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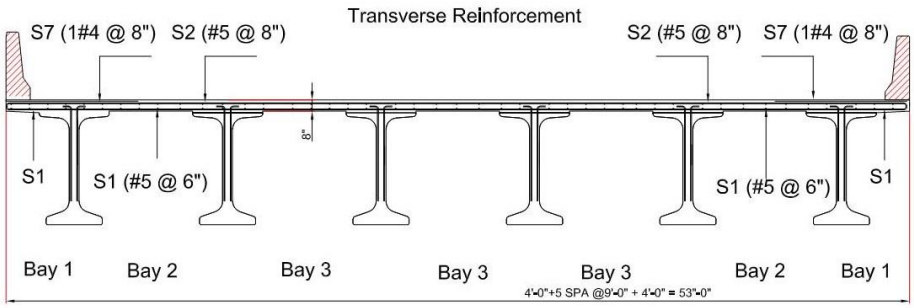
Project:	PennDOT Project	Designed By:	MM	Date:	06/24/2016		
Subject:	Utilizing MMFX in Deck Slab Design	Checked By:	AG	Sheet	1	of	34

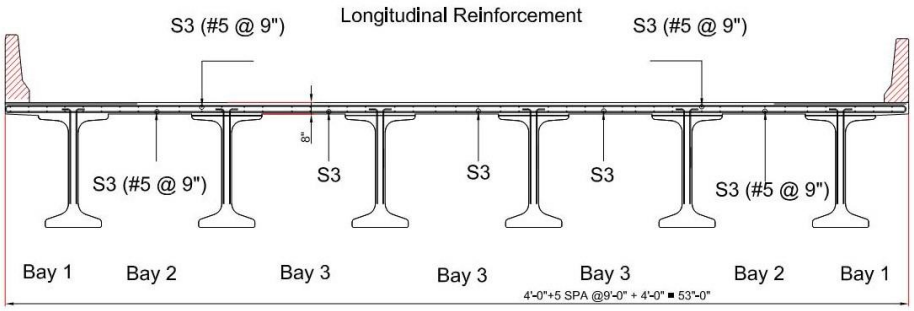
Project:

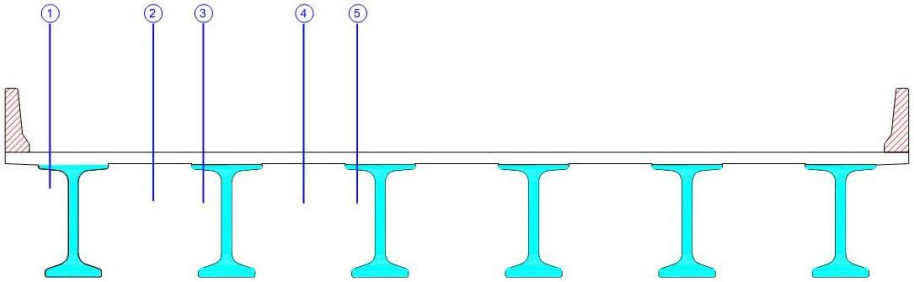
OPTIMIZING DECK SLAB REINFORCEMENT

UTILIZING CHROMX 9100 or 4100

For PennDOT







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1. INTRODUCTION

The purpose of this report is to optimize the deck reinforcement quantity for PennDOT utilizing ChromX 9100, or 4100 (Grade 75, or 100 ksi).

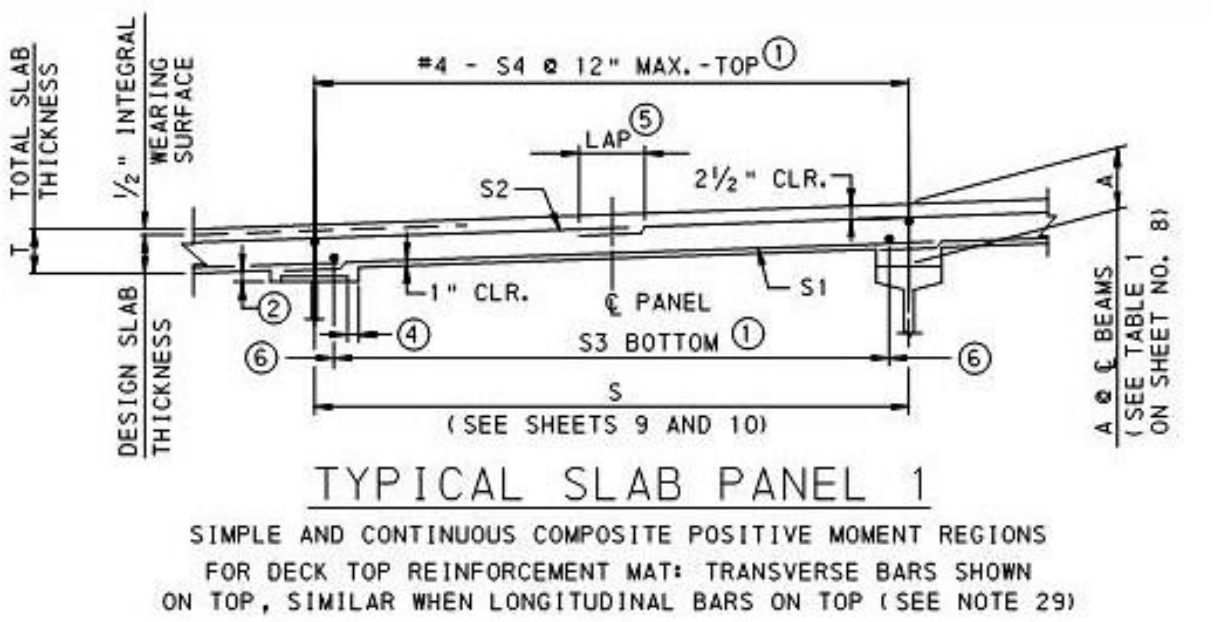
2.1 Concrete

Cast in place deck $f'_c = 4.5$ ksi

2.2 Reinforcement

Epoxy-Coated Steel Reinforcing Bars ASTM A775/ A775M-17 $F_y = 60$ ksi
ChromX 9100, or 4100 Steel ASTM A1035 Designed at $F_y = 75$ ksi
ChromX 9100, or 4100 Steel ASTM A1035 Designed at $F_y = 100$ ksi

2.3 Slab Panel Section



TYPICAL SLAB PANEL 1

SIMPLE AND CONTINUOUS COMPOSITE POSITIVE MOMENT REGIONS
FOR DECK TOP REINFORCEMENT MAT: TRANSVERSE BARS SHOWN
ON TOP, SIMILAR WHEN LONGITUDINAL BARS ON TOP (SEE NOTE 29)

e.construct

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2.4 Steel Details Provided by Client

Please See PennDOT Drawings titled (Standard Concrete Deck Slab Design & Details for Beam and Bridges)

9 ft span selected for analysis

TABLE 4: DISTANCE FROM DESIGN SECTION FOR NEGATIVE MOMENT TO CENTERLINE OF BEAM = 12 IN.

USE FOR:
- **PRECAST PRESTRESSED PA BULB-TEE AND I-BEAMS WITH TOP FLANGE WIDTH ≥ 36"**
- **STEEL I-BEAMS OR STEEL CLOSED BOXES WITH TOP FLANGE WIDTH ≥ 48"**

S	T(in.)	S1	S2	S3	S7+	So	L	NOTES
4'-3"	8	#5 @9-1/2	#5 @11-1/2	#4 @9	1#6	2'-8"	3'-9"	
4'-7"	8	#5 @9-1/2	#5 @11-1/2	#4 @9	1#6	2'-10"	3'-9"	
4'-11"	8	#5 @9	#5 @11-1/2	#4 @9	1#6	3'-1"	3'-9"	
5'-2"	8	#5 @9	#5 @11-1/2	#4 @9	1#6	3'-3"	3'-9"	
5'-6"	8	#5 @9	#5 @11-1/2	#4 @8-1/2	1#6	3'-5"	3'-9"	
5'-10"	8	#5 @9	#5 @11-1/2	#4 @8-1/2	1#6	3'-8"	3'-10"	
6'-2"	8	#5 @8-1/2	#5 @11-1/2	#4 @8	1#6	3'-10"	3'-11"	
6'-6"	8	#5 @8	#5 @11-1/2	#4 @7-1/2	1#6	4'-1"	4'-1"	
6'-10"	8	#5 @8	#5 @11	#4 @7-1/2	1#6	4'-3"	4'-0"	
7'-2"	8	#5 @7-1/2	#5 @11	#5 @11	1#6	4'-6"	4'-0"	
7'-6"	8	#5 @7	#5 @10	#5 @11	1#5	4'-8"	3'-10"	
7'-10"	8	#5 @7	#5 @9-1/2	#5 @10	1#5	4'-10"	3'-10"	
8'-2"	8	#5 @7	#5 @9	#5 @10	1#5	4'-11"	3'-10"	
8'-6"	8	#5 @7	#5 @9	#5 @10	1#5	4'-11"	3'-10"	
8'-10"	8	#5 @6-1/2	#5 @8-1/2	#5 @9-1/2	1#4	4'-8"	3'-9"	
9'-2"	8	#5 @6	#5 @8	#5 @9	1#4	4'-10"	3'-8"	
9'-6"	8	#5 @6	#5 @7-1/2	#5 @9	1#4	4'-11"	3'-5"	A,C
9'-10"	8	#5 @5-1/2	#5 @7	#5 @8-1/2	1#4	5'-1"	3'-5"	A,C
10'-2"	8	#5 @5-1/2	#5 @7	#5 @8-1/2	1#4	5'-1"	3'-4"	A,C
10'-5"	8	#5 @5-1/2	#5 @6-1/2	#5 @7-1/2	1#4	5'-4"	4'-0"	A,C
10'-9"	8	#5 @5-1/2	#5 @6	#5 @7-1/2	1#4	5'-6"	4'-0"	A,C
11'-1"	8-1/2	#5 @5-1/2	#5 @6	#5 @7-1/2	1#4	5'-10"	4'-0"	A,C
11'-5"	8-1/2	#5 @5-1/2	#5 @5-1/2	#5 @7-1/2	---	4'-10"	---	B,C
11'-9"	8-1/2	#5 @5-1/2	#5 @5-1/2	#5 @7-1/2	---	4'-10"	---	B,C
12'-1"	9	#5 @5-1/2	#5 @5-1/2	#5 @7-1/2	---	5'-0"	---	B,C
12'-5"	9	#5 @5-1/2	#6 @7	#5 @7-1/2	---	5'-3"	---	B,C
12'-9"	9	#6 @7	#6 @7	#5 @7	---	5'-3"	---	B,C
13'-1"	9-1/2	#5 @5-1/2	#6 @7	#5 @8	---	5'-5"	---	B,C
13'-5"	9-1/2	#5 @5-1/2	#6 @6-1/2	#5 @8	---	5'-8"	---	B,C
13'-9"	9-1/2	#6 @7	#6 @6	#5 @7	---	5'-10"	---	B,C
14'-1"	9-1/2	#5 @5-1/2	#6 @6	#5 @8-1/2	---	5'-10"	---	B,C
14'-5"	9-1/2	#6 @7	#6 @6	#5 @7-1/2	---	5'-10"	---	B,C
14'-9"	9-1/2	#6 @7	#6 @5-1/2	#5 @7-1/2	---	6'-0"	---	
15'-1"	10	#6 @7	#6 @6	#5 @7-1/2	---	6'-0"	---	

2. ANALYSIS

Please refer to FIG-1 for assumed bridge width, deck thickness, beam spacing, and overhang length, which was used in performing the comparison.

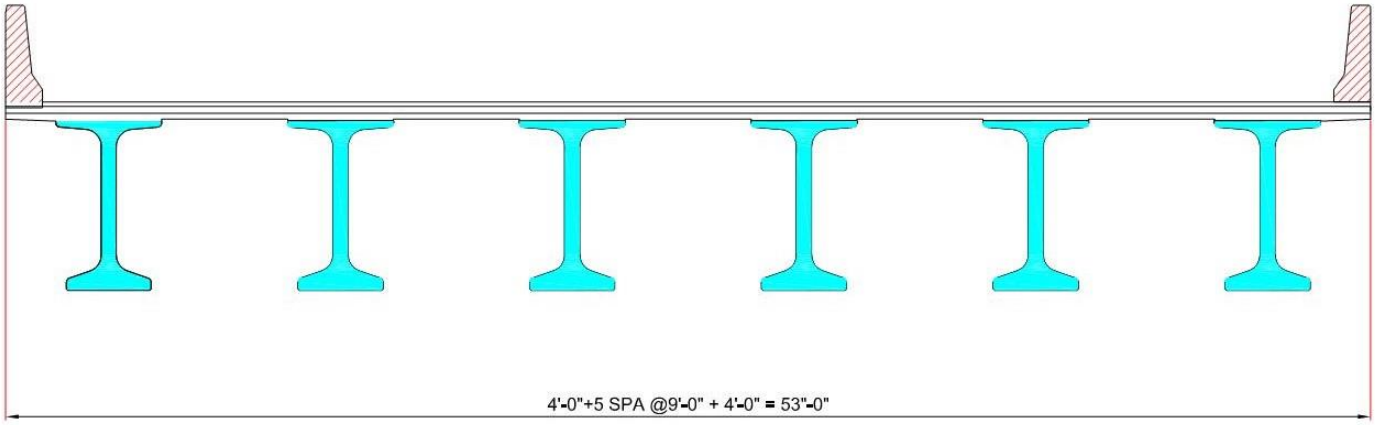


FIG-1 Typical Cross Section

Barrier assumed to resist TL4 crash loading.

Assumed girder span is 120 ft

No splicing allowance is assumed in the calculated weight

3. STRIP WIDTH

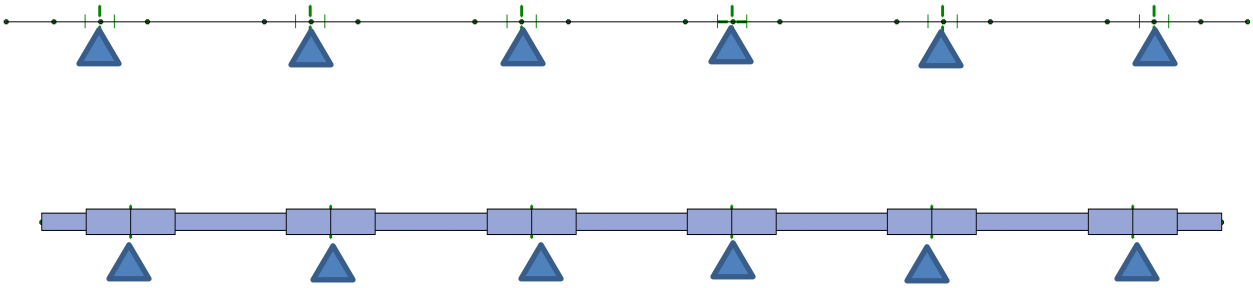
According to the AASHTO LORFD Bridge Design Specifications, Chapter 4:

The strip width for the +M = 26.0 +6.6 S
The strip width for the -M = 48.0 + 3.0 S

Using S= 9', the strip widths are:

The strip width for the +M = 26.0 +6.6 x 9 = 85.4 in. = 7.12 ft
The strip width for the -M = 48.0 + 3.0 x 9 = 75 in. = 6.25 ft

The analysis was performed using RISA 3D. The web of each I-beam was treated as the support for the transverse strip. The flange of the I-beam is assumed to add 3" to the thickness of the deck over a width of 4 feet at the top of the girder. This is conservative. Knowledge of the actual girder dimensions being used may result in further increase in the equivalent slab thickness and reduction of the required negative moment reinforcement.

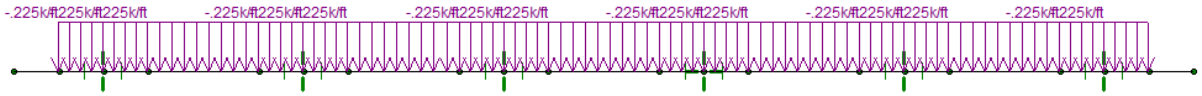


4. LOADING

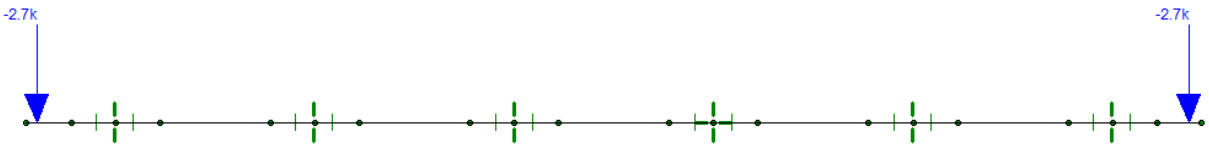
Loads on 6 ft strip width:

Deck Self-weight (assuming unit weight of 0.15 kip/ft^3):

Wearing Surface (37.5 psf):

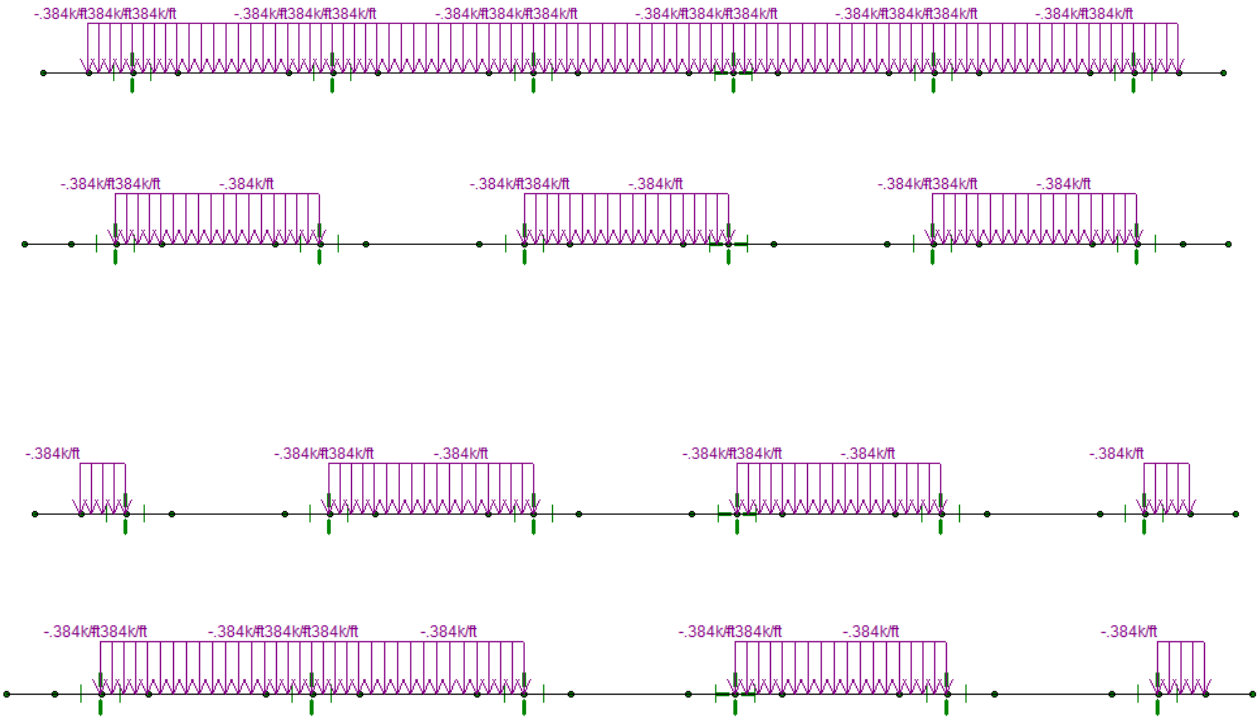


Barrier weight (assuming 450 lb /ft /barrier)



Live loads

The following arrangements for the lane loads of 0.064 ksf x 6 ft = 0.384 k/ft were used



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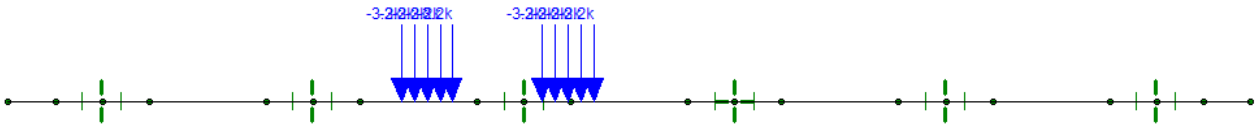
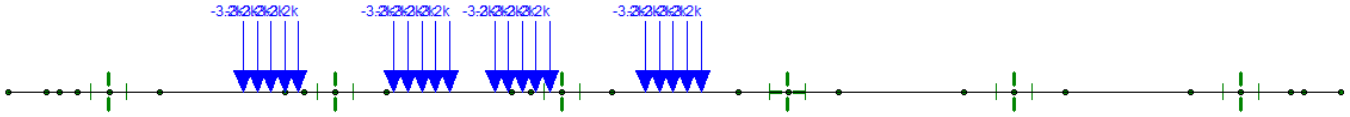
One truck axle (16 kips +16 kips) was used as moving load. It was positioned transversally to produce the most critical effects. Each wheel was distributed over a width of 2.2 ft, which is = the 20 in. in the Specs for foot print of wheel + 6.5 in. to distribute to mid-thickness of slab. . Multiple presence factor = 1.2.



Two axles (16 kips +16 kips + 16 kips + 16 kips) used as moving loads transversally. Each wheel distributed over 2.2 ft . Multiple presence factor = 1.0



5. CRITICAL SECTION LOCATIONS CONSIDEDED

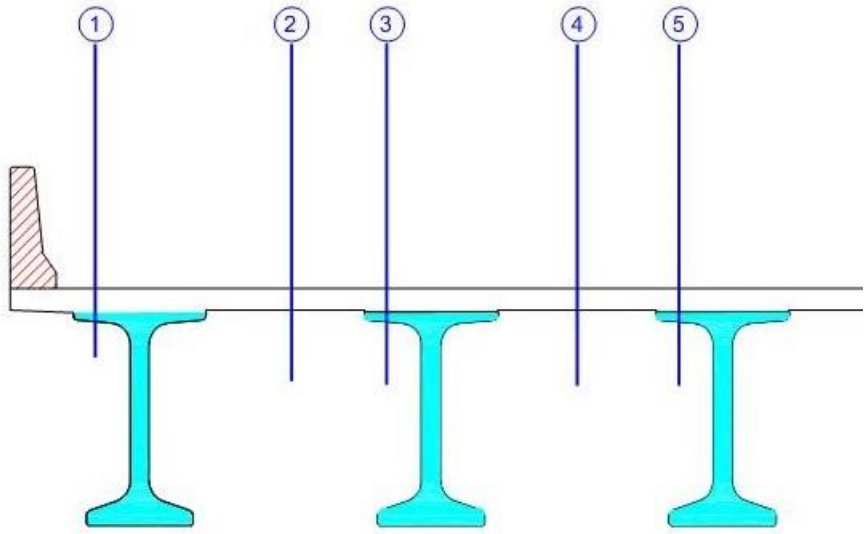


FIG-2 Section Locations

Sections 1, 3 and 5 represent negative moment sections. They are placed at 15 in. from the C.L of the girder web. Sections 2 and 4 are the positive moment sections.

6. SECTION ANALSYSIS RESULTS

The table below shows the moments, in k-ft, due to live loads. The lane load moments, assuming a 6 ft strip width, will be later converted to moment per ft of deck width. . The effects of the truck wheel loads are given as per AASHTO defined strip widths as given earlier and summarized in the bottom table of the following set of tables. Table 1 relates to LL effects. Table 2 represents the dead load effects. Table 3 shows the strip widths used for the overhang, for the positive moment and for the negative moment.

Table 1. Live Load effects

Sec #	Lane load (LL) Moments using 6 ft strip width						Moments /AASHTO strip width
		LL Case 1	LL Case 2	LL Case 3	LL Case 4	Max LL	Truck+I
1	-ve M1	-0.1	0	-0.1	0	-0.1	-10.8
2	+ve M1	1.7	2.9	-1.3	1.8	2.9	34.0
3	-ve M2	-1.6	0	-1.7	-2.5	-2.5	-26.9
4	+ve M2	0.5	-1.8	2.2	1.6	2.2	23.8
5	-ve M3	-1.2	-1.5	0.3	0.9	-1.5	-25.0

Table 2. Dead Load effects

	Moments using 6 ft strip width			
Sec #		Selfweight (SW)	Future Wearing Surface (FWS)	Barriers
1	-ve M1	-2.30	-0.10	-6.10
2	+ve M1	1.20	1.00	-3.00
3	-ve M2	-1.90	-1.00	1.60
4	+ve M2	1.50	0.30	1.30
5	-ve M3	-1.90	-0.70	-0.30

Table 3. AASHTO Strip widths

X(ft)	Support Spacing (ft)	Section	AASHTO Eq. Strip (in.)	AASHTO Eq. Strip (ft)
0.25		Cant.	47.5	4.0
	9	-ve	75.0	6.3
	9	+ve	85.4	7.1

The following tables show the values per actual AASHTO strip width rather than assumed 6 ft width.

Table 4. Service Moments per strip widths

		Moments /AASHTO strip width				
		Loads combinations for crack control checks				
Sec #		SW	FWS	Barriers	Live load	Ms (Service)
1	-ve M1	-2.40	-0.10	-6.35	-10.87	-19.72
2	+ve M1	1.42	1.19	-3.56	37.44	36.49
3	-ve M2	-1.98	-1.04	1.67	-29.50	-30.86
4	+ve M2	1.78	0.36	1.54	26.41	30.09
5	-ve M3	-1.98	-0.73	-0.31	-26.56	-29.58

Table 5. Factored Moment per strip widths

		Moments /AAHSTO strip width				
		Loads combinations for ultimate checks				
Sec #		SW	FWS	Barriers	Live load	Mu
1	-ve M1	-2.40	-0.10	-6.35	-10.87	-30.1
2	+ve M1	1.42	1.19	-3.56	37.44	64.6
3	-ve M2	-1.98	-1.04	1.67	-29.50	-53.6
4	+ve M2	1.78	0.36	1.54	26.41	50.9
5	-ve M3	-1.98	-0.73	-0.31	-26.56	-50.4

The moments in the four tables below are in k-ft/ft of slab width. The resulting reinforcement would be in in^2/ft.

Table 6. Service Moments per foot width of the slab

		Loads combinations for crack control checks				
Sec #		SW	FWS	Barriers	Live load	Ms (Service)
1	-ve M1	-0.38	-0.02	-1.02	-2.75	-4.16
2	+ve M1	0.20	0.17	-0.50	5.26	5.13
3	-ve M2	-0.32	-0.17	0.27	-4.72	-4.94
4	+ve M2	0.25	0.05	0.22	3.71	4.23
5	-ve M3	-0.32	-0.12	-0.05	-4.25	-4.73

Table 7. Factored Moment per foot width of the slab

		Loads combinations for ultimate checks				
Sec #		SW	FWS	Barriers	Live load	Mu
1	-ve M1	-0.38	-0.02	-1.02	-2.75	-6.58
2	+ve M1	0.20	0.17	-0.50	5.26	9.08
3	-ve M2	-0.32	-0.17	0.27	-4.72	-8.57
4	+ve M2	0.25	0.05	0.22	3.71	7.15
5	-ve M3	-0.32	-0.12	-0.05	-4.25	-8.07

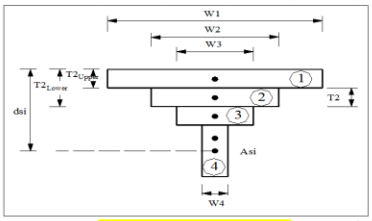
7. FLEXURAL STRENGTH ANALYSIS

The top and bottom clear covers used are 2" and 1", respectively, for both Grade 60 and ChromX steels. Using the information for the section where the largest positive moment occurs (Section #2), and using e.construct's strain compatibility spreadsheet:

8.1 Positive Moment Section

Using Grade 60 steel

Flexural Strength



ε_{cu}	0.003
c=	0.982
a	0.810
Sum of forces	0.00
Design	R/C AASHTO
ANSWER:	
ϕ	0.90
ϕM_n kip-in	129
kip*ft	10.73

Calculate

Av. β_1 : 0.825

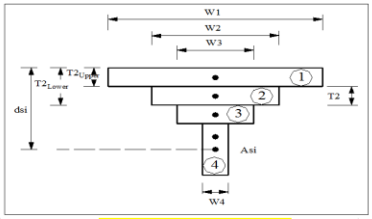
Units in kips and inches

Concrete Layers		f'c	Width, W	Thick., T	Depth, d_c	β_1	T_{upper}	T_{lower}	Revised T	Beta1calcuation			Area	Force	M_n k-in.		
	1	4.500	12.000	7.500	0.405	0.825	0.000	7.500	0.810	36.10588235	43.7647059		9.725	-37.20	-15.07		
				7.500						36.10588235	43.7647059						

Steel Layers		Area A_{si}	Grade	Effective Prest.	Depth d_{si}	E_s	Q	fpy	R	K	ε_{so}	$\Delta\varepsilon$	Total ε_s	Stress	Force	Moment	Modified stress	corresp. f'c
Grade 60 Bars	1	0.31	60	0	2.3125	29000	0	60	100	1.096	0.0000	0.0041	0.0041	60.00	18.60	43.01	60.00	4.50
	2	0.31	60	0	6.1875	29000	0	60	100	1.096	0.0000	0.0159	0.0159	60.00	18.60	115.09	60.00	4.50
	Sum of M									MAXIMUM	$\Delta\varepsilon$:	0.0159		Moment (K	0.00	143.03 kip*in		
																11.92 kip*f		

Using Grade 75 Steel:

Flexural Strength



ε_{cu}	0.003
c=	0.864
a	0.713
Sum of forces	0.00
Design	R/C AASHTO
ANSWER:	
ϕ	0.90
ϕM_n kip-in	116
kip*ft	9.6

Calculate

Av. β_1 : 0.825

Units in kips and inches

Concrete Layers		f'c	Width, W	Thick., T	Depth, d_c	β_1	T_{upper}	T_{lower}	Revised T	Beta1calcuation			Area	Force	M_n k-in.		
	1	4.500	12.000	7.500	0.357	0.825	0.000	7.500	0.713	31.76470588	38.5026738		8.556	-32.73	-11.67		
				7.500						31.76470588	38.5026738						

Steel Layers		Area A_{si}	Grade	Effective Prest.	Depth d_{si}	E_s	Q	fpy	R	K	ε_{so}	$\Delta\varepsilon$	Total ε_s	Stress	Force	Moment	Modified stress	corresp. f'c
Grade 60 Bars	1	0.218181818	75	0	2.3125	29000	0	75	100	1.096	0.0000	0.0050	0.0050	75.00	16.36	37.84	75.00	4.50
	2	0.218181818	75	0	6.2500	29000	0	75	100	1.096	0.0000	0.0187	0.0187	75.00	16.36	102.27	75.00	4.50
	Sum of M									MAXIMUM	$\Delta\varepsilon$:	0.0187		Moment (K"):	0.00	128.45 kip*in		
																10.70 kip*f		

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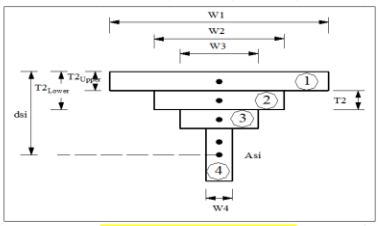
Using ChromX 9100:

Flexural Strength



ε_{cu}	0.003
c=	1.005
a	0.829
Sum of forces	0.00
Design	R/C AASHTO

Calculate

ANSWER:

ϕ	0.90
ϕM_n kip-in	131
kip*ft	10.9

Av. β_1 : 0.825

Units in kips and inches

Concrete Layers		f'c	Width, W	Thick., T	Depth, d_c	β_1	T_{upper}	T_{lower}	Revised T	Beta1calcuation			Area	Force	M_n k-in.
	1	4.500	12.000	7.500	0.415	0.825	0.000	7.500	0.829	36.94759313	44.7849614		9.952	-38.07	-15.79
				7.500						36.94759313	44.7849614				

Steel Layers		Area A_{si}	Grade	Effective Prest.	Depth d_{si}	E_s	Q	kpy	R	K	ε_{so}	$\Delta\varepsilon$	Total ε_s	Stress	Force	Moment	Modified stress	corresp. f'c
Grade 72.5 Bars	1	0	72.5	0	0	29000	0	72.5	100	1.096	0.0000	0.0000	-0.0030	-72.50	0.00	0.00	-68.68	4.50
MMFX Bars	2	0.22	100	0	2.25	29000	0.035	140	2.042	1.02	0.0000	0.0037	0.0037	87.32	19.21	43.22	87.32	4.50
MMFX Bars	3	0.19	100	0	6.250	29000	0.035	140	2.042	1.02	0.0000	0.0157	0.0157	100.00	18.86	117.86	100.00	4.50
	Sum of M									MAXIMUM	$\Delta\varepsilon$:	0.0157		Moment (K	0.00	145.29	kip*in	
																12.11	kip*f	

Using Grade 60 #5@ 12 in.
Using Grade 75 #4@ 9.5 in.
Using ChromX 9100: #3@ 7.0 in.

Using grade 60: ϕM_n = 10.7 k-ft /ft > M_u = 9.08 k-ft / ft
Using grade 75: ϕM_n = 9.6 k-ft /ft > M_u = 9.08 k-ft / ft
Using ChromX: ϕM_n = 10.9 k-ft /ft > M_u = 9.08 k-ft / ft

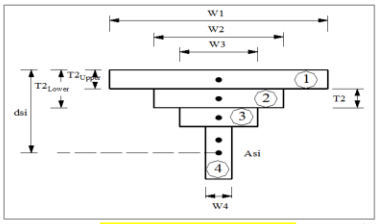
Using ChromX with reduced cover will remain unchanged:
ϕM_n = 10.9 k-ft /ft > M_u = 9.08 k-ft / ft

8.2 Negative Moment Section

Use section depth = 7.5 in. + 3.5 in. (haunch and girder flange) = 11 in

Using Grade 60 steel

Flexural Strength



ε_{cu}	0.003
c=	0.863
a	0.712
Sum of forces	0.00
Design	R/C AASHTO
ANSWER:	
ϕ	0.90
ϕMn kip-in	152
kip*ft	12.6

Calculate

Av. β_1 : 0.825

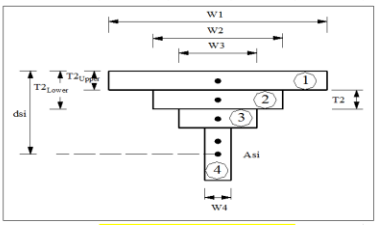
Units in kips and inches

Concrete Layers		f'c	Width, W	Thick., T	Depth, d_c	β_1	T_{upper}	T_{lower}	Revised T	Beta1calcuation		Area	Force	M_n k-in.
	1	4.500	12.000	11.000	0.356	0.825	0.000	11.000	0.712	31.70458359	38.4297983	8.540	-32.67	-11.62
				11.000						31.70458359	38.4297983			

Steel Layers		Area A_{si}	Grade	Effective Prest.	Depth d_{si}	E_s	Q	fpy	R	K	ε_{so}	Δε	Total ε_s	Stress	Force	Moment	Modified stress	corresp. f'c
Grade 60 Bars	1	0.310	60	0	1.3125	29000	0	60	100	1.096	0.0000	0.0016	0.0016	45.37	14.07	18.46	45.37	4.50
	2	0.310	60	0	8.688	29000	0	60	100	1.096	0.0000	0.0272	0.0272	60.00	18.60	161.59	60.00	4.50
	Sum of M									MAXIMUM	Δε :	0.0272		Moment (K	0.00	168.43 kip*in		
																14.04 kip*f		

Using Grade 75 Steel:

Flexural Strength



ε_{cu}	0.003
c=	0.777
a	0.641
Sum of forces	0.00
Design	R/C AASHTO
ANSWER:	
ϕ	0.90
ϕMn kip-in	136
kip*ft	11.3

Calculate

Av. β_1 : 0.825

Units in kips and inches

Concrete Layers		f'c	Width, W	Thick., T	Depth, d_c	β_1	T_{upper}	T_{lower}	Revised T	Beta1calcuation		Area	Force	M_n k-in.
	1	4.500	12.000	11.000	0.321	0.825	0.000	11.000	0.641	28.56819002	34.6281091	7.695	-29.43	-9.44
				11.000						28.56819002	34.6281091			

Steel Layers		Area A_{si}	Grade	Effective Prest.	Depth d_{si}	E_s	Q	fpy	R	K	ε_{so}	Δε	Total ε_s	Stress	Force	Moment	Modified stress	corresp. f'c
Grade 60 Bars	1	0.218	75	0	1.3125	29000	0	75	100	1.096	0.0000	0.0021	0.0021	59.91	13.07	17.15	59.91	4.50
	2	0.218	75	0	8.750	29000	0	75	100	1.096	0.0000	0.0308	0.0308	75.00	16.36	143.18	75.00	4.50
	Sum of M									MAXIMUM	Δε :	0.0308		Moment (K	0.00	150.90 kip*in		
																12.57 kip*f		

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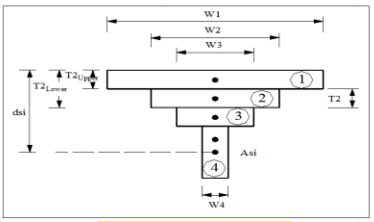
Using ChromX 9100



ε_{cu}	0.003
c=	1.079
a	0.890
Sum of forces	0.00
Design	R/C AASHTO
ANSWER:	
ϕ	0.90
ϕM_n kip-in	237
kip*ft	19.8

Calculate

Av. β_1 : 0.825

Units in kips and inches

Concrete Layers		f'c	Width, W	Thick., T	Depth, d_c	β_1	T_{upper}	T_{lower}	Revised T	Beta1calcuation			Area	Force	M_n k-in.
	1	4.500	12.000	11.000	0.445	0.825	0.000	11.000	0.890	39.65546218	48.0672269		10.682	-40.86	-18.18
				11.000						39.65546218	48.0672269				

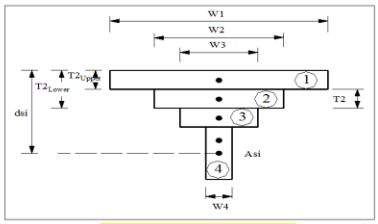
Steel Layers		Area A_{si}	Grade	Effective Prest.	Depth d_{si}	E_s	Q	kpy	R	K	ε_{so}	Δε	Total ε_s	Stress	Force	Moment	Modified stress	corresp. f'c
Grade 72.5 Bars	1	0	72.5	0	0	29000	0	72.5	100	1.096	0.0000	0.0000	-0.0030	-72.50	0.00	0.00	-68.68	4.50
MMFX Bars	2	0.189	100	0	4.75	29000	0.035	140	2.042	1.02	0.0000	0.0102	0.0102	100.00	18.86	89.57	100.00	4.50
MMFX Bars	3	0.220	100	0	8.750	29000	0.035	140	2.042	1.02	0.0000	0.0213	0.0213	100.00	22.00	192.50	100.00	4.50
	Sum of M									MAXIMUM	Δε :	0.0213		Moment (K	0.00	263.89 kip*in		
																21.99 kip*f		

Using Grade 60 # 5 @ 11 in.
Using Grade 75 # 4 @ 8 in.
Using ChromX 9100: # 3 @ 6 in.

Using grade 60: ϕM_n = 12.6 k-ft /ft > M_u = 8.6 k-ft / ft
Using grade 75: ϕM_n = 11.3 k-ft /ft > M_u = 9.08 k-ft / ft
Using ChromX: ϕM_n = 19.2 k-ft /ft > M_u = 8.6 k-ft / ft

Using ChromX with reduced cover:
ϕM_n = 20.6 k-ft /ft > M_u = 8.6 k-ft / ft

Flexural Strength Analysis Using Reduced Cover:



ε_{cu}	0.003
c=	1.079
a	0.890
Sum of forces	0.00
Design	R/C AASHTO
ANSWER:	
ϕ	0.90
ϕM_n kip-in	247
kip*ft	20.6

Calculate

Av. β_1 : 0.825

Units in kips and inches

Concrete Layers		f'c	Width, W	Thick., T	Depth, d_c	β_1	T_{upper}	T_{lower}	Revised T	Beta1calcuation			Area	Force	M_n k-in.
	1	4.500	12.000	11.000	0.445	0.825	0.000	11.000	0.890	39.65546218	48.0672269		10.682	-40.86	-18.18
				11.000						39.65546218	48.0672269				

Steel Layers		Area A_{si}	Grade	Effective Prest.	Depth d_{si}	E_s	Q	kpy	R	K	ε_{so}	Δε	Total ε_s	Stress	Force	Moment	Modified stress	corresp. f'c
MMFX Bars	2	0.189	100	0	4.75	29000	0.035	140	2.042	1.02	0.0000	0.0102	0.0102	100.00	18.86	89.57	100.00	4.50
MMFX Bars	3	0.22	100	0	9.250	29000	0.035	140	2.042	1.02	0.0000	0.0227	0.0227	100.00	22.00	203.50	100.00	4.50
	Sum of M									MAXIMUM	Δε :	0.0227		Moment (K	0.00	274.89 kip*in		
																22.91 kip*f		

8. CRACK CONTROL ANALYSIS

Using ChromX 9100: (#3@6) top and (#3@7) bottom. Top and bottom clear cover are 2" and 1" respectively

9.1 Positive Moment Section

For grade 60 ksi:
Using #4@12 result is higher steel stress than 60% of 60 ksi = 34.59 ksi
Use #5@12 in

Crack Control at Footing

Per AASHTO LRFD Art. 5.7.3.4		
Provided A_s	in^2	0.31
Concrete cover from extreme fiber to center of extreme bar layer, d_c	in.	1.31
f_y	ksi	60
f'_c	ksi	4.5
E_s	ksi	29000
E_c	ksi	4067
n		7.13
Web width, b_w	in.	12
Assumed section overall height, h	in.	7.5
Section depth for steel, d	in.	6.19
$\rho = A_s/bd =$		0.004
$n\rho =$		0.030
$k = [2n\rho + (n\rho)^2]^{0.5} - n\rho =$		0.216
$j = 1 - k/3 =$		0.928
Unfactored moment, M_s	kips-ft	5.1
Stress $f_{ss} = M_s / A_s jd$	ksi	34.59
Class 1 or 2 for exposure condition		1
γ_e		1.00
$\beta_s = 1+d_c/(0.7(h-d_c))$		1.30
Req'd spacing, $s = 700\gamma_e/(\beta_s * f_{ss}) - 2.0\ d_c$	in.	12.91
Prov'd spacing, s	in.	12.0
Check "s"		OK

For grade 75 ksi:

Per AASHTO LRFD Art. 5.7.3.4		
Provided A_s	in^2	0.25
Concrete cover from extreme fiber to center of extreme bar layer, d_c	in.	1.31
f_y	ksi	75
f'_c	ksi	4.5
E_s	ksi	29000
E_c	ksi	4067
n		7.13
Web width, b_w	in.	12
Assumed section overall height, h	in.	7.5
Section depth for steel, d	in.	6.19
$\rho = A_s/bd =$		0.003
$n\rho =$		0.024
$k = [2n\rho + (n\rho)^2]^{0.5} - n\rho =$		0.198
$j = 1 - k/3 =$		0.934
Unfactored moment, M_s	kips-ft	5.1
Stress $f_{ss} = M_s / A_s jd$	ksi	42.16
Class 1 or 2 for exposure condition		1
γ_e		1.00
$\beta_s = 1+d_c/(0.7(h-d_c))$		1.30
Req'd spacing, $s = 700\gamma_e/(\beta_s * f_{ss)} - 2.0\ d_c$	in.	10.12
Prov'd spacing, s	in.	9.5
Check "s"		OK

For ChromX:

Per AASHTO LRFD Art. 5.7.3.4		
Provided A_s	in^2	0.19
Concrete cover from extreme fiber to center of extreme bar layer, d_c	in.	1.25
f_y	ksi	100
f'_c	ksi	4.5
E_s	ksi	29000
E_c	ksi	4067
n		7.13
Web width, b_w	in.	12
Assumed section overall height, h	in.	7.5
Section depth for steel, d	in.	6.25
$\rho = A_s/bd =$		0.003
$n\rho =$		0.018
$k = [2n\rho + (n\rho)^2]^{0.5} - n\rho =$		0.172
$j = 1 - k/3 =$		0.943
Unfactored moment, M_s	kips-ft	5.1
Stress $f_{ss} = M_s / A_s jd$	ksi	55.42
Class 1 or 2 for exposure condition		1
γ_e		1.00
$\beta_s = 1+d_c/(0.7(h-d_c))$		1.29
Req'd spacing, $s = 700\gamma_e/(\beta_s * f_{ss)} - 2.0\ d_c$	in.	7.32
Prov'd spacing, s	in.	7.0
Check "s"		OK

#3 @ 7.32 in can be used. The steel stress is 55.42 ksi < 60% of 100 ksi OK
Spacing of 7 in was used to simplify the quantity analysis

9.2 Negative Moment Section

Section depth was assumed to be 11" to account for the haunch and the girder flange

For grade 60 ksi:

Per AASHTO LRFD Art. 5.7.3.4		
Provided A_s	in^2	0.34
Concrete cover from extreme fiber to center of extreme bar layer, d_c	in.	2.31
f_y	ksi	60
f'_c	ksi	4.5
E_s	ksi	29000
E_c	ksi	4067
n		7.13
Web width, b_w	in.	12
Assumed section overall height, h	in.	11
Section depth for steel, d	in.	8.69
$\rho = A_s/bd =$		0.003
$n\rho =$		0.023
$k = [2n\rho + (n\rho)^2]^{0.5} - n\rho =$		0.193
$j = 1 - k/3 =$		0.936
Unfactored moment, M_s	kips-ft	4.95
Stress $f_{ss} = M_s / A_s jd$	ksi	21.61
Class 1 or 2 for exposure condition		2
γ_e		0.75
$\beta_s = 1+d_c/(0.7(h-d_c))$		1.38
Req'd spacing, $s = 700\gamma_e/(\beta_s * f_{ss)} - 2.0\ d_c$	in.	12.98
Prov'd spacing, s	in.	11.0
Check "s"		OK

For grade 60 using the class 2 spacing of #5@ 11" (controlled by crack control)
Section depth was assumed to be 11" to account for the haunch and the girder flange

For grade 75 ksi:

Per AASHTO LRFD Art. 5.7.3.4		
Provided A_s	in^2	0.30
Concrete cover from extreme fiber to center of extreme bar layer, d_c	in.	2.31
f_y	ksi	75
f'_c	ksi	4.5
E_s	ksi	29000
E_c	ksi	4067
n		7.13
Web width, b_w	in.	12
Assumed section overall height, h	in.	11
Section depth for steel, d	in.	8.69
$\rho = A_s/bd =$		0.003
$n\rho =$		0.021
$k = [2n\rho + (n\rho)^2]^{0.5} - n\rho =$		0.183
$j = 1 - k/3 =$		0.939
Unfactored moment, M_s	kips-ft	4.95
Stress $f_{ss} = M_s / A_s jd$	ksi	24.27
Class 1 or 2 for exposure condition		2
γ_e		0.75
$\beta_s = 1+d_c/(0.7(h-d_c))$		1.38
Req'd spacing, $s = 700\gamma_e/(\beta_s * f_{ss}) - 2.0\ d_c$	in.	11.05
Prov'd spacing, s	in.	11.0
Check "s"		OK

For ChromX Grade 100 Steel:

Per AASHTO LRFD Art. 5.7.3.4		
Provided A_s	in^2	0.22
Concrete cover from extreme fiber to center of extreme bar layer, d_c	in.	2.25
f_y	ksi	100
f'_c	ksi	4.5
E_s	ksi	29000
E_c	ksi	4067
n		7.13
Web width, b_w	in.	12
Assumed section overall height, h	in.	11
Section depth for steel, d	in.	8.75
$\rho = A_s/bd =$		0.002
$n\rho =$		0.015
$k = [2n\rho + (n\rho)^2]^{0.5} - n\rho =$		0.159
$j = 1 - k/3 =$		0.947
Unfactored moment, M_s	kips-ft	4.94
Stress $f_{ss} = M_s / A_s jd$	ksi	32.52
Class 1 or 2 for exposure condition		2
γ_e		0.75
$\beta_s = 1+d_c/(0.7(h-d_c))$		1.37
Req'd spacing, $s = 700\gamma_e/(\beta_s * f_{ss}) - 2.0\ d_c$	in.	7.31
Prov'd spacing, s	in.	6.5
Check "s"		OK

For ChromX Using the class 2 spacing of #3 can be 7.31”
Spacing of 6.0 in was used to match the bottom reinforcement
Class 2 was chosen here because of the corrosion resistance criteria of the steel

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Crack Control Analysis with Reduced Cover:

Per AASHTO LRFD Art. 5.7.3.4		
Provided A_s	in^2	0.18
Concrete cover from extreme fiber to center of extreme bar layer, d_c	in.	1.75
f_y	ksi	100
f'_c	ksi	4.5
E_s	ksi	29000
E_c	ksi	4067
n		7.13
Web width, b_w	in.	12
Assumed section overall height, h	in.	11
Section depth for steel, d	in.	9.25
$\rho = A_s/bd =$		0.002
$n\rho =$		0.012
$k = [2n\rho + (n\rho)^2]^{0.5} - n\rho =$		0.142
$j = 1 - k/3 =$		0.953
Unfactored moment, M_s	kips-ft	4.94
Stress $f_{ss} = M_s / A_s jd$	ksi	36.95
Class 1 or 2 for exposure condition		2
γ_e		0.75
$\beta_s = 1+d_c/(0.7(h-d_c))$		1.27
Req'd spacing, $s = 700\gamma_e/(\beta_s * f_{ss)} - 2.0\ d_c$	in.	7.69
Prov'd spacing, s	in.	7.3
Check "s"		OK

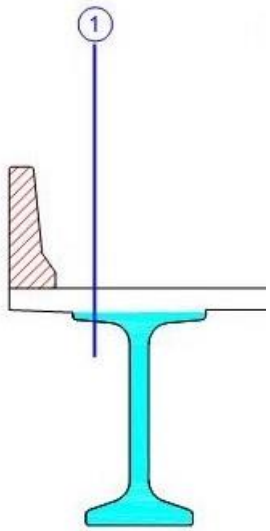
With reducing the cover #3@7 in will be used

9.3 Longitudinal Direction

AASHTO requires 67% of the transverse reinforcement can be used in the longitudinal direction

For Grade 60 use #4 @11” top and #4 @12” bottom.
For Grade 75 use #4 @11.5” top and #4 @14” bottom.
For ChromX use #3 @9” top and #3 @10” bottom.
For ChromX with reduced cover use #3 @10” top and #3 @10” bottom.

9. CRASH LOADING SECTION



Bending Moment from vehicular collision

$M_{CT} = M_C$ =16.16 k-ft/ft [Refer to PennDOT manual for TL4]

T_{Axial} =7.18 k /ft [Refer to PennDOT manual for TL4]

Mu $= 1.0\ M_{DC} + 1.0\ M_{DW} + 1.0\ M_{CT}$
$= 1.0\ (0.38+1.02) + 1.0\ (0.02) + 1.0\ (16.16)$
$= 17.58$ k-ft/ft

Using ChromX 9100

Adding #3 @ 9.5" to #4 @ 9.5" Using depth of 10"

T_{reif} = As fy = 0.392 x 100 = 39.2 kips
a=39.2/(0.85x4.5x12) = 0.854
ϕM_n = 39.2 x (7.75- (0.854/2)) – 7.18 (10/2- 0.854/2) = 287.06- 32.83 =254.226 k-in /ft = 21.19 k-ft/ft
Spacing of 8" was used to simplify the quantity analysis

Using Grade 60

Adding #5 @ 10" to #5@ 10" Using depth of 10"

T_{reif} = As fy = 0.62 x 60 = 37.2 kips
a=37.2/(0.85x4.5x12) = 0.81
ϕM_n = 37.2 x (7.75- (0.81/2)) – 7.18 (10/2- 0.81/2) = 273.23- 33 =240.234 k-in /ft = 20 k-ft/ft

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10. PennDOT DECK SLAB REQUIREMENTS

9 ft span selected for analysis

TABLE 4: DISTANCE FROM DESIGN SECTION FOR NEGATIVE MOMENT TO CENTERLINE OF BEAM = 12 IN.

USE FOR:
* PRECAST PRESTRESSED PA BULB-TEE AND I-BEAMS WITH TOP FLANGE WIDTH ≥ 36"
* STEEL I-BEAMS OR STEEL CLOSED BOXES WITH TOP FLANGE WIDTH ≥ 48"

S	T(in.)	S1	S2	S3	S7+	So	L	NOTES
4'-3"	8	#5 @9-1/2	#5 @11-1/2	#4 @9	1#6	2'-8"	3'-9"	
4'-7"	8	#5 @9-1/2	#5 @11-1/2	#4 @9	1#6	2'-10"	3'-9"	
4'-11"	8	#5 @9	#5 @11-1/2	#4 @9	1#6	3'-1"	3'-9"	
5'-2"	8	#5 @9	#5 @11-1/2	#4 @9	1#6	3'-3"	3'-9"	
5'-6"	8	#5 @9	#5 @11-1/2	#4 @8-1/2	1#6	3'-5"	3'-9"	
5'-10"	8	#5 @9	#5 @11-1/2	#4 @8-1/2	1#6	3'-8"	3'-10"	
6'-2"	8	#5 @8-1/2	#5 @11-1/2	#4 @8	1#6	3'-10"	3'-11"	
6'-6"	8	#5 @8	#5 @11-1/2	#4 @7-1/2	1#6	4'-1"	4'-1"	
6'-10"	8	#5 @8	#5 @11	#4 @7-1/2	1#6	4'-3"	4'-0"	
7'-2"	8	#5 @7-1/2	#5 @11	#5 @11	1#6	4'-6"	4'-0"	
7'-6"	8	#5 @7	#5 @10	#5 @11	1#5	4'-8"	3'-10"	
7'-10"	8	#5 @7	#5 @9-1/2	#5 @10	1#5	4'-10"	3'-10"	
8'-2"	8	#5 @7	#5 @9	#5 @10	1#5	4'-11"	3'-10"	
8'-6"	8	#5 @7	#5 @9	#5 @10	1#5	4'-11"	3'-10"	
8'-10"	8	#5 @6-1/2	#5 @8-1/2	#5 @9-1/2	1#4	4'-8"	3'-9"	
9'-2"	8	#5 @6	#5 @8	#5 @9	1#4	4'-10"	3'-8"	
9'-6"	8	#5 @6	#5 @7-1/2	#5 @9	1#4	4'-11"	3'-5"	A,C
9'-10"	8	#5 @5-1/2	#5 @7	#5 @8-1/2	1#4	5'-1"	3'-5"	A,C
10'-2"	8	#5 @5-1/2	#5 @7	#5 @8-1/2	1#4	5'-1"	3'-4"	A,C
10'-5"	8	#5 @5-1/2	#5 @6-1/2	#5 @7-1/2	1#4	5'-4"	4'-0"	A,C
10'-9"	8	#5 @5-1/2	#5 @6	#5 @7-1/2	1#4	5'-6"	4'-0"	A,C
11'-1"	8-1/2	#5 @5-1/2	#5 @6	#5 @7-1/2	1#4	5'-10"	4'-0"	A,C
11'-5"	8-1/2	#5 @5-1/2	#5 @5-1/2	#5 @7-1/2	---	4'-10"	---	B,C
11'-9"	8-1/2	#5 @5-1/2	#5 @5-1/2	#5 @7-1/2	---	4'-10"	---	B,C
12'-1"	9	#5 @5-1/2	#5 @5-1/2	#5 @7-1/2	---	5'-0"	---	B,C
12'-5"	9	#5 @5-1/2	#6 @7	#5 @7-1/2	---	5'-3"	---	B,C
12'-9"	9	#6 @7	#6 @7	#5 @7	---	5'-3"	---	B,C
13'-1"	9-1/2	#5 @5-1/2	#6 @7	#5 @8	---	5'-5"	---	B,C
13'-5"	9-1/2	#5 @5-1/2	#6 @6-1/2	#5 @8	---	5'-8"	---	B,C
13'-9"	9-1/2	#6 @7	#6 @6	#5 @7	---	5'-10"	---	B,C
14'-1"	9-1/2	#5 @5-1/2	#6 @6	#5 @8-1/2	---	5'-10"	---	B,C
14'-5"	9-1/2	#6 @7	#6 @6	#5 @7-1/2	---	5'-10"	---	B,C
14'-9"	9-1/2	#6 @7	#6 @5-1/2	#5 @7-1/2	---	6'-0"	---	
15'-1"	10	#6 @7	#6 @6	#5 @7-1/2	---	6'-0"	---	

11. QUANTITIES

For Grade 60:
Using 1 ft strip width L = 53 ft. using, we used;
For transverse direction: (#5@11") for positive moment, and (#5@12") for negative moment.
For Longitudinal direction: (#4 @11") top and (#4 @12") bottom.

For Grade 60 STEEL

Transverse Reinforcement per ft of deck length					
	Bar Size	Bar weight (lb/ft)	Bar Length (ft)	No. of Bars /ft	Weight of bars /ft
T1	#5	1.05	53	1.09	60.94
T2	#5	1.05	20	1.09	23.00
B	#5	1.05	53	1.00	55.86
Total Weight					139.80
Longitudinal Reinforcement per ft of deck length					
	Bar Size	Bar weight (lb/ft)	Bar Length (ft)	No. of Bars /ft	Weight of bars /ft
T	#4	0.68	1	58.00	39.44
B	#4	0.68	1	54.00	36.72
Total Weight					76.16
Total Weight for Transverse +Longitudinal Reinforcement /ft					215.96
Total Weight for Transverse +Longitudinal Reinforcement / Square feet					4.07

For Grade 75:
Using 1 ft strip width L = 53 ft. using, we used;
For transverse direction: (#4@9.5") for positive moment analysis, and (#4@8") for negative moment analysis.
For Longitudinal direction: (#4 @11.5") top and #4 @14") bottom.

For Grade 75 STEEL

Transverse Reinforcement per ft of deck length					
	Bar Size	Bar weight (lb/ft)	Bar Length (ft)	No. of Bars /ft	Weight of bars /ft
T1	#4	0.68	53	1.50	54.06
T2	#4	0.68	20	1.50	20.40
B	#4	0.68	53	1.26	45.52
Total Weight					119.98
Longitudinal Reinforcement per ft of deck length					
	Bar Size	Bar weight (lb/ft)	Bar Length (ft)	No. of Bars /ft	Weight of bars /ft
T	#4	0.68	1	54.00	36.72
B	#4	0.68	1	45.00	30.60
Total Weight					67.32
Total Weight for Transverse +Longitudinal Reinforcement /ft					187.30
Total Weight for Transverse +Longitudinal Reinforcement / Square feet					3.53

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For ChromX:

Using 1 ft strip width L = 53 ft. using, we used;
For transverse direction: (#3@7") for positive moment analysis, and (#3@6") for negative moment analysis.
For Longitudinal direction: (#3 @9") top and (#3 @10") bottom.

For Grade 100 STEEL

Transverse Reinforcement per ft of deck length					
	Bar Size	Bar weight (lb/ft)	Bar Length (ft)	No. of Bars /ft	Weight of bars /ft
T1	#3	0.37	53	2.00	39.64
T2	#3	0.37	20	2.00	14.96
B	#3	0.37	53	1.71	33.98
Total Weight					88.58
Longitudinal Reinforcement per ft of deck length					
	Bar Size	Bar weight (lb/ft)	Bar Length (ft)	No. of Bars /ft	Weight of bars /ft
T	#3	0.37	1	72.00	26.93
B	#3	0.37	1	61.00	22.81
Total Weight					49.74
Total Weight for Transverse +Longitudinal Reinforcement /ft					138.33
Total Weight for Transverse +Longitudinal Reinforcement / Square feet					2.61

For ChromX with Reduced Cover:

Using 1 ft strip width L = 53 ft. using, we used;
For transverse direction: (#3@7") for positive moment analysis, and (#3@7") for negative moment analysis.
For Longitudinal direction: (#3 @10") top and (#3 @10") bottom.

For Grade 100 STEEL with Reduced Cover

Transverse Reinforcement per ft of deck length					
	Bar Size	Bar weight (lb/ft)	Bar Length (ft)	No. of Bars /ft	Weight of bars /ft
T1	#3	0.37	53	1.71	33.98
T2	#3	0.37	20	1.71	12.82
B	#3	0.37	53	1.71	33.98
Total Weight					80.78
Longitudinal Reinforcement per ft of deck length					
	Bar Size	Bar weight (lb/ft)	Bar Length (ft)	No. of Bars /ft	Weight of bars /ft
T	#3	0.37	1	61.00	22.81
B	#3	0.37	1	61.00	22.81
Total Weight					45.63
Total Weight for Transverse +Longitudinal Reinforcement /ft					126.41
Total Weight for Transverse +Longitudinal Reinforcement / Square feet					2.39

12. SUMMARY

The following reinforcement is required:

Using Grade 60:
For transverse direction: (#5@11") for positive moment, and (#5@12") for negative moment.
For Longitudinal direction: (#4 @11") top and (#4 @12") bottom.
For Crash loading # 5@12" need to be added in the overhang and the first bay.

Using Grade 60 using PennDOT Design Manual Guidelines:
Please refer to Appendix A

Using Grade 75:
For transverse direction: (#4@9.5") for positive moment analysis, and (#4@8") for negative moment analysis.
For Longitudinal direction: (#4 @11.5") top and #4 @14") bottom.
For Crash loading #4@8" need to be added in the overhang and the first bay.

Using ChromX 9100:
For transverse direction: (#3@7") for positive moment analysis, and (#3@6") for negative moment analysis.
For Longitudinal direction: (#3 @9") top and (#3 @10") bottom.
For Crash loading # 3@6" need to be added in the overhang and the first bay.

Using ChromX 9100 with reduced top cover:
For transverse direction: (#3@7") for positive moment analysis, and (#3@7") for negative moment analysis.
For Longitudinal direction: (#3 @10") top and (#3 @10") bottom.
For Crash loading # 3@7" need to be added in the overhang and the first bay.

The weight of grade 60 steel per PennDOT requirements is	6.73 psf
The weight of grade 60 steel using AASHTO LRFD requirements using the Strip Method	4.07 psf
The weight of ChromX 9100, or 4100 steel designed at Fy = 75 ksi using the Strip Method	3.53 psf
ChromX 9100, or 4100 ASTM A1035 steel designed at Fy = 100 ksi using the Strip Method	2.61 psf
ChromX 9100, or 4100 ASTM A1035 steel designed at Fy = 100 ksi using the Strip Method	2.39 psf

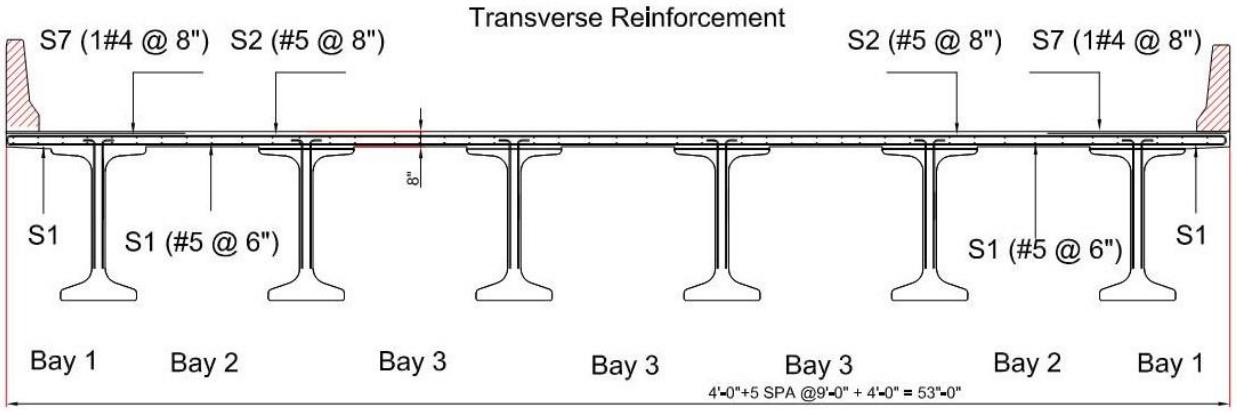
Using grade 75 saves 13 % compared to grade 60 steel with AASHTO LRFD requirements
Using ChromX 9100 saves 36 % compared to grade 60 steel with AASHTO LRFD requirements
Using ChromX 9100 with reduced cover saves 41 % compared to grade 60 steel with AASHTO LRFD requirements

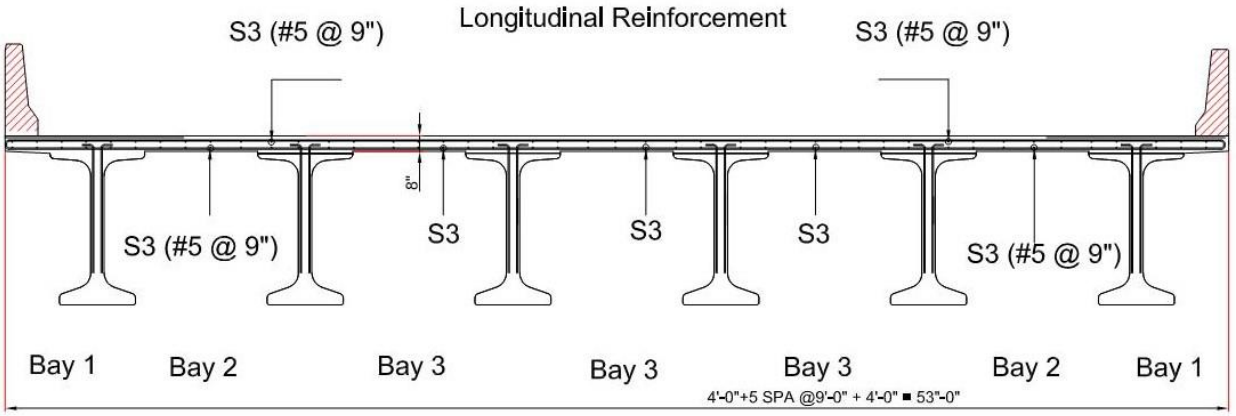
Using grade 75 saves 48 % compared to grade 60 steel with PennDOT requirements
Using ChromX 9100 saves 61 % compared to grade 60 steel with PennDOT requirements
Using ChromX 9100 with reduced cover saves 64 % compared to grade 60 steel with PennDOT requirements

13. CONCLUSIONS

(1) Getting a waiver to use the basic AASHTO LRFD Bridge Design Specifications without the modifications required in the PennDOT BMM results in significant savings
(2) Additional savings are achievable with utilization of grade 75 or ChromX steel as compared to Grade 60 steel.
(3) Further savings will be achieved by utilizing the corrosion resistant qualities of ChromX steel through reduction of the top clear cover by ½”

APPENDIX A:


Transverse Reinforcement
S7 (1#4 @ 8")
S2 (#5 @ 8")
S2 (#5 @ 8")
S7 (1#4 @ 8")
8"
S1
S1 (#5 @ 6")
S1 (#5 @ 6")
S1
Bay 1
Bay 2
Bay 3
Bay 3
Bay 3
Bay 2
Bay 1
4'-0"+5 SPA @9'-0" + 4'-0" = 53"-0"


Longitudinal Reinforcement
S3 (#5 @ 9")
S3 (#5 @ 9")
8"
S3
S3
S3
S3 (#5 @ 9")
S3 (#5 @ 9")
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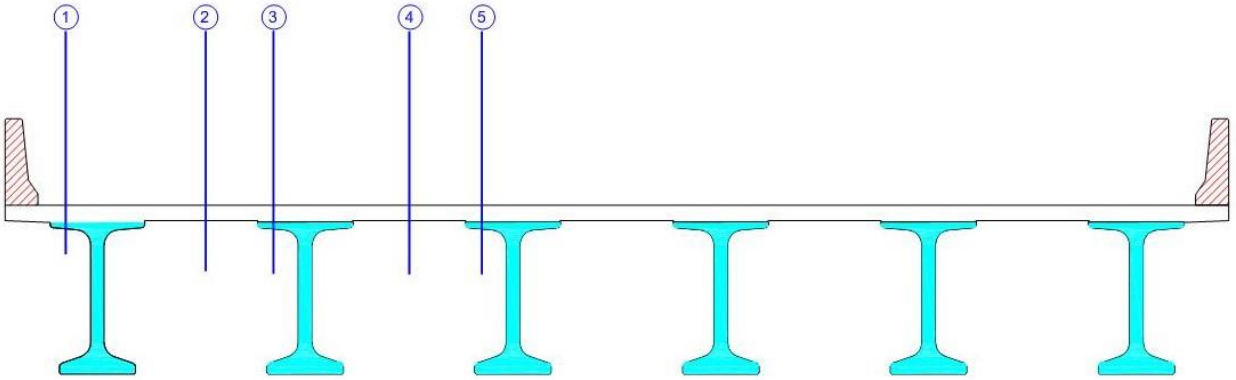
Bay 2
Bay 3
Bay 3
Bay 3
Bay 2
Bay 1
4'-0"+5 SPA @9'-0" + 4'-0" = 53"-0"


1
2
3
4
5

For Grade 60 STEEL

Transverse Reinforcement per ft of deck length					
	Bar Size	Bar weight (lb/ft)	Bar Length (ft)	No. of Bars /ft	Weight of bars /ft
T1	#5	1.05	53	1.09	60.94
T2	#5	1.05	20	1.09	23.00
B	#5	1.05	53	1.00	55.86
Total Weight					139.80
Longitudinal Reinforcement per ft of deck length					
	Bar Size	Bar weight (lb/ft)	Bar Length (ft)	No. of Bars /ft	Weight of bars /ft
T	#4	0.68	1	58.00	39.44
B	#4	0.68	1	54.00	36.72
Total Weight					76.16
Total Weight for Transverse +Longitudinal Reinforcement /ft					215.96
Total Weight for Transverse +Longitudinal Reinforcement / Square feet					4.07

For Grade 75 STEEL

Transverse Reinforcement per ft of deck length					
	Bar Size	Bar weight (lb/ft)	Bar Length (ft)	No. of Bars /ft	Weight of bars /ft
T1	#4	0.68	53	1.50	54.06
T2	#4	0.68	20	1.50	20.40
B	#4	0.68	53	1.26	45.52
Total Weight					119.98
Longitudinal Reinforcement per ft of deck length					
	Bar Size	Bar weight (lb/ft)	Bar Length (ft)	No. of Bars /ft	Weight of bars /ft
T	#4	0.68	1	54.00	36.72
B	#4	0.68	1	45.00	30.60
Total Weight					67.32
Total Weight for Transverse +Longitudinal Reinforcement /ft					187.30
Total Weight for Transverse +Longitudinal Reinforcement / Square feet					3.53

For Grade 100 STEEL

Transverse Reinforcement per ft of deck length					
	Bar Size	Bar weight (lb/ft)	Bar Length (ft)	No. of Bars /ft	Weight of bars /ft
T1	#3	0.37	53	2.00	39.64
T2	#3	0.37	20	2.00	14.96
B	#3	0.37	53	1.71	33.98
Total Weight					88.58
Longitudinal Reinforcement per ft of deck length					
	Bar Size	Bar weight (lb/ft)	Bar Length (ft)	No. of Bars /ft	Weight of bars /ft
T	#3	0.37	1	72.00	26.93
B	#3	0.37	1	61.00	22.81
Total Weight					49.74
Total Weight for Transverse +Longitudinal Reinforcement /ft					138.33
Total Weight for Transverse +Longitudinal Reinforcement / Square feet					2.61

For Grade 100 STEEL with Reduced Cover

Transverse Reinforcement per ft of deck length					
	Bar Size	Bar weight (lb/ft)	Bar Length (ft)	No. of Bars /ft	Weight of bars /ft
T1	#3	0.37	53	1.71	33.98
T2	#3	0.37	20	1.71	12.82
B	#3	0.37	53	1.71	33.98
Total Weight					80.78
Longitudinal Reinforcement per ft of deck length					
	Bar Size	Bar weight (lb/ft)	Bar Length (ft)	No. of Bars /ft	Weight of bars /ft
T	#3	0.37	1	61.00	22.81
B	#3	0.37	1	61.00	22.81
Total Weight					45.63
Total Weight for Transverse +Longitudinal Reinforcement /ft					126.41
Total Weight for Transverse +Longitudinal Reinforcement / Square feet					2.39

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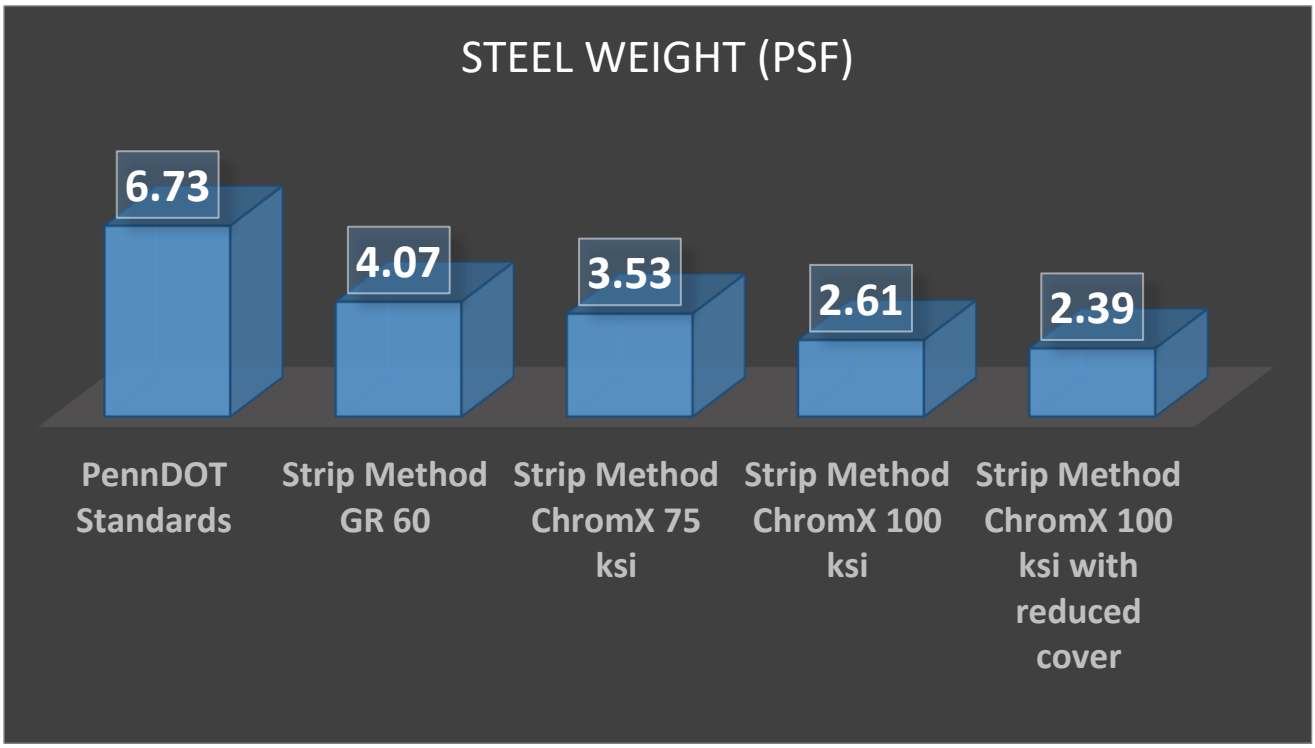
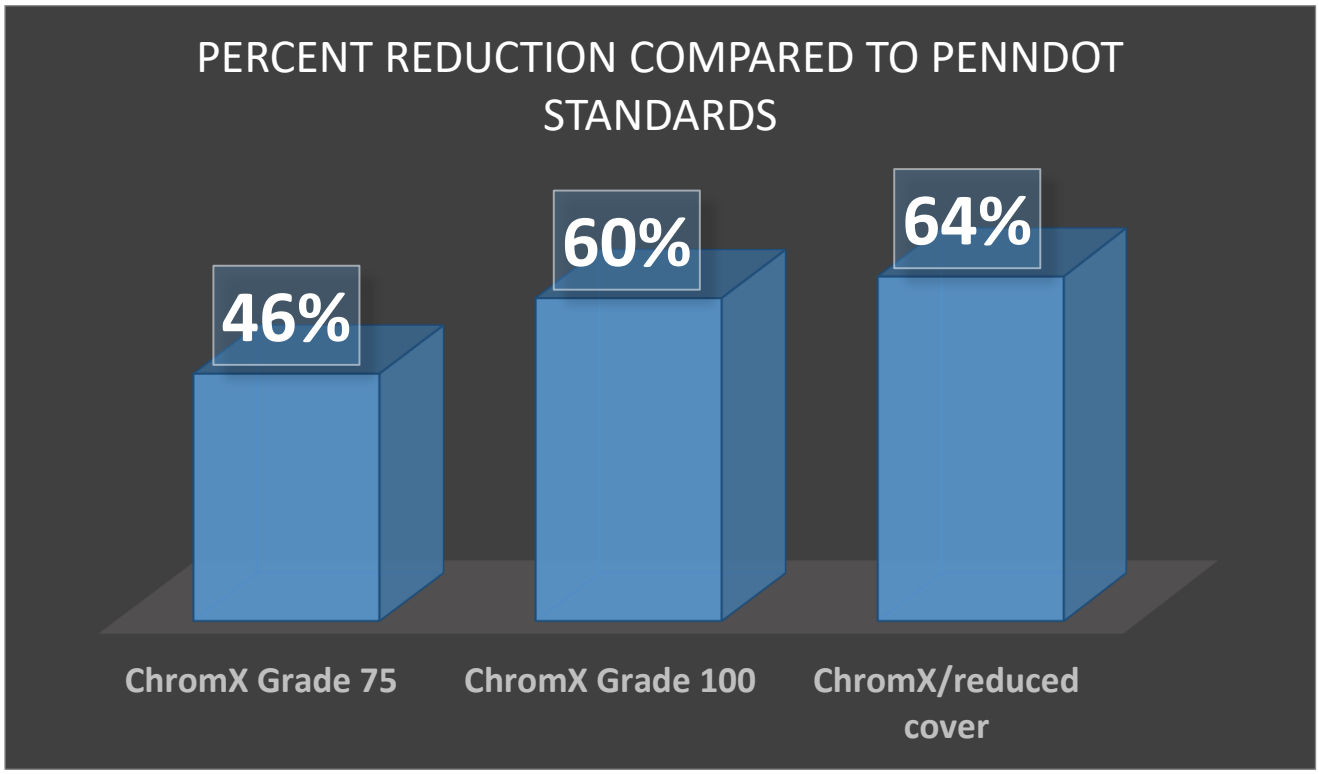
Project:	PennDOT Project	Designed By:	MM	Date:	06/24/2016		
Subject:	Utilizing MMFX in Deck Slab Design	Checked By:	AG	Sheet	33	of	34





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