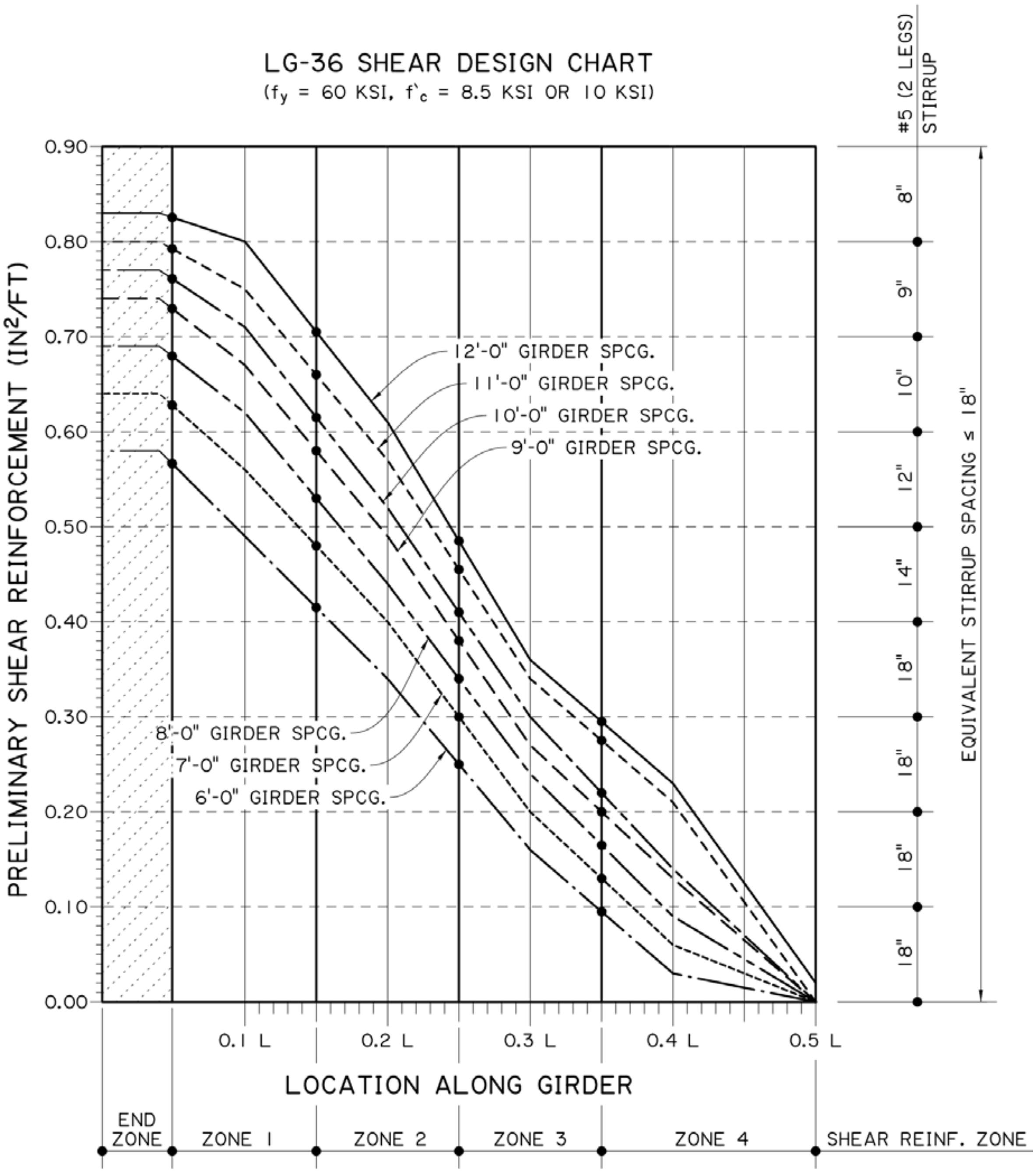
1.1.4.2─LG-25, Grade 75 WWR



NOTES:

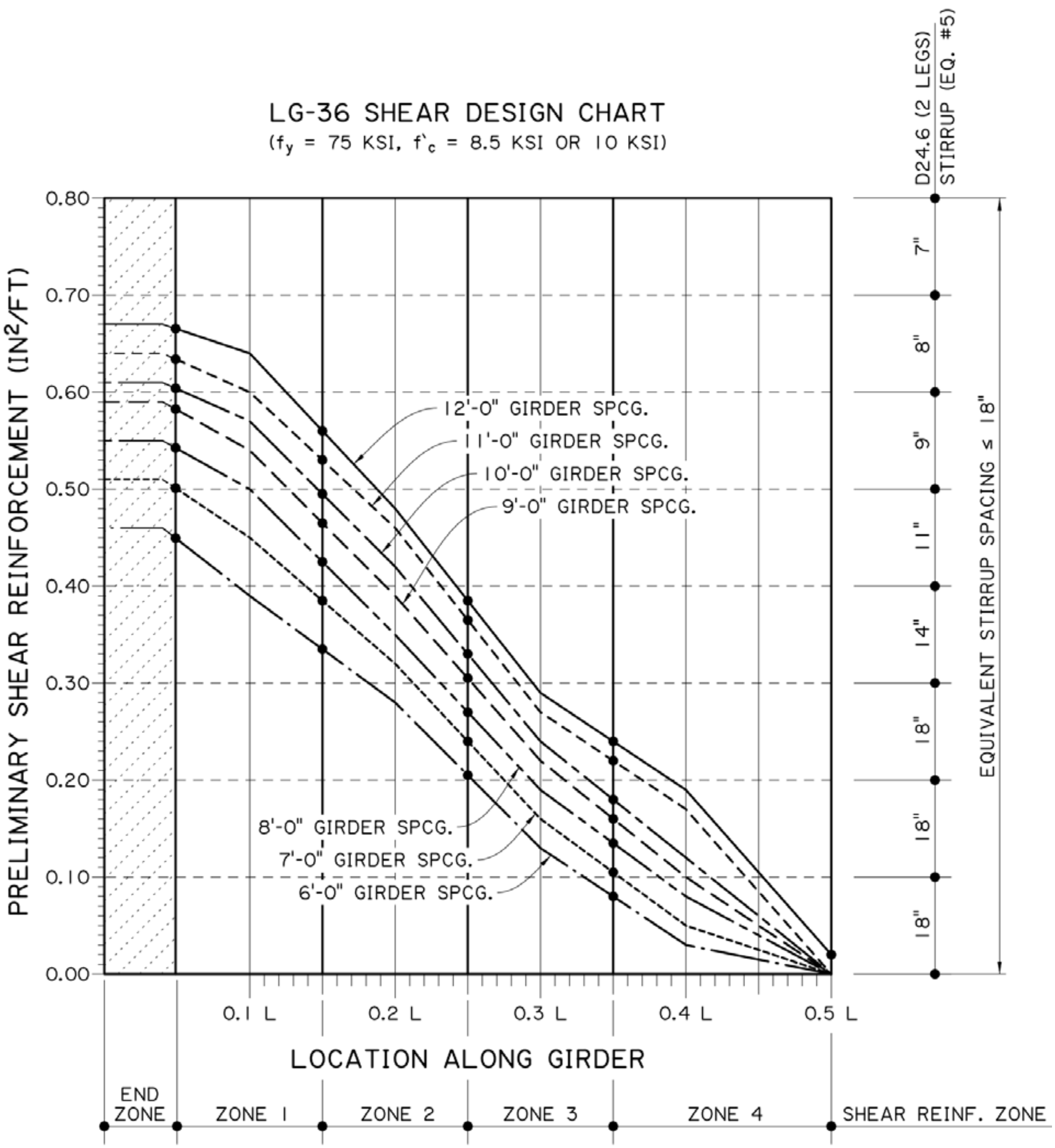
1. “L” IS THE GIRDER LENGTH FROM CENTER OF BEARING TO CENTER OF BEARING.
2. THE REQUIRED SHEAR REINFORCEMENT IN THIS CHART IS BASED ON THE MAXIUM ESTIMATED SPAN LENGTHS IN SECTIONS 1.1.3.1 AND 1.1.3.2. FOR LG-25 ONLY ADD ADDITIONAL AMOUNT OF REINFORCEMENT EQUAL TO THOSE SHOWN IN THE DESIGN CHART TO SATISFY INTERFACE SHEAR REQUIREMENT (TOP OF LG-25 WEB TO DECK).
3. END ZONE IS DEFINED AS THE DISTANCE FROM END OF GIRDER TO THE BEGINNING OF ZONE I AND THIS DISTANCE IS TYPICALLY AROUND 1.5 TIMES GIRDER DEPTH “H”. SEE LG GIRDER STANDARD PLANS FOR THE END ZONE DIMENSION AND REINFORCEMENT.

1.1.4.3─LG-36, Grade 60 Steel



NOTES:
1. "L" IS THE GIRDER LENGTH FROM CENTER OF BEARING TO CENTER OF BEARING.
2. THE REQUIRED SHEAR REINFORCEMENT IN THIS CHART IS BASED ON THE MAXIUM ESTIMATED SPAN LENGTHS IN SECTIONS 1.1.3.1 AND 1.1.3.2.
3. END ZONE IS DEFINED AS THE DISTANCE FROM END OF GIRDER TO THE BEGINNING OF ZONE I AND THIS DISTANCE IS TYPICALLY AROUND 1.5 TIMES GIRDER DEPTH "H". SEE LG GIRDER STANDARD PLANS FOR THE END ZONE DIMENSION AND REINFORCEMENT.

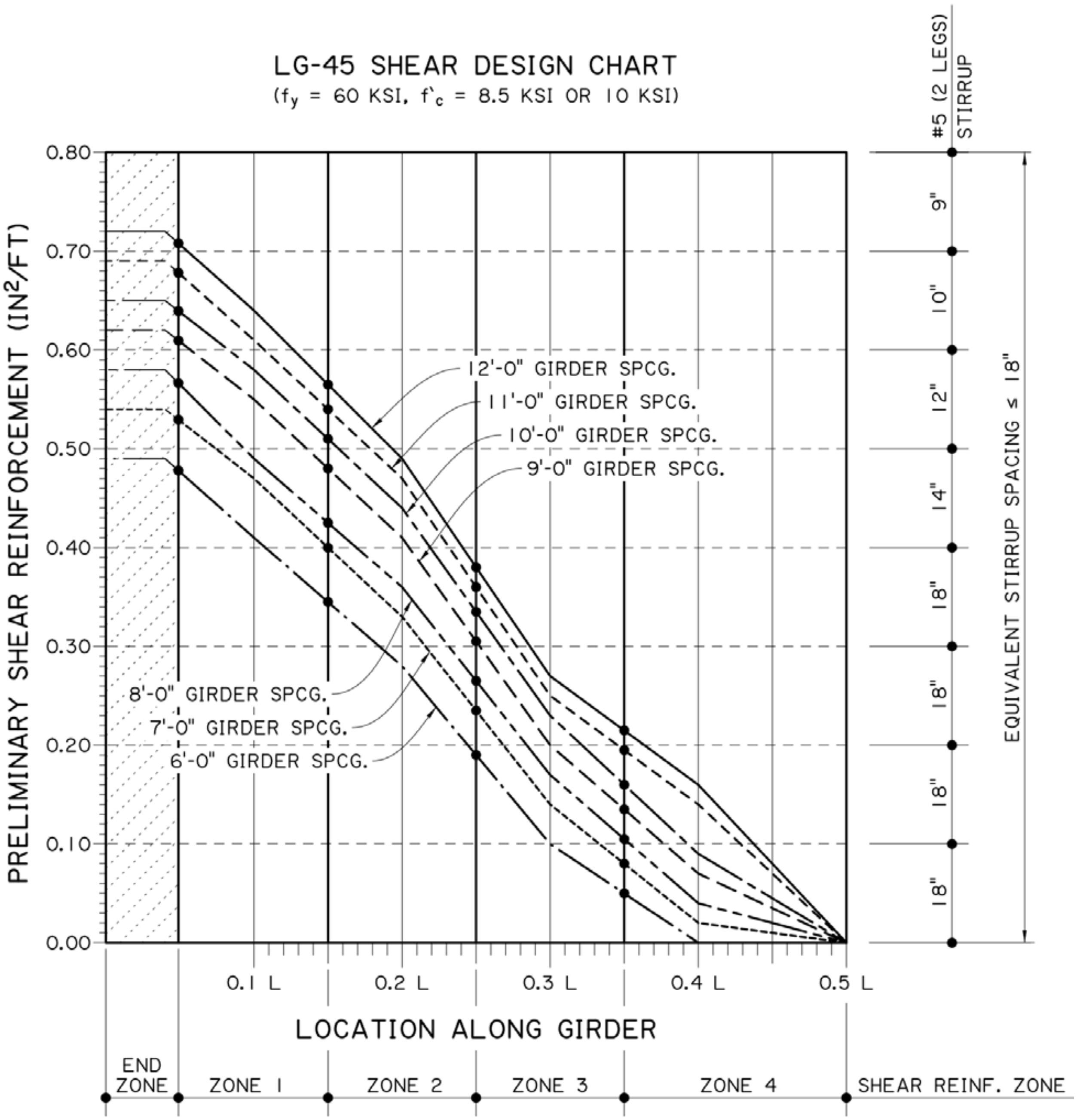
1.1.4.4─LG-36, Grade 75 WWR



NOTES:

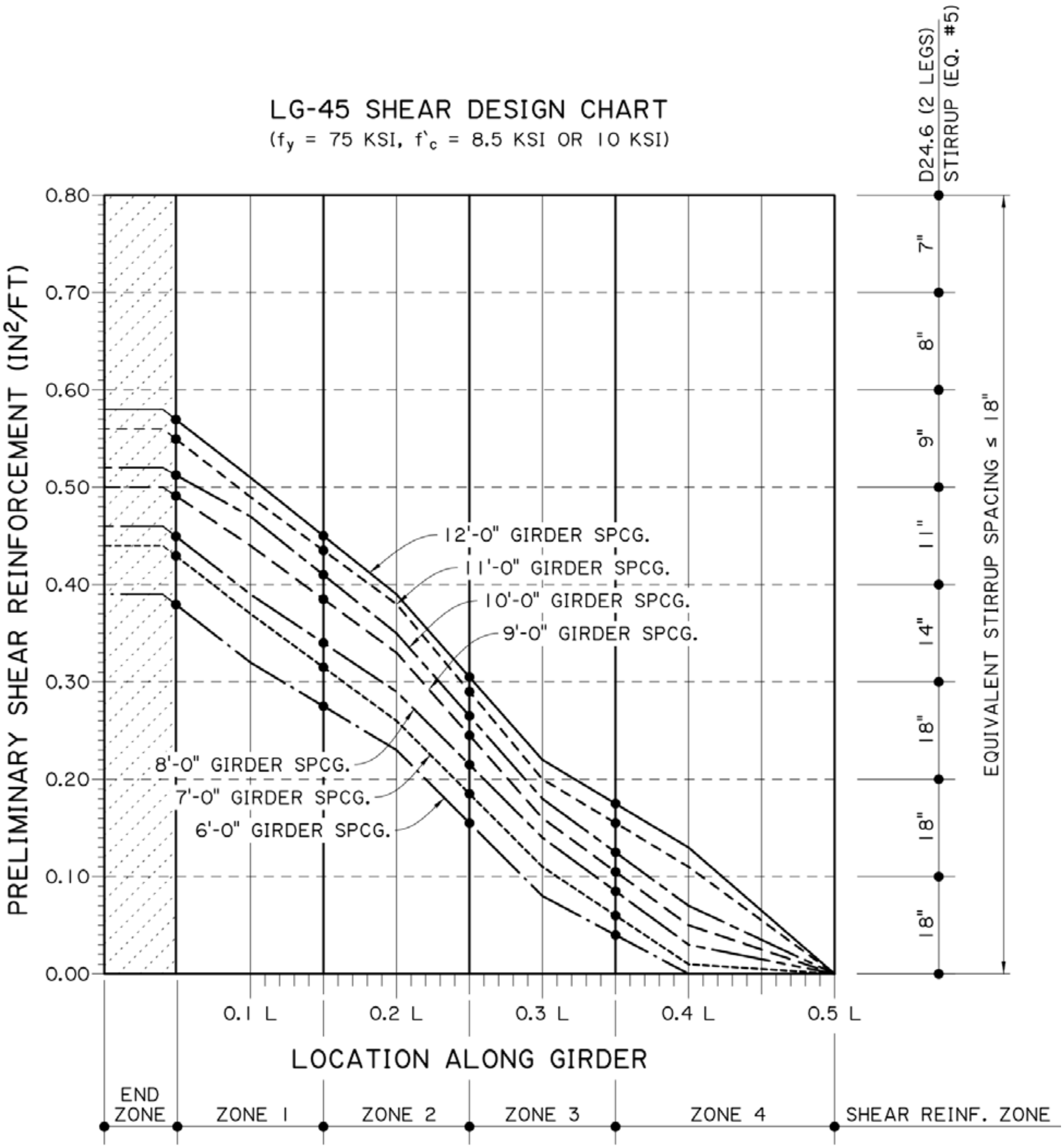
1. "L" IS THE GIRDER LENGTH FROM CENTER OF BEARING TO CENTER OF BEARING.
2. THE REQUIRED SHEAR REINFORCEMENT IN THIS CHART IS BASED ON THE MAXIUM ESTIMATED SPAN LENGTHS IN SECTIONS 1.1.3.1 AND 1.1.3.2.
3. END ZONE IS DEFINED AS THE DISTANCE FROM END OF GIRDER TO THE BEGINNING OF ZONE I AND THIS DISTANCE IS TYPICALLY AROUND 1.5 TIMES GIRDER DEPTH "H". SEE LG GIRDER STANDARD PLANS FOR THE END ZONE DIMENSION AND REINFORCEMENT.

1.1.4.5─LG-45, Grade 60 Steel



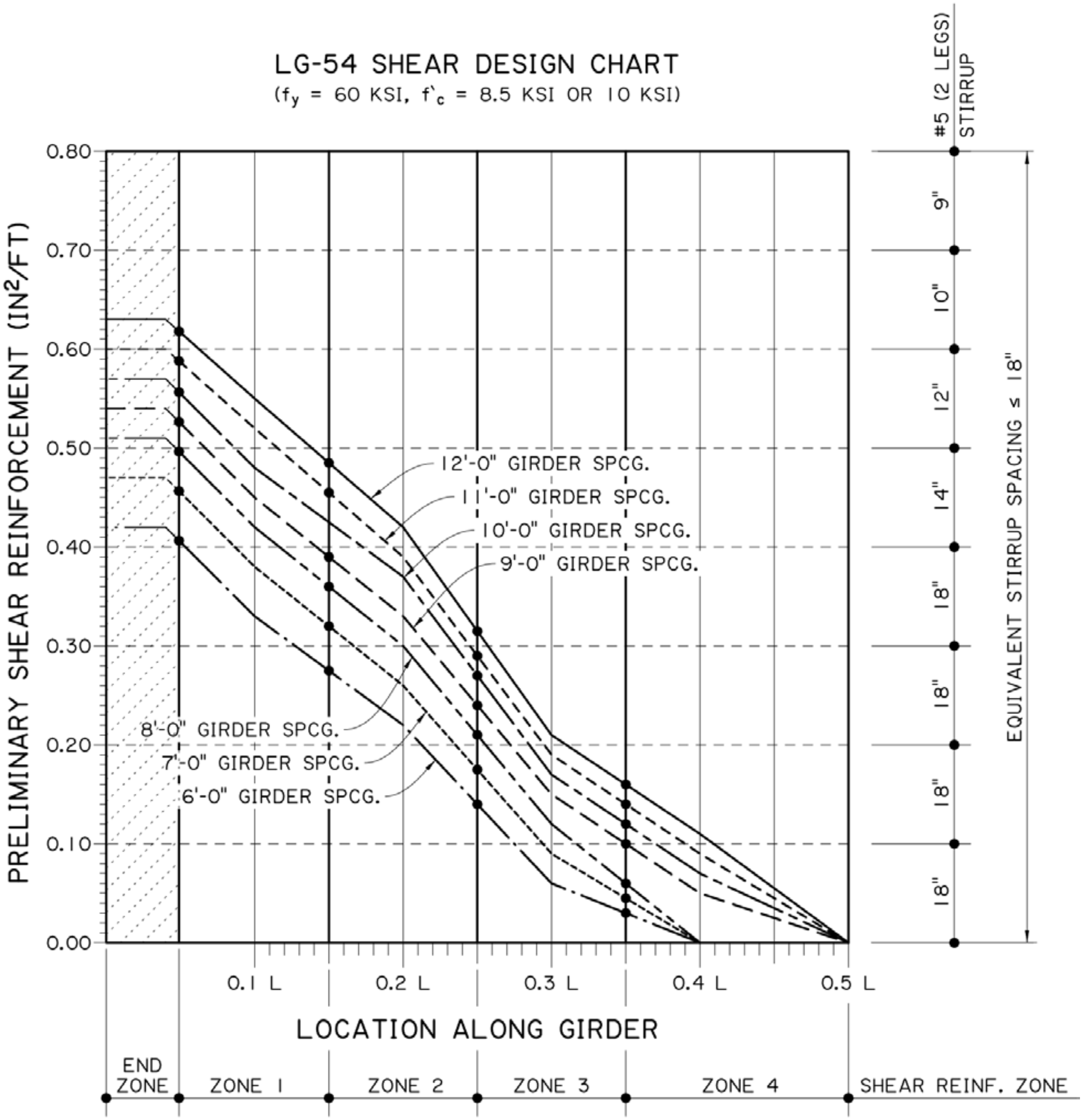
NOTES:
1. “L” IS THE GIRDER LENGTH FROM CENTER OF BEARING TO CENTER OF BEARING.
2. THE REQUIRED SHEAR REINFORCEMENT IN THIS CHART IS BASED ON THE MAXIUM ESTIMATED SPAN LENGTHS IN SECTIONS 1.1.3.1 AND 1.1.3.2.
3. END ZONE IS DEFINED AS THE DISTANCE FROM END OF GIRDER TO THE BEGINNING OF ZONE I AND THIS DISTANCE IS TYPICALLY AROUND 1.5 TIMES GIRDER DEPTH “H”. SEE LG GIRDER STANDARD PLANS FOR THE END ZONE DIMENSION AND REINFORCEMENT.

1.1.4.6─LG-45, Grade 75 WWR



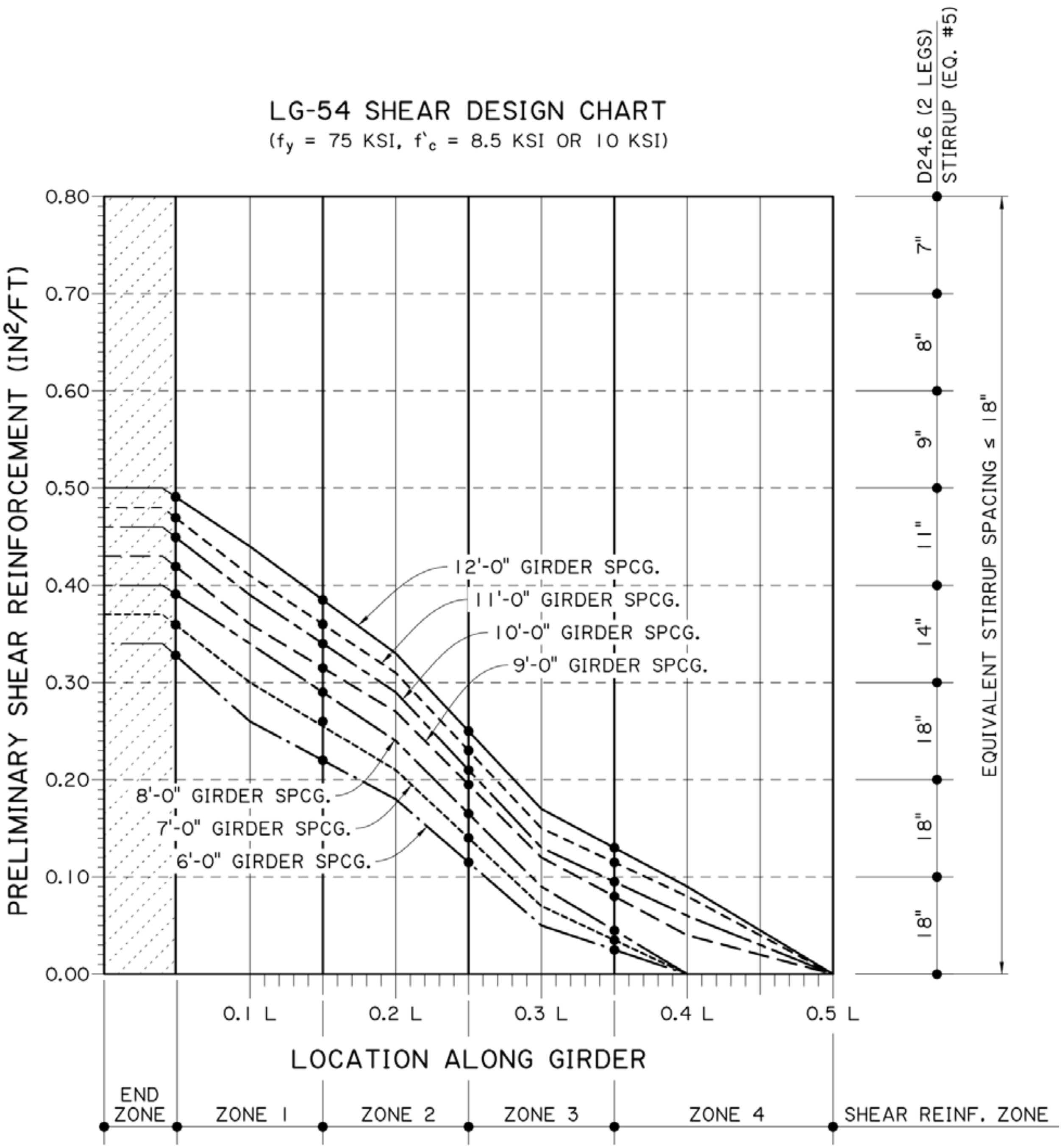
NOTES:
1. “L” IS THE GIRDER LENGTH FROM CENTER OF BEARING TO CENTER OF BEARING.
2. THE REQUIRED SHEAR REINFORCEMENT IN THIS CHART IS BASED ON THE MAXIUM ESTIMATED SPAN LENGTHS IN SECTIONS 1.1.3.1 AND 1.1.3.2.
3. END ZONE IS DEFINED AS THE DISTANCE FROM END OF GIRDER TO THE BEGINNING OF ZONE I AND THIS DISTANCE IS TYPICALLY AROUND 1.5 TIMES GIRDER DEPTH “H”. SEE LG GIRDER STANDARD PLANS FOR THE END ZONE DIMENSION AND REINFORCEMENT.

1.1.4.7─LG-54, Grade 60 Steel



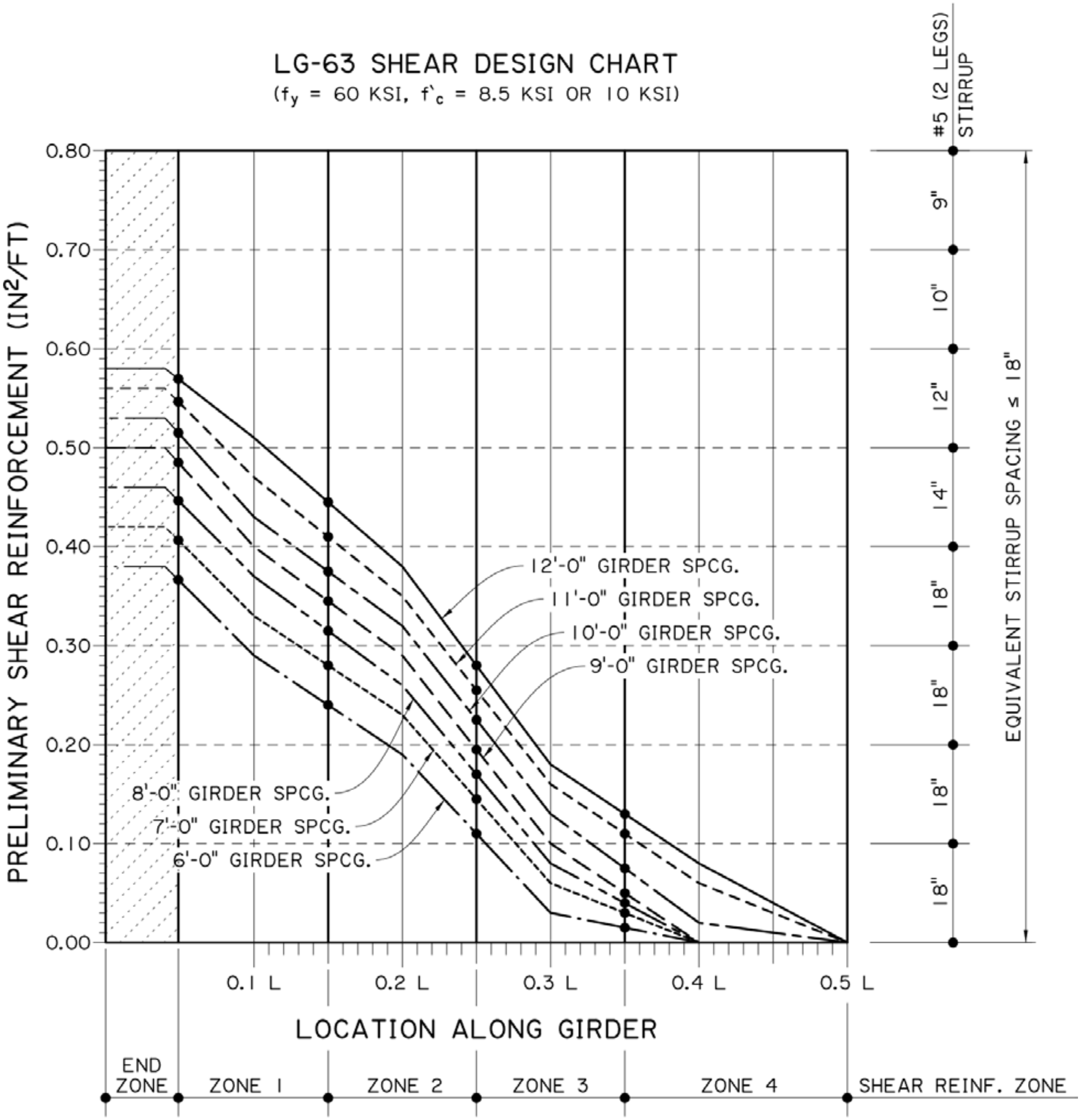
NOTES:
1. "L" IS THE GIRDER LENGTH FROM CENTER OF BEARING TO CENTER OF BEARING.
2. THE REQUIRED SHEAR REINFORCEMENT IN THIS CHART IS BASED ON THE MAXIUM ESTIMATED SPAN LENGTHS IN SECTIONS 1.1.3.1 AND 1.1.3.2.
3. END ZONE IS DEFINED AS THE DISTANCE FROM END OF GIRDER TO THE BEGINNING OF ZONE I AND THIS DISTANCE IS TYPICALLY AROUND 1.5 TIMES GIRDER DEPTH "H". SEE LG GIRDER STANDARD PLANS FOR THE END ZONE DIMENSION AND REINFORCEMENT.

1.1.4.8─LG-54, Grade 75 WWR



NOTES:
1. "L" IS THE GIRDER LENGTH FROM CENTER OF BEARING TO CENTER OF BEARING.
2. THE REQUIRED SHEAR REINFORCEMENT IN THIS CHART IS BASED ON THE MAXIUM ESTIMATED SPAN LENGTHS IN SECTIONS 1.1.3.1 AND 1.1.3.2.
3. END ZONE IS DEFINED AS THE DISTANCE FROM END OF GIRDER TO THE BEGINNING OF ZONE I AND THIS DISTANCE IS TYPICALLY AROUND 1.5 TIMES GIRDER DEPTH "H". SEE LG GIRDER STANDARD PLANS FOR THE END ZONE DIMENSION AND REINFORCEMENT.

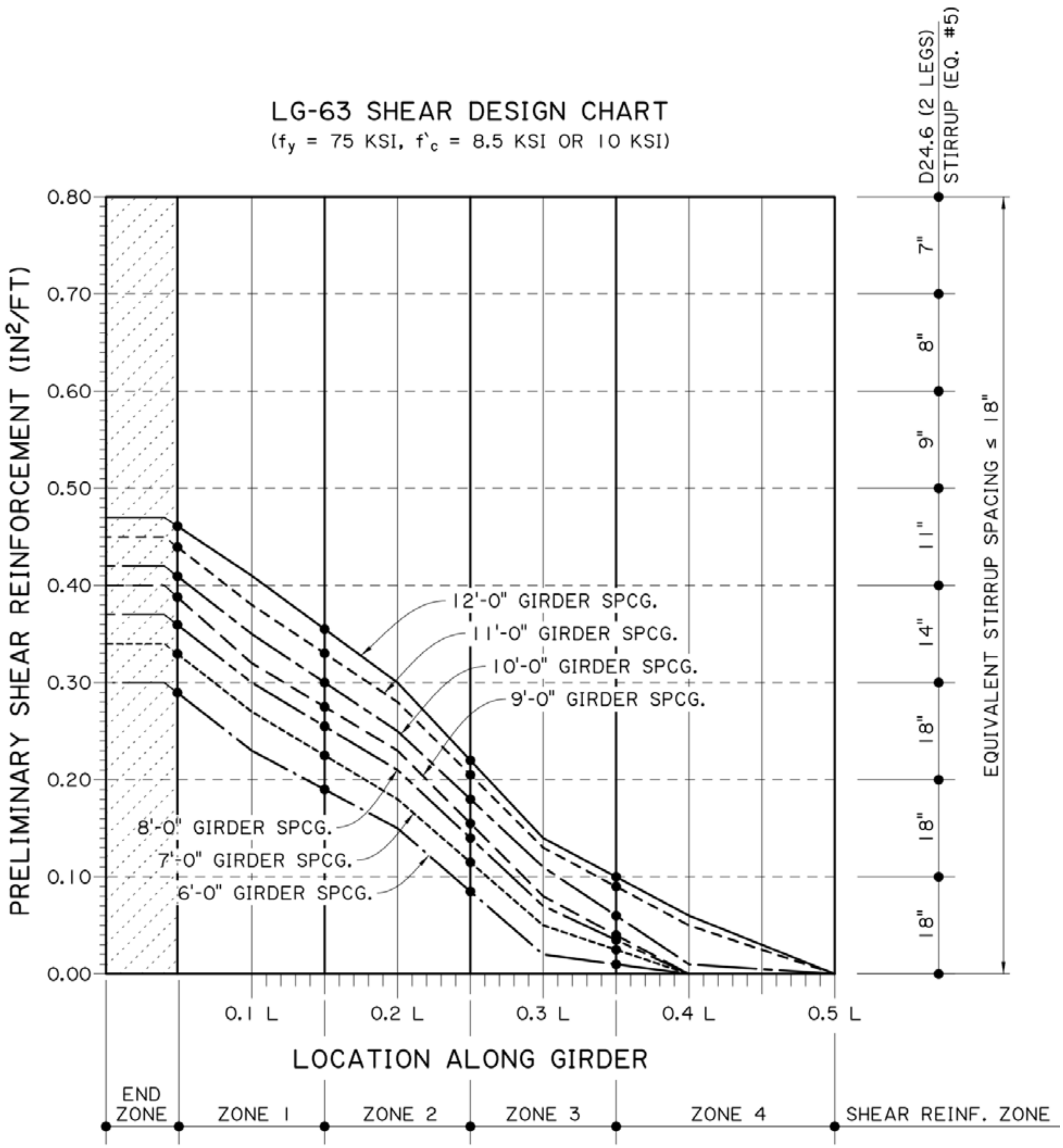
1.1.4.9─LG-63, Grade 60 Steel



NOTES:

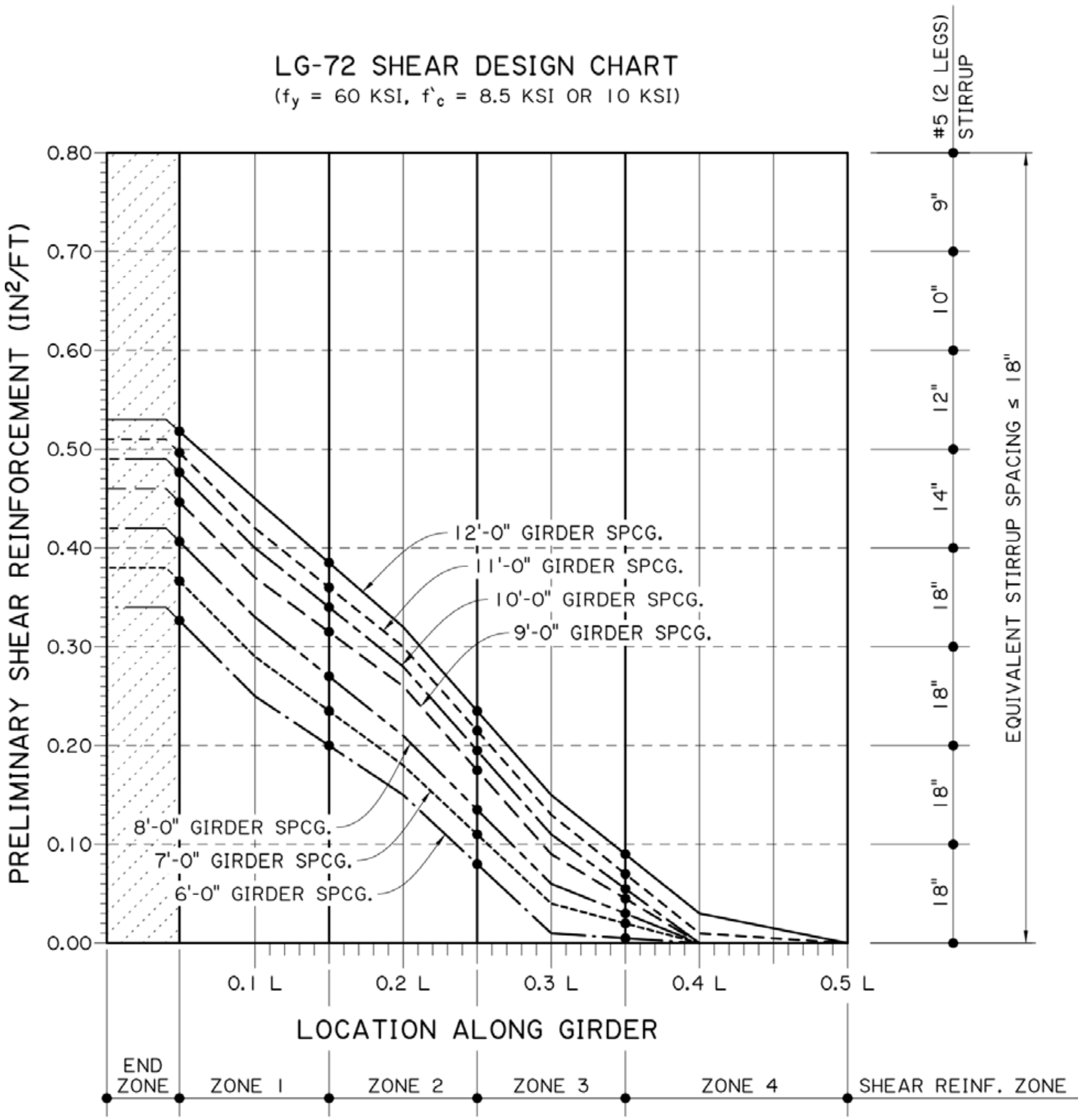
1. "L" IS THE GIRDER LENGTH FROM CENTER OF BEARING TO CENTER OF BEARING.
2. THE REQUIRED SHEAR REINFORCEMENT IN THIS CHART IS BASED ON THE MAXIUM ESTIMATED SPAN LENGTHS IN SECTIONS 1.1.3.1 AND 1.1.3.2.
3. END ZONE IS DEFINED AS THE DISTANCE FROM END OF GIRDER TO THE BEGINNING OF ZONE I AND THIS DISTANCE IS TYPICALLY AROUND 1.5 TIMES GIRDER DEPTH "H". SEE LG GIRDER STANDARD PLANS FOR THE END ZONE DIMENSION AND REINFORCEMENT.

1.1.4.10─LG-63, Grade 75 WWR



NOTES:
1. "L" IS THE GIRDER LENGTH FROM CENTER OF BEARING TO CENTER OF BEARING.
2. THE REQUIRED SHEAR REINFORCEMENT IN THIS CHART IS BASED ON THE MAXIUM ESTIMATED SPAN LENGTHS IN SECTIONS 1.1.3.1 AND 1.1.3.2.
3. END ZONE IS DEFINED AS THE DISTANCE FROM END OF GIRDER TO THE BEGINNING OF ZONE I AND THIS DISTANCE IS TYPICALLY AROUND 1.5 TIMES GIRDER DEPTH "H". SEE LG GIRDER STANDARD PLANS FOR THE END ZONE DIMENSION AND REINFORCEMENT.

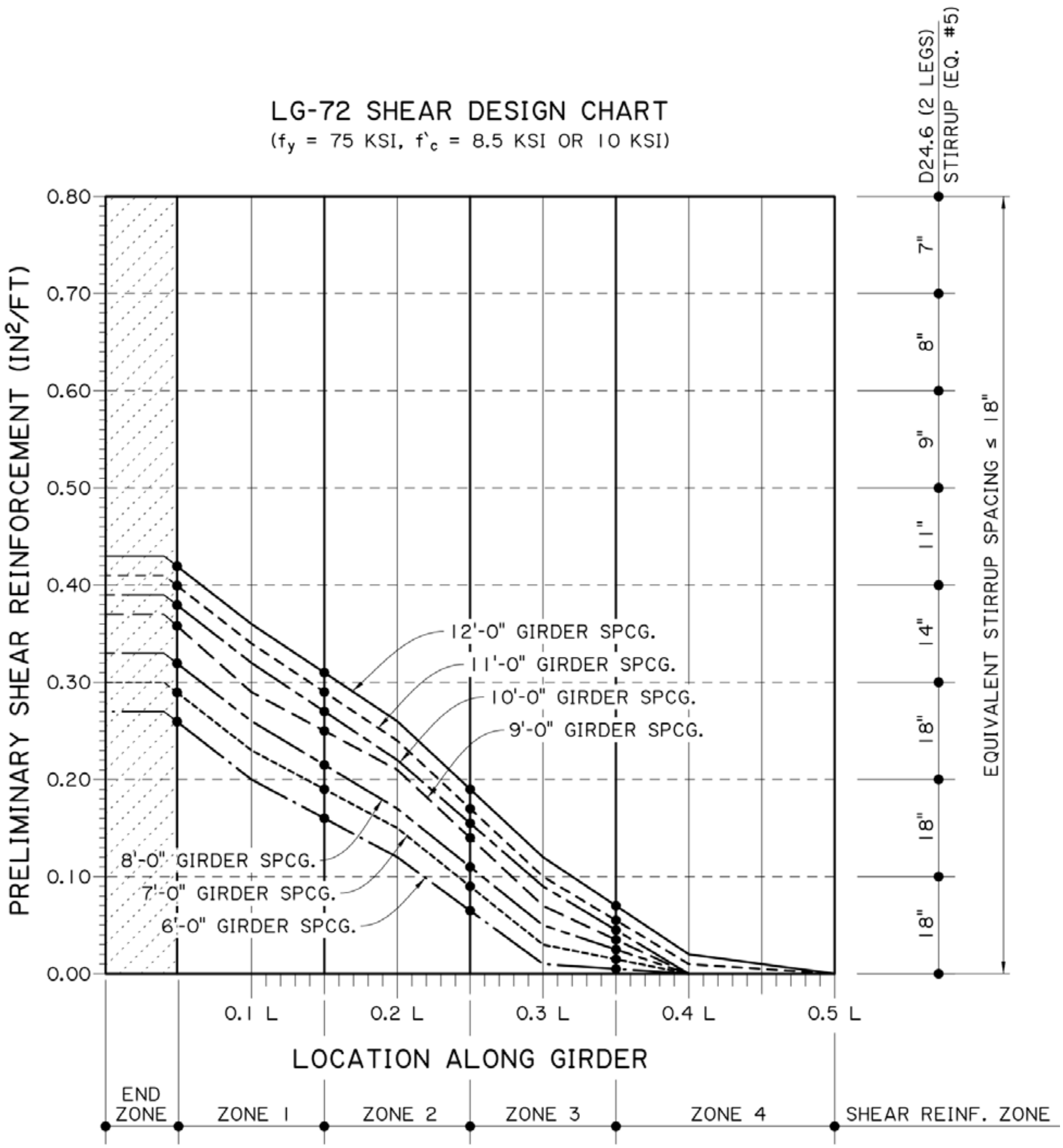
1.1.4.11─LG-72, Grade 60 Steel



NOTES:

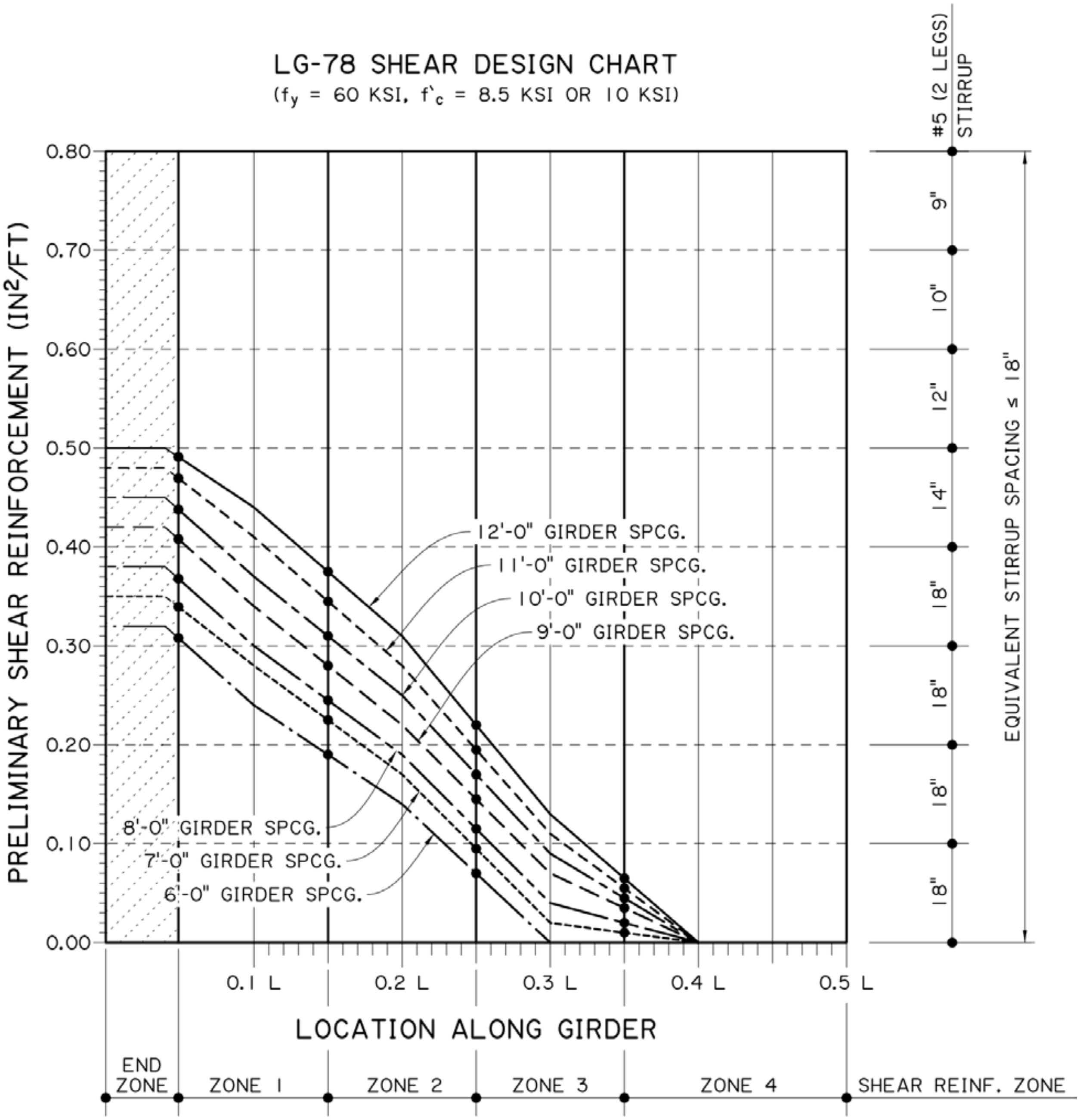
1. "L" IS THE GIRDER LENGTH FROM CENTER OF BEARING TO CENTER OF BEARING.
2. THE REQUIRED SHEAR REINFORCEMENT IN THIS CHART IS BASED ON THE MAXIUM ESTIMATED SPAN LENGTHS IN SECTIONS 1.1.3.1 AND 1.1.3.2.
3. END ZONE IS DEFINED AS THE DISTANCE FROM END OF GIRDER TO THE BEGINNING OF ZONE I AND THIS DISTANCE IS TYPICALLY AROUND 1.5 TIMES GIRDER DEPTH "H". SEE LG GIRDER STANDARD PLANS FOR THE END ZONE DIMENSION AND REINFORCEMENT.

1.1.4.12─LG-72, Grade 75 WWR



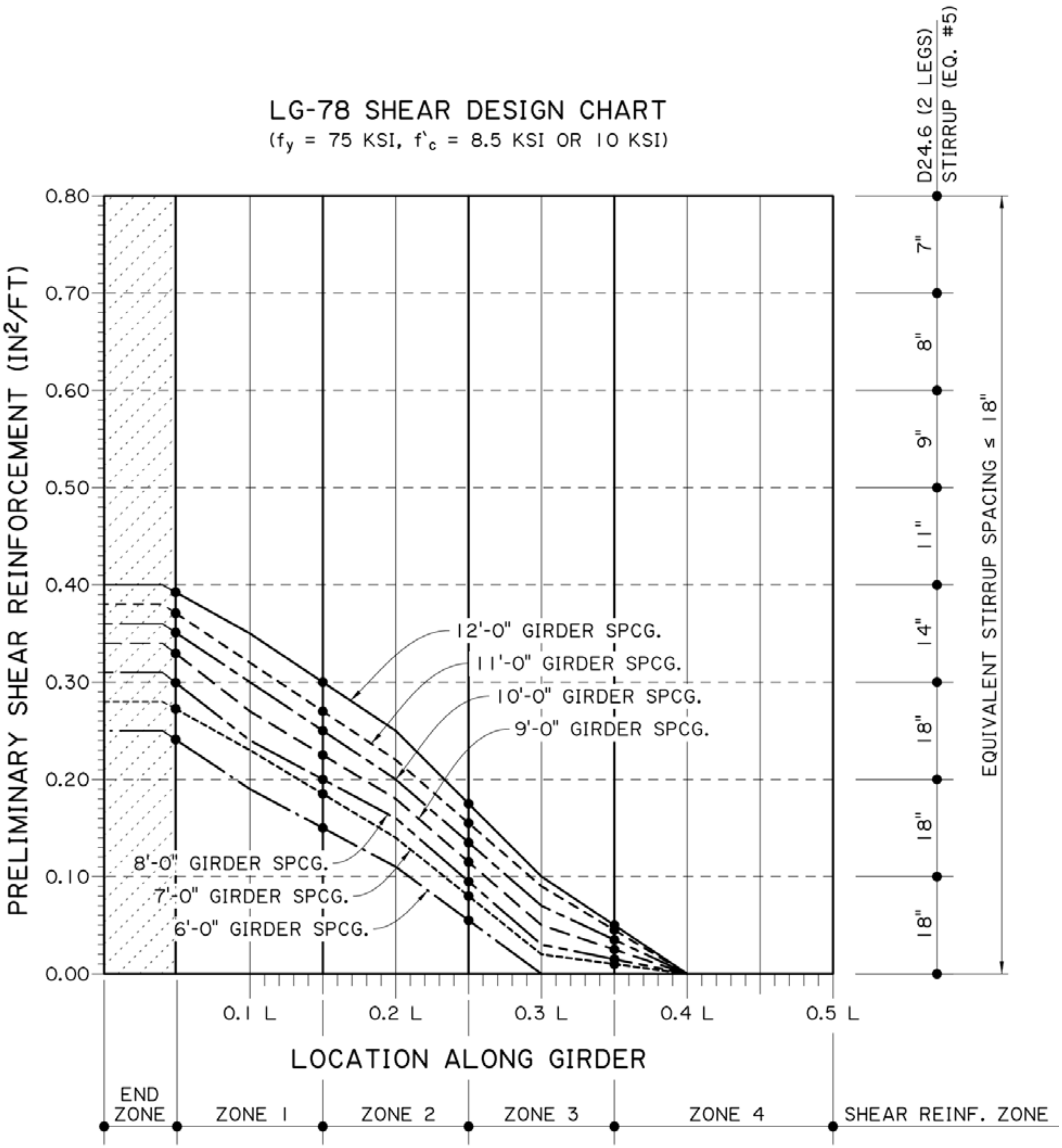
NOTES:
1. "L" IS THE GIRDER LENGTH FROM CENTER OF BEARING TO CENTER OF BEARING.
2. THE REQUIRED SHEAR REINFORCEMENT IN THIS CHART IS BASED ON THE MAXIUM ESTIMATED SPAN LENGTHS IN SECTIONS 1.1.3.1 AND 1.1.3.2.
3. END ZONE IS DEFINED AS THE DISTANCE FROM END OF GIRDER TO THE BEGINNING OF ZONE I AND THIS DISTANCE IS TYPICALLY AROUND 1.5 TIMES GIRDER DEPTH "H". SEE LG GIRDER STANDARD PLANS FOR THE END ZONE DIMENSION AND REINFORCEMENT.

1.1.4.13─LG-78, Grade 60 Steel



NOTES:
1. "L" IS THE GIRDER LENGTH FROM CENTER OF BEARING TO CENTER OF BEARING.
2. THE REQUIRED SHEAR REINFORCEMENT IN THIS CHART IS BASED ON THE MAXIUM ESTIMATED SPAN LENGTHS IN SECTIONS 1.1.3.1 AND 1.1.3.2.
3. END ZONE IS DEFINED AS THE DISTANCE FROM END OF GIRDER TO THE BEGINNING OF ZONE I AND THIS DISTANCE IS TYPICALLY AROUND 1.5 TIMES GIRDER DEPTH "H". SEE LG GIRDER STANDARD PLANS FOR THE END ZONE DIMENSION AND REINFORCEMENT.

1.1.4.14─LG-78, Grade 75 WWR



NOTES:

1. "L" IS THE GIRDER LENGTH FROM CENTER OF BEARING TO CENTER OF BEARING.
2. THE REQUIRED SHEAR REINFORCEMENT IN THIS CHART IS BASED ON THE MAXIUM ESTIMATED SPAN LENGTHS IN SECTIONS 1.1.3.1 AND 1.1.3.2.
3. END ZONE IS DEFINED AS THE DISTANCE FROM END OF GIRDER TO THE BEGINNING OF ZONE I AND THIS DISTANCE IS TYPICALLY AROUND 1.5 TIMES GIRDER DEPTH "H". SEE LG GIRDER STANDARD PLANS FOR THE END ZONE DIMENSION AND REINFORCEMENT.

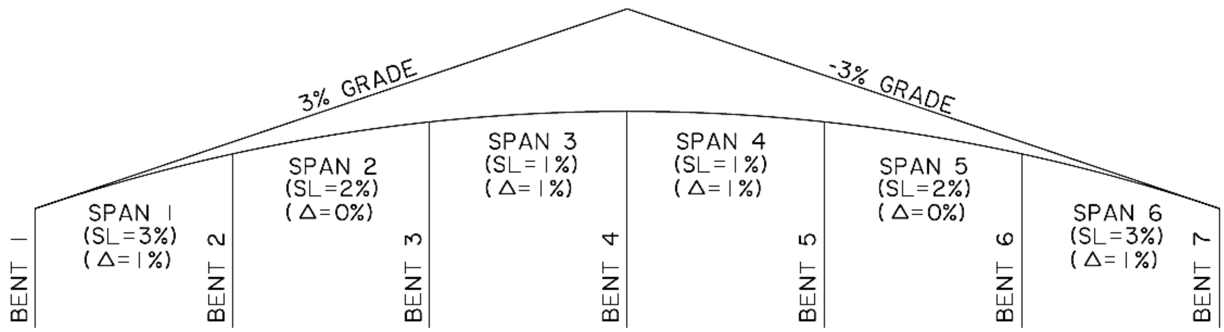
1.2─LG GIRDER BEARING DESIGN CHART

Nine (9) standard steel-reinforced elastomeric bearings (Types B-1 to B-9) as shown in Table 1.2.1-1 and the design chart for these standard bearings (Figure 1.2.2-2) are developed based on the assumptions listed in 1.2.1. Refer to LG girder Standard Plans for bearing details.

1.2.1─Bearing Design Assumptions and Requirements

1. The bearings are designed using Method B in accordance with *AASHTO LRFD Bridge Design Specifications* (7th Edition with 2016 Interim, will be referred to as "LRFD" in this chapter) *Section 14.7.5*.
2. The bearing pads are steel reinforced elastomeric bearing, rectangular-shaped. All internal layers of the bearing pad are of the same thickness, and no tapered layer is allowed. The thickness of elastomeric layer shall be ½ inch and ¼ inch for the internal and external layers respectively.
3. The steel layers shall be 1/8-inch steel plate (ASTM A36).
4. The elastomer specified shear modulus (G) shall be 150 psi. Shear modulus is taken as 115% of the specified shear modulus (1.15G) for calculation of the force due to shear deformation. For all other calculations, the shear modulus is taken as 0.85G per *LRFD 14.7.5.2*.
5. The bearing pad is placed perpendicular to the girder longitudinal axis. For bearing pads placed along the skew, the EOR must check bearings for skew conditions per AASHTO Spec.
6. An allowance of 0.005 radian is included in the design to account for uncertainties per *LRFD 14.4.2.1*.
7. The temperature range for the design of bearing pads for concrete girder bridges is taken as 85°F.
8. Service load factor for temperature is taken as 1.2 per *LRFD Table 3.4.1-1*.
9. 65% of the temperature range is used to calculate the thermal movement per *LFRD 14.7.5.3.2*.
10. Coefficient for thermal expansion = 0.000006/°F for concrete.
11. Shrinkage and creep movement is taken as 1.0 inch per 325 feet ($2.564\text{x}10^{-4}$ ft./ft.) according to *BDEM*. Apply reduction factor of 0.5 for continuous deck spans.
12. For girders with girder slope SL ≤ 1%, use level riser. For girders with SL > 1%, use level riser with a beveled plate at girder ends. Refer to LG girder Standard Plans for beveled plate details.

13. Allowance of additional 1% slope is included in bearing design in order to use flat riser for girders with SL ≤ 1%. For girders with SL > 1%, the beveled plate is provided at end of girders to provide a leveled surface in contact with bearings. Beveled plate slope should match girder slope. However, because a 1% slope allowance is included in the bearing design, the beveled plate slope may vary from the girder slope by up to 1%. Same-sized bearings with slightly varying slopes may be designed with the same beveled plates in order to reduce the number of various plates per project, thus reducing overall fabrication cost (see example below).



In this example, the slope of the girders (SL) is shown. Assuming that the bearing pads are all the same size, then the beveled plates at the girder ends shall all be specified with a 2% slope.

$$\Delta = |\ \text{SL} - \text{Beveled Plate Slope}\ | \ \leq 1.0$$

Note that this example shows a straight alignment, so each girder within a span has the same slope. For bridges with vertical slope on a horizontal curve, the slope of each girder within a span may vary. The same principle of beveled plate design may be used to unify the plate design for each girder within the span.

Beveled Plate Slope Example

Table 1.2.1-1: LADOTD Standard Steel-Reinforced Elastomeric Bearings

Type	Length, L (in)[1]	Width, W (in)[2]	Total Pad Thickness (in)	Number of 1/2" Interior Elastomer Layers	Number of 1/8" Steel Plate	Total Elastomer Thickness h_{rt} (in)	Maximum Shear Deform. Δ_S (in)	Horizontal Force Due to Shear Deform.[3] (kips/in)
B-1	8	30	1 7/8	2	3	1.5	0.75	27.6
B-2	10	30	1 7/8	2	3	1.5	0.75	34.5
B-3	10	30	2 1/2	3	4	2	1	25.9
B-4	10	30	3 1/8	4	5	2.5	1.25	20.7 *
B-5	12	30	3 3/4	5	6	3	1.5	20.7
B-6	12	30	4 3/8	6	7	3.5	1.75	17.7
B-7	12	30	5	7	8	4	2	15.5
B-8	14	30	5 5/8	8	9	4.5	2.25	16.1
B-9	14	30	6 1/4	9	10	5	2.5	14.5

Notes:

1. L is the length of bearing pad along the girder.
2. W is the width of bearing pad perpendicular to centerline of girder.
3. The "Horizontal Force Due to Shear Deform." is the horizontal force that will be transferred from the bearing pad to substructure when the bearing pad is subjected to shear deformation. This force shall be taken into account in substructure design. The value shown is calculated assuming bearings rest on infinitely rigid substructure. Considering flexibility of substructures (such as pile bent) may reduce the magnitude of this force. Therefore, the EOR shall evaluate specific project condition and adjust this value accordingly.
   The calculation of this horizontal force is based on 115% of the specified shear modulus of 150 psi, according to *LRFD 14.7.5.2*.
   Example: For bearing pad B-4, the horizontal force due to maximum shear deformation is calculated as:
   $H_{bu}= 1.15GA\Delta_s/h_{rt} = 1.15\times(150/1000)\times(10\times30)\times1.25/2.5= 25.9$ kips *(LRFD Eq. 14.6.3.1-2)*
   Horizontal force per inch of shear deformation = 25.9 kips/1.25 = 20.7 kips/in *

1.2.2─Development of Bearing Design Chart

According to *AASHTO LRFD Bridge Design Specifications*, the bearing design at service limit state is mainly controlled by the following equation:

$$\gamma_{a,st} + \gamma_{r,st} + \gamma_{s,st} + 1.75(\gamma_{a,cy} + \gamma_{r,cy} + \gamma_{s,cy}) \leq 5.0$$ *LRFD Eq. 14.7.5.3.3-1*

where:

γ_a= Shear strain caused by axial load

γ_r = Shear strain caused by rotation

γ_s = Shear strain caused by shear displacement

Subscripts "*st*" and "*cy*" indicate static and cyclic loading, respectively.

Among all variables shown in this equation, axial load (or reaction) usually has the maximum effect on the bearing design. Therefore, the simplest and effective approach is to focus on the reaction and assume the rotation and shear displacement. The general procedures to develop the design chart for each standard bearing pad are listed below and shown in Figure 1.2.2-1 in the form of a flowchart.

1. The chart was developed assuming that the live load rotations are in the opposite direction to the static rotations. The rotations due to dead load and live load were calculated for all different LG girders and spacing, as shown in Appendix A. The combination of maximum dead load rotation (0.0102) and minimum live load rotation (-0.00182) for 10.0 ksi concrete was used to cover all cases. For dead load, an additional rotation of 0.01 radians was added to account for 1% slope, and 0.005 radians was added to account for any uncertainties.
2. The chart was developed using the maximum shear deformation (0.5h_{rt}, *LRFD Eq. 14.7.5.3.2-1*) for each standard pad. The maximum shear deformation for each standard bearing pad is shown in the bearing design chart. User will be able to select bearing pad based on the calculated shear deformation.
3. For each standard bearing pad, the relationship between the dead load and live load reactions is plotted in the chart shown in Figure 1.2.2-2.
4. Bearing stability, steel laminates, and instantaneous live load deflection were also checked in developing the bearing design chart.

A design chart development example for standard pad B-1 is included in Appendix B to illustrate the development process for each standard pad.

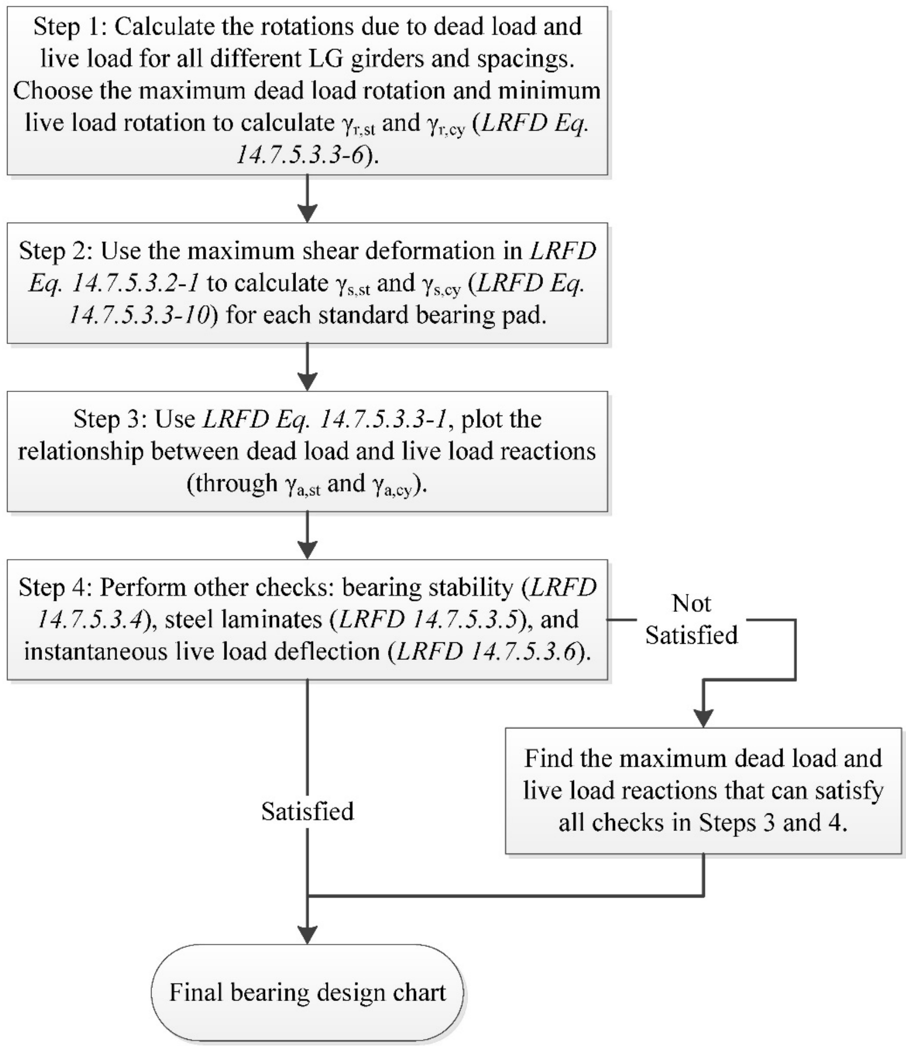


Figure 1.2.2-1: Flowchart for Developing Bearing Design Chart

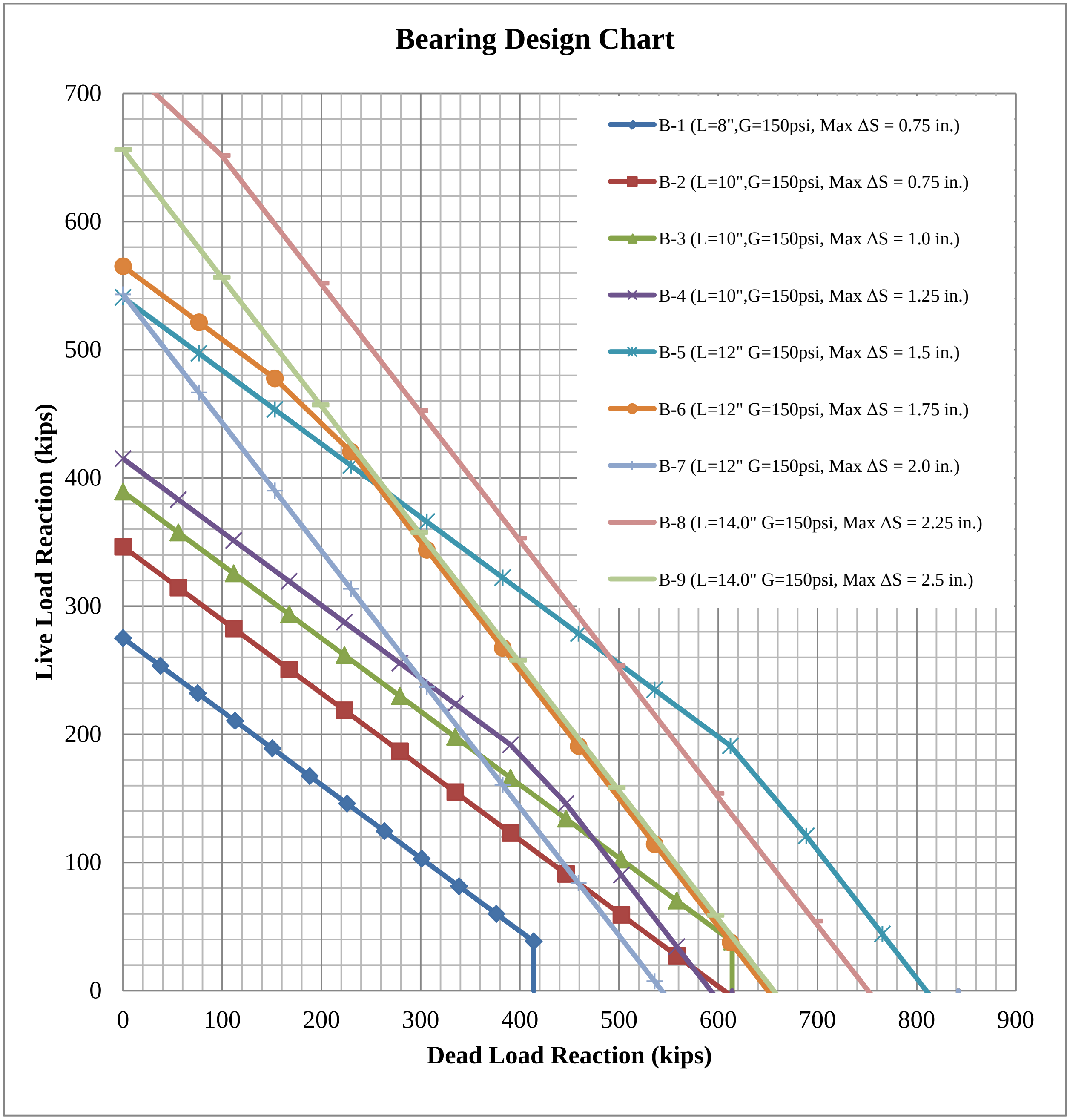


Figure 1.2.2-2: Bearing Design Chart

(Max ΔS = Maximum shear deformation)

1.2.3─Application of Bearing Design Chart

The flowchart to apply the bearing design chart for bearing design is shown in Figure 1.2.2-3. Since the shear deformation due to braking force is a function of the bearing pad size, an initial assumption of bearing pad type is needed, and the total shear deformation is checked later.

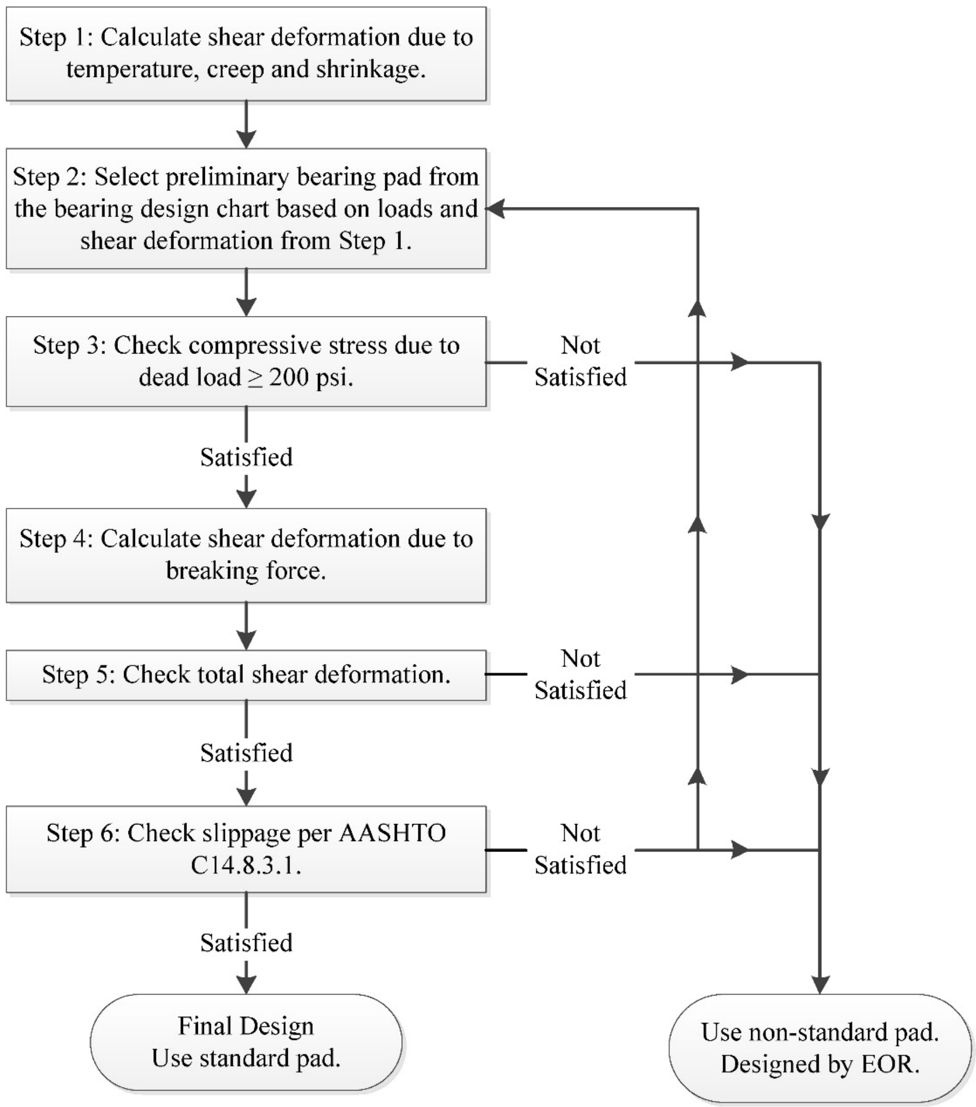


Figure 1.2.3-1: Flowchart to Use the Bearing Design Chart

1.2.4─Bearing Design Examples

1.2.4.1─Example 1: Simple Span

Bridge information:

LG-63 girder, Span length = 110 ft., Girder spacing = 9 ft., Number of girders = 6, Number of design lanes = 4. Assume traffic on both directions. The bridge profile is shown in Figure 1.2.3.1-1.

Service reactions from superstructure analysis: P_{DL} = 140 kips, P_{LL} = 161 kips

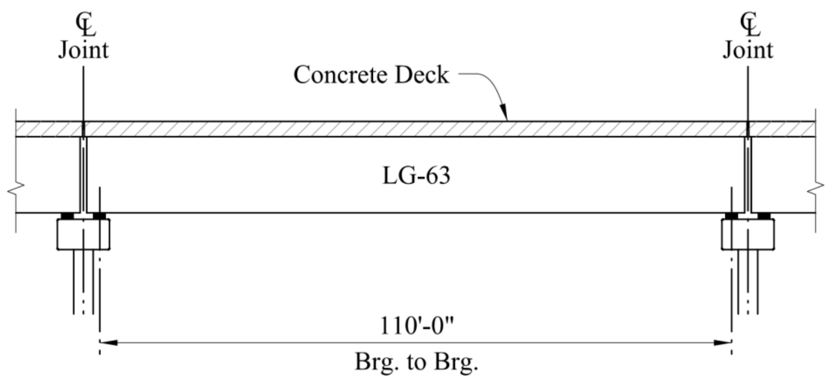


Figure 1.2.4.1-1: Bridge Profile for Design Example 1

Case 1: Girder slope SL = 0.5%

For SL ≤ 1%, use level riser.

Step 1: Calculate shear deformation due to temperature, creep, and shrinkage

Temperature range = 85°F

Coefficient of thermal expansion = 0.000006/°F

Creep and shrinkage coefficient = $\frac{1.0in}{325ft}$ = 2.564x10^{-4} ft./ft.

Load factor for temperature = 1.2

Assuming the mid-point of span as the zero movement point, the shear deformation due to temperature, creep and shrinkage at each joint is calculated as:

$\Delta_{S\_t,cr,sh}$ = [(1.2×0.000006/°F×0.65×85°F×110×12) + (0.0002564×110×12)]/2 = 0.432 in.

Step 2: Select preliminary bearing pad based on loads and shear deformation from Step 1

Refer to Figure 1.2.4.1-2, find X = 140 and Y=161 (black dashed lines), preliminarily select Type B-1 with maximum shear deformation = 0.75 in.

Step 3: Check compressive stress due to dead load

140 kips / (8")(30") = 583 psi > 200 psi, OK

Step 4: Calculate shear deformation due to braking force

The magnification factor for LADV-11 is taken as 1.6 for bearing design.

The braking force per lane is the larger of 25% of the truck weight, or 5% of the truck + lane load:

Braking force per lane = Max[(1.6×0.25×72), (1.6×0.05×(72+0.64×110))] = 28.8 kips

Apply the braking force in two lanes (one direction) and use a multiple presence factor of 1.0.

Total braking force = 1.0×2×28.8 = 57.6 kips

Assume the braking force is equally distributed to all bearing pads (total of 12):

Braking force per bearing = 57.6/12 = 4.8 kips

The shear deformation due to braking force is calculated as:

$$\Delta_{S\_br} = \frac{h_{rt}}{GA_b} H$$

where,

H = Horizontal force (i.e., braking force)

G = Shear modulus, permitting a variation of ±15 percent

h_{rt} = Thickness of total elastomeric layers

A_b = Area of bearing pad,

Δ_{S_br} = 4.8×1000×1.5/(0.85×150×30×8) =0.235 in.

Check per BDEM PART II, Volume 1, D14.7.5.3.2.

Δ_{S_br}/1.6 = 0.235 in/1.6 = 0.147 in < 10% h_{rt} = 10% (1.5) = 0.15.

Step 5: Check total shear deformation

Total shear deformation = $\Delta_{S\_t,cr,sh} + \Delta_{S\_br}$ = 0.432 + 0.235 = 0.67 in. < 0.75 in.

If the bearing pad assumed in Step 2 does not satisfy the maximum shear deformation, select a thicker pad and repeat Steps 2 to 4.

Step 6: Check slippage per AASHTO C14.8.3.1

P_{DL} = 140 kips

Lateral force due to total shear deformation of 0.67 in for B-1

= 27.6 k/in (per table 1.2.1-1) x 0. 67 in = 18.5 k

Coefficient of friction = 0.2

Lateral resistance = 140 k x 0.2 = 70 k > 18.5 k OK

Final Design

Conclusion: Use Type B-1 pad

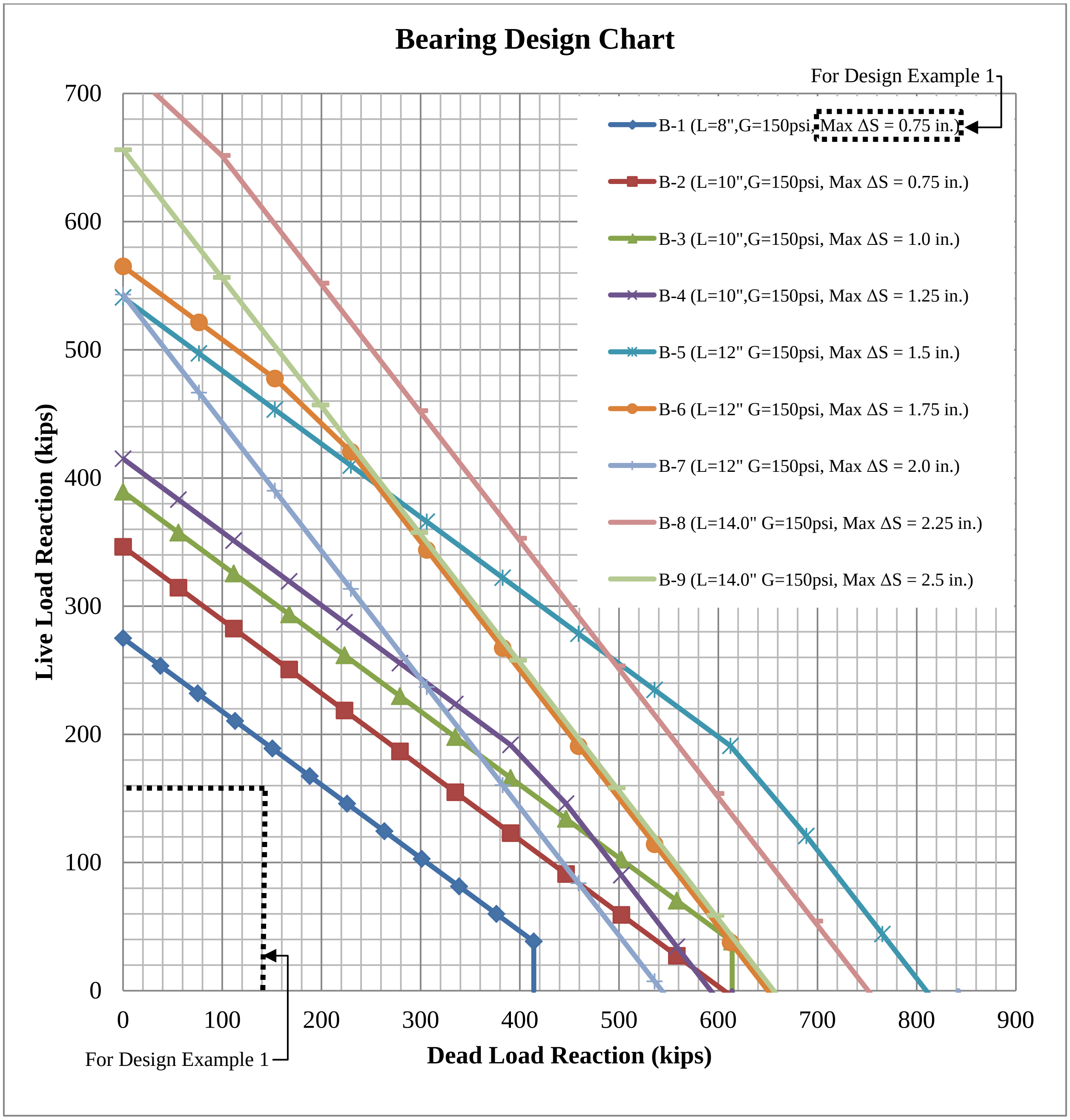


Figure 1.2.4.1-2: Bearing Design Chart - Example 1

Case 2: Girder slope SL = 3.0%

For SL > 1%, use level riser with a Beveled Plate at girder ends. The design will be the same as in Case 1. See note 13 in 1.2.1 for beveled plate design. See LG girder Standard Plans for beveled plate details.

1.2.4.2─Example 2: Continuous Deck Span

Bridge information:

LG-78 girders, Span length = 183 ft., 4 span deck continuous, Girder spacing = 6 ft., Number of girders = 8, Number of design lanes = 3. Assume one-directional traffic. The bridge profile is shown in Figure 1.2.3.2-1 below. For simplicity, the bearing pads will be designed using the span lengths between the centerlines of supports.

Service reactions from superstructure analysis: P_{DL} = 198.1 kips, P_{LL} = 158.5 kips

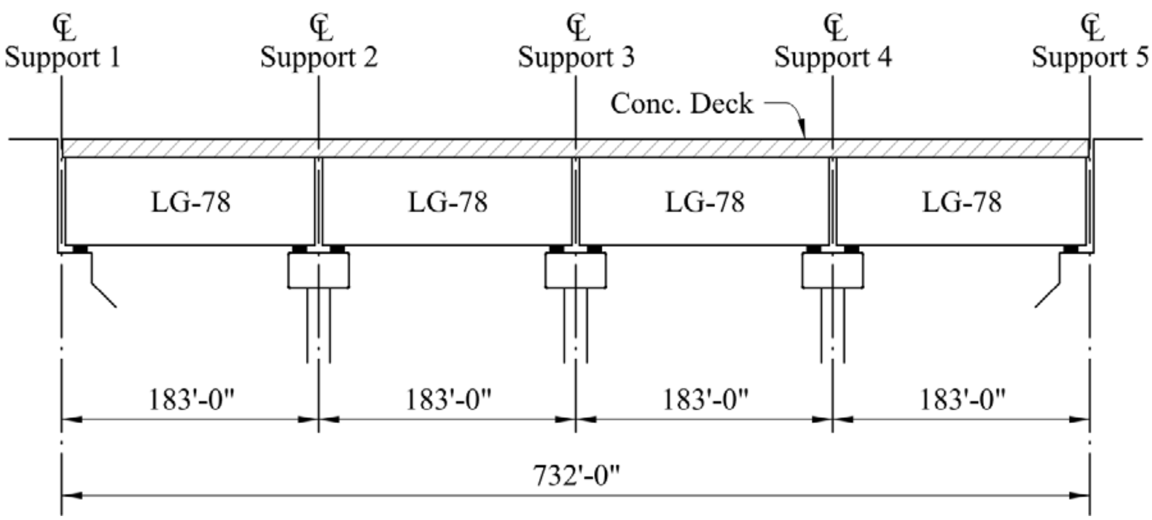


Figure 1.2.3.2-1: Bridge Profile for Design Example 2

Case 1: Girder slope SL = 0.5%

Step 1: Calculate shear deformation due to temperature, creep and shrinkage:

Temperature range = 85°F

Coefficient of thermal expansion = 0.000006/°F

Creep and shrinkage coefficient = $\frac{1.0\text{in}}{325\text{ft}}$ = 0.0002564 in/in

Load factor for temperature = 1.2

Reduction factor for shear deformation due to creep and shrinkage = 0.5 (According to *BDEM Vol. 1 Part II Section 3.12.5* and only apply to continuous deck spans)

Assuming the center of entire 4-span continuous unit as the zero movement point, the shear deformation due to temperature, creep, and shrinkage for Supports 1 and 5 is calculated as:

$\Delta_{S\_t,cr,sh\_1\&5}$= (1.2×0.000006/°F×0.65×85°F×366×12)+(0.5×0.0002564×366×12) = 2.310 in.

The shear deformation due to temperature, creep and shrinkage for Supports 2 and 4 is calculated as:

$\Delta_{S\_t,cr,sh\_2\&4}$= (1.2×0.000006/°F×0.65×85°F×183×12)+(0.5×0.0002564×183×12) = 1.155 in.

The shear deformation due to temperature, creep and shrinkage for Support 3 is taken as 0.

Step 2: Select preliminary bearing pad based on loads and shear deformation from Step 1

Refer to Figure 1.2.4.2-2, find X = 198.1 and Y=158.5 (black dashed lines), preliminarily select Type B-9 (max ΔS = 2.5 in.) for Supports 1 and 5, Type B-5 (max ΔS = 1.5 in.) for Supports 2&4, and Type B-1 (max ΔS = 0.75 in.) for Support 3.

Step 3: Check compressive stress due to DL

For Support 1&5:

198 kips /14"x30" = 471 psi > 200 psi OK

For Support 2&4:

198 kips /12"x30" = 550 psi > 200 psi OK

For Support 3:

198 kips /8"x30" = 825 psi > 200 psi OK

Step 4: Calculate shear deformation due to braking force:

The magnification factor for LADV-11 is taken as 1.6 for bearing design.

The braking force per lane is the larger of 25% of the truck weight, or 5% of the truck + lane load:

Braking force per lane = Max[(1.6×0.25×72), (1.6×0.05×(72+0.64×4×183))] = 43.2 kips

Maximum braking force is produced by loading the three lanes (one direction) and using multiple presence factor of 0.85.

Total braking force = 0.85×3×43.2 = 110.2 kips

For bridges with three different bearing pad types, the shear deformation due to braking force is calculated as follows:

$$\Delta_{S\_br} = \frac{H_{total}}{\frac{Numb_{br1}\times G_1\times A_{b1}}{h_{rt1}}+\frac{Numb_{br2}\times G_2\times A_{b2}}{h_{rt2}}+\frac{Numb_{br3}\times G_3\times A_{b3}}{h_{rt3}}}$$

where,

H_{total} = Total horizontal force (i.e., braking force) on all bearing pads

$Numb_{br}$ = Number of bearing pads

G = Shear modulus, permitting a variation of ±15 percent

h_{rt} = Thickness of total elastomeric layers

A_b = Area of bearing pad

Subscripts 1, 2, and 3 indicate bearing pad types 1, 2 and 3, respectively.

There are 16 Type B-9, 32 Type B-5, and 16 Type B-1 pads in this continuous bridge. The shear deformation due to braking force considering the different stiffness of bearing pads is calculated as:

$$\Delta_{S\_br} = \frac{110.2\times1000}{\frac{16\times0.85\times150\times30\times14}{5}+\frac{32\times0.85\times150\times30\times12}{3}+\frac{16\times0.85\times150\times30\times8}{1.5}} = 0.112 \text{ in.}$$

Check per BDEM PART II, Volume 1, Chapter 14, D 14.7.5.3.2.

$\Delta_{S\_br}/1.6 = 0.112/1.6 = 0.07$ in $<$ 10%(h_{rt}) min = 10% (1.5) = 0.15 in. OK

Step 5: Check total shear deformation

For Supports 1&5:

Total shear deformation = $\Delta_{S\_t,cr,sh\_1\&5} + \Delta_{S\_br}$ = 2.310 + 0.112 = 2.422 in. < 2.5 in. OK

For Supports 2&4:

Total shear deformation = $\Delta_{S\_t,cr,sh\_2\&4} + \Delta_{S\_br}$ = 1.155 + 0.112 = 1.267 in. < 1.5 in. OK

For Support 3:

Total shear deformation = 0 + Δ_{S_br} = 0 + 0.112 = 0.112 in. < 0.75 in. OK

If the bearing pad assumed in Step 2 does not satisfy the maximum shear deformation, select a thicker pad and repeat Steps 2 to 4. If the maximum shear deformation exceeds the limit for Type B-9, use non-standard pad.

Step 6: Check slippage per AASHTO C14.8.3.1

$P_{DL} = 198.1^k$, coefficient of friction = 0.2

For Supports 1&5: Lateral force due to total shear deformation of 2.422 in for B-9

= 14.5 k/in (Table 1.2.1-1) x 2.422 in

= 35.1 k < 198.1 k x 0.2 = 39.6 k, OK

For Supports 2&4: Lateral force due to total shear deformation of 1.267 in for B-5

= 20.7 k/in (Table 1.2.1-1) x 1.267 in

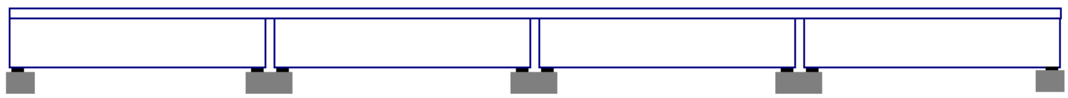
= 26.2 k < 198.1 k x 0.2 = 39.6 k, OK

For Support 3: Lateral force due to total shear deformation of 0.112 in for B-1

= 27.6 k/in x 0.112 in = 3.1 k < 39.6 k, OK

Final Design

Conclusion: Use Type B-9 bearing pad for Supports 1&5, Type B-5 bearing pad for Supports 2&4, and Type B-1 bearing pad for Support 3. The final design is summarized in the table below:



Support:	1	2	3	4	5
Bearing pad:	B-9	B-5	B-1	B-5	B-9
Δ_S total (in.):	2.422	1.267	0.112	1.267	2.422

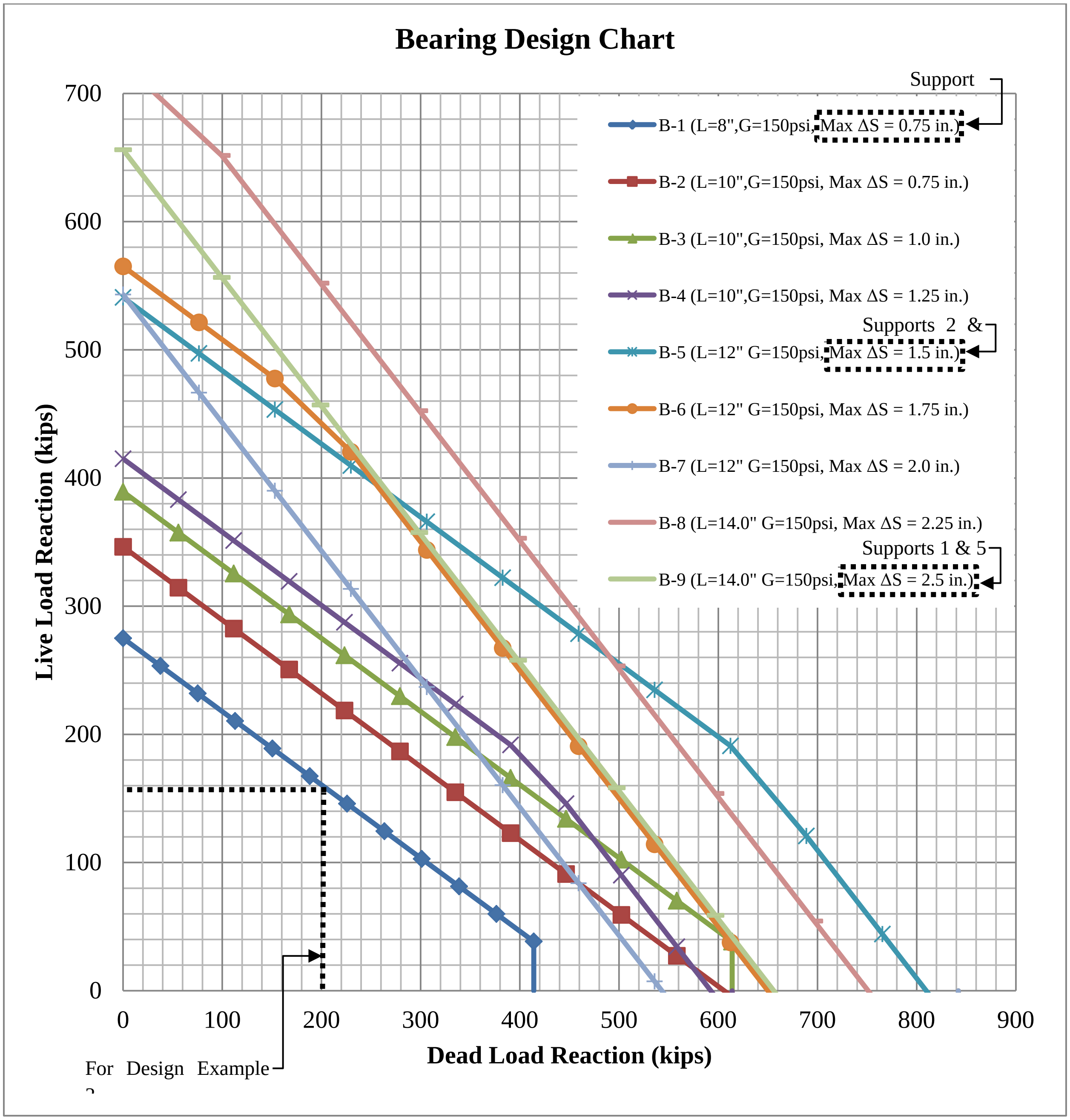


Figure 1.2.4.2-2: Bearing Design Chart - Example 2

Case 2: Girder slope SL = 3.0%

For SL > 1%, use level riser with Embedded and Beveled Plate Assembly at girder ends. The design will be the same as in Case 1. See note 13 in 1.2.1 for beveled plate design. See LG Girder Standard Plans for beveled plate details.

1.3─LG GIRDER STANDARD PLANS AND DESIGN AIDS

1.3.1─LG Girder Standard Plans

LG girder Standard Plans shown in Table 1.3.1-1 have been developed for LG-25 to LG-78. The Standard Plans are organized into Common Details (11 sheets) and Specific Details (2 sheets for each girder type), where common details are applicable to all LG girders regardless of girder type, and specific details are applicable for a specific girder type.

Table 1.3.1-1: LG Girder Standard Plans

		BRIDGE STANDARDS INDEX NO.	SERIES	DESCRIPTION
COMMON DETAILS		BD.3.4.1.01	1 OF 11	INDEX, GENERAL NOTES AND DEFINITIONS
		BD.3.4.1.02	2 OF 11	DIMENSIONS AND STRAND TEMPLATES
		BD.3.4.1.03	3 OF 11	END OF GIRDERS
		BD.3.4.1.04	4 OF 11	END OF GIRDERS
		BD.3.4.1.05	5 OF 11	STANDARD STEEL-REINFORCED BEARING PADS
		BD.3.4.1.06	6 OF 11	NON-STANDARD STEEL-REINFORCED BEARING PADS
		BD.3.4.1.07	7 OF 11	EMBEDDED AND BEVELED PLATES - SQUARE END OF GIRDER
		BD.3.4.1.08	8 OF 11	EMBEDDED AND BEVELED PLATES - CLIPPED END OF GIRDER
		BD.3.4.1.09	9 OF 11	COIL INSERTS AND PREFORMED HOLES FOR DIAPHRAGMS
		BD.3.4.1.10	10 OF 11	CAMBER DETAILS
		BD.3.4.1.11	11 OF 11	MISC. LG DETAILS
SPECIFIC DETAILS	LG-25	BD.3.4.2.01	1 OF 2	LG-25 REINFORCEMENT DETAILS - CONVENTIONAL
		BD.3.4.2.02	2 OF 2	LG-25 REINFORCEMENT DETAILS - WWR
	LG-36	BD.3.4.3.01	1 OF 2	LG-36 REINFORCEMENT DETAILS - CONVENTIONAL
		BD.3.4.3.02	2 OF 2	LG-36 REINFORCEMENT DETAILS - WWR
	LG-45	BD.3.4.4.01	1 OF 2	LG-45 REINFORCEMENT DETAILS - CONVENTIONAL
		BD.3.4.4.02	2 OF 2	LG-45 REINFORCEMENT DETAILS - WWR
	LG-54	BD.3.4.5.01	1 OF 2	LG-54 REINFORCEMENT DETAILS - CONVENTIONAL
		BD.3.4.5.02	2 OF 2	LG-54 REINFORCEMENT DETAILS - WWR
	LG-63	BD.3.4.6.01	1 OF 2	LG-63 REINFORCEMENT DETAILS - CONVENTIONAL
		BD.3.4.6.02	2 OF 2	LG-63 REINFORCEMENT DETAILS - WWR
	LG-72	BD.3.4.7.01	1 OF 2	LG-72 REINFORCEMENT DETAILS - CONVENTIONAL
		BD.3.4.7.02	2 OF 2	LG-72 REINFORCEMENT DETAILS - WWR
	LG-78	BD.3.4.8.01	1 OF 2	LG-78 REINFORCEMENT DETAILS - CONVENTIONAL
		BD.3.4.8.02	2 OF 2	LG-78 REINFORCEMENT DETAILS - WWR

1.3.1.1─Common Details

Common details consist of eleven (11) sheets that cover general notes, standard definitions, dimensions of all LG girders, standard strand templates, various details at end of girders, standard and non-standard steel-reinforced elastomeric bearing details, embedded and beveled plates details, coil inserts and preformed holes for diaphragms, camber details, and misc. details that are specific to LG girders. Common details (11 sheets in series) shall be included in project plan set for all LG girder projects. Information in common details, such as dimensions for girders and strand templates, etc., shall not be repeated in project plans to avoid repetition and conflict. All definitions shown in common details shall be followed when developing project plan set.

1.3.1.2─Specific Details

Specific details for each girder type consist of two sheets, Sheet 1 of 2 shows conventional reinforcement details including standard end zone reinforcement, standard designations for shear reinforcement (rebar size and spacing) in Zone 1 to 4, strands at top of flange for handling purposes, and miscellaneous reinforcement. Sheet 2 of 2 shows the alternative welded wire reinforcement details where allowed. The EOR shall select applicable specific details per girder types used in a project, noting the sheets in series shall be kept together.

1.3.2─LG Girder Design Aids

Design aids shown in Table 1.3.2-1 have been developed for LG-25 to LG-78. The purpose of developing design aids is to provide consistent design principles, preferred details, and standardized data tables. These aids shall be utilized to develop project specific details that are not covered by Standard Plans, such as girder framing plan, span details, bent details, etc. Instructions for designers are provided in each design aid. CAD conformed cells for typical details, such as girder shapes, strand templates, harped strand elevation, and data table templates, etc., have been created and included in CAD Conform cell library.

Table 1.3.2-1: LG Girder Design Aids

Subject	Figure No.	Series	Description
Girder Data Table and Camber Data Table	Figure 1.3.2-1	1 of 1	Girder Data Table, Camber Data Table, and Notes
Strand Pattern and Strand Pattern Data Table	Figure 1.3.2-2	1 of 1	Example Strand Patterns, Typical Harped Strand Elevation, Standard Strand Pattern Data Table, and Notes
Non-Standard Steel-Reinforced Elastomeric Bearings data Table	Figure 1.3.2-3	1 of 1	Non-Standard Steel-Reinforced Elastomeric Bearings data Table and Notes
Typical Simple Span Made Continuous Deck Unit with Link Slab	Figure 1.3.2-4	1 of 2	Typical Simple Span Made Continuous Deck Unit with Link Slab (Plan and Elevation) and Notes
		2 of 2	Link Slab Reinforcement
Diaphragms	Figure 1.3.2-5	1 of 3	Plan and Notes
		2 of 3	Section A-A
		3 of 3	Section B-B and C-C
Seismic Shear Key	Figure 1.3.2-6	1 of 4	Interior Bent (Same- Depth Girders) – Plan
		2 of 4	Transition Interior Bent – Plan
		3 of 4	End Bent - Plan
		4 of 4	Section A-A, B-B, and C-C

1.3.2.1─Girder Data Table and Camber Data Table

Girder Data Table and Camber Data Table shown in Figure 1.3.2-1 provide standard templates to present girder data and camber data in a centralized location. These templates shall be used in all projects. Design information in the data table shall be provided by the EOR. These sheets shall be stamped and signed by the EOR.

1.3.2.2─Strand Patterns and Strand Pattern Data Table

Figure 1.3.2-2 shows an example of strand patterns including a typical harped strand elevation and a template for a Strand Pattern Data Table. Similar details shall be provided in project plan set.

1.3.2.3─Non-Standard Steel-Reinforced Elastomeric Bearing Data Table

Figure 1.3.2-3 provides a standard template for a non-standard steel-reinforced bearing data table. This table shall be included in projects where non-standard steel-reinforced bearings are used. The details for standard and non-standard steel-reinforced elastomeric bearings and the data table for standard steel-reinforced elastomeric bearings are included in LG common details and shall not be repeated in project plans.

1.3.2.4─Typical Simple Spans Made Continuous Deck Unit with Link Slabs

Figure 1.3.2-4 provides a typical simple spans made continuous deck unit and details for link slab reinforcement. The link slab reinforcement shall be incorporated in project plans. A typical floating span unit (no fixed bearing) is shown for illustrative purposes. Refer to BDEM Part II Vol. 1 Chapter 5 for more discussions on floating span and link slab.

1.3.2.5─Diaphragms

Figure 1.3.2-5 provides standard design and details for intermediate and end diaphragms that shall be incorporated in project plans.

1.3.2.6─Seismic Shear Key

Seismic shear keys are used to transfer seismic load from girder bottom flange to substructures.

Figure 1.3.2-6 provides conceptual layout and typical details of seismic shear key for interior bents (same-depth girders) at expansion joint and link slab, transition bents, and end bents for non-skew and skew conditions. The shear key details shall be incorporated in project plans. The EOR is responsible for determining number of shear keys and reinforcement details and providing sufficient bearing area between shear keys and girder bottom flanges to transfer project specific seismic force. Refer to BDEM Part II Vol. 1 Chapter 5 for more discussion on this subject.

MATCHLINE

GIRDER DATA TABLE																														
												SHEAR REINFORCEMENT BAR 501								END A										
												ZONE 1		ZONE 2		ZONE 3		ZONE 4												
SPAN NO.	GIRDER DESIGNATION	GIRDER TYPE	CONCRETE CLASS	COMP. STRENGTH @ 28 DAYS (KSI)	COMP. STRENGTH @ RELEASE (KSI)	LG (FT.)	SL (+% OR -%)	P (FT.)	STRAND PATTERN	UNFACTORED DL REACTIONS (KIP)	Y (IN.)	N1	V1 (IN.)	N2	V2 (IN.)	N3	V3 (IN.)	N4	V4 (IN.)	θ (DEGREE)	X (IN.)△	J (IN.)	K (IN.)	CLIPPED TOP FLANGE (Y/N)	CLIPPED BOTTOM FLANGE (Y/N)	BEARING PAD TYPE	EMBEDDED PL "A" LP (IN.)	EMBEDDED PL "B" AND BEVELED PL LP (IN.)	LPC (IN.)	BEVELED PL T (IN.)
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

MATCHLINE

GIRDER DATA TABLE										
END B										
θ (DEGREE)	X (IN.)△	J (IN.)	K (IN.)	CLIPPED TOP FLANGE (Y/N)	CLIPPED BOTTOM FLANGE (Y/N)	BEARING PAD TYPE	EMBEDDED PL "A" LP (IN.)	EMBEDDED PL "B" AND BEVELED PL LP (IN.)	LPC (IN.)	BEVELED PL T (IN.)
-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-

CAMBER DATA TABLE															
		DESIGN DATA				FIELD MEASURED DATA *									
SPAN NO.	GIRDER DESIGNATION	C1 (IN.)	C2 (IN.)	C3 (IN.)	D5 (IN.)	MC1 (IN.)	MC1a (IN.)	MC2 (IN.)	fb1 (KSI)	fb1a (KSI)	fb2 (KSI)	Eb1 (KSI)	Eb1a (KSI)	Eb2 (KSI)	* DATE OF GIRDER CASTING	* DATE OF RISER POUR
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

INSTRUCTIONS FOR DESIGNERS:

1. THE DESIGNER SHALL INCLUDE THE NOTE BELOW IN GIRDER DATA TABLE SHEET.
"SEE LG COMMON DETAILS AND SPECIFIC DETAILS FOR DEFINITIONS, DETAILS, AND INSTRUCTIONS ON MC1, MC2, AND THE DATE OF CASTING."

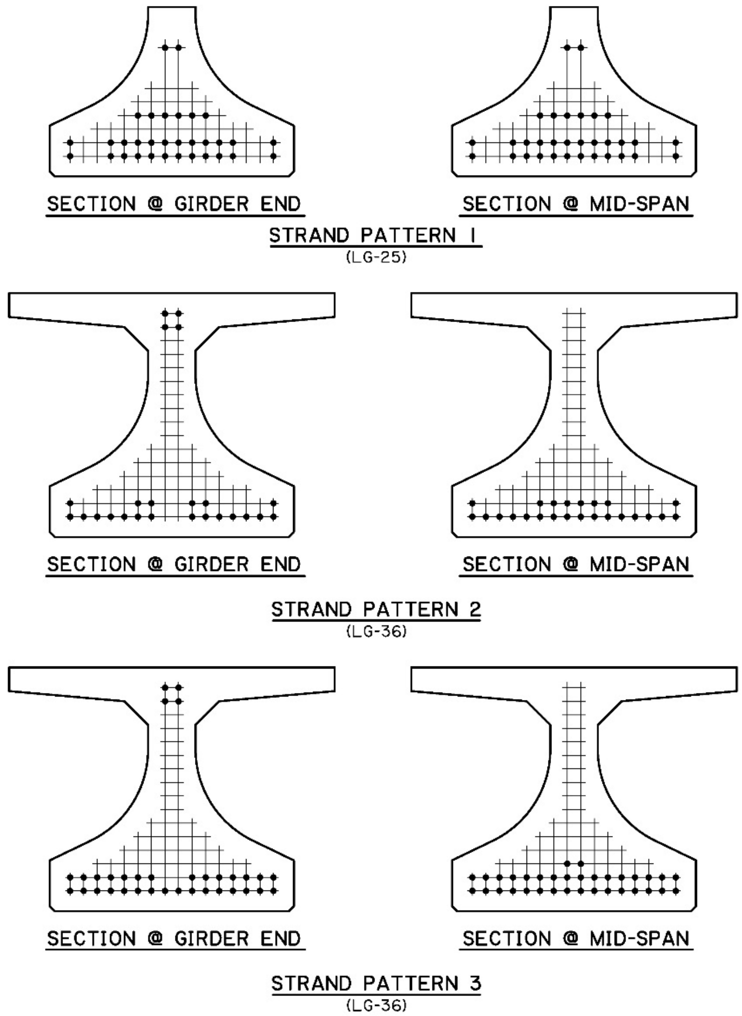
* 2. FIELD MEASURED DATA (MC1, MC1a, MC2, fb1, fb1a, fb2, Eb1, Eb1a AND Eb2) AND GIRDER CASTING DATE AND RISER POUR DATE SHALL BE SUBMITTED BY THE CONTRACTOR PER NOTES ON LG COMMON SHEETS. EOR IS RESPONSIBLE FOR TRANSMITTING THESE SUBMITTALS TO THE BRIDGE STANDARDS MANAGER FOR THE PURPOSES OF DATA COLLECTION AND RESEARCH EFFORT TO VALIDATE CAMBER CALCULATION METHODOLOGY.

△ 3. DETERMINATION OF "X" DIMENSION FOR GIRDERS AT SKEWED EXPANSION JOINTS MUST BE DONE ASSUMING THE JOINT IS OPEN TO Δ_{MAX}. SEE LG COMMON DETAILS SHT. 1 OF 11 FOR DEFINITION OF Δ_{MAX} AND SHT. 3 OF 11 FOR DETAILS OF GIRDERS AT SKEWED EXPANSION JOINTS.

4. MICROSTATION CELL FOR GIRDER DATA TABLE AND CAMBER DATA TABLE ARE AVAILABLE IN THE CADCONFORM CELL LIBRARY.

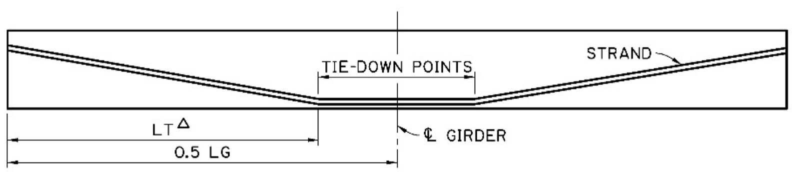
Figure 1.3.2-1: Girder Data Table and Camber Data Table

(1 of 1)



STRAND PATTERN DATA TABLE

STRAND PATTERN	STRAND DIA. (IN.)	PRESTRESSING FORCE PER STRAND (KIPS)	NO. OF STRANDS	NO. OF HARPED STRANDS	LT (FT.)
1	0.6	43.95	32	0	-
2	0.6	43.95	24	4	23.8
3	0.6	43.95	34	4	31.8



HARPED STRAND ELEVATION

INSTRUCTIONS FOR DESIGNERS:

1. THE DESIGNER SHALL INCLUDE THE NOTE BELOW IN THE SHEET SHOWING STRAND PATTERNS AND STRAND PATTERN DATA TABLE.
"SEE LG COMMON DETAILS FOR DEFINITIONS, GIRDER DIMENSIONS, AND STRAND PATTERN TEMPLATE DIMENSIONS."

△ 2. LT SHALL BE CONSISTENT WITHIN A PROJECT WHENEVER POSSIBLE.

3. MICROSTATION CELLS FOR STRAND TEMPLATES, HARPED STRAND ELEVATION, AND STRAND PATTERN DATA TABLE ARE AVAILABLE IN CADCONFORM CELL LIBRARY.

Figure 1.3.2-2: Strand Pattern and Strand Pattern Data Table

(1 of 1)

NON-STANDARD STEEL-REINFORCED ELASTOMERIC BEARINGS DATA TABLE						
TYPE	L	W	D	TB	NO. OF INTERIOR ELASTOMER LAYERS	NO. OF 1/8" STEEL PLATES
NB-1	9"	2'-3"	-	1 7/8"	2	3
NB-2	11"	2'-3"	-	1 7/8"	2	3
NB-3	-	-	1'-7"	2 1/2"	3	4
NB-4	-	-	1'-11"	3 1/8"	4	5

INSTRUCTIONS FOR DESIGNERS:

1. THE DESIGNER SHALL INCLUDE THE NOTE BELOW IN PLAN SHEET SHOWING THIS DATA TABLE. "SEE LG COMMON DETAILS FOR DEFINITIONS, DETAILS OF STANDARD AND NON-STANDARD STEEL-REINFORCED BEARINGS, AND STANDARD BEARING DATA TABLE."

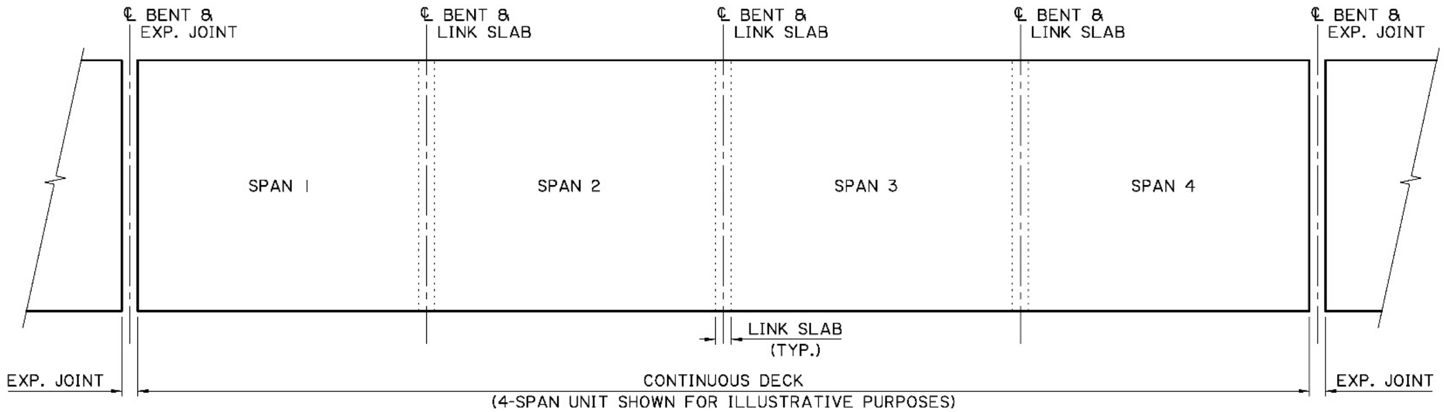
2. NON-STANDARD REINFORCED BEARING PADS SHALL EACH BE DENOTED BY A UNIQUE DESIGNATION (NB-1, NB-2, ETC.). THIS INFORMATION WILL THEN BE USED IN THE GIRDER DATA TABLE.

3. IN THIS EXAMPLE, THIS PROJECT IS USING TWO RECTANGULAR BEARING PADS OF NON-STANDARD SIZE, AND TWO CIRCULAR BEARING PADS.

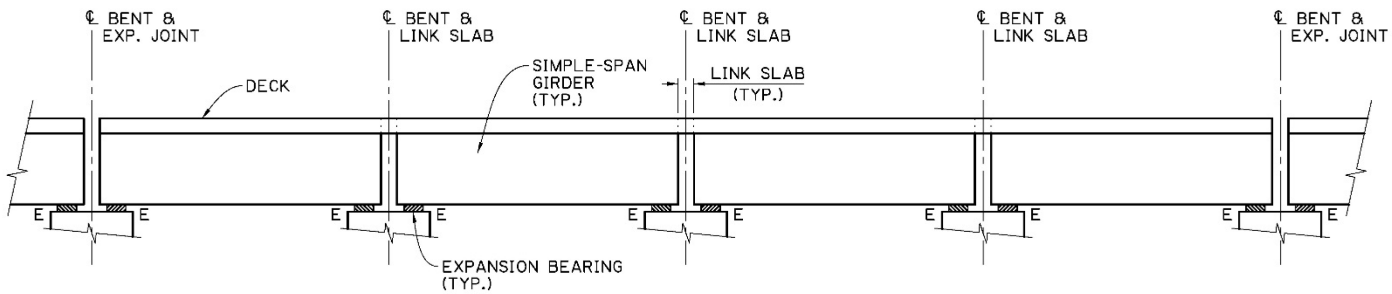
4. MICROSTATION CELL FOR GIRDER DATA TABLE IS AVAILABLE IN CADCONFORM CELL LIBRARY.

Figure 1.3.2-3: Non-Standard Steel-Reinforced Elastomeric Bearings Data Table

(1 of 1)



PLAN



ELEVATION

(FLOATING SPAN SHOWN FOR ILLUSTRATIVE PURPOSES)

INSTRUCTIONS FOR DESIGNERS:

1. A TYPICAL FLOATING SPAN IS SHOWN FOR ILLUSTRATIVE PURPOSES. REFER TO BDEM PART II VOL I CHAPTER 5 FOR MORE INFORMATION ON FLOATING SPAN AND LINK SLAB.
2. INCORPORATE STANDARD LINK SLAB REINFORCEMENT (SHT. 2 OF 2) INTO PROJECT PLAN.

Figure 1.3.2-4: Typical Simple Span Made Continuous Deck Unit with Link Slab

(1 of 2)

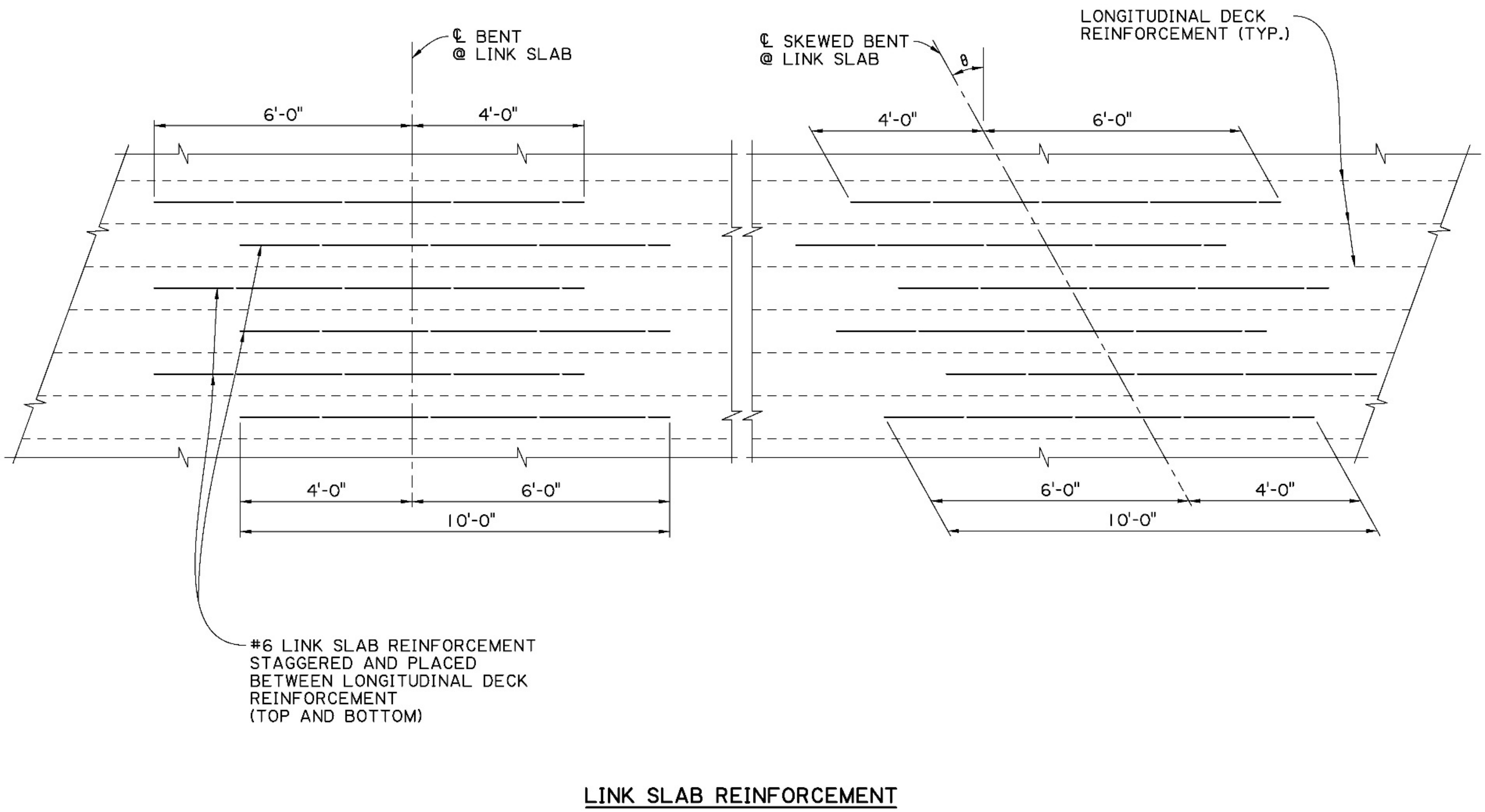
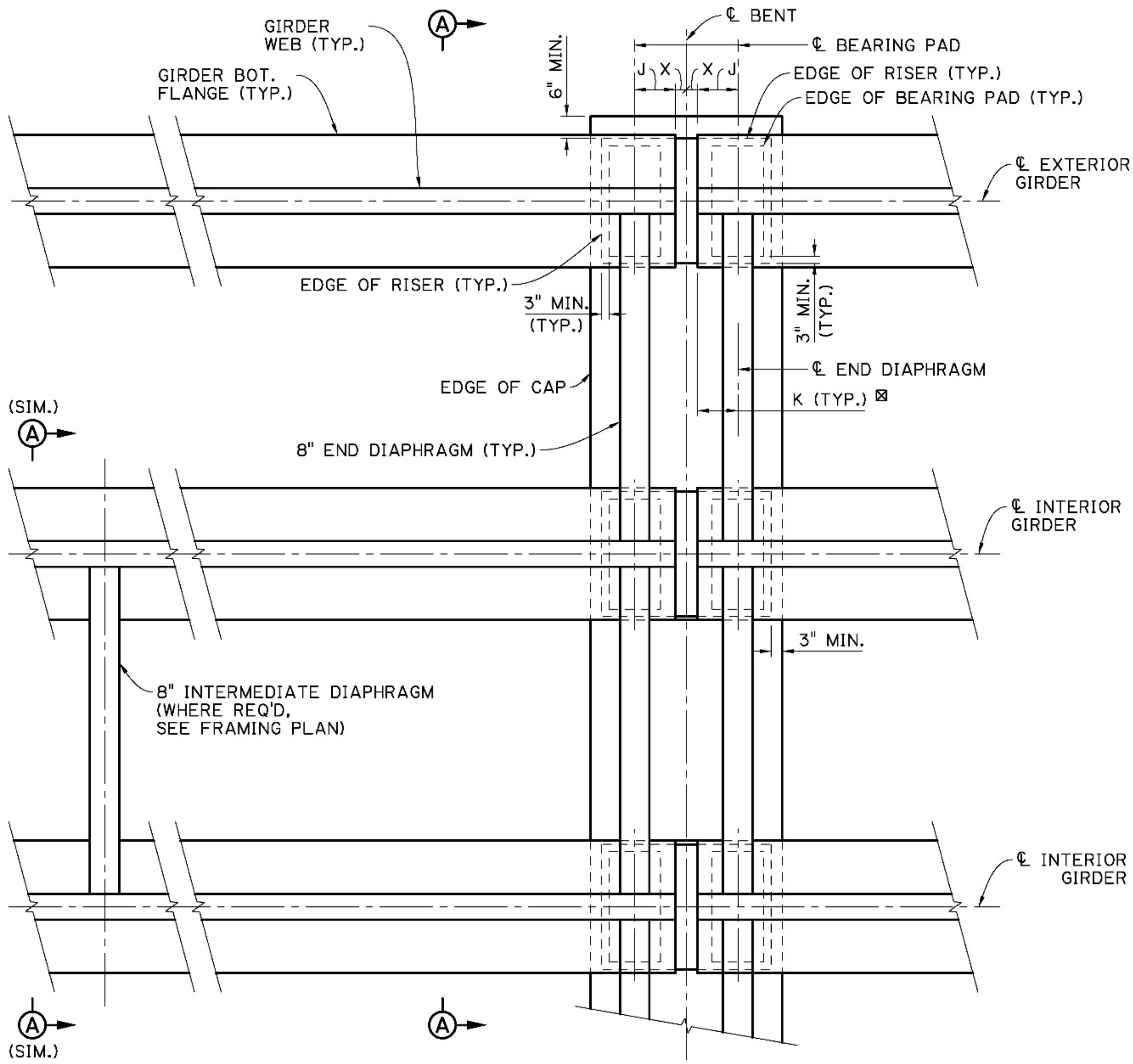


Figure 1.3.2-4: Typical Simple Span Made Continuous Unit with Link Slab

(2 of 2)



PLAN AT NON-SKEWED BENT

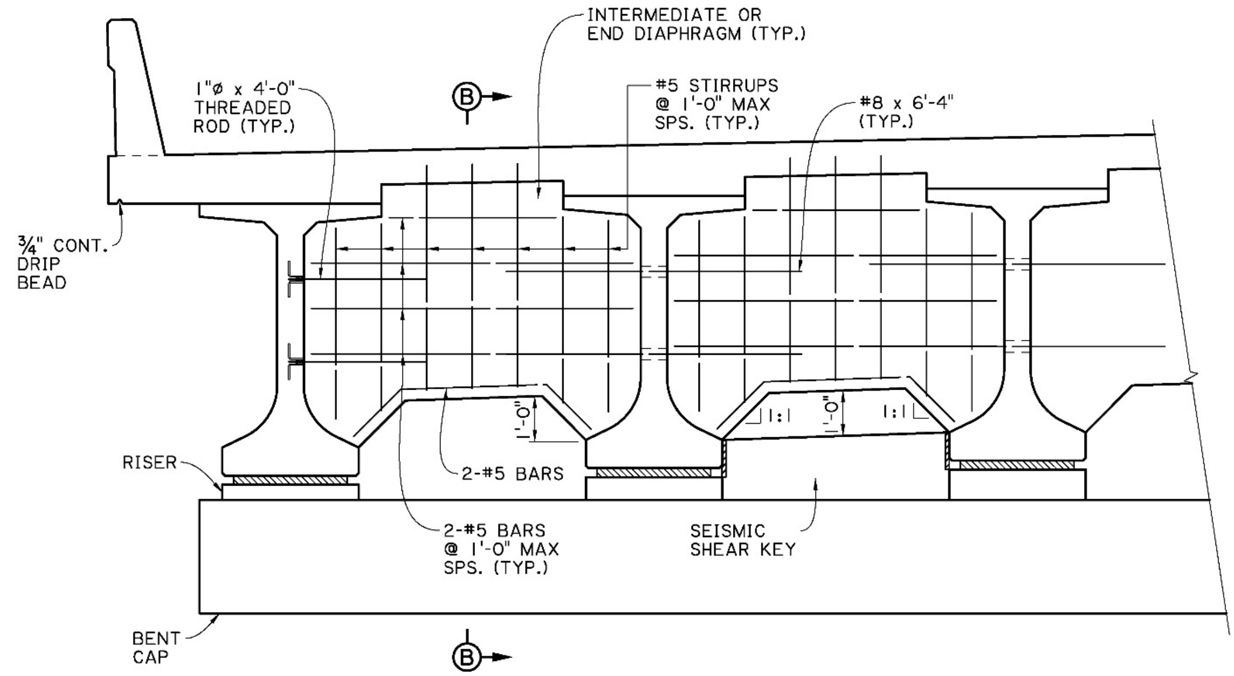
(GIRDER TOP FLANGE, DECK, AND BARRIER NOT SHOWN FOR CLARITY)

INSTRUCTIONS FOR DESIGNERS:

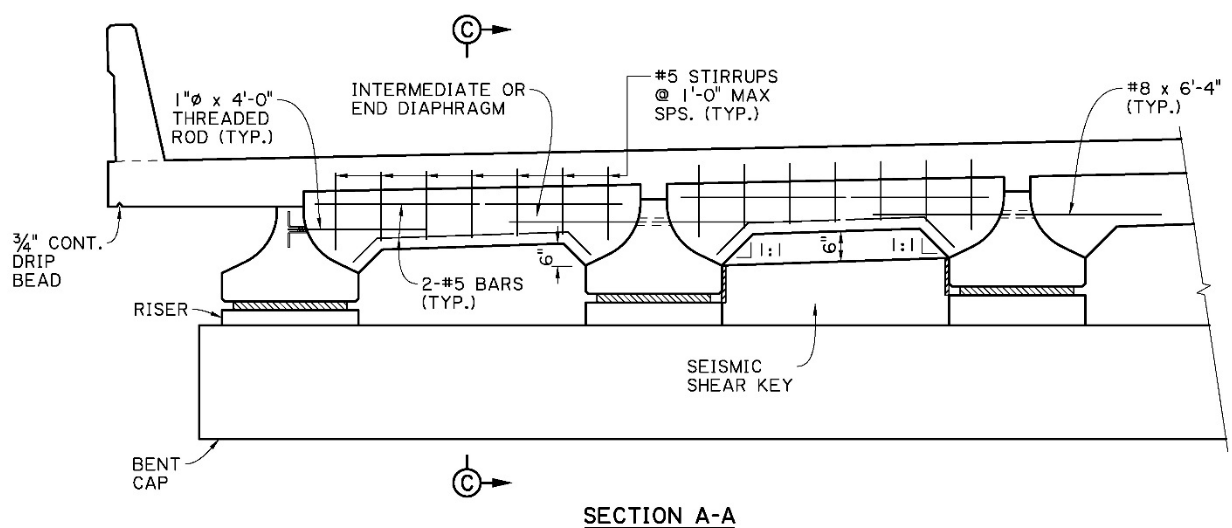
1. SEE LG COMMON DETAILS FOR DEFINITIONS.
2. THIS DESIGN AID PROVIDES CONSISTENT DESIGN AND DETAILS FOR INTERMEDIATE AND END DIAPHRAGMS. INFORMATION SHOWN SHALL BE INCORPORATED INTO PROJECT PLAN.
3. NON-SKEWED BENT SHOWN. SKEWED BENTS SIMILAR.
4. ⊠ K DIMENSION VARIES FOR GIRDER SIZES AND FOR NON-SKEW AND SKEW BENTS. SEE LG COMMON DETAILS (SHT. 9 OF 11) FOR MINIMUM DIMENSION. IF K DIMENSION MUST BE LARGER THAN MINIMUM VALUES BASED ON PROJECT-SPECIFIC GEOMETRY, THE DESIGNER MUST CHECK THE DECK TO DETERMINE IF AN EDGE BEAM IS REQUIRED.

Figure 1.3.2-5: Diaphragms

(1 of 3)



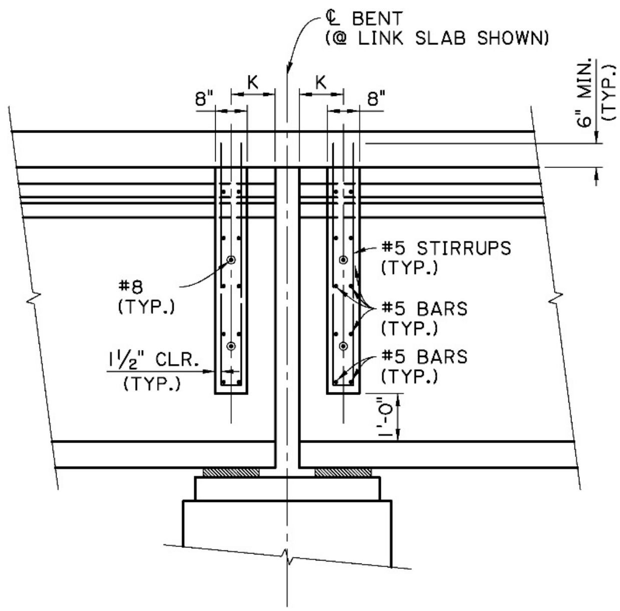
SECTION A-A
(LG-36 TO LG-78)



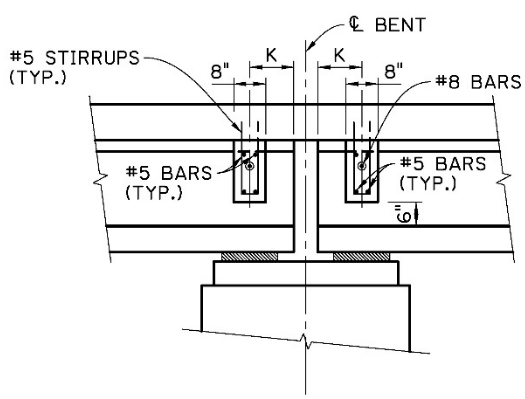
SECTION A-A
(LG-25)

Figure 1.3.2-5: Diaphragms

(2 of 3)



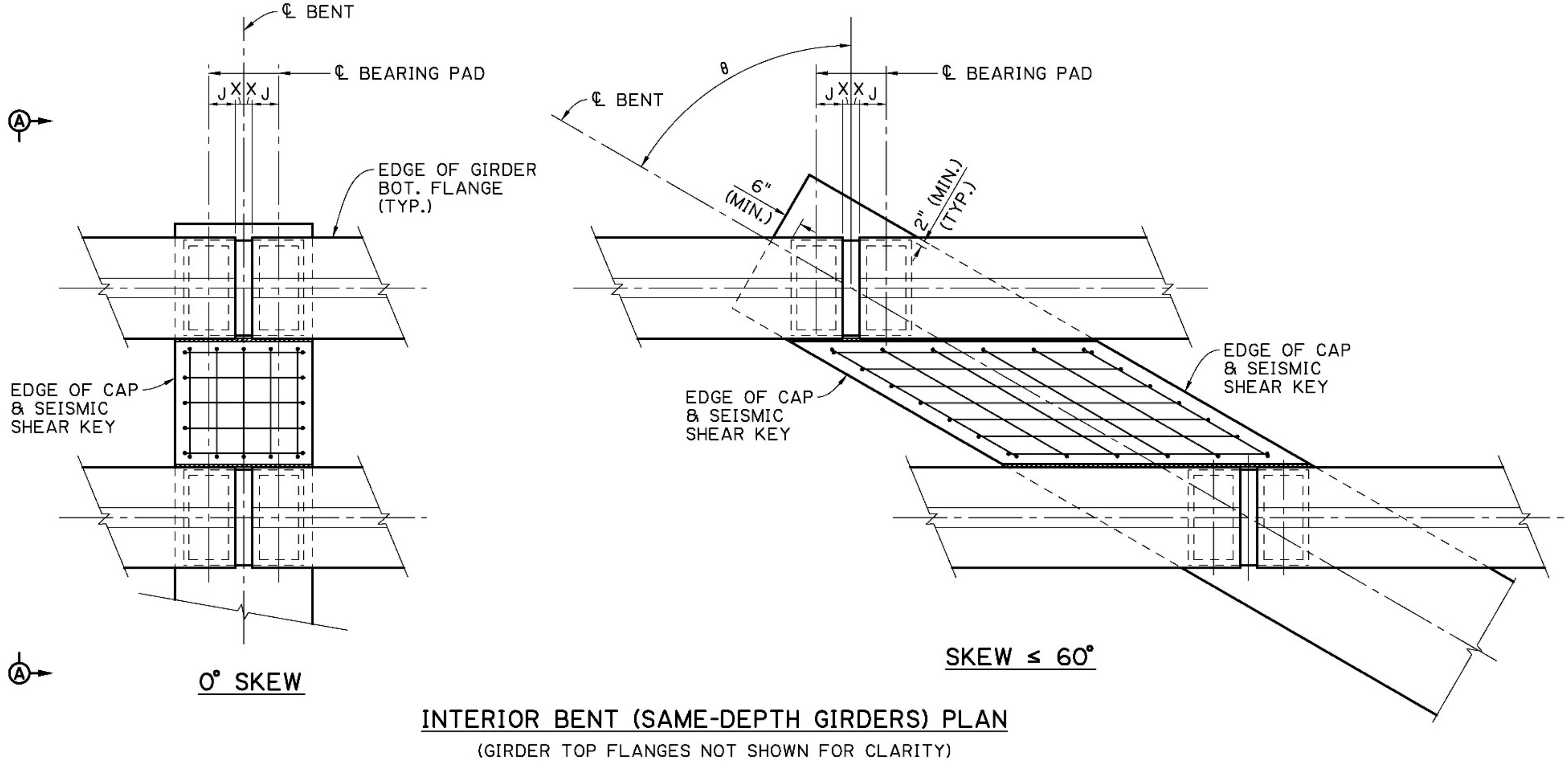
SECTION B-B
(LG-36 TO LG-78)



SECTION C-C
(LG-25)

Figure 1.3.2-5: Diaphragms

(3 of 3)



INSTRUCTIONS FOR DESIGNERS:

1. SEE LG COMMON DETAILS FOR DEFINITIONS AND UHMWP WEAR PAD DETAIL.
2. FIGURE 1.3.2-6 PROVIDES CONCEPTUAL LAYOUT AND TYPICAL DETAILS OF SEISMIC SHEAR KEYS THAT SHALL BE INCORPORATED IN PROJECT PLANS. THE EOR IS RESPONSIBLE FOR DETERMINING NUMBER OF SHEAR KEYS REQUIRED AND REINFORCEMENT DETAILS AND PROVIDING SUFFICIENT BEARING AREA BETWEEN SHEAR KEYS AND GIRDER BOTTOM FLANGE TO TRANSFER PROJECT SPECIFIC SEISMIC LOAD.

Figure 1.3.2-6: Seismic Shear Key

(1 of 4)

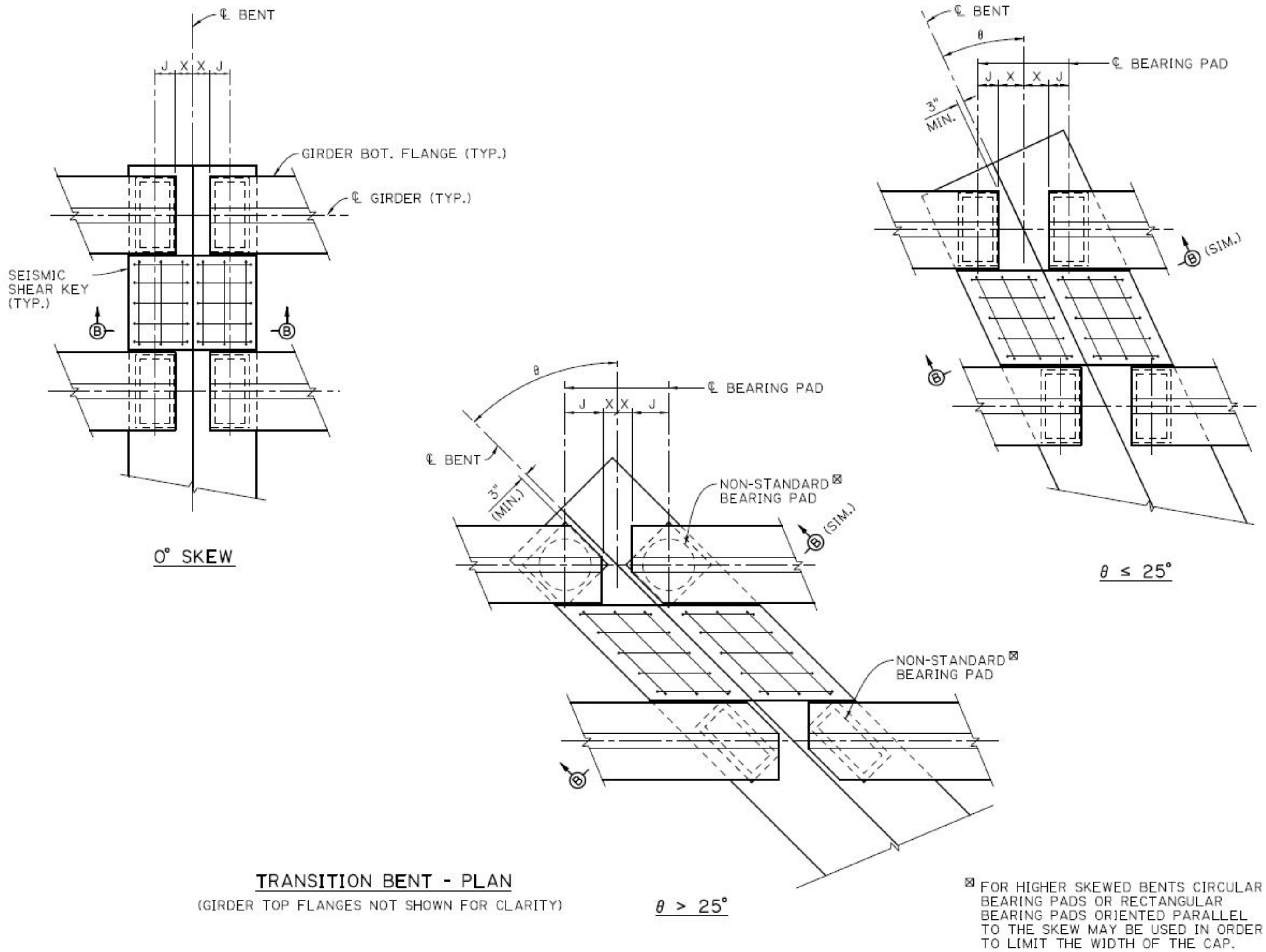
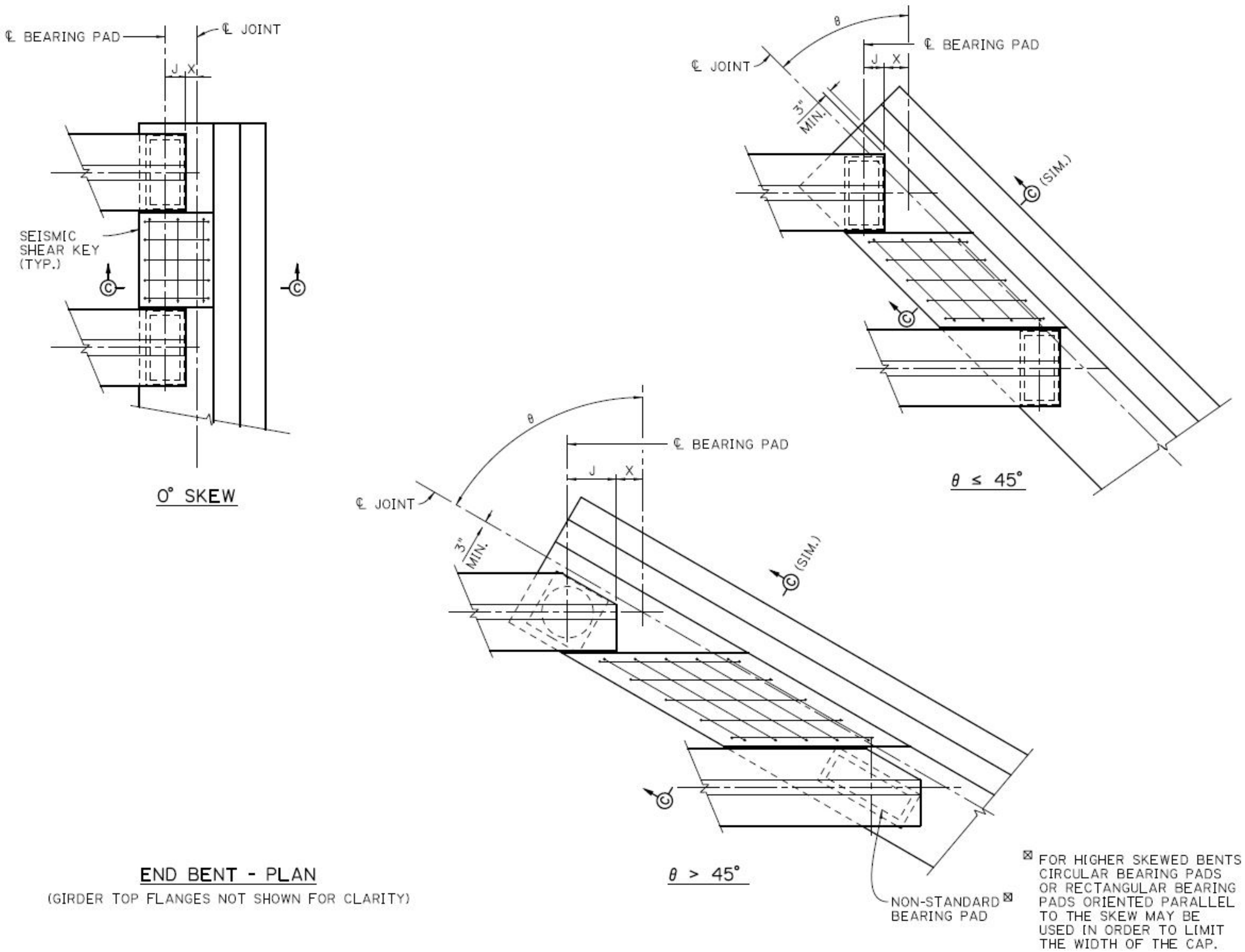


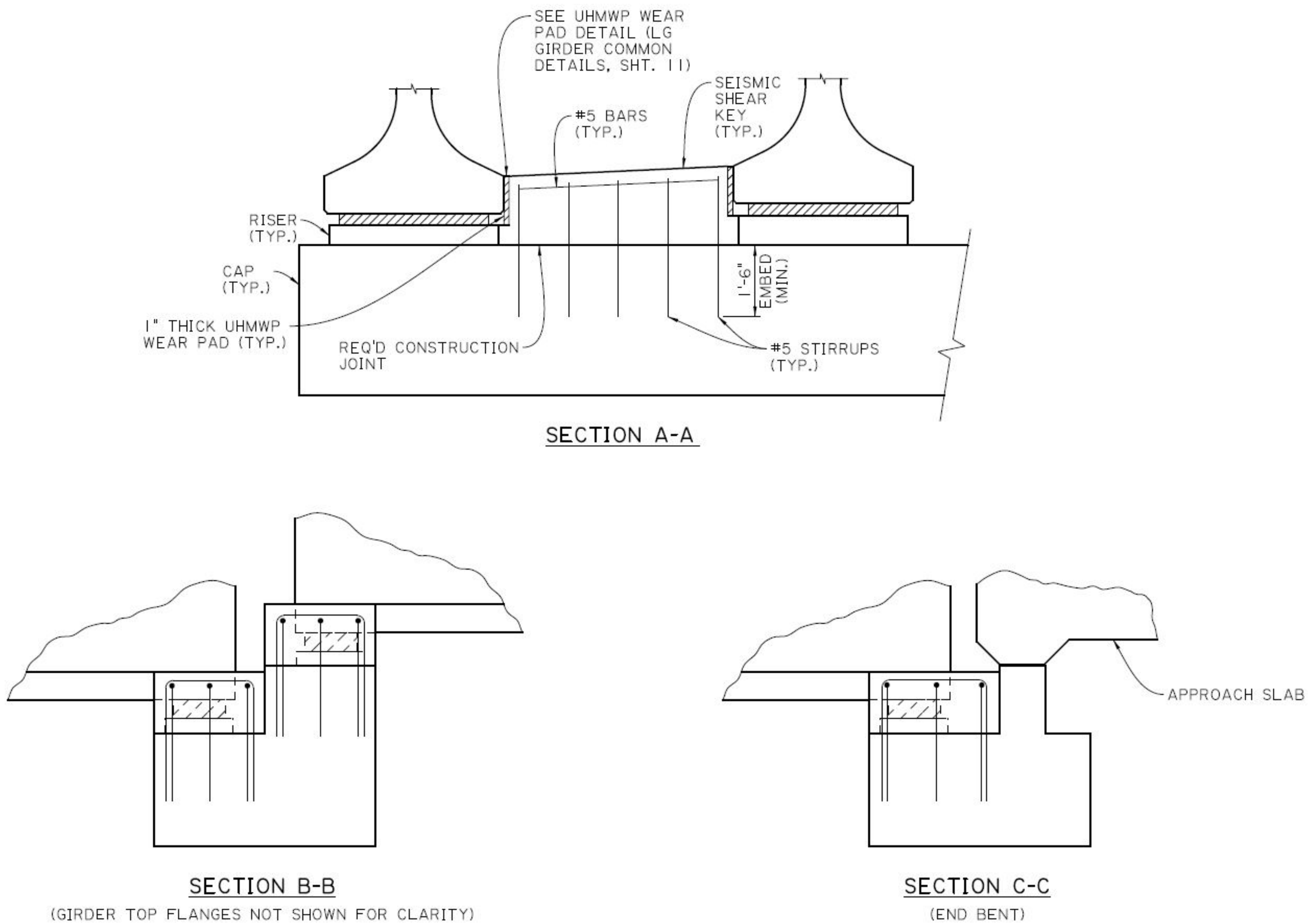
Figure 1.3.2-6: Seismic Shear Key

(2 of 4)



<u>Figure 1.3.2-6: Seismic Shear Key</u>

(3 of 4)



<u>Figure 1.3.2-6: Seismic Shear Key</u>

(4 of 4)

1.3.3─Typical Organization of LG Girder Project Plan Set

Project plan set for LG girder projects shall be developed and organized utilizing LG common details, specific details, and design aids. Typical organization of a project plan set and application guidance on LG specific details and design aids are illustrated in Table 1.3.3-1 through an example project shown in Figure 1.3.3-1, where LG-25 and LG-36 were used. All LG girder project plan sets shall be prepared and organized in a similar fashion for consistency.

Table 1.3.3-1: Typical Organization of LG Girder Project Plan Set

Plan Sheet Order	Description	Application Guidance on LG Girder Standard Plans and Design Aids
1	Bridge Index	n/a
2	General Notes	n/a
3	General Bridge Plan	n/a
4	Sequence of Construction (if applicable)	n/a
5	Boring Logs	n/a
6	Foundation Layout	n/a
7	Pile Details	n/a
8	Pile Data Table	n/a
9	Bent Details	Incorporate concrete seismic shear key (design aid Figure 1.3.2-6). The shear key detail replaces previous practice of clip angle and anchor bolts at girder ends.
10	Bent and Riser Elevation Table	n/a
11	Girder Framing Plan	n/a
12	Girder Strand Patterns and Strand Pattern Data Table	Use strand pattern and strand pattern data table templates (design aid Figure 1.3.2-2).
13	Girder Data Table	Use girder data table (design aid Figure 1.3.2-1).
14	LG Common Details (11 sheets)	Include all eleven sheets in series
15	LG-25 Details (2 sheets)	Include two sheets in series
16	LG-36 Details (2 sheets)	Include two sheets in series
17	Span Details	Incorporate link slab reinforcement (design aid Figure 1.3.2-4) and diaphragm details (design aid Figure 1.3.2-5).

(*continued on next page)*

Table 1.3.3-1: Typical Organization of LG Girder Project Plan Set (continued)

18	Misc. Span Common Details	n/a
19	Expansion Joint Details	n/a
20	Bridge Barrier Railing	n/a
21	Year Plate	n/a
22	Approach Slab Common Details	Standards and non-standard sheets
23	Approach Slab Drainage Details	n/a
24	Revetment Details	n/a
(These sheets are typically included in title sheet, not in bridge index)		
25	Guard Rail	n/a
26	Rebar Support	n/a

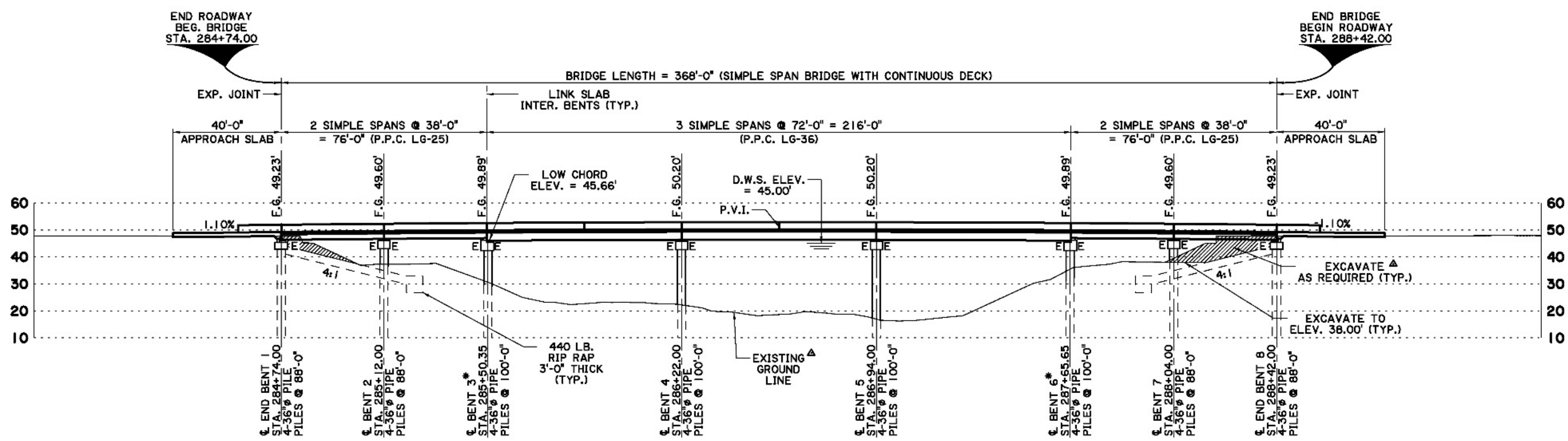


Figure 1.3.3-1: Example LG Girder Project

APPENDIX A─SUMMARY OF REACTIONS AND END ROTATIONS

The girder end rotations for different LG girders and spacing are calculated for 8.5 ksi and 10.0 ksi concrete and summarized in Table A-1 and A-2, respectively. The information presented in these tables are only used to develop the standard bearing design charts, and not intended to replace the designer's calculation for a specific bridge.

The rotation at the end of girder is calculated using the following equation:

$$\text{Rotation} = 4\times(y_{mid}/L)$$

where: y_{mid} = Deflection at mid span (inches)

L = Span length between centerline of bearing (inches)

Table A-1: Girder Reactions and End Rotations for LG Girders (8.5 ksi Concrete)

Girder	Girder Spacing (ft.)	Span Length (ft.)	Camber (in.)		Reaction (kips)		Rotation (radian)	
			DL*	LL**	DL	LL	DL	LL
LG-25	6	52	0.463	-0.348	40.4	100.6	0.00297	-0.00223
	7	49	0.484	-0.316	42.3	109.7	0.00329	-0.00215
	8	47	0.512	-0.285	44.0	118.3	0.00363	-0.00202
	9	45	0.542	-0.255	45.4	126.4	0.00401	-0.00189
	10	44	0.510	-0.245	47.6	134.7	0.00386	-0.00186
	11	42	0.545	-0.216	48.4	141.8	0.00433	-0.00171
	12	41	0.525	-0.204	50.3	149.3	0.00427	-0.00166
LG-36	6	90	2.241	-0.860	87.9	122.9	0.00830	-0.00319
	7	86	2.321	-0.795	89.3	134.2	0.00900	-0.00308
	8	83	2.176	-0.709	92.4	145.1	0.00874	-0.00285
	9	79	2.282	-0.680	93.8	155.1	0.00963	-0.00287
	10	76	2.241	-0.632	96.0	164.8	0.00983	-0.00277
	11	74	2.180	-0.607	99.0	174.5	0.00982	-0.00273
	12	71	2.140	-0.557	100.3	183.1	0.01005	-0.00262
LG-45	6	107	2.109	-0.893	108.5	130.4	0.00657	-0.00278
	7	103	2.148	-0.846	112.1	142.7	0.00695	-0.00274
	8	99	2.186	-0.794	115.2	154.1	0.00736	-0.00267
	9	95	2.216	-0.738	117.7	165.0	0.00778	-0.00259
	10	92	2.221	-0.701	119.7	175.7	0.00805	-0.00254
	11	89	2.192	-0.663	122.6	185.8	0.00821	-0.00248
	12	86	2.163	-0.623	125.0	195.4	0.00838	-0.00241

(*continued on next page*)

Table A-1: Girder Reactions and End Rotations for LG Girders (8.5 ksi Concrete) - Continued

Girder	Girder Spacing (ft)	Span Length (ft)	Camber (in.)		Reaction (kips)		Rotation (radian)	
			DL*	LL**	DL	LL	DL	LL
LG-54	6	124	1.576	-0.932	132.7	137.4	0.00424	-0.00251
	7	119	1.795	-0.878	134.9	150.0	0.00503	-0.00246
	8	115	1.951	-0.838	137.7	162.6	0.00566	-0.00243
	9	110	2.071	-0.774	140.0	173.5	0.00628	-0.00235
	10	106	2.109	-0.727	142.9	184.4	0.00663	-0.00229
	11	103	2.089	-0.696	146.6	195.5	0.00676	-0.00225
	12	100	2.073	-0.664	150.0	205.5	0.00691	-0.00221
LG-63	6	140	1.360	-0.954	154.7	143.8	0.00324	-0.00227
	7	134	1.624	-0.894	158.4	156.8	0.00404	-0.00222
	8	129	1.767	-0.846	162.5	169.3	0.00457	-0.00219
	9	124	1.899	-0.793	165.9	181.1	0.00510	-0.00213
	10	120	1.945	-0.755	169.9	192.8	0.00540	-0.00210
	11	116	2.147	-0.714	169.4	203.6	0.00617	-0.00205
	12	113	2.126	-0.687	173.6	214.5	0.00627	-0.00203
LG-72	6	153	1.090	-0.929	174.6	148.9	0.00237	-0.00202
	7	147	1.353	-0.881	179.1	162.6	0.00307	-0.00200
	8	141	1.593	-0.826	182.8	175.3	0.00377	-0.00195
	9	137	1.711	-0.799	185.8	188.1	0.00416	-0.00194
	10	132	1.838	-0.752	189.2	199.6	0.00464	-0.00190
	11	127	1.888	-0.702	194.6	210.4	0.00496	-0.00184
	12	123	1.93	-0.666	198.3	221.3	0.00523	-0.00180
LG-78	6	165	0.725	-0.972	192.0	153.5	0.00146	-0.00196
	7	158	1.120	-0.914	196.2	167.1	0.00236	-0.00193
	8	151	1.483	-0.849	199.3	179.8	0.00327	-0.00187
	9	146	1.619	-0.811	204.1	192.7	0.00370	-0.00185
	10	141	1.750	-0.768	208.3	204.8	0.00414	-0.00182
	11	137	1.799	-0.737	213.2	216.7	0.00438	-0.00179
	12	133	1.85	-0.704	217.5	227.9	0.00464	-0.00176
Max dead load rotation and minimum live load rotation:							**0.01005**	**-0.00166**

* Upward camber after all DLs. Equals to C3 as defined in D5.7.3.6.2.

** Downward deflection due to LL.

Table A-2: Girder Reactions and End Rotations for LG Girders (10.0 ksi Concrete)

Girder	Girder Spacing (ft)	Span Length (ft)	Camber (in.)		Reaction (kips)		Rotation (radian)	
			DL*	LL**	DL	LL	DL	LL
LG-25	6	53	0.344	-0.401	42.2	102.8	0.00216	-0.00252
	7	51	0.395	-0.357	44.4	112.2	0.00258	-0.00233
	8	48	0.468	-0.313	45.8	120.2	0.00325	-0.00217
	9	46	0.501	-0.282	47.4	128.4	0.00363	-0.00204
	10	45	0.499	-0.264	49.3	137.4	0.00370	-0.00196
	11	43	0.509	-0.241	50.7	144.1	0.00395	-0.00187
	12	42	0.489	-0.229	52.7	152.3	0.00388	-0.00182
LG-36	6	98	2.330	-1.040	95.6	126.4	0.00793	-0.00354
	7	93	2.479	-0.943	93.9	113.9	0.00889	-0.00338
	8	90	2.447	-0.899	101.1	149.3	0.00906	-0.00333
	9	87	2.465	-0.851	103.1	160.2	0.00944	-0.00326
	10	83	2.492	-0.773	104.6	169.5	0.01001	-0.00310
	11	81	2.414	-0.747	108.1	180.0	0.00993	-0.00307
	12	78	2.386	-0.693	109.9	188.8	0.01020	-0.00296
LG-45	6	119	1.879	-1.141	120.4	135.4	0.00526	-0.0032
	7	114	2.078	-1.067	123.8	147.8	0.00608	-0.00312
	8	109	2.252	-0.987	126.5	159.3	0.00689	-0.00302
	9	105	2.315	-0.928	129.7	170.7	0.00735	-0.00295
	10	101	2.371	-0.865	132.2	181.4	0.00783	-0.00285
	11	98	2.355	-0.824	135.8	191.8	0.00801	-0.00280
	12	95	2.404	-0.782	136.7	202.1	0.00844	-0.00274
LG-54	6	133	1.454	-1.072	142.0	141.2	0.00364	-0.00269
	7	128	1.789	-1.019	144.9	154.2	0.00466	-0.00265
	8	123	1.966	-0.957	148.3	166.5	0.00533	-0.00259
	9	119	1.947	-0.913	152.9	178.4	0.00545	-0.00256
	10	115	2.131	-0.864	154.7	190.0	0.00618	-0.00250
	11	111	2.188	-0.813	157.7	200.6	0.00657	-0.00244
	12	107	2.236	-0.759	160.1	210.6	0.00697	-0.00236
LG-63	6	154	0.755	-1.176	169.8	149.4	0.00163	-0.00255
	7	148	1.118	-1.115	174.5	162.9	0.00252	-0.00251
	8	142	1.455	-1.045	178.3	175.6	0.00342	-0.00245
	9	137	1.732	-0.990	182.6	188.1	0.00421	-0.00241
	10	133	1.818	-0.950	185.0	200.4	0.00456	-0.00238
	11	128	1.908	-0.888	190.5	211.2	0.00497	-0.00231
	12	124	1.985	-0.842	194.3	221.7	0.00534	-0.00226

(*continued on next page)*

Table A-2: Girder Reactions and End Rotations for LG Girders (10.0 ksi Concrete) - Continued

Girder	Girder Spacing (ft)	Span Length (ft)	Camber (in.)		Reaction (kips)		Rotation (radian)	
			DL*	LL**	DL	LL	DL	LL
LG-72	6	171	0.254	-1.194	194.5	155.7	0.00050	-0.00233
	7	164	0.777	-1.128	199.2	169.8	0.00158	-0.00229
	8	158	1.120	-1.071	204.0	183.1	0.00236	-0.00226
	9	153	1.32	-1.026	209.4	196.2	0.00288	-0.00224
	10	148	1.513	-0.976	214.1	208.6	0.00341	-0.00220
	11	143	1.705	-0.922	218.0	220.3	0.00397	-0.00215
	12	139	1.876	-0.884	219.6	231.7	0.00450	-0.00212
LG-78	6	183	-0.632	-1.222	212.4	160.2	-0.00115	-0.00223
	7	176	-0.052	-1.164	217.8	174.7	-0.00010	-0.00220
	8	170	0.340	-1.114	223.5	188.7	0.00067	-0.00218
	9	165	0.578	-1.075	229.7	202.3	0.00117	-0.00217
	10	159	0.945	-1.012	233.7	214.7	0.00198	-0.00212
	11	154	1.169	-0.963	238.4	226.7	0.00253	-0.00208
	12	150	1.271	-0.929	244.0	238.5	0.00282	-0.00206
Max dead load rotation and minimum live load rotation:							**0.01020**	**-0.00182**

* Upward camber after all DLs. Equals to C3 as defined in D5.7.3.6.2.

** Downward deflection due to LL.

APPENDIX B─BEARING DESIGN CHART DEVELOPMENT EXAMPLE (STANDARD PAD B-1)

This example demonstrates the development of the bearing design chart for standard pad B-1. The dimensions and material properties of the bearing pad are:

$L = 8$ in (*Length of bearing pad parallel to girder*)

$W = 30$ in (*Width of bearing pad perpendicular to girder)*

$A_{brg} = L \cdot W = 240\ in^2$

$h_{ri} = 0.5$ in (*Internal individual elastomeric layer thickness*)

$n_{int} = 2$ (*Number of internal elastomeric layers*)

$h_{ri\_ext} = 0.25$ in (*Exterior individual elastomeric layer thickness*)

$n = 2$ (int.) + 0.5 x 2 (ext.) = 3

Note: n is the number of interior layers of elastomer. If the exterior layer thickness is equal to or more than 1/2 of the interior layer thickness, n *may be increased by 1/2 for each such exterior layer per AASHTO 14.7.5.3.3.*

$h_s = 0.125$ in (*Steel layer thickness)*

$h_{rt} = 1.5$ in (*Total elastomer thickness)*

$h_{total} = 1.875$ in (*Total pad thickness*)

$F_y = 36$ ksi (*Yield strength of the steel laminate*)

$G = 150$ psi (*Shear modulus*)

$G_{min} = G \cdot 0.85 = 0.127$ ksi (*Allow 15% variation according to LRFD 14.7.5.2*)

For rectangular bearing pad, the shape factor is calculated as:

$$S_i = \frac{L \cdot W}{2 \cdot h_{ri} \cdot (L+W)} = 6.316$$ *LRFD Eq. 14.7.5.1-1*

1. Calculate shear strain caused by rotation using maximum DL rotation and minimum LL rotation:

The rotation due to cyclic load is taken as the minimum live load rotation (See Table A-2):

$$\theta_{s,cy} = -0.00182$$

The rotation due to static load is taken as the maximum dead load rotation (See Table A-2):

$$\theta_{s,st} = 0.0102$$

Add 0.005 to account for uncertainties (LRFD 14.4.2.1) and 0.01 for slope:

$$\theta_{s,st} = 0.0102 + 0.005 + 0.01 = 0.025$$

For rectangular bearing:

$$D_r = 0.5$$

The shear strain due to rotation by static load is:

$$\gamma_{r,st} = D_r \cdot \left(\frac{L}{h_{ri}}\right)^2 \cdot \frac{\theta_{s,st}}{n} = 1.075$$

The shear strain due to rotation by cyclic load is:

$$\gamma_{r,cy} = D_r \cdot \left(\frac{L}{h_{ri}}\right)^2 \cdot \frac{\theta_{s,cy}}{n} = -0.078$$

2. Calculate shear strain caused by shear deformation using the maximum shear deformation $0.5 \cdot h_{rt}$:

The maximum cyclic shear deformation is taken as 10% of h_{rt} (*LRFD C14.7.5.3.2*):

$$\Delta_{s,cy} = 0.1 \cdot h_{rt} = 0.15 \text{ in}$$

The maximum static shear deformation is taken as 40% of h_{rt}:

$$\Delta_{s,st} = 0.4 \cdot h_{rt} = 0.6 \text{ in}$$

The shear strain due to shear deformation by static load is:

$$\gamma_{s,st} = \frac{\Delta_{s,st}}{h_{rt}} = 0.4$$

The shear strain due to shear deformation by cyclic load is:

$$\gamma_{s,cy} = \frac{\Delta_{s,cy}}{h_{rt}} = 0.1$$

3. Find the relationship between dead load and live load reactions:

The combinations of axial load, rotation, and shear at the service limit need to satisfy:

$$\left(\gamma_{a,st} + \gamma_{r,st} + \gamma_{s,st}\right) + 1.75 \cdot \left(\gamma_{a,cy} + \gamma_{r,cy} + \gamma_{s,cy}\right) = 5 \qquad (\textit{LRFD Eq. 14.7.5.3.3-1})$$

where:

$$\gamma_{a,st} = D_a \cdot \frac{\sigma_{s,st}}{G_{min} \cdot S_i}$$ For rectangular bearing, $D_a = 1.4$

$$\sigma_{s,st} = \frac{P_{DL}}{A_{brg}}$$ P_{DL} is the dead load reaction

$$\gamma_{a,cy} = D_a \cdot \frac{\sigma_{s,cy}}{G_{min} \cdot S_i}$$

$$\sigma_{s,cy} = \frac{P_{LL}}{A_{brg}}$$ P_{LL} is the live load reaction

Substitute into Equation 14.7.5.3.3-1:

$$\left(D_a \cdot \frac{\frac{P_{DL}}{A_{brg}}}{G_{min} \cdot S_i} + \gamma_{r,st} + \gamma_{s,st}\right) + 1.75 \cdot \left(D_a \cdot \frac{\frac{P_{LL}}{A_{brg}}}{G_{min} \cdot S_i} + \gamma_{r,cy} + \gamma_{s,cy}\right) = 5$$

Rearrange the equation above and get the relationship between P_{DL} and P_{LL}:

$$P_{LL} = 274.96 \text{ kip} - 0.571 \cdot P_{DL}$$

The static component of γ_a shall also satisfy:

$\gamma_{a,st} \leqslant 3.0$ *LRFD Eq. 14.7.5.3.3-2*

Since: $\gamma_{a,st} = D_a \cdot \dfrac{\sigma_{s,st}}{G_{min} \cdot S_i}$ and $\sigma_{s,st} = \dfrac{P_{DL}}{A_{brg}}$

The corresponding upper limit for dead load reaction is:

$$P_{DL\_Max} = \frac{G_{min} \cdot S_i \cdot A_{brg}}{D_a} \cdot 3 = 414.135 \text{ kip}$$

Plot the relationship between the dead load and live load reactions as shown in Figure B-1 (the lines for other bearing pads are developed using the same procedure as shown in this example):

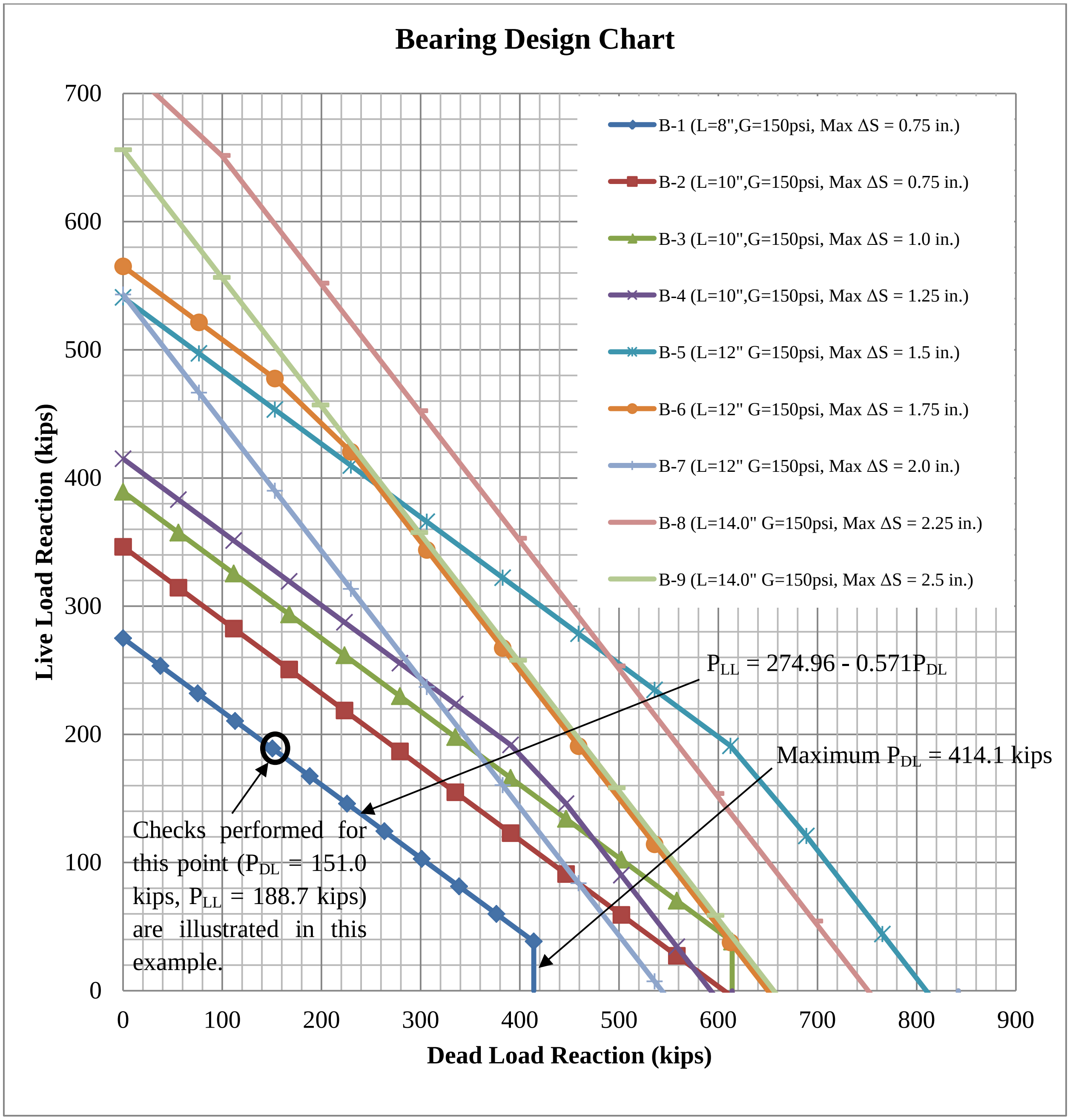


Figure B-1: Dead Load and Live Load Reactions

4. Perform other checks:

The other checks are performed at 12 points with equal spacing along the line. In case any check is not satisfied at a certain point, this point will be dropped down to satisfy all checks.

In this example the following point is checked:

Reaction caused by dead load: $P_{DL} = 151$ kip

$$\sigma_D = \frac{P_{DL}}{A_{brg}} = 629.167 \text{ psi}$$

Reaction caused by live load: $P_{LL} = 188.7$ kip

$$\sigma_L = \frac{P_{LL}}{A_{brg}} = 0.786 \text{ ksi}$$

Reaction caused by total load: $P_{TL} = P_{DL} + P_{LL} = 339.7$ kip

$$\sigma_s = \frac{P_{TL}}{A_{brg}} = 1.415 \text{ ksi}$$

***4.1 Check stability of elastomeric bearings (LRFD 14.7.5.3.4)*:**

For rectangular bearing:

$$A = \frac{1.92 \cdot \frac{h_{rt}}{L}}{\sqrt{1 + \frac{2.0 \cdot L}{W}}} = 0.291$$ *LRFD Eq. 14.7.5.3.4-2*

$$B = \frac{2.67}{(S_i + 2.0) \cdot \left(1 + \frac{L}{4.0 \cdot W}\right)} = 0.301$$ *LRFD Eq. 14.7.5.3.4-3*

Check if $2A \leqslant B$ — *Note: if it is satisfied, no additional check is required. The bearing is stable*

$2 \cdot A = 0.581$ $B = 0.301$ N.G. Additional Check Required

Therefore, *LRFD Eq. 14.7.5.3.6-4* needs to be checked.

If the bridge deck is free to translate horizontally:

$$\frac{G_{min} \cdot S_i}{2 \cdot A - B} = 2.871 \text{ ksi}$$

$$\sigma_s = 1.415 \text{ ksi}$$

$$\sigma_s < \frac{G_{min} \cdot S_i}{2 \cdot A - B}$$ O.K. *LRFD Eq. 14.7.5.3.4-4*

4.2 Check reinforcement layer thickness (LRFD 14.7.5.3.5):

$$h_s = 0.125 \text{ in}$$

The thickness of the steel reinforcement shall satisfy:

At the service limit state:

$$\frac{3 \cdot h_{ri} \cdot \sigma_s}{F_y} = 0.059 \text{ in} < 0.125 \text{ in}$$ O.K. *LRFD Eq. 14.7.5.3.5-1*

At the fatigue limit state:

$\Delta F_{TH} = 24$ ksi

$\frac{2 \cdot h_{ri} \cdot \sigma_L}{\Delta F_{TH}} = 0.033 \text{ in} < 0.125 \text{ in}$ O.K. *LRFD Eq. 14.7.5.3.5-2*

4.3 Check compressive deflection (LRFD 14.7.5.3.6):

The instantaneous live load compressive strain in the internal elastomeric layer is:

$$\varepsilon_{Li} = \frac{\sigma_L}{4.8 \cdot G_{min} \cdot S_i^2} = 0.032$$

The instantaneous live load compressive strain in the external elastomeric layer is:

$$S_{i\_ext} = \frac{L \cdot W}{2.0 \cdot h_{ri\_ext} \cdot (L + W)} = 12.632$$

$$\varepsilon_{Li\_ext} = \frac{\sigma_L}{4.8 \cdot G_{min} \cdot S_{i\_ext}^2} = 8.052 \times 10^{-3}$$

The total instantaneous live load deflection should be less than 0.125 inch.

$\delta_L = n_{int} \cdot \varepsilon_{Li} \cdot h_{ri} + 2 \cdot \varepsilon_{Li\_ext} \cdot h_{ri\_ext} = 0.036$ in O.K.

4.4 Check anchorage for bearings without bonded external plates (LRFD 14.7.5.4):

$\theta_s = \theta_{s,st} + 1.75 \cdot \theta_{s,cy} = 0.022$

$n = 3$

$$\varepsilon_a = \frac{\sigma_D + 1.75 \cdot \sigma_L}{4.8 \cdot G_{min} \cdot S_i^2} = 0.082$$

$S_i = 6.316$

$$\frac{\theta_s}{n} = 7.338 \times 10^{-3}$$

$$\frac{3 \cdot \varepsilon_a}{S_i} = 0.039$$

$\frac{\theta_s}{n} < \frac{3 \cdot \varepsilon_a}{S_i}$ O.K.