Implementation of 0.7 in. Diameter Strands in Prestressed Concrete Girders

Nebraska Department of Roads (NDOR)

Project Number: SPR-P1(13) M333

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FINAL REPORT

Principal Investigator

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12. Abstract

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In this paper, the application of 0.7 in. diameter strands at 2 in. by 2 in. spacing to the Oxford South Bridge in Nebraska is presented. Twenty-six strand samples were tested to evaluate the breaking strength, yield strength, and modulus of elasticity of 0.7 in. diameter strands. Test results indicated that the tested strands meet the requirements of the ASTM A416-07. Also, transfer length measurements were taken at three different locations on two prestressed concrete girders at release and after 14 days using DEMEC gauges. Measurements indicated that the transfer length of 0.7 in. diameter strands can be conservatively estimated using the AASHTO LRFD Bridge Design Specifications. All fabricated girders were monitored for end zone cracking and camber growth and were found in compliance with current production tolerances, as specified by PCI and the Nebraska Department of Roads.

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ABSTRACT

For several years, 0.7 in. diameter strands have been successfully used in cable bridges and for mining applications. Using these large diameter strands at 2 in. by 2 in. spacing in pretensioned concrete girders results in approximately 35% increase in the prestressing force compared to the same number of 0.6 in. diameter strands and 92% increase in the prestressing force compared to the same number of 0.5 in. diameter strands. This will, consequently, allow for longer spans, shallower structural depth, and/or wider girder spacing in bridge construction.

In this paper, the application of 0.7 in. diameter strands at 2 in. by 2 in. spacing to the Oxford South Bridge in Nebraska is presented. Twenty-six strand samples were tested to evaluate the breaking strength, yield strength, and modulus of elasticity of 0.7 in. diameter strands. Test results indicated that the tested strands meet the requirements of the ASTM A416-07. Also, transfer length measurements were taken at three different locations on two prestressed concrete girders at release and after 14 days using DEMEC gauges. Measurements indicated that the transfer length of 0.7 in. diameter strands can be conservatively estimated using the AASHTO LRFD Bridge Design Specifications. All fabricated girders were monitored for end zone cracking and camber growth and were found in compliance with current production tolerances, as specified by PCI and the Nebraska Department of Roads.

INTRODUCTION

For several years, 0.7 in. diameter strands have been used in cable bridges and mining applications in the US, and for post-tensioning tendons in Europe and Japan. The 0.7 in. diameter strand has a cross-sectional area of 0.294 in^2 and it weighs 1 lb/ft. Prestressing one 0.7 in. diameter strand up to 75% its ultimate strength results in a prestressing force of 59.5 kip, which is 35% higher than that of 0.6 in. diameter strand and 92% higher than that of 0.5 in. diameter strand. Also, for the same prestressing force, using 0.7 in. diameter strand results in a fewer number of strands to jack and release, fewer chucks, and more efficient use of prestressing due to lowering the center of gravity of the strands.

The Pacific Street Bridge over I-680 in Omaha, NE, is the first bridge in the world to use 0.7 in. diameter prestressing strands in the precast-pretensioned concrete girders (Schuler, 2009). Based on the results of the experimental investigation on the bond of 0.7 in. diameter strands with concrete at the time of designing the Pacific Street Bridge, strands were spaced 2 in. horizontally and 2.5 in. vertically and were tensioned at 64% of the ultimate strength, which does not fully utilize the advantage of 0.7 in. diameter strands. Since then, several experimental investigations were carried out to evaluate the bond strength of 0.7 in. diameter strands at different levels of concrete strength and bottom flange confinement (Morcous and Tadros, 2011). These investigations have concluded that 0.7 in. diameter strands can be tensioned up to 75% their ultimate strength and spaced at 2 in. horizontally by 2 in. vertically, while satisfying the transfer length and development length provisions of the 6th Edition of AASHTO LRFD specifications. The investigations have also addressed the challenges associated with handling, jacking, and depressing 0.7 in. diameter strands (Morcous, et al. 2010; Morcous et al. 2011). It should be noted that bridge producers need to perform necessary retooling of their facilities to accommodate the use of 0.7 in. diameter strands.

The objective of this paper is to present the implementation of 0.7 in. diameter strands at 2 in. by 2 in. spacing in the Oxford South Bridge, Oxford, NE. This is believed to be the first application in the US with 0.7 in. diameter strands tensioned at 75% of the ultimate strength at 2 in. spacing horizontally and vertically.

PROJECT DESCRIPTION

In this project, a new two-lane bridge approximately 82 ft. east (downstream) of an existing bridge will be constructed. Construction has already begun in the spring of 2012 and be completed by the fall of 2013. The roadway width of the new bridge is 32 ft. and its skew angle is 0^o. The bridge is 580 ft long and consists of five spans (110, 110, 140, 110, and 110). The bridge was initially designed as a cast-in-place reinforced concrete deck on four NU1600 precast/prestressed concrete girders per span spaced at 9 ft. The prestressing of these girders was 42-0.6 in. diameter strands per girder for the 140 ft span and 26-0.6 in. diameter strands per girder for the 110 ft span assuming that the girders are simply supported for dead loads and continuous for live loads and superimposed dead loads. The design was revised to be four NU1350 precast/prestressed concrete girders per span spaced at 9 ft as shown in Figure 1. This revision provides an additional 10 in. in the vertical clearance.

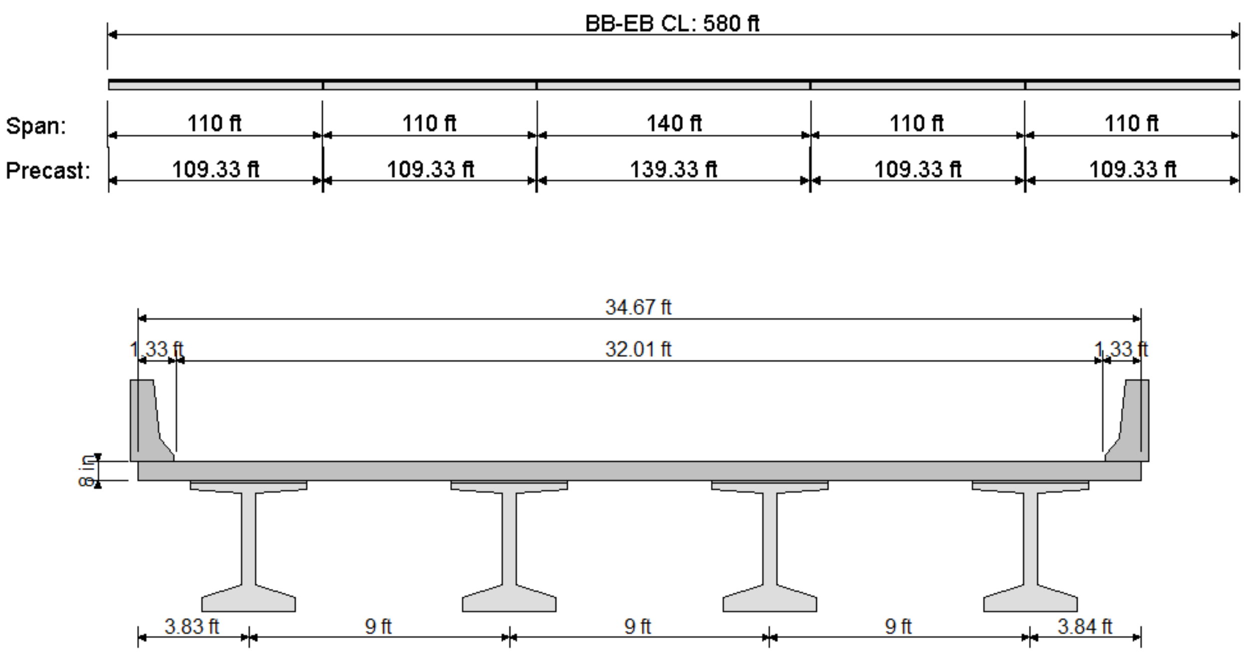
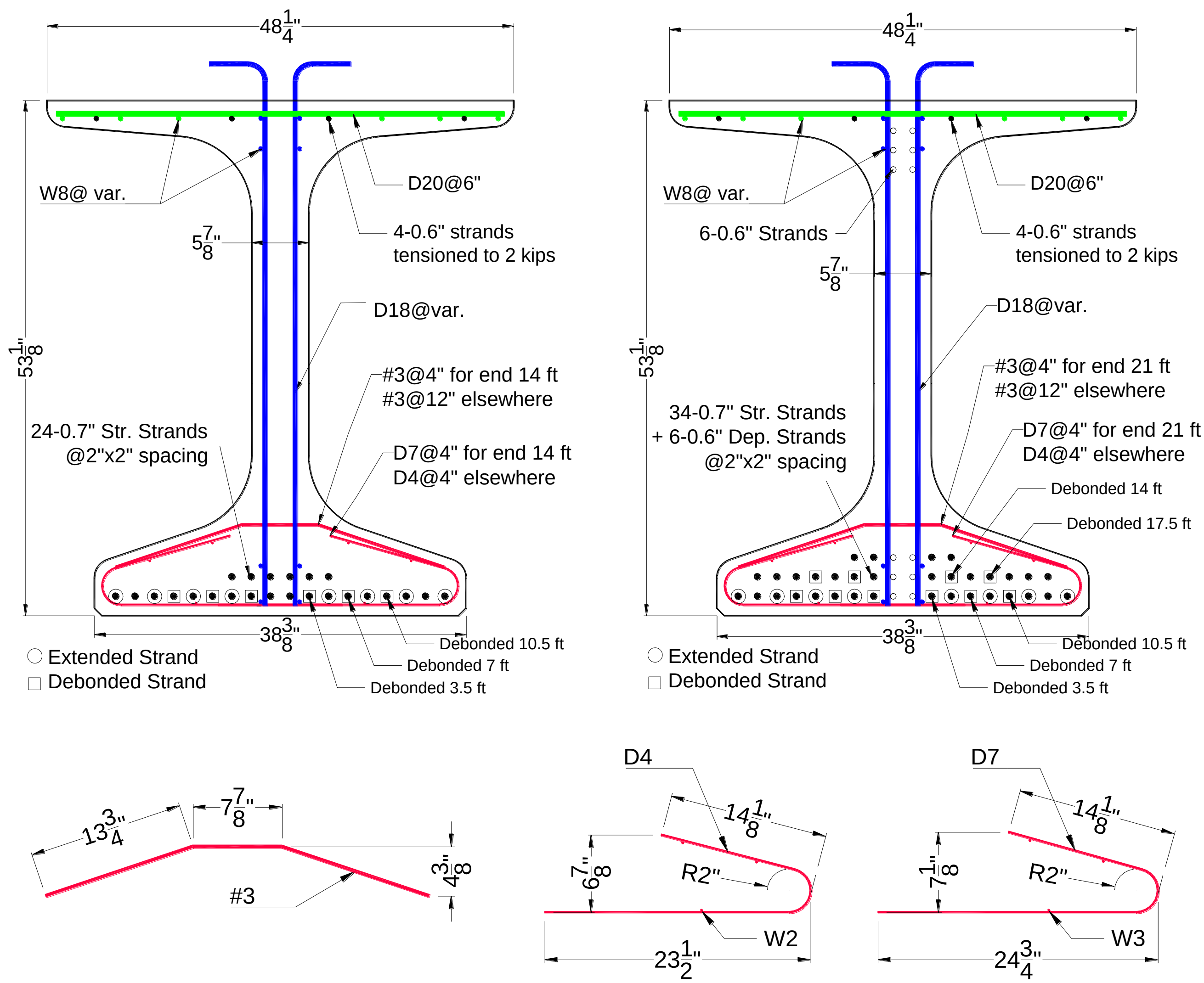
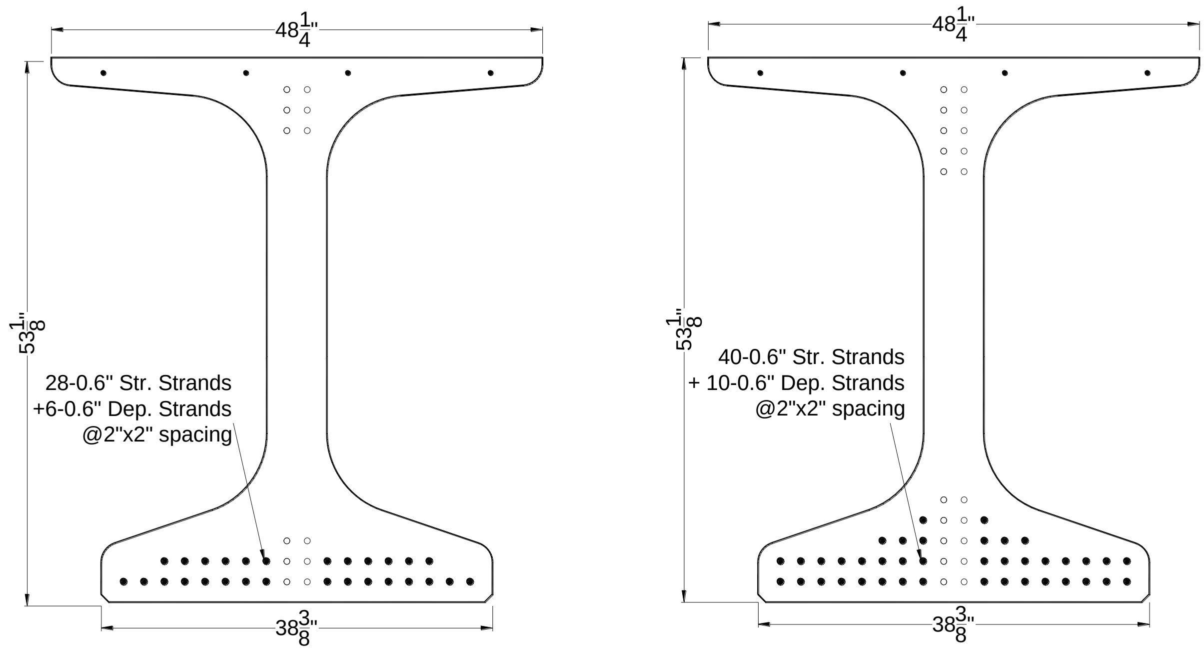


Figure 1: Elevation and cross section views of the Oxford South Bridge, NE (not to scale)

The prestressing of the NU1350 girders was 34 - 0.7 in. diameter straight strands and 6-0.6 in. diameter depressed strands for the 140 ft span; and 24-0.7 in. diameter straight strands with no depressed strands for the 110 ft spans as shown in Figure 2a. To clarify the advantage of using 0.7 in. diameter strands, Figure 2b shows the same girders designed using 0.6 in. diameter strands. For the same structural depth, using 0.7 in. diameter strands reduced the number of strands by 10 strands per girder, which results in significantly more economical production due to the lower number of strands to install, jack, and release.



a) Design of NU1350 using 0.7 in. diameter strands



b) Design of NU1350 using 0.6 in. diameter strands

Figure 2: Cross sections of the 110 ft long girder (left) and 140 ft long girder (right)

Figure 2a also shows the reinforcement details and the location of debonded and extended strands for the 140 ft and 110 ft NU1350 girders. Confinement reinforcement (WWR D7@4") equivalent to those required by AASHTO LRFD Section 5.10.10.2 (#3@6") were added as shown in Figure 2a. This reinforcement was extended from each girder end to the end of the debonded length plus one transfer length. Additional confinement reinforcement (WWR D4@4") was added to the remaining length of the girder in accordance to the policies and procedures of Nebraska Bridge Division (NDOR, 2013). Debonded strands are staggered at 3.5 ft increments, which is the predicted transfer length of 0.7 in. diameter strands. Extended strands are bent in 90 degree hooks and embedded in the cast-in-place diaphragms. The 0.7 in. diameter strands were not depressed in this project due to the unavailability of hold-down depressing devices for 0.7 in. diameter strands. Six 0.6 in. diameter strands were depressed instead.

STRAND PROPERTIES

Twenty six 0.7 in. diameter prestressing strand samples were tested to verify that the currently produced strands meet the ASTM A416-06 requirements. Testing was performed according to the testing specifications of ASTM A370-05 – Annex A7 at the Nebraska Department of Roads (NDOR) material testing laboratory. The requirements for 0.7 in. diameter strands include minimum breaking strength, load at 1% extension and extension at failure as shown in Table 1.

Table 1: ASTM A416 requirements for 0.7 in. diameter strands

Steel Area	0.294 in.2
Minimum Breaking Strength	79,400 lbs
Minimum Load @ 1% Extension	71,500 lbs
Minimum Extension	3.5%

All tested strand samples were received in ideal condition free of lubricants, rust, and any visible defects. Two groups of strands obtained from separate production heat or mill order were tested: Group 1 was tested on Aug. 9, 2012; and Group 2 was tested on Aug. 17, 2012. Tables 2 and 3 list testing results for the two strand groups.

Table 2: Summary of testing results of strand samples group #1

Lab ID	Area (in.^{2})	Tangent Modulus (psi)	Load at 1% Strain (lb)	Stress at 1% Strain (psi)	Maximum Load (lb)	Maximum Stress (psi)
PSS12-116	0.2920	28,379,300	73,600	252,055	79,600	272,603
PSS12-117	0.2920	28,384,900	73,600	252,055	79,600	272,603
PSS12-118	0.2920	28,506,200	73,600	252,055	79,600	272,603
PSS12-119	0.2920	28,279,000	73,600	252,055	79,600	272,603
PSS12-120	0.2920	28,795,300	74,000	253,425	80,000	273,973
PSS12-121	0.2920	28,407,400	73,800	252,740	79,800	273,288
PSS12-122	0.2920	28,520,100	73,600	252,055	79,600	272,603
PSS12-123	0.2920	28,396,900	73,800	252,740	79,800	273,288
PSS12-124	0.2920	28,626,600	74,000	253,425	79,800	273,288
PSS12-125	0.2920	28,876,600	72,400	247,945	79,800	273,288
PSS12-126	0.2920	28,776,800	72,400	247,945	79,800	273,288
PSS12-127	0.2920	28,988,600	73,600	252,055	79,800	273,288
PSS12-128	0.2920	28,615,500	73,600	252,055	79,800	273,288
PSS12-129	0.2920	28,561,100	73,800	252,740	79,800	273,288
Average	0.2920	28,579,593	73,529	251,810	79,743	273,092
Std. Dev.	5.8E-17	2.1E+05	5.0E+02	1.7E+03	1.2E+02	4.2E+02
COV	0.0%	0.7%	0.7%	0.7%	0.2%	0.2%

Table 3: Summary of testing results of strand sample group #2

Lab ID	Area (in.2)	Tangent Modulus (psi)	Load at 1% Strain (lb)	Stress at 1% Strain (psi)	Maximum Load (lb)	Maximum Stress (psi)
PSS12-130	0.2945	28,198,700	72,000	244,482	80,000	271,647
PSS12-131	0.2934	28,227,100	72,200	246,080	80,000	272,665
PSS12-132	0.2934	28,404,800	74,000	252,215	80,000	272,665
PSS12-133	0.2945	28,115,400	72,400	245,840	79,600	270,289
PSS12-134	0.2934	28,472,500	73,250	249,659	82,000	279,482
PSS12-135	0.2938	28,691,400	73,714	250,899	79,600	270,933
PSS12-136	0.2934	28,649,600	73,667	251,080	79,600	271,302
PSS12-137	0.2934	28,325,200	73,667	251,080	79,600	271,302
PSS12-138	0.2938	28,331,600	74,000	251,872	79,600	270,933
PSS12-139	0.2938	28,528,200	73,000	248,468	79,600	270,933
PSS12-140	0.2941	28,515,600	73,800	250,935	79,600	270,656
PSS12-141	0.2938	28,162,200	72,600	247,107	79,600	270,933
Average	0.2938	28,385,192	73,192	249,143	79,900	271,978
Std. Dev.	3.9E-04	1.8E+05	7.0E+02	2.5E+03	6.6E+02	2.4E+03
COV	0.1%	0.6%	1.0%	1.0%	0.8%	0.9%

All strand samples were tensioned until they reach the minimum breaking strength and then released before rupture to eliminate the damage of testing apparatus due to the violent rupture of prestressing strands. Therefore, the actual ultimate load and extension were not recorded. The extensometer used for the strand tension testing had a gauge length of 24 in. (ASTM A370 – A7.5.2) and an accuracy of at least 0.01 % (ASTM A416 – 6.3.1). Tables 2 and 3 indicate that all strand samples from both groups consistently met the minimum load at 1% strain and minimum breaking strength requirements shown in Table 1 with a coefficient of variation (COV) equal to or less than 1%.

CONCRETE PROPERTIES

The specified minimum compressive strengths for the Oxford South Bridge girders were 6,000 psi at release and 8,000 psi at 28 days for the 110 ft long girders; and 7,000 psi at release and 9,000 psi at 28 days for the 140 ft long girders. Table 4 lists the self-consolidating concrete (SCC) mixture proportions that were used for all the girders. This table indicates that the nominal maximum size aggregate (NMSA) is ½ in. and water-cementitious material ratio is approximately 0.3. Due to the extremely low water-cementitious materials ratio, special attention was given to the sequence of adding materials to allow the mixer to work effectively. Also, a large dosage of high-range water reducing admixtures was used to achieve an average spread of 27 in. for all the batches.

Table 4: Mixture proportions of the concrete

Material	Quantity (lb/cy)
Portland Cement Type III	705
Class C Fly Ash	124
Fine Aggregate	1550
Coarse Aggregate (NMSA = ½”)	1263
Water	254
Air (%)	4.2

Table 5 lists average concrete compressive strength at release, at 7 days, and at 28 days in the plant and at NDOR laboratory for all girders. Results indicate that the 28-day compressive strength of all girders exceeded 9,000 psi. Release compressive strength of all 110 ft long girders exceeded 6,000 psi and for all 140 ft long girders (shaded rows) exceeded 7,000 psi by keeping the girders in the bed for a longer duration. Figure 3 shows girder numbering and location in the bridge.

Table 5: Compressive strength testing results of all girders

Girder #	**Average Release Strength (psi)**	**Average 7-day Strength (psi)**	**Average 28-day Strength (psi)**	**NDOR Average 28-day Strength (psi)**
G-1	6,845	-	9,437	-
G-1	6,286	10,390	10,242	9,994
G-2	6,269	-	10,800	10,752
G-2	7,650	10,838	11,054	9,640
G-2	9,045	8,980	9,873	-
G-2	7,067	9,232	9,139	10,051
G-3	6,223	10,318	10,874	11,506
G-3	8,300	9,897	9,998	10,246
G-4	6,177	9,467	10,679	-
G-4	-	9,732	9,841	10,583
G-4	6,643	9,534	10,263	10,341
G-4	7,991	10,341	10,896	11,272
G-5	7,741	-	10,661	9,915
G-5	6,307	9,840	9,926	10,003
G-5	9,041	10,407	9,943	-
G-5	6,258	9,306	10,495	9,915

G-6	7,318	9,491	10,021	10,291
G-6	7,753	8,202	9,656	10,391
G-7	7,318	9,491	10,021	10,291
G-7	7,753	8,202	9,656	10,391
Average	7,262	9,628	10,174	10,349
Min.	6,177	8,202	9,139	9,640
Max.	9,045	10,838	11,054	11,506

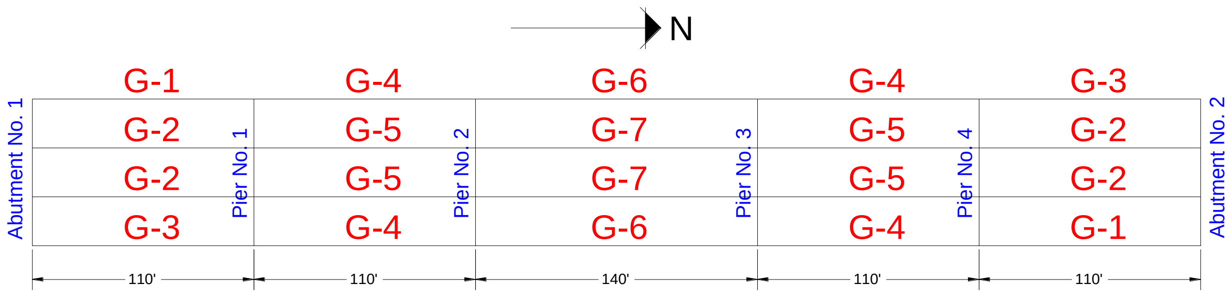


Figure 3: Girder numbering and location in the bridge

STRAND TRANSFER LENGTH

Transfer length is the length of the strand measured from the end of the prestressed concrete member over which the effective prestress is transferred to the concrete. The transferred force along the transfer length is assumed to increase linearly from zero at the end of the member to the effective prestress at the end of the transfer length. Transfer length is important for shear design and concrete stresses at release at girder ends. An over-estimated transfer length might result in inefficient shear design and higher than predicted stresses at release, while an under-estimated transfer length might result in inadequate shear design and lower than predicted stresses at release. According to the 2012 AASHTO LRFD specifications (6^{th} Edition), the transfer length of a fully bonded prestressing strand is calculated as follows:

$$l_t = 60 d_b$$

where, l_t= transfer length (in.), and d_b= nominal strand diameter (in.)

Since this equation was developed for prestressing strands of 0.6 in. diameter or less, the transfer length of 0.7 in. diameter strands used in this project was measured to ensure that the previous equation is applicable. Detachable mechanical (DEMEC) gauges were placed at two ends of one 110 ft long girder and one end of another 110 ft long girder. The gauges were placed prior to prestress release along the side of the bottom flange at the elevation of the centroid of prestressing strands. These gauges were manufactured by Hayes Manufacturing Company in the United Kingdom and attached to the concrete surface using rapid set glue. The number of DEMEC gauges used on each side was 20 at 4-in-spacing to ensure accurate readings and cover the predicted transfer length, which is 3.5 ft. DEMEC readings were taken at release and at 14 days using W.H. Mayes & Son caliper gauge. The change in the measured distance between DEMEC gages was used to calculate the strain in the concrete.

The transfer length was determined using the 95% average maximum strain method (AMS) as noted in Ramirez and Russell (2008). After prestress release, the prestressed concrete strain is zero at the girder ends, then increases and becomes relatively constant as the distance from the girder end increases and the strand fully transfers its force to the girder. The point where the strain becomes constant indicates where all of the prestressing forces are transferred to the concrete. The transfer length was determined by measuring the distance from the end of the girder to the point where 95% of the maximum concrete strain is measured. Figures 4, 5, and 6 shows the strain profiles obtained from DEMEC gage readings at the north and south ends of the girder released on October 24, 2012 and at the south end of the girder released on November 8, 2012 respectively.

According to Figure 4, 5, and 6, the average transfer length at release of 0.7 in. diameter strands calculated using the AMS method was found to be approximately 32 in. This value increases after 14 days to be approximately 36 in., which is very close to the value predicted using American Concrete Institute’s (ACI’s) *Building Code Requirements for Structural Concrete (ACI 318-011) and Commentary* ($l_t = 50\ d_b$ = 35 in.), and slightly less than the value predicted using 2012 AASHTO LRFD specifications (42 in.). These values of transfer length are consistent with the measurements conducted in earlier research (Morcous, et al., 2011; and Patzlaff, et al. 2012). The change in the strain with time is primarily due to the shrink and creep of the prestressed concrete, which happens at higher rates at the early ages and slows down thereafter. It should also be noted that the measured strain is very close to the strain calculated at release after considering the elastic shortening losses (790 microstrain).

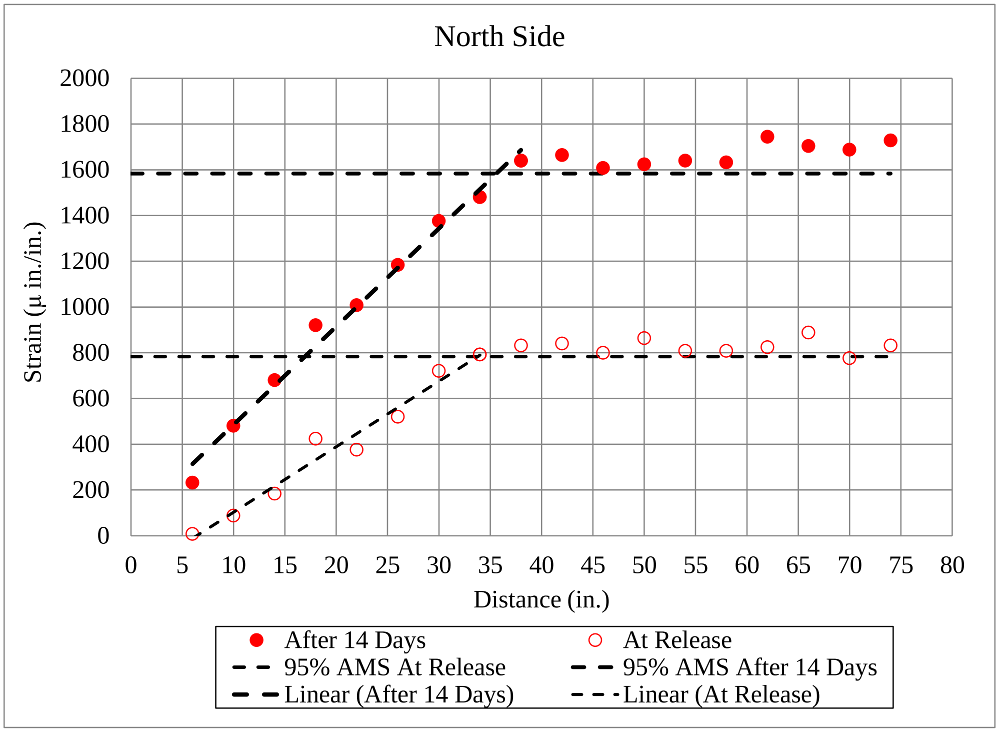


Figure 4:Strain measurements on the north side of the girder released on Oct. 24, 2012

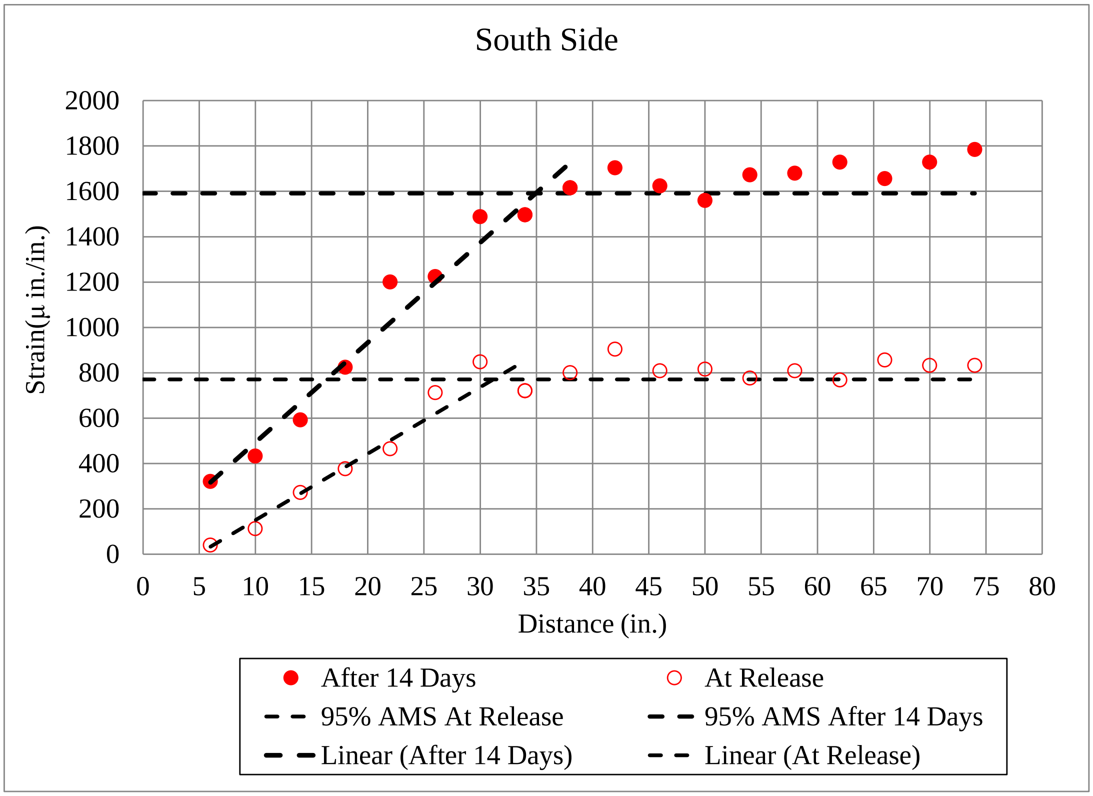


Figure 5: Strain measurements on the south side of the girder released on Oct. 24, 2012

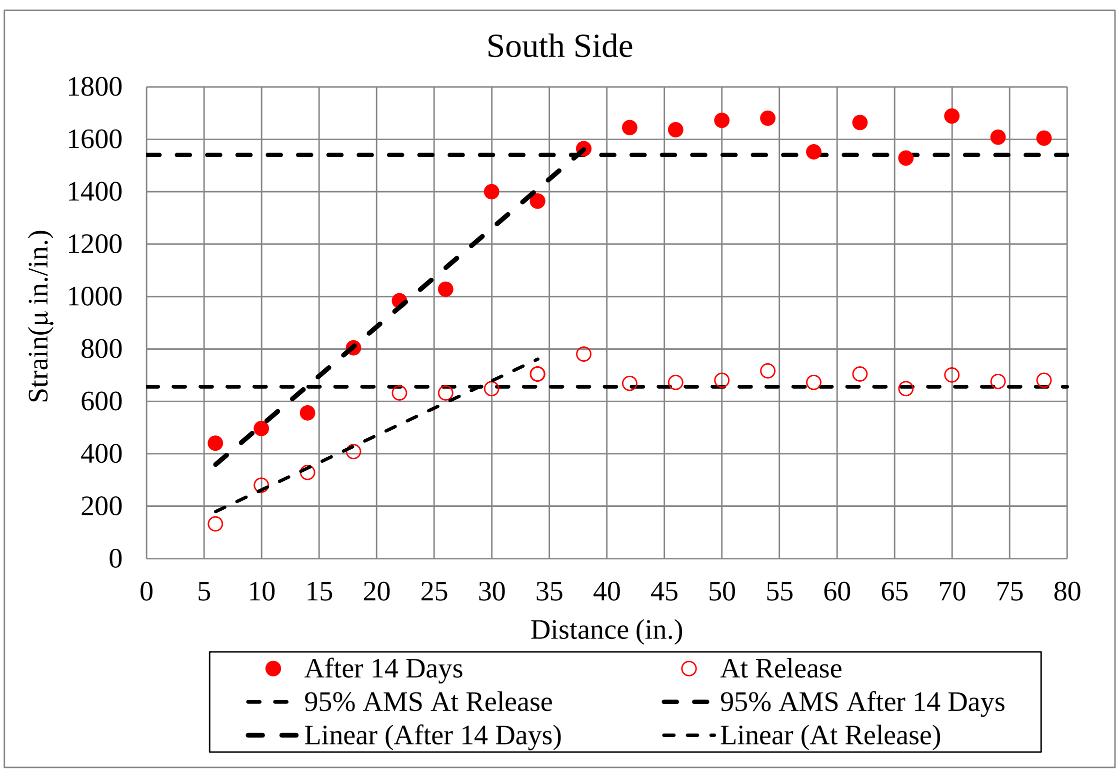


Figure 6: Strain measurements on the south side of the girder released on Nov. 8, 2012

GIRDER CAMBER

Camber is the deflection that occurs in prestressed concrete members due to bending resulting from the eccentricity of prestress force. Camber is a function of the girder cross section, prestressing force, strand location, concrete properties, girder age, and environmental factors, which leads to camber variability from predicted values and from one girder to another. According to the Quality Control for Plants and Production of Structural Precast Concrete Products (PCI, 1999), for members with span-to-depth ratios less than 25, the tolerance for camber variation at release (within 72 hours from prestress transfer) from design camber is ±1/8 in. per 10 ft of girder length with a maximum of ±1/2 in. for girder up to 80 ft long and ± 1 in. maximum for girders over 80 ft long. This rule applies only to the 110 ft long girder as their span-to-depth ratio is approximately 25, while the 140 ft long girder has span-to-depth ratio of approximately 32.

Table 6 lists the camber measured at release and on January 8, 2013 (before girder shipping) for the sixteen 110 ft long girders. This table indicates that the measure release camber varies from 1.5 in. to 2.25 in. and the 60-day camber varies from 3.75 in. to 5.25 in. The release camber is within the acceptable tolerance (± 1 in.) from the predicted value of 2.2 in. calculated using the PCI Method (PCI, 2010), while the 60-day camber is slightly higher than the predicted value of 3.8 in. in some girders.

Table 6: Measured camber for 110 ft long girders

Girder #	**Cast Date**	**Girder length (ft)**	**Release Camber (in.)**	**Age (days)**	**Camber Measured on 1/08/2013 (in.)**
G-1	29-Oct	110.2	1.75	71	3.75
G-1	1-Nov	110.2	1.50	68	5.25
G-2	23-Oct	110.2	1.63	77	5.00
G-2	25-Oct	110.2	1.63	75	5.25
G-2	2-Nov	110.2	1.50	67	4.25
G-2	5-Nov	110.2	1.62	64	5.00
G-3	7-Nov	110.2	1.62	62	4.00
G-3	9-Nov	110.2	1.75	60	4.13

G-4	20-Nov	109.4	2.25	49	4.13
G-4	21-Nov	109.4	2.25	48	4.25
G-4	26-Nov	109.4	2.00	43	4.00
G-4	29-Nov	109.4	1.75	40	4.00
G-5	12-Nov	109.4	2.00	57	3.75
G-5	14-Nov	109.4	1.85	55	5.00
G-5	16-Nov	109.4	2.00	53	4.13
G-5	19-Nov	109.4	2.00	50	5.00
Average		**109.8**	**1.82**	**59**	**4.43**
Minimum		**109.4**	**1.50**	**40**	**3.75**
Maximum		**110.2**	**2.25**	**77**	**5.25**

Table 7 lists the camber measured at release and on January 8, 2013 for the four 140 ft long girders. This table indicates that the measured camber at release varied from 2.75 in. to 3.0 in. among girders, while the 70-day camber varied from 8.5 in. to 9.1 in. The release camber values are below the predicted value of 4.3 in. and the 70-day camber values are higher than the predicted value of 7.5 in. calculated using the PCI Method. These deviations from the predicted values can be considered acceptable given the length of the girders, span-to-depth ratio of 32, and variation in concrete strength.

Table 7: Measured camber for 140 ft long girders

Girder #	Cast Date	Girder length (ft)	Release Camber (in.)	Age (days)	Camber Measured on 1/08/2013 (in.)
G-6	29-Oct	139.4	3.00	71	8.63
G-6	31-Oct	139.4	2.75	69	8.88
G-7	29-Oct	139.4	2.87	71	9.13
G-7	31-Oct	139.4	2.75	69	8.50
Average		**139.4**	**2.84**	**70**	**8.78**
Minimum		**139.4**	**2.75**	**69**	**8.50**
Maximum		**139.4**	**3.00**	**71**	**9.13**

Figure 7 plots the camber values measured at release and on January 8, 2013 (solid lines) versus the predicted release and 90-day camber (dotted lines) to evaluate the camber growth in the different girders. This plot indicates the consistency in the camber growth among the girders of the same length. It also shows the significantly higher rate of camber growth in longer girders than shorter ones. Special attention should be given to this high rate during deck construction. Figure 8 shows a photo of the 140 ft long girder and its camber shortly after release. It should be noted that the camber growth is not linear with time, however straight lines were used in Figure 7 to simplify the plot.

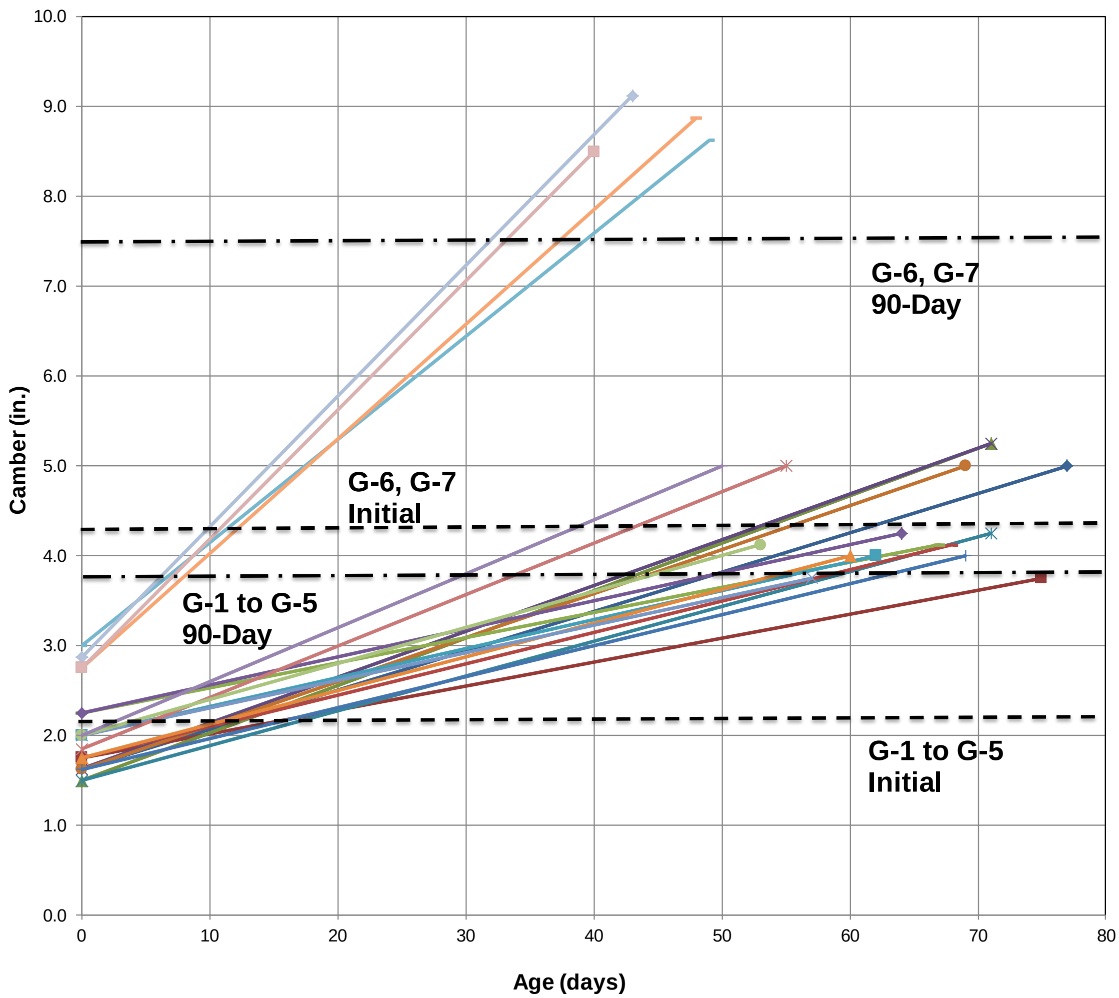


Figure 7: Camber growth with time in different girders

Figure 8: Camber of the 140 ft long girders at release

END ZONE CRACKING

End zone cracking was evaluated by the visual examination of the girder ends immediately and few days after release. Figure 9 shows that no vertical or horizontal cracks were observed by the naked eye at the girder ends or between strands due to bursting force of prestressing or due to using 2 in. spacing between strands, which indicate that current AASHTO LRFD requirements for bursting and confinement reinforcement were adequate for these girders.

Figure 9: Photos of end zone of the 110 ft long girder (top left) ,end zone of 140 ft (top right) long girder, and between strands in the 110 ft long girder (bottom)

It should be mentioned that some of the 110 ft long girders had experienced cracking in the top portion of the web at girder ends where the top flange is recessed as shown in Figure 10. Investigating the cause of this cracking has shown that the tension stresses due to prestressing release and the absence of continuous reinforcement (discontinuous cross wires of the WWR used in shear reinforcement) at the transition are the main reasons. Figure 11 shows the properties of the sections before and after the recessed top flange. Below are the calculations used to verify the top flange stresses and the recommended reinforcement to overcome this problem. Figure 12 shows the girder ends after adding 10#4 bars at 3 in. spacing in each girder end (5#4 in each side of the web).

Figure 10: Craching at girder ends where flanges are recessed.

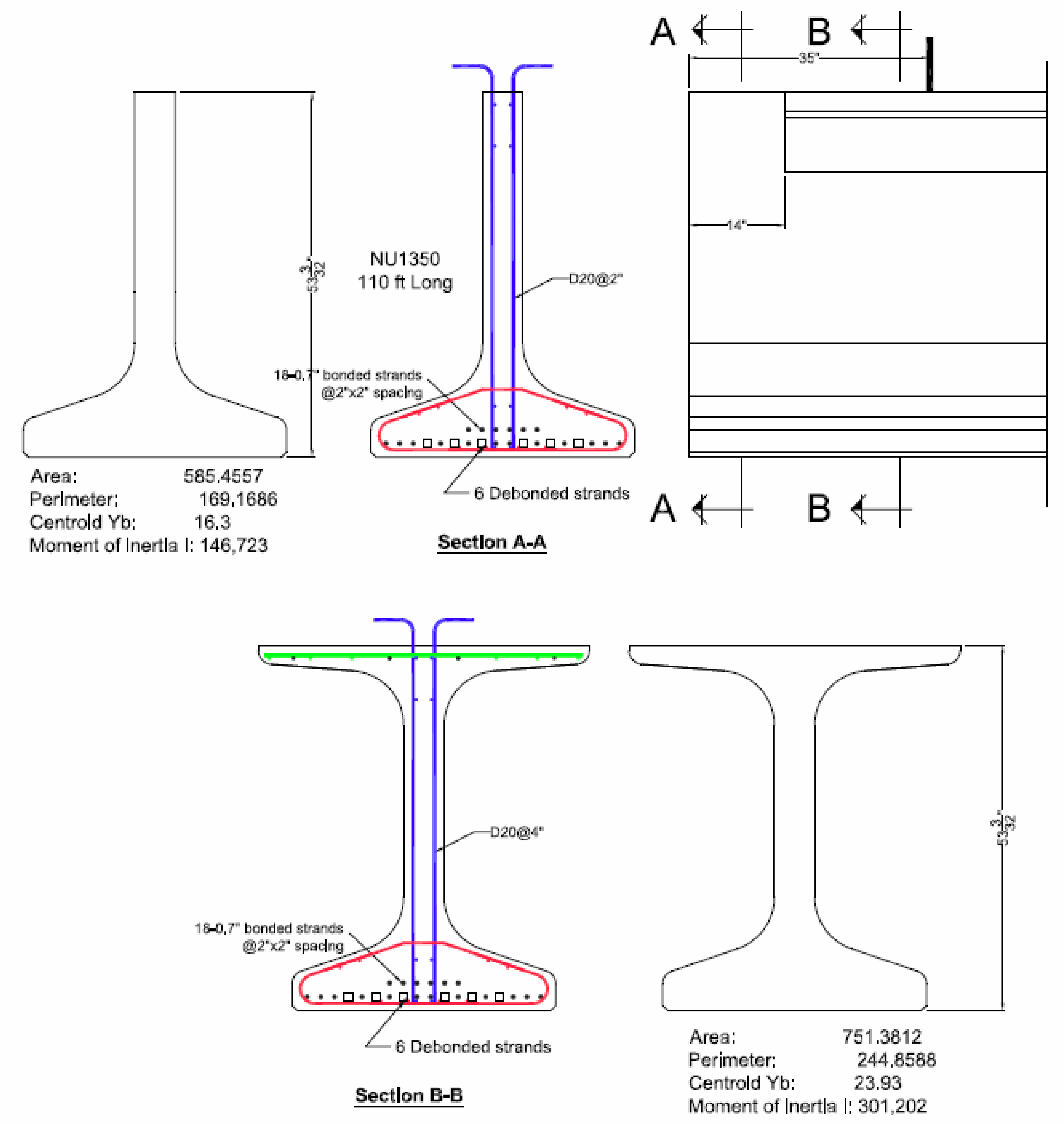
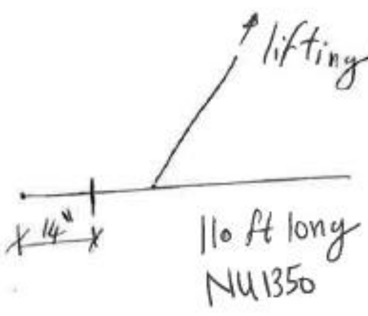


Figure 11: Section properties at the girder ends

Stresses at end section at release:



$\omega = \frac{58.5}{144} * 0.15 = 0.61 \text{ K/ft}$

$M_{at\ 14in.} = \frac{0.61 * \frac{14^2}{12}}{2} = 5 \text{ Kip.in.}$

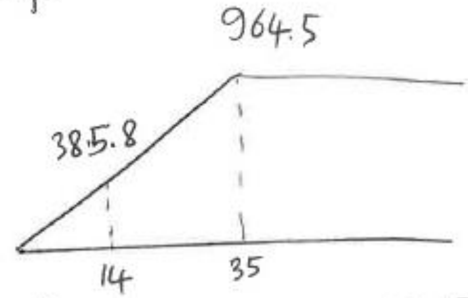
$l_t = 35 \text{ in.}$

$P_o = 0.9 * 18 * 0.297 * 202.5 = 964.5 \text{ kip}$

$y_p = \frac{12*2 + 6*4}{18} = 2.67 \text{ in.}$

$e = 16.3 - 2.67 = 13.63 \text{ in.}$

$y_t = 53.1 - 16.3 = 36.8 \text{ in.}$



$f_{top} = \frac{385.8}{585.5} - \frac{385.8 * 13.63 * 36.8}{146{,}723} - \frac{5 * 36.8}{146{,}723} = -0.66 > \frac{7.5\sqrt{6000}}{1000} \text{ ksi}$

$f_{bot} = \frac{385.8}{585.5} + \frac{385.8 * 13.63 * 16.3}{146{,}723} - \frac{5 * 16.3}{146{,}723} = 1.24 \text{ ksi}$

$T = \frac{0.66 * 18.4 * 5.9}{2} = 35.8 \text{ Kip}$

$A_s = \frac{35.8}{20} = 1.79 \text{ in}^2$

use 10 #4 in the top 18 in.
for at least 3 ft from
girder ends.

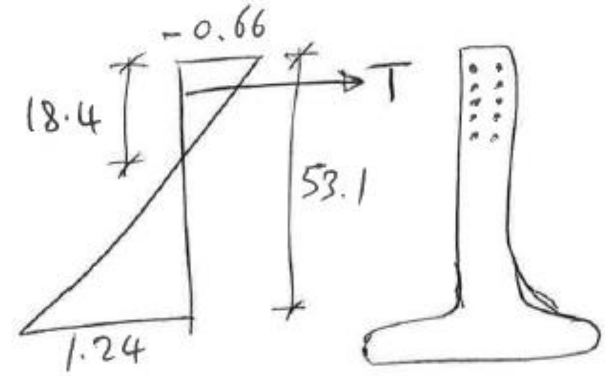


Figure 12: Girder ends after adding recommended reinforcement

GIRDER ERECTION

A site visit was conducted on March 15, 2013 to observe girder erection of the Oxford South Bridge located at Oxford, NE. At that time, the four 110 ft long NU1350 girders of span 2 were being erected as shown below. Girder erection was successfully completed using two cranes and following the conventional practice of erecting precast/prestressed I-girders. Bridge deck was cast in May 2013 using stay-in-place forms, while the bridge was open to traffic in September 2013.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CONCLUSIONS

This report presented the first application of 0.7 in. diameter strands in prestressed concrete bridge girders at 2 in. by 2 in. spacing for the Oxford South Bridge in Nebraska. The results of testing 26 strand samples indicated that all strands satisfy the ASTM A416 requirements. Transfer length measurements in three girder ends indicated that the transfer length of 0.7 in. diameter strands can be accurately predicted using AASHTO LRFD specifications. Also, measurements of girder camber indicated that camber variability at release is within the acceptable tolerance. No end zone cracking was observed at girder ends due to the use of 0.7 in. diameter strands at 2 in. by 2 in. spacing. Girder erection was successfully completed during the month of March 2013.

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