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Client Name:	**Ohio Department of Transportation**
Job Title:	**Cleveland Innerbelt Design-Build Contract**
Job Number:	**CUY-90-14.90**
Document Title:	Safety Cable Sag Calculation - RFI 225

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Calculate required pre-tension in horizontal life line

Max. span of wire rope is located in span 10 = 30'-2 1/8" = 30.177'

try 3½" sag to keep safety cable from interfering with the hand rail.

use 3/8" cable ASTM A603
wt = 0.24 #/ft

see Attached Wire Rope Engineering handbook for equations

$$t = \frac{s(2G + ws)}{8\,y_c}$$

$s = 30.177'$
$w = 0.24$ #/ft
$y_c = 3.5" = 0.292'$

We are finding Pre-tension force required ∴ G = 0

$$t = \frac{30.177[0 + 0.24(30.177)]}{8\,(0.292)} = 93.56\ \#$$

$$\beta_1 = \tan^{-1}\left(\frac{G + ws}{2t}\right) = \tan^{-1}\left(\frac{0 + 0.24(30.177)}{2(93.56)}\right)$$

$$\beta_1 = 0.0387 = 2.21^\circ$$

cable tension at support

$$t' = \frac{t}{\cos\beta_1} = \frac{93.56}{\cos 2.21} = \underline{93.63\ \#}$$

The 3/4" x 4½" Eye Bolts have a Safe working load of 7200 #

Calculate the Fall force (G) that will produce a force on the eye bolt, t = 7200 # @ y_c = 3.5"

$$t = \frac{s(2G + ws)}{8\,y_c}$$

$$7200 = \frac{30.177(2G + 0.24(30.177))}{8(0.292')}$$

$$G = 275\ \#$$

30'-2 1/8" is the longest span for the horizontal life line as the span lengths decrease, if the 3½" sag distance is maintained, the fall force that can be applied will increase. This is shown on the attached spread sheet.

∴ Specify the horizontal life line shall be installed with a sag of 3½ inches in the unloaded condition.

ME101-1204

This Spreadsheet is to show that as the span length of the Safety Cable decreases. The fall force that can be applied to the cable to produce a force on the support equal to the Working Strength of the Eye Bolt anchorage increases.

cable wt= 0.24 #/ft
t= 7200 # Tension in Cable equal to the working strength of Eye Bolt

Span (ft)	yc (in)	t (#) (self wt only)	Beta 1 (degree)	L1 (ft)
18	3.5	33.326	3.708	18.013
20	3.5	41.143	3.338	20.011
22	3.5	49.783	3.036	22.010
24	3.5	59.246	2.783	24.009
26	3.5	69.531	2.569	26.009
28	3.5	80.640	2.386	28.008
30.177	3.5	93.667	2.214	30.185

G* (#)
464.5067
417.6000
379.1782
347.1200
319.9569
296.6400
274.7364

* Allowable fall force to produce a cable tension (t) at the eye bolt equal to the working load limit of the eye bolt (7200#).

STRESSES IN SUSPENDED CABLES

Cable spans may be divided into two general classes, Anchored Spans, and Counterweighted Spans. In each of these divisions, we find it necessary to solve for stresses and deflections of uniformly loaded spans and also of spans supporting one or more individual concentrated loads. It is, therefore, necessary to analyze the conditions of each problem carefully and the following points must be considered:

1. Horizontal distance between supports.
2. Difference in elevation between supports.
3. Maximum allowable deflection, measured vertically from chord to cable.
4. Length of cable between supports.
5. Weight per foot of cable, to which must be added in certain cases the additional weight imposed by snow and ice.
6. Maximum load to be supported by the cable.
   a. Load uniformly distributed over the length of the span.
   b. A single load supported at any point in the span.
   c. Multiple individual loads.
7. Is the cable anchored at both ends or is it anchored at one end and counterweighted at the other end?
8. Modulus of elasticity in tension.
9. Wind loads on the cable and on the suspended load.
10. Changes in length of cable due to changes in temperature.

Since our purpose is to present means for obtaining results quickly, we will not give derivations of the following formulas. Computations are simplified by the assumption that uniform loading is distributed horizontally, and that the cable assumes a parabolic arc. For the great majority of cases encountered in practice, the results thus obtained are sufficiently accurate. If special cases occur where the ratio of deflection to span is very large, then the catenary equations should be applied. These are available in several textbooks.

The following nomenclature will be used:

A = Net cross sectional area of cable.

a = Horizontal spacing of loads.

b $= \frac{n(n-1)}{2}$ c $= \frac{u(u-1)}{2}$

e = Base of Naperian system of logarithms = 2.7182818.

E = Modulus of elasticity in tension.

G = Weight of an individual concentrated load.

h = Vertical difference in elevation of supports.

k = Ratio of deflection to span $= \frac{y}{s}$ for level spans and $\frac{ws\cos^2\alpha}{8t}$ for inclined spans.

L_1 = Length along cable when the cable only is supported in a span.

L_2 = Hypothetical length along cable at zero tension.

L = Length along cable when either a uniformly distributed load or one or more concentrated loads are suspended.

m = Horizontal distance from left support to the first load.

n = Number of concentrated loads.

P = Change in total length of cable per pound of tension $= \frac{L}{AE}$

s = Horizontal distance between supports.

s_1 = Chord length of sub-span between load and support or between two loads.

t = Horizontal component of cable tension.

t' = Maximum cable tension at left support.

t'' = Maximum cable tension at right support.

t_e = Erection tension of empty cable in an anchored span.

u = Number of loads to left of xy in a multiple loaded span.

w = Weight per foot of horizontal length of span for a uniformly distributed load, $w = w' \sec \alpha$.

w' = Weight per foot of uniformly distributed load along the cable, which is assumed for purposes of parabolic curve calculations, as equivalent to uniformly distributed load along the chord.

w'' = Weight per foot of uniformly distributed load along the cable for purposes of catenary curve calculations.

x = Horizontal distance from support to xy.

y = Vertical deflection from support to xy.

y_c = Vertical deflection from support at center of span.

z = A term in the general formula for multiple loaded counterweighted spans.

α = Alpha = Angle between the horizontal and a chord between supports.

β_1 = Beta_1 = Angle between the horizontal and a tangent to a cable curve at the left support.

β_2 = Beta_2 = Angle between the horizontal and a tangent to a cable curve at the right support.

β_3 = Beta_3 = Angle between the horizontal and a tangent to a cable curve at any point in a span.

LEVEL SPAN—SINGLE LOAD AT CENTER—ANCHORED

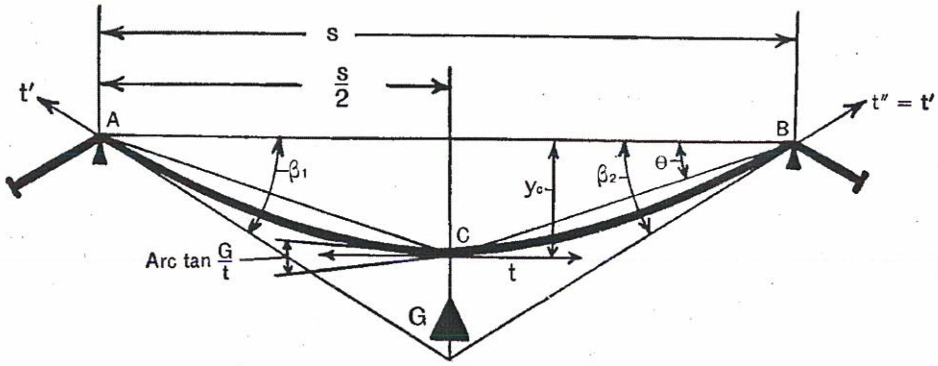

Figure 4

The deflection produced by a concentrated load suspended midway between two fixed points A and B forms two equal sub-chords AC and CB. The cable assumes two catenary arcs which intersect at C. The following formulas are, however, based on the parabola, as the difference in results is negligible.

The center deflection is found from:

$$y_c = \frac{Gs}{4t} + \frac{ws^2}{8t} = \frac{s\,(2G + ws)}{8t} \qquad (26)$$

$$\text{and } t = \frac{s\,(2G + ws)}{8y_c} \qquad (27)$$

$$t' = t \sec \beta_1 = t \sec \beta_2 = t'' \qquad (28)$$

$$\tan \beta_1 = \frac{G + ws}{2t} = \tan \beta_2 \qquad (29)$$

Example: A rolling load weighing 2000 pounds is to be supported in a level span 2000 ft. long by a cable anchored at both ends. The deflection must not exceed 83 feet. No wind or ice conditions.

(a) What are the specifications of the cable?

(b) What is the maximum tension in the cable?

(c) What is the slope at the supports with the load at center of span?

(d) What is the cable length between supports, with no rolling load on the cable?

(e) What is the erection tension and erection deflection of the cable?

It is necessary to assume a size and grade of cable for the calculations. If the first selection does not prove suitable, the calculations must be revised. We shall assume that a 1⅛" diameter Standard Locked Coil Cable will be suitable.

Since this is a level span, $\alpha = o$ and $w = w'$

$w = 3.16$ pounds per foot $\qquad A = .8503$ square inches

From (27) $\quad t = \dfrac{2000\,(2 \times 2000 + 3.16 \times 2000)}{8 \times 83} = 31{,}084$ pounds

From (29) $\quad \tan \beta_1 = \dfrac{2000 + (3.16 \times 2000)}{2 \times 31084} = .1338 \qquad \beta_1 = 7°\text{–}37'$

From (28) $\quad t' = 31084 \times 1.0089 = 31360$ pounds

Designation: A603 – 98 (Reapproved 2009)$^{\varepsilon 1}$

Standard Specification for Zinc-Coated Steel Structural Wire Rope[1]

This standard is issued under the fixed designation A603; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

ε^1 NOTE—Reapproved with editorial changes in May 2009.

1. Scope

1.1 This specification covers zinc-coated steel structural wire rope, prestretched or nonprestretched for use where a high-strength, relatively flexible prefabricated zinc-coated multiple-wire tension member is desired as a component part of a structure.

1.2 The wire rope is furnished with Class A weight zinc-coated wires throughout. It can be furnished with Class B weight or Class C weight zinc-coated outer wires or Class B weight or Class C weight zinc-coated wires throughout where additional corrosion protection is required.

1.3 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A90/A90M Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings

A902 Terminology Relating to Metallic Coated Steel Products

B6 Specification for Zinc

3. Terminology

3.1 *Definitions*—For definitions of terms used in this specification, see Terminology A902.

4. Ordering Information

4.1 Orders for material under this specification shall include the following information:

4.1.1 Length of wire rope,

4.1.2 Nominal diameter of wire rope (Tables 1-4),

4.1.3 Prestretched (see 8.3) or nonprestretched,

4.1.4 Coating-weight class if other than Class A (Table 5),

4.1.5 Mechanical tests if required (see 10.1),

4.1.6 Special packaging requirements (Section 13), and

4.1.7 Inspection (Section 12).

5. Materials and Manufacture

5.1 *Base Metal*—The base metal shall be carbon steel made by the open-hearth, basic-oxygen, or electric-furnace process and of such quality that the finished wire rope and the hard-drawn individual zinc-coated wires coated by the hot-dip or electrolytic process shall have the properties and characteristics as prescribed in this specification.

5.2 *Zinc*—The slab zinc when used shall conform to Specification B6 or better.

6. Physical Properties

6.1 *Tensile Properties*:

6.1.1 The zinc-coated wire used in the wire rope shall conform to the mechanical properties in Table 6 prior to fabrication, but the wire test sample may be prestretched to 55 % of the minimum tensile strength specified in Table 6 prior to conducting the tests.

6.1.2 The tensile strength and the stress at 0.7 % extension shall be based on the actual cross-sectional area of the finished wire, including the zinc coating.

6.1.3 *Test Specimens*—The test specimens shall be free of bends or kinks other than the curvature resulting from the usual coiling operation. The hand straightening necessary to permit insertion of the specimen in the jaws of the testing machine shall be performed by drawing between wood blocks or by some other equally satisfactory means.

6.2 *Stress at 0.7 % Extension Under Load*—The value of stress at 0.7 % extension under load shall be determined by one of the following procedures, depending on the type of extensometer used:

6.2.1 *Non-Autographic Extensometer*—When a non-autographic extensometer is used to measure the 0.7 % extension, it shall have a gage length of 10 in. (254 mm), and it shall

[1] This specification is under the jurisdiction of ASTM Committee A05 on Metallic-Coated Iron and Steel Products and is the direct responsibility of Subcommittee A05.12 on Wire Specifications.

Current edition approved May 1, 2009. Published August 2009. Originally approved in 1970. Last previous edition approved in 2003 as A603 – 98(2003). DOI: 10.1520/A0603-98R09E01.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

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TABLE 1 Properties of Single-Class Zinc-Coated Steel Structural Wire Rope (Inch-Pound Units)

Nominal Diameter, in.	Minimum Breaking Strength in Tons of 2000 lb			Approximate Gross Metallic Area, in.^{2}	Approximate Weight/ft, lb
	Class A Coating Throughout	Class B Coating Throughout	Class C Coating Throughout		
3/8	6.5	6.2	5.9	0.065	0.24
7/16	8.8	8.4	8.0	0.091	0.32
1/2	11.5	11.0	10.5	0.119	0.42
9/16	14.5	13.8	13.2	0.147	0.53
5/8	18.0	17.2	16.4	0.182	0.65
11/16	21.5	20.5	19.5	0.221	0.79
3/4	26.0	24.8	23.6	0.268	0.95
13/16	30.0	28.6	27.3	0.311	1.10
7/8	35.0	33.4	31.8	0.361	1.28
15/16	40.0	38.2	36.4	0.414	1.47
1	45.7	43.6	41.5	0.471	1.67
1 1/8	57.8	55.1	52.5	0.596	2.11
1 1/4	72.2	68.9	65.6	0.745	2.64
1 3/8	87.8	83.8	79.8	0.906	3.21
1 1/2	104.0	99.2	94.5	1.076	3.82
1 5/8	123.0	117.0	112.0	1.270	4.51
1 3/4	143.0	136.0	130.0	1.470	5.24
1 7/8	164.0	150.0	149.0	1.600	6.03
2	186.0	177.0	169.0	1.920	6.85
2 1/8	210.0	200.0	191.0	2.170	7.73
2 1/4	235.0	224.0	214.0	2.420	8.66
2 3/8	261.0	249.0	237.0	2.690	9.61
2 1/2	288.0	275.0	262.0	2.970	10.60
2 5/8	317.0	302.0	288.0	3.270	11.62
2 3/4	347.0	331.0	315.0	3.580	12.74
2 7/8	379.0	362.0	344.0	3.910	13.90
3	412.0	393.0	374.0	4.250	15.11
3 1/4	475.0	453.0	432.0	5.040	18.00
3 1/2	555.0	529.0	504.0	5.830	21.00
3 3/4	640.0	611.0	582.0	6.670	24.00
4	730.0	696.0	664.0	7.590	27.00

TABLE 2 Properties of Single-Class Zinc-Coated Steel Structural Wire Rope (SI Units)

Nominal Diameter, mm	Minimum Breaking Strength in Metric Tons			Approximate Gross Metallic Area, mm^2	Approximate Weight/m, kg
	Class A Coating Throughout	Class B Coating Throughout	Class C Coating Throughout		
9.53	5.9	5.6	5.4	41.9	0.36
11.11	8.0	7.6	7.3	58.7	0.48
12.70	10.4	10.0	9.5	76.8	0.62
14.29	13.2	12.5	12.0	94.8	0.79
15.88	16.3	15.6	14.9	117.4	0.97
17.46	19.5	18.6	17.7	142.6	1.18
19.05	23.6	22.5	21.4	172.9	1.41
20.64	27.2	25.9	24.8	200.7	1.64
22.23	31.8	30.3	28.8	232.9	1.90
23.81	36.3	34.7	33.0	267.1	2.19
25.40	41.5	39.6	37.6	303.9	2.48
28.58	52.4	50.0	47.6	384.5	3.14
31.75	65.5	62.5	59.5	480.7	3.93
34.93	79.7	76.0	72.4	584.6	4.78
38.10	94.3	90.0	85.7	694.2	5.68
41.28	112.0	106.0	101.0	819.4	6.71
44.45	130.0	124.0	118.0	948.4	7.80
47.63	149.0	142.0	135.0	1090.4	8.97
50.80	169.0	161.0	153.0	1238.8	10.19
53.98	190.0	182.0	173.0	1400.1	11.50
57.15	213.0	203.0	194.0	1561.4	12.89
60.33	237.0	226.0	215.0	1735.6	14.30
63.50	261.0	249.0	238.0	1916.2	15.77
66.68	288.0	274.0	261.0	2109.8	17.29
69.85	315.0	300.0	286.0	2309.8	18.96
73.03	344.0	328.0	312.0	2522.7	20.68
76.20	374.0	356.0	340.0	2742.1	22.48
82.55	431.0	411.0	392.0	3251.8	26.78
88.90	504.0	480.0	458.0	3761.5	31.25
95.25	581.0	554.0	528.0	4303.5	35.71
101.60	662.0	632.0	602.0	4897.1	40.18

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TABLE 3 Properties of Multi-Class Zinc-Coated Steel Structural Wire Rope (Inch-Pound Units)

Nominal Diameter, in.	Minimum Breaking Strength in Tons of 2000 lb: Class A Coating Throughout	Class B Coating Outer Wires Class A Coating Inner Wire	Class C Coating Outer Wires Class A Coating Inner Wires	Approximate Gross Metallic Area, in.^{2}	Approximate Weight/ft, lb
3/8	6.5	6.3	6.1	0.065	0.24
7/16	8.8	8.5	8.2	0.091	0.32
1/2	11.5	11.1	10.7	0.119	0.42
9/16	14.5	14.0	13.5	0.147	0.53
5/8	18.0	17.4	16.8	0.182	0.65
11/16	21.5	20.8	20.0	0.221	0.79
3/4	26.0	25.1	24.2	0.268	0.95
13/16	30.0	29.0	28.0	0.311	1.10
7/8	35.0	33.8	32.6	0.361	1.28
15/16	40.0	38.6	37.3	0.414	1.47
1	45.7	44.1	42.6	0.471	1.67
1 1/8	57.8	55.8	53.9	0.596	2.11
1 1/4	72.2	69.7	67.3	0.745	2.64
1 3/8	87.8	84.8	81.8	0.906	3.21
1 1/2	104.0	100.0	96.9	1.076	3.82
1 5/8	123.0	120.0	117.0	1.270	4.51
1 3/4	143.0	140.0	136.0	1.470	5.24
1 7/8	164.0	160.0	156.0	1.690	6.03
2	186.0	182.0	177.0	1.920	6.85
2 1/8	210.0	205.0	200.0	2.170	7.73
2 1/4	235.0	230.0	224.0	2.420	8.66
2 3/8	261.0	255.0	249.0	2.690	9.61
2 1/2	288.0	281.0	275.0	2.970	10.60
2 5/8	317.0	310.0	302.0	3.270	11.62
2 3/4	347.0	339.0	331.0	3.580	12.74
2 7/8	379.0	372.0	365.0	3.910	13.90
3	412.0	405.0	397.0	4.250	15.11
3 1/4	475.0	466.0	457.0	5.040	18.00
3 1/2	555.0	545.0	534.0	5.830	21.00
3 3/4	640.0	628.0	616.0	6.670	24.00
4	730.0	717.0	703.0	7.590	27.00

be so graduated that the smallest division corresponds to a strain not larger than 0.0001 in./in. (0.0001 mm/mm) of gage length. Apply a load corresponding to the tensile stress indicated in Table 5, using the nominal diameter of the specimen. Maintain this load while a 10-in. extensometer is attached and adjusted to the initial setting shown in Table 5. Then increase the load uniformly until the extensometer indicates an extension of 0.07 in. (1.78 mm) or 0.7 % extension. Record the load for this extension. The stress corresponding to this load shall meet the requirements for the stress of 0.7 % extension specified in Table 6, depending on the class of coating under consideration. Hold the specimen at 0.7 % extension under load and remove the extensometer used to measure the stress at 0.7 % extension; then replace it with an elongation extensometer. Continue the application of load until fracture occurs. Record the elongation attained from the elongation extensometer and add to it 0.7 % obtained from the stress at 0.7 % extensometer to get the total elongation.

6.2.2 *Autographic Extensometer*—When an autographic extensometer is used, it shall have a gage length of at least 2 in. (50.8 mm) and the magnification of strain shall not be less than 250. Apply a load, corresponding to the tensile stress indicated in Table 5, using the nominal diameter of the specimen. Maintain this load and attach the extensometer. Then increase the load uniformly until the extension recorded by the extensometer is at least 0.7 %. Determine the load at 0.7 % extension from the load-strain curve. The stress corresponding to this load shall meet the requirements for stress at 0.7 % extension prescribed in Table 6, depending on the class of coating under consideration. Hold the specimen at 0.7 % extension under load and remove the extensometer used to measure the stress at 0.7 % extension; then replace it with an elongation extensometer. Continue the application of load until fracture occurs. Record the elongation attained from the elongation extensometer and add to it 0.7 % obtained from the stress at 0.7 % extensometer to get the total elongation.

NOTE 1—The extensometer used for the stress at 0.7 % extension and the elongation extensometer may be the same instrument. Two separate instruments are advisable in that the more sensitive stress at 0.7 % extensometer which could be damaged when the wire fractures, may be removed following the determination of the 0.7 % extension. The elongation extensometer may be constructed with less sensitive parts or be constructed in such a way that little damage would result if fracture occurs while the extensometer is attached to the specimen.

6.3 *Elongation*—In determining total elongation (elastic plus plastic extension) autographic or extensometer methods may be employed. If fracture takes place outside the middle third of the gage length, the elongation value obtained may not be representative of the material.

6.4 *Tensile Strength*—The tensile strength is determined from the maximum load during the total elongation test.

6.5 *Ductility of Steel*—The zinc-coated wire, prior to fabrication into wire rope, shall be capable of being wrapped two turns in a close helix at a rate not exceeding 15 turns/min

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TABLE 4 Properties of Multi-Class Zinc-Coated Steel Structural Wire Rope (SI Units)

Nominal Diameter, mm	Minimum Breaking Strength in Metric Tons			Approximate Gross Metallic Area, mm²	Approximate Weight/m, kg
	Class A Coating Throughout	Class B Coating Outer Wires Class A Coating Inner Wires	Class C Coating Outer Wires Class A Coating Inner Wire		
9.53	5.9	5.7	5.5	41.9	0.36
11.11	8.0	7.7	7.4	58.7	0.48
12.70	10.4	10.1	9.7	76.8	0.62
14.29	13.2	12.7	12.2	94.8	0.79
15.88	16.3	15.8	15.2	117.4	0.97
17.46	19.5	18.9	18.1	142.6	1.18
19.05	23.6	22.8	22.0	172.9	1.41
20.64	27.2	26.3	25.4	200.7	1.64
22.23	31.8	30.7	29.6	232.9	1.90
23.81	36.3	35.0	33.8	267.1	2.19
25.40	41.5	40.0	38.6	303.9	2.48
28.58	52.4	50.6	48.9	384.5	3.14
31.75	65.5	63.2	61.1	480.7	3.93
34.93	79.7	76.9	74.2	584.6	4.78
38.10	94.3	91.2	87.9	694.2	5.68
41.28	112.0	109.0	106.0	810.4	6.71
44.45	130.0	127.0	124.0	948.4	7.80
47.63	149.0	145.0	142.0	1090.4	8.97
50.80	169.0	165.0	161.0	1238.8	10.19
53.98	190.0	186.0	182.0	1400.1	11.50
57.15	213.0	208.0	203.0	1561.4	12.89
60.33	237.0	231.0	226.0	1735.6	14.30
63.50	261.0	255.0	249.0	1916.2	15.77
66.68	288.0	281.0	274.0	2109.8	17.29
69.85	315.0	308.0	300.0	2309.8	18.96
73.03	344.0	338.0	331.0	2522.7	20.68
76.20	374.0	367.0	360.0	2742.1	22.48
82.55	431.0	423.0	415.0	3251.8	26.78
88.90	504.0	494.0	485.0	3761.5	31.25
92.25	581.0	570.0	559.0	4303.5	35.71
101.60	662.0	650.0	638.0	4897.1	40.18

TABLE 5 Initial Settings for Determining Stress at 0.7 % Extension

Nominal Diameter		Initial Stress		Initial Setting of Extensometer, in./in. or mm/mm
in.	mm	ksi	MPa	
0.040 to 0.089, incl	1.270 to 2.283, incl	14	100	0.0005 (0.05 % extension)
0.090 to 0.119, incl	2.286 to 3.045, incl	28	190	0.0010 (0.10 % extension)
0.120 and larger[A]	3.048 and larger[A]	42	290	0.0015 (0.15 % extension)

[A] This is not to imply that larger wire will be manufactured to any unlimited diameter. It only implies that the wire sizes chosen by the strand manufacturer must meet the requirements of this specification.

TABLE 6 Mechanical Requirements

Zinc Coating Class	Nominal Diameter		Stress at 0.7 % Extension Under Load, min		Tensile Strength, min		Total Elongation in 10 in. or 250 mm, min, %
	in.	mm	psi	MPa	psi	MPa	
A	0.040 to 0.110	1.016 to 2.794	150 000	1030	220 000	1520	2.0
	0.111 and larger[A]	2.820 and larger[A]	160 000	1100	220 000	1520	4.0
B	0.090 and larger[A]	2.286 and larger[A]	150 000	1030	210 000	1450	4.0
C	0.090 and larger[A]	2.286 and larger[A]	140 000	970	200 000	1380	4.0

[A] This is not to imply that larger wire will be manufactured to any unlimited diameter. It only implies that the wire sizes chosen by the strand manufacturer must meet the requirements of this specification.

around a cylindrical steel mandrel equal to three times the nominal diameter of the wire under test without fracture of the wire.

6.6 *Weight of Zinc Coating*—The weight of the zinc coating on the individual wires prior to the fabrication of the wire rope shall be not less than that specified in Table 7 when tested in accordance with the stripping test of Test Method A90/A90M.

6.7 *Adherence of Coating*—The zinc-coated wire, prior to fabrication into wire rope, shall be capable of being wrapped two turns in a close helix at a rate not exceeding 15 turns/min around a cylindrical steel mandrel equal to five times the nominal diameter of the wire under test without cracking or flaking the zinc coating to such an extent that any zinc can be removed by rubbing with the bare fingers. Loosening or detachment during the adherence test of superficial small particles of zinc, formed by mechanical polishing of the surface of zinc-coated wire, shall not be considered cause for rejection.

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TABLE 7 Minimum Weight of Coating

Nominal Diameter of Coated Wire		Weight of Zinc Coating, min					
		oz/ft²of Uncoated Wire Surface			g/m² of Uncoated Wire Surface		
in.	mm	Class A Coating	Class B Coating	Class C Coating	Class A Coating	Class B Coating	Class C Coating
0.040 to 0.061, incl	1.016 to 1.549, incl	0.40	0.80	1.20	122	244	366
0.062 to 0.079, incl	1.575 to 2.007, incl	0.50	1.00	1.50	153	305	458
0.080 to 0.092, incl	2.032 to 2.337, incl	0.60	1.20	1.80	183	366	549
0.093 to 0.103, incl	2.362 to 2.616, incl	0.70	1.40	2.10	214	427	641
0.104 to 0.119, incl	2.642 to 3.023, incl	0.80	1.60	2.40	244	488	732
0.120 to 0.142, incl	3.048 to 3.607, incl	0.85	1.70	2.55	259	519	778
0.143 to 0.187, incl	3.632 to 4.750, incl	0.90	1.80	2.70	275	549	824
0.188 and larger[A]	4.775 and larger[A]	1.00	2.00	3.00	305	610	915

[A] This is not to imply that larger wire will be manufactured to any unlimited diameter. It only implies that the wire sizes chosen by the strand manufacturer must meet the requirements of this specification.

6.8 *Finish*—The zinc-coated wire surface shall be free of imperfections not consistent with good commercial practice. The coating shall be continuous and reasonably uniform.

NOTE 2—It is recognized that the surface of heavy zinc coatings, particularly those produced by the hot-dip galvanizing process, are not perfectly smooth and not devoid of irregularities.

7. Test for Coating Weight

7.1 The weight of the zinc coating shall be determined by a stripping test made on the individual wires prior to fabrication of strand, in accordance with Test Method A90/A90M.

8. Wire Rope

8.1 The zinc-coated wire rope shall consist of a plurality of strands helically preformed and laid around a core composed of a strand or another wire rope. The number and size of wires and the number of layers of wires in the strands shall be determined by the manufacturer.

8.2 The wire rope properties are shown in Tables 1-4.

8.3 When specified, the wire rope shall be prestretched. The prestretched rope shall meet the minimum modulus of elasticity as shown in Table 8.

9. Joints and Splices

9.1 No splicing or joining of strands shall be permitted in the manufactured length of rope.

9.2 Welds made prior to wire drawing are permitted. Joining of wires by welding during the stranding operation is permissible, and such joints shall be dispersed sufficiently so as to maintain the minimum breaking strength as listed in Tables 1-4. Joints made during stranding in any wire shall be recoated in a workmanlike manner with zinc or a lead-zinc compound containing a minimum of 50 % zinc.

10. Sampling and Testing of Rope

10.1 If specified, a test specimen shall be taken from each manufactured length of wire rope and tested to minimum breaking strength. If a specimen fails to attain a strength equal to 95 % of the minimum breaking strength requirement, the wire rope represented shall be rejected. If a specimen attains a strength equal to at least 95 % but less than 100 % of the minimum breaking strength requirement, two additional test specimens shall be cut from the same manufactured length and tested. If the average test results of the original specimen and the two retest specimens fail to meet the minimum breaking strength requirement, the wire rope shall be rejected. Any test, however, that fails due to faulty attachment of the sockets shall be disregarded.

11. Rejection and Retest of Wire

11.1 If any wire test specimens breaking within the grips or the jaws of the testing machine results in values below the specified limits for tensile strength, stress at 0.7 % extension or elongation, the results shall be considered invalid and retesting shall be required.

11.2 In case there is reasonable doubt in the first trial as the ability of the wire to meet the requirements of Sections 6 and 7, two additional tests shall be made on samples of wire from the same coil or reel. If failure occurs in either of these tests, the wire shall be rejected.

12. Inspection

12.1 All tests and inspection shall be made at the place of manufacture unless otherwise specified and shall be so conducted as not to interfere unnecessarily with the operation of the works. The manufacturer shall afford the inspector representing the purchaser all reasonable facilities to satisfy the inspector that the material is being furnished in accordance with this specification. When specified, inspection may be waived, and certified copies of test reports furnished.

13. Packaging

13.1 Structural wire rope shall be packaged in coils or on reels at the discretion of the manufacturer unless otherwise

TABLE 8 Minimum Modulus of Elasticity of Prestretched Structural Wire Rope

Nominal Diameter Wire Rope		Minimum Modulus—Class A Coating[A]	
in.	mm	psi	GPa
3/8 to 4	9.52 to 101.60	20 000 000	140

[A] For Class B or Class C weight of zinc-coated outer wires, reduce minimum modulus 1 000 000 psi or 7 GPa. For Class B or Class C weight of zinc-coated wires throughout, consult manufacturer.

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specified. Wire rope shall be packaged in such a manner so that no permanent deformation of wires in the strand or strands in the wire rope will occur.

14. Keywords

14.1 steel wire; wire; wire rope; zinc-coated wire

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Forged Eye Bolts

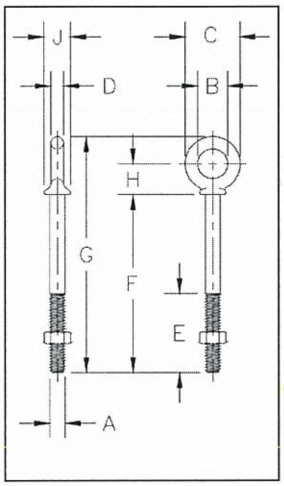
Fatigue Rated® QUIC-CHECK®

SEE APPLICATION AND WARNING INFORMATION
Para Español: www.thecrosbygroup.com
On Page 180-181

Rigging Accessories

G-277

- Forged Steel - Quenched and Tempered.
- Fatigue rated at 1-1/2 times the Working Load Limit at 20,000 cycles.
- Working Load Limits shown are for in-line pull. For angle loading, see page 180.
- Meets or exceeds all requirements of ASME B30.26 including identification, ductility, design factor, proof load and temperature requirements. Importantly, these bolts meet other critical performance requirements including fatigue life, impact properties and material traceability, not addressed by ASME B30.26.
- All Bolts Hot Dip galvanized after threading (UNC).
- Furnished with standard Hot Dip galvanized, heavy hex nuts.



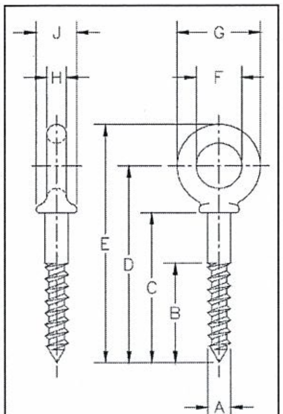
G-277 Shoulder Nut Eye Bolts

Shank Dia. & Length (in.)	G-277 Stock No.	Working Load Limit (lbs.)*	Weight Each Per 100 (lbs.)	Dimensions (in.)								
				A	B	C	D	E	F	G	H	J
1/4 x 2	1045014	650	6.60	.25	.50	.88	.19	1.50	2.00	2.94	.50	.47
1/4 x 4	1045032	650	9.10	.25	.50	.88	.19	2.50	4.00	4.94	.50	.47
5/16 x 2-1/4	1045050	1200	12.50	.31	.62	1.12	.25	1.50	2.25	3.50	.69	.56
5/16 x 4-1/4	1045078	1200	18.80	.31	.62	1.12	.25	2.50	4.25	5.50	.69	.56
3/8 x 2-1/2	1045096	1550	21.40	.38	.75	1.38	.31	1.50	2.50	3.97	.78	.66
3/8 x 4-1/2	1045112	1550	25.30	.38	.75	1.38	.31	2.50	4.50	5.97	.78	.66
1/2 x 3-1/4	1045130	2600	42.60	.50	1.00	1.75	.38	1.50	3.25	5.12	1.00	.91
1/2 x 6	1045158	2600	56.80	.50	1.00	1.75	.38	3.00	6.00	7.88	1.00	.91
5/8 x 4	1045176	5200	68.60	.62	1.25	2.25	.50	2.00	4.00	6.44	1.31	1.12
5/8 x 6	1045194	5200	102.40	.62	1.25	2.25	.50	3.00	6.00	8.44	1.31	1.12
3/4 x 4-1/2	1045210	7200	144.50	.75	1.50	2.75	.62	2.00	4.50	7.44	1.56	1.38
3/4 x 6	1045238	7200	167.50	.75	1.50	2.75	.62	3.00	6.00	8.94	1.56	1.38
7/8 x 5	1045256	10600	225.00	.88	1.75	3.25	.75	2.50	5.00	8.46	1.84	1.56
1 x 6	1045292	13300	366.30	1.00	2.00	3.75	.88	3.00	6.00	9.97	2.09	1.81
1 x 9	1045318	13300	422.50	1.00	2.00	3.75	.88	4.00	9.00	12.97	2.09	1.81
1-1/4 x 8	1045336	21000	650.00	1.25	2.50	4.50	1.00	4.00	8.00	12.72	2.47	2.28
1-1/4 x 12	1045354	21000	795.00	1.25	2.50	4.50	1.00	4.00	12.00	16.72	2.47	2.28
1-1/2 x 15	1045372	24000	1425.00	1.50	3.00	5.50	1.25	6.00	15.00	20.75	3.00	2.75

*Ultimate Load is 5 times the Working Load Limit. Maximum Proof Load is 2 times the Working Load Limit.

G-275

- Forged Steel — Quenched and Tempered.
- Hot Dip galvanized.



G-275 Screw Eye Bolts

Shank Dia. & Length (in.)	G-275 Stock No.	Weight Per 100 (lbs.)	Dimensions (in)								
			A	B	C	D	E	F	G	H	J
1/4 x 2	1046111	4.30	.25	1.50	2.00	2.50	2.94	.50	.88	.19	.47
5/16 x 2-1/4	1046139	9.90	.31	1.69	2.25	2.94	3.50	.63	1.13	.25	.56
3/8 x 2-1/2	1046157	18.88	.38	1.88	2.50	3.28	3.97	.75	1.38	.31	.66
1/2 x 3-1/4	1046175	37.50	.50	2.44	3.25	4.25	5.12	1.00	1.75	.38	.91
5/8 x 4	1046193	85.50	.63	3.00	4.00	5.31	6.44	1.25	2.25	.50	1.12

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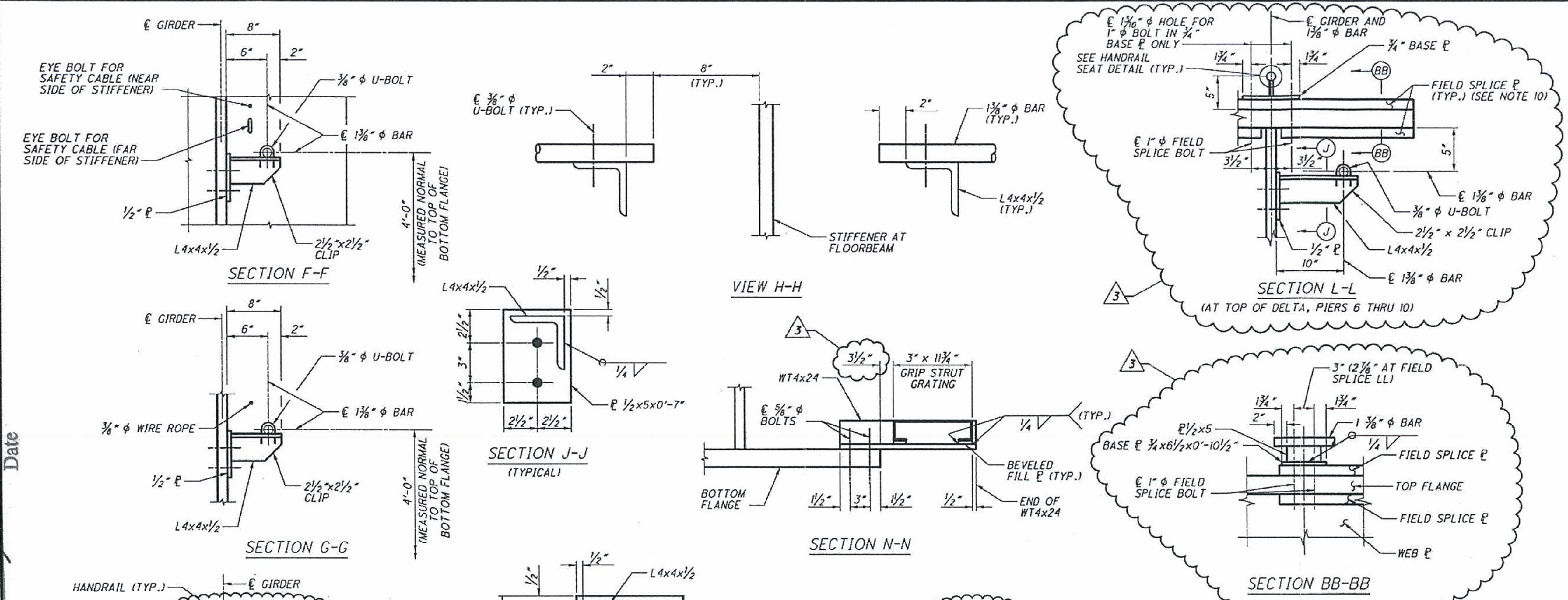

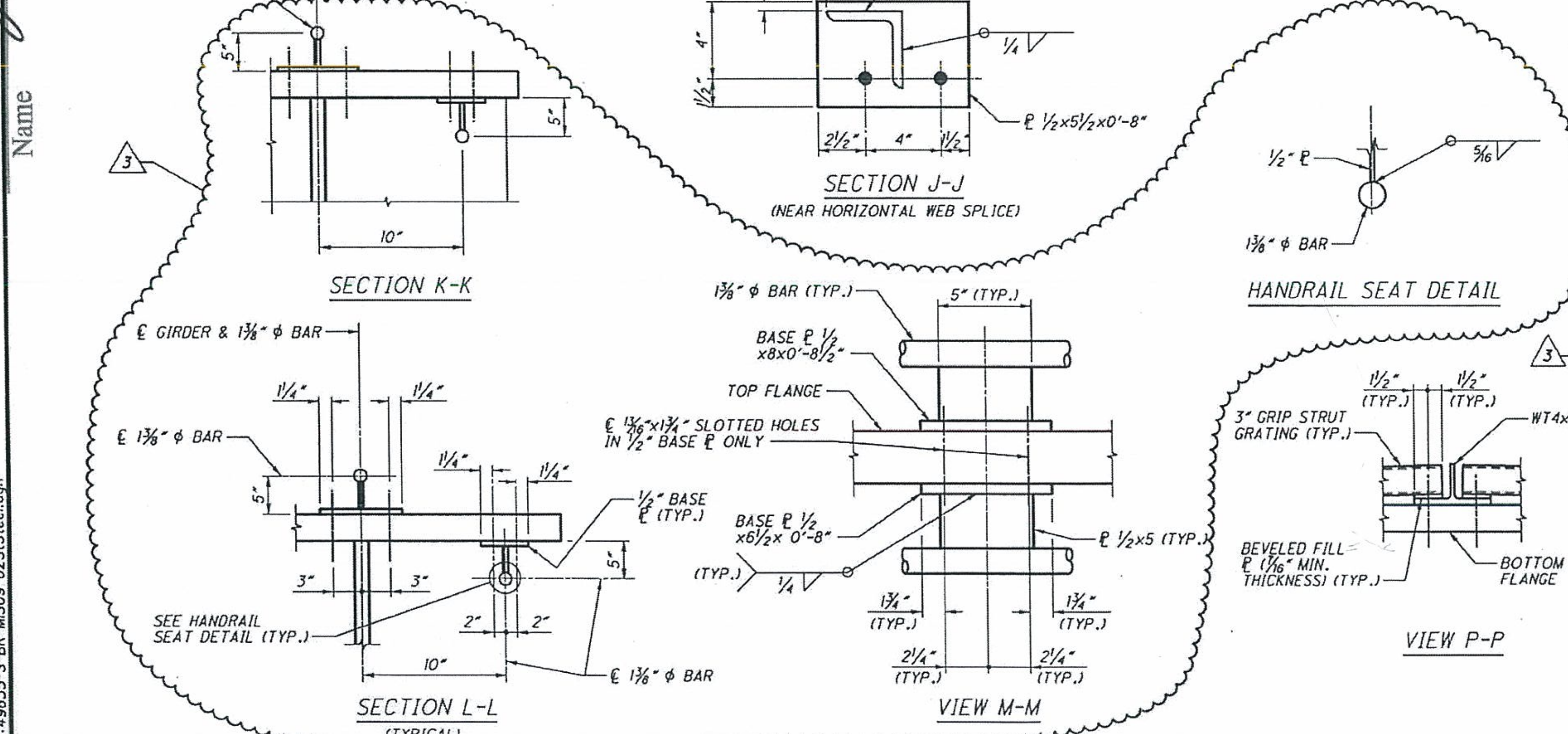

NOTES:

1. FOR LOCATION OF SECTIONS F-F, G-G, J-J, K-K, L-L, & N-N, SEE SHEET 77/84.
2. FOR LOCATION OF VIEWS H-H, M-M, & P-P, SEE SHEET 77/84.
3. ALL STEEL USED FOR THE FABRICATION AND ASSEMBLY OF THE GIRDER HANDRAIL AND WALKWAY SHALL MEET THE REQUIREMENTS OF ASTM A709, GRADE 50, AND BE GALVANIZED PER CMS 711.02, UNLESS NOTED OTHERWISE.
4. WELDING SHALL BE IN ACCORDANCE WITH AWS D1.1, CURRENT EDITION.
5. WELDING FILLER METAL SHALL BE MATCHING.
6. BOLTS CONNECTING THE HANDRAIL SHALL BE ¾" ϕ. ALL BOLTS SHALL BE ASTM A325, TYPE I, GALVANIZE PER CMS 711.02, WITH COMPLIMENTARY CIRCULAR FLAT WASHER AND HEAVY HEX NUT, UNLESS NOTED OTHERWISE.
7. HOLES IN STEEL COMPONENTS FOR A325 BOLTS SHALL BE 1/16" LARGER IN DIAMETER THAN THE ASSOCIATED BOLTS, UNLESS NOTED OTHERWISE.
8. GRIP STRUT GRATING SHALL BE MCNICHOLS 12 GA.-5 DIAMOND PLANK, 11¾" WIDE x 3" DEEP. THERE SHALL BE A MINIMUM OF 6 GRATING FASTENERS PER PANEL. INSTALL IN ACCORDANCE WITH MANUFACTURER'S RECOMMENDATIONS. FIELD DRILL HOLES IN WT4x24 TO ACCOMMODATE GRATING FASTENERS.
9. SAFETY CABLE SHALL BE ⅜" ϕ WIRE ROPE, MANUFACTURED IN ACCORDANCE WITH ASTM A603, CLASS A COATING. PER ATTACHMENT, PROVIDE 1 - ¾"x4½" CROSBY FORGED SHOULDER NUT EYE BOLT, 3 FORGED CROSBY WIRE ROPE CLIPS WITH 10" MIN. ROPE TURNBACK AND 1 CROSBY OPEN PATTERN WIRE ROPE THIMBLE. ALL HARDWARE SHALL BE GALVANIZED IN ACCORDANCE WITH ASTM A153. THE SAFETY CABLE SHALL BE INSTALLED SNUG TIGHT AND PER MANUFACTURER'S RECOMMENDATIONS.
10. FOR FIELD SPLICE NOTES AND DETAILS, SEE SHEETS 29/84 AND 30/84.

STATE OF OHIO — HANS REED HUTTON — E-73282 — PROFESSIONAL ENGINEER
11-23-11

NO.	REVISIONS	DATE
B	FINAL SUBMITTAL	04/14/11
C	FINAL SUBMITTAL - REVISED	06/09/11
D	FINAL SUBMITTAL - REVISED	08/09/11
1	APPROVED FOR CONSTRUCTION	09/21/11
2	NOC 0027	10/21/11
3	RFI 00143	11/16/11

CLEVELAND'S INNERBELT BRIDGE — OHIO DEPARTMENT OF TRANSPORTATION
DESIGN AGENCY: WALSH CONSTRUCTION — HNTB

MAIN SPAN
UNIT 2
STRUCTURAL STEEL

CATWALK AND ACCESS DETAILS
BRIDGE NO. CUY-90-1532
I-90 WEST BOUND

DESIGNED	DRAWN	REVIEWED	DATE
MCC	CEM	HRH	09/21/11
CHECKED	CHECKED	STRUCTURE FILE NUMBER	
CMS	MX	1809431	

CUY-90-14.90
PID No. 77332/85531

Date: 11/17/2011
Model: Sheet1
File: 49633-S-BR-MIS09-U2StSteel.dgn