TH3, BRIDGE 11, BRO 1443(48)
CLARENDON, VT

STATE OF VERMONT
ERNEST J. BROD
NO. 3814
CIVIL
LICENSED
PROFESSIONAL ENGINEER

▶ NEXT BEAM CAMBER/DEFLECTION CALCULATIONS

AS REQUIRED BY CONTRACT DRAWING NOTE 47, THE FOLLOWING CALCULATIONS EVALUATE THE ESTIMATED CAMBER AND DEFLECTIONS IN THE NEXT 36D BEAMS, DESIGNED BY OTHERS. THE MAGNITUDE OF CALCULATED CAMBER IS AN ESTIMATE ONLY.

BEAM: NEXT 36D × 7'-8" WIDE FLANGE
(SEE MODIFIED SECTION PROPERTIES ATTACHED)

$f'_c = 10$ ksi

$f'_{ci} = 8$ ksi

$w_c = 143$ pcf

BEAM LENGTH = 75'-0 1/8" (STEM LENGTH)

$y_b = 22.87''$

$I = 174{,}671 \text{ in}^4$

$A = 1537 \text{ in}^2$ $\quad W = \frac{1537}{144} \times 143 = 1{,}526$ PLF

DETERMINE CG OF STRANDS:

$$CG_y = \frac{(6)\times 2\tfrac{1}{2}'' + (10)\times 4\tfrac{1}{2}'' + (10)\times 6\tfrac{1}{2}'' + (10)\times 8\tfrac{1}{2}'' + (6)\times 10\tfrac{1}{2}'' + (4)\times 29\tfrac{1}{2}''}{46} = 8.5''$$

$e = y_b - CG_y = 22.87'' - 8.5'' = 14.37''$

PRESTRESS FORCE

$P = (46)\text{ea.} \times 44^K = 2{,}024^K$

$P_o = 2{,}024^K \times (1 - 0.089) = 1{,}844^K$ • ASSUME 8.9% LOSSES AS PER WORKSHEET A EXAMPLE

$E_{ci} = 33{,}000\ K_1\ w^{1.5} \sqrt{f'_{ci}}$ AS PER LRFD 5.4.2.4

$= 33{,}000\,(0.66)\left(\frac{143}{1000}\right)^{1.5}(8)^{0.5}$ • USE $K_1 = 0.66$ AS PER WORKSHEET A AVERAGE FOR JPC MIX 430M

$= 3{,}331$ ksi

ESTIMATED CAMBER AT RELEASE

$$\Delta_{release} = \frac{P_o e \ell^2}{8EI} = \frac{(1{,}844^K)(14.37'')(75'\text{-}0\tfrac{1}{8}'' \times 12)^2(1000)}{(8)(3{,}331{,}000\ \text{psi})(174{,}671\ \text{in}^4)}$$

$= 4.61'' \uparrow$

ESTIMATED DEFLECTION AT RELEASE DUE TO SELF WEIGHT

$$\Delta_{release} = \frac{5w\ell^4}{384EI} = \frac{(5)(1526/12)(75'\text{-}0\tfrac{1}{8} \times 12)^4}{(384)(3{,}331{,}000\ \text{psi})(174{,}671\ \text{in}^4)}$$

$= 1.87'' \downarrow$

ALSO DETERMINE DEFLECTIONS AT ERECTION FROM SUPERIMPOSED DEAD LOADS.

FROM CONTRACT DRAWING SHEET 4

SERVICE LOAD:

SUPERIMPOSED DEAD LOAD MOMENT 514.8 K-FT

CONVERT THIS LOAD TO A UNIFORM LOAD TO COMPUTE DEFLECTION.

$514.8\text{ K-FT} = w\ell^2/8$ WHERE $\ell = 75'\text{-}0\tfrac{1}{8}''$

$w_{SDL} = 0.732$ KLF

COMPUTE THEORETICAL E_c AT ERECTION

$$E_c = 33{,}000\, K_1 \cdot w^{1.5} \sqrt{f'_c}$$

$$= 33{,}000\,(0.66)\left(\tfrac{143}{150}\right)^{1.5}(10)^{0.5}$$

$$= 3{,}724 \text{ KSI}$$

ESTIMATED DEFLECTION AT ERECTION DUE TO SDL:

$$\Delta_{ERECTION} = \frac{5\,w\ell^4}{384\,EI} = \frac{(5)(.732/12)(75'\text{-}0\tfrac{1}{8}\times 12)^4}{384\,(3{,}724{,}000)(174{,}671)} = 0.80'' \downarrow$$

DEFLECTION SUMMARY (WITH PCI MULTIPLIERS)

	RELEASE (IN.)	MULT.	ERECTION (IN.)	MULT.	FINAL (IN.)
PRESTRESS	4.61 ↑	1.8	8.30 ↑	2.45	11.29 ↑
SELF-WEIGHT	-1.87 ↓	1.85	-3.46 ↓	2.7	-5.05 ↓
SUPERIMPOSED DL.			-0.80 ↓	3.0	-2.40 ↓
TOTAL*	2.74 ↑		4.04 ↑		3.84 ↑

* DEFLECTION SUMMARY NOTES

- ESTIMATED CAMBER AT RELEASE OF 2.74" EXCEEDS THE ESTIMATED CAMBER OF 1.63" SHOWN IN THE CONTRACT DRAWINGS.

- JPC BELIEVES THAT THE ESTIMATED CAMBER OF 2.74" IS A MORE ACCURATE ESTIMATE AS IT CONSIDERS A PAST PROJECT THAT USES THE SAME MIX DESIGN. CAMBER DATA FROM PREVIOUSLY FABRICATED NEXT BEAMS IS USED TO ESTIMATE THE K_1 FACTOR FOR AGGREGATE WHICH AFFECTS THE ELASTIC MODULUS OF CONCRETE, E_c. A LOWER E_c WILL INCREASE THE MAGNITUDE OF CAMBER AND DEFLECTION.

- THE FINAL CAMBER, INCLUDING SUPERIMPOSED DEAD LOAD IS ESTIMATED TO BE 3.84" VERSUS 2¼" ESTIMATED IN THE CONTRACT DRAWINGS.

TH3, Bridge 11, BRO 1443 (48)
NEXT Beam Properties

J. P. Carrara & Sons, Inc.
Project 23476-015

NEXT 36D Beam Properties for 7'8" Wide Beam

Section Properties

Cross-Sectional Area, A	1536.69	in^2
Moment of Inertia, I	174670.95	in^4
Height of the Centroid, yb	22.87	in
Volume to Surface Ratio, V/S	5.14	in
Shear Width, bw	28.18	in
Height of Section	36	in
Width of Section	92	in
Section Type	Double Tee	

Edit Section

OK

TH3 Bridge 11 BRO 1443 (48)
Clarendon, VT

J. P. Carrara & Sons, Inc.
Project 23476-015
3/9/16 R0

Worksheet A: Determination of Elastic Modulus & K_1 Factor for JPC Concrete Mix 430M

Based on Analysis of Data for NEXT 36D x 8'0" for JPC Project 23413-013
VTAOT Project: VT 12 Bridge 25 ER BRF 0241(39) Barnard, VT

P=	2,200	kips
Losses	8.9%	(Est. as per Concise output)
Po =	2,004	kips
For NEXT 36D x 8'0" Wide		
yb =	23.03	in
e=	14.37	in
I=	176,674	in^4
beam length =	86.17	feet
Unit Wt.=	150	pcf
w =	1627	plf

# Strands	y	
6	2.5	15
10	4.5	45
10	6.5	65
10	8.5	85
10	10.5	105
4	29.5	118
50		433
	Cgy =	8.66 in

	Case 1: W-NB1	Case 2: W-NB2	Case 3: W-NB2	Case 4: W-NB3
	Pour 1	Pour 1	Pour 2	Pour 2
	3/7/2014	3/7/2014	3/20/2014	3/20/2014
Unit Wt.=	142.11 pcf	142.11 pcf	144.52 pcf	144.52 pcf
w =	1541 plf	1541 plf	1568 plf	1568 plf
f'ci =	9.545 ksi	9.545 ksi	9.711 ksi	9.711 ksi
Camber @ Rls. =	3.25 in	3.125 in	3 in	2.625 in
delta-ps*E =	21,787,624	21,787,624	21,787,624	21,787,624
delta-bm*E =	10,823,187	10,823,187	11,006,735	11,006,735
E =	3,374 ksi	3,509 ksi	3,594 ksi	4,107 ksi
K_1 =	0.62	0.64	0.64	0.73

Average E =	3,646 ksi
Average K_1 =	0.66

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JP Carrara & Sons, Inc.
Pour Report - 3/7/2014

Pour Info

Job Number(s)	23413-013						
Job Name(s)	Barnard Bridge						
Bed	250' Next Beam	**Thickness**	36" D	**Mix**	430M	**3/8" Strands**	
Date / Time	3/7/2014 9:30 AM	**Concrete**	71.50 yds	**Location**	Door #2	**0.5" Strands**	
Status	Completed	**Grout**		**Slip #**	117923	**0.6" Strands**	50
Jack #							

Service

Air	7%	**Yield**	26.70
Slump/Spread	24"	**Ambient Temp**	35 °F
VSI	0	**Concrete Temp**	66 °F
Unit Weight	142.11 lbs	**# of Cylinders**	10
Workability	ok		
Weather			

Specifications

Air	7%	+/- 2%
Max. Slump	28"	
Release Strength	8,000	
28 Day Strength	10,000	
Notes		

Breaks

	Release	28-Day	Other
Date	3/10/2014	4/4/2014	3/21/2014
Test 1	9,835	11,979	11,032
Test 2	9,254	10,629	11,049
Average	9,545	11,304	11,041

Notes

3-day release

RESULTS FOR 14 DAY ON 1 BEAM 2ND IN TESTING:10, 349 10, 630
28 Day 1st: 12, 192 11,521

Results for 1st set of cylinders, W-NB2(1):
AIR:7%
UNIT WEIGHT: 142.11
YIELD: 26.8
SLUMP: 20
VSI:0
CONCRETE TEMP.: 65
3-day strength: 9,422 & 9,678 psi
28-day strength:

Production

Job	Mark	Mark Range	Camber	Quantity	Total Weight	Total LF	Total SF
23413-013	W-NB1		3 1/4	1	146,760 lbs	86	
23413-013	W-NB2	(1)	3 1/8"	1	139,340 lbs	86	
		Job (23413-013) Totals:		**2**	**286,100 lbs**	**172**	
		Pour Totals		**2**	**286,100 lbs**	**172**	

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JP Carrara & Sons, Inc.

Pour Report - 3/20/2014

Pour Info

Job Number(s)	23413-013						
Job Name(s)	Barnard Bridge						
Bed	250' Next Beam	**Thickness**	36" D	**Mix**	430M	**3/8" Strands**	
Date / Time	3/20/2014 7:30 AM	**Concrete**	71.50 yds	**Location**	Door #2	**0.5" Strands**	
Status	Completed	**Grout**		**Slip #**	118052	**0.6" Strands**	50
Jack #							

Service

Air	5.4%	**Yield**	26.50
Slump/Spread	22"	**Ambient Temp**	55 °F
VSI	0	**Concrete Temp**	66 °F
Unit Weight	144.52 lbs	**# of Cylinders**	10
Workability	OK		
Weather			

Specifications

Air	7%	+/- 2%
Max. Slump	28"	
Release Strength	8,000	
28 Day Strength	10,000	
Notes		

Breaks

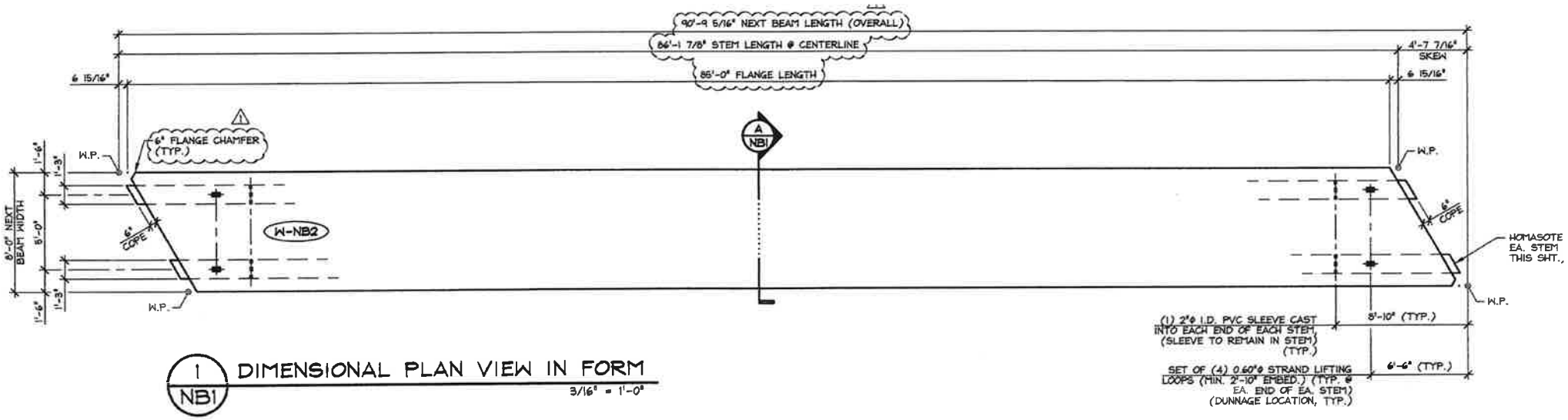
	Release	28-Day	Other
Date	3/24/2014	4/17/2014	
Test 1	9,648	12,202	
Test 2	9,773	11,604	
Average	9,711	11,903	

Notes

1 st load: 143.52lb/ft^3 5.9% 70degrees 22" 0 vsi
4th: 142.52lb/ft^3 6.9% 69degrees 24" vsi 0 10cylinders
BREAK @
6:30 am:south beam- 7312 north beam- 6965
10am: north-7688
11:15:south- 7700
2: north- 8722, 8583 - south 7973,7863
2:30: south- 7792
3/24/14: 6:30 AM BREAKS
NORTH- 10,592-10,887
SOUTH RECORDED IN TESTING & ANALYSIS
NORTH NB3 28day- 12,759-11,861

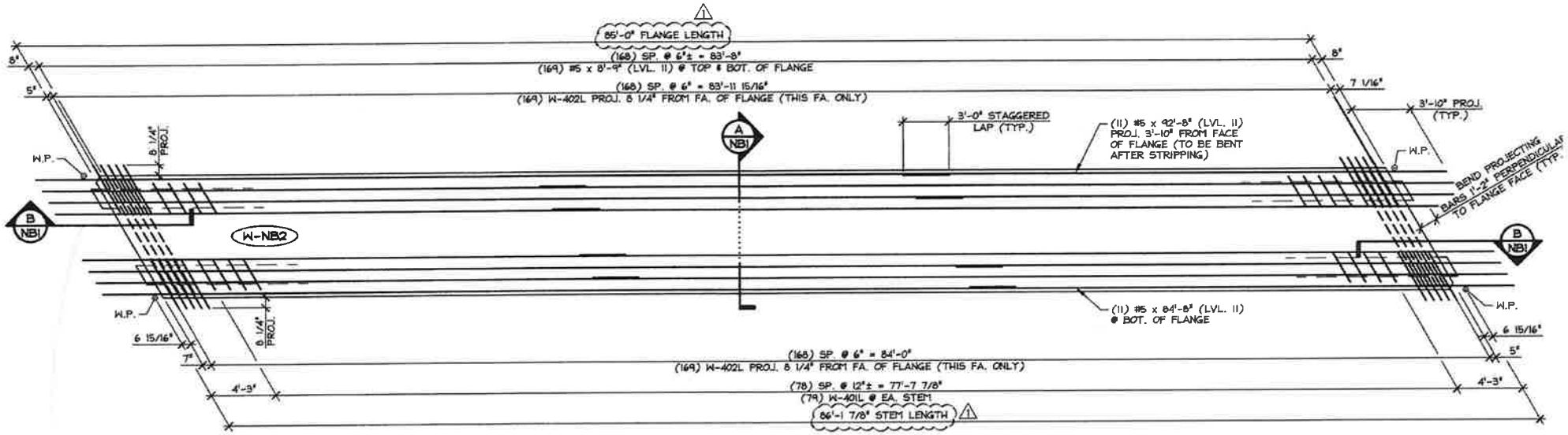
Production

Job	Mark	Mark Range	Camber	Quantity	Total Weight	Total LF	Total SF
23413-013	W-NB2	(2)	3"	1	139,340 lbs	86	
23413-013	W-NB3	(1)	2 5/8"	1	146,760 lbs	86	
		Job (23413-013) Totals:		**2**	**286,100 lbs**	**172**	
		Pour Totals		**2**	**286,100 lbs**	**172**	



1 / NB1 DIMENSIONAL PLAN VIEW IN FORM

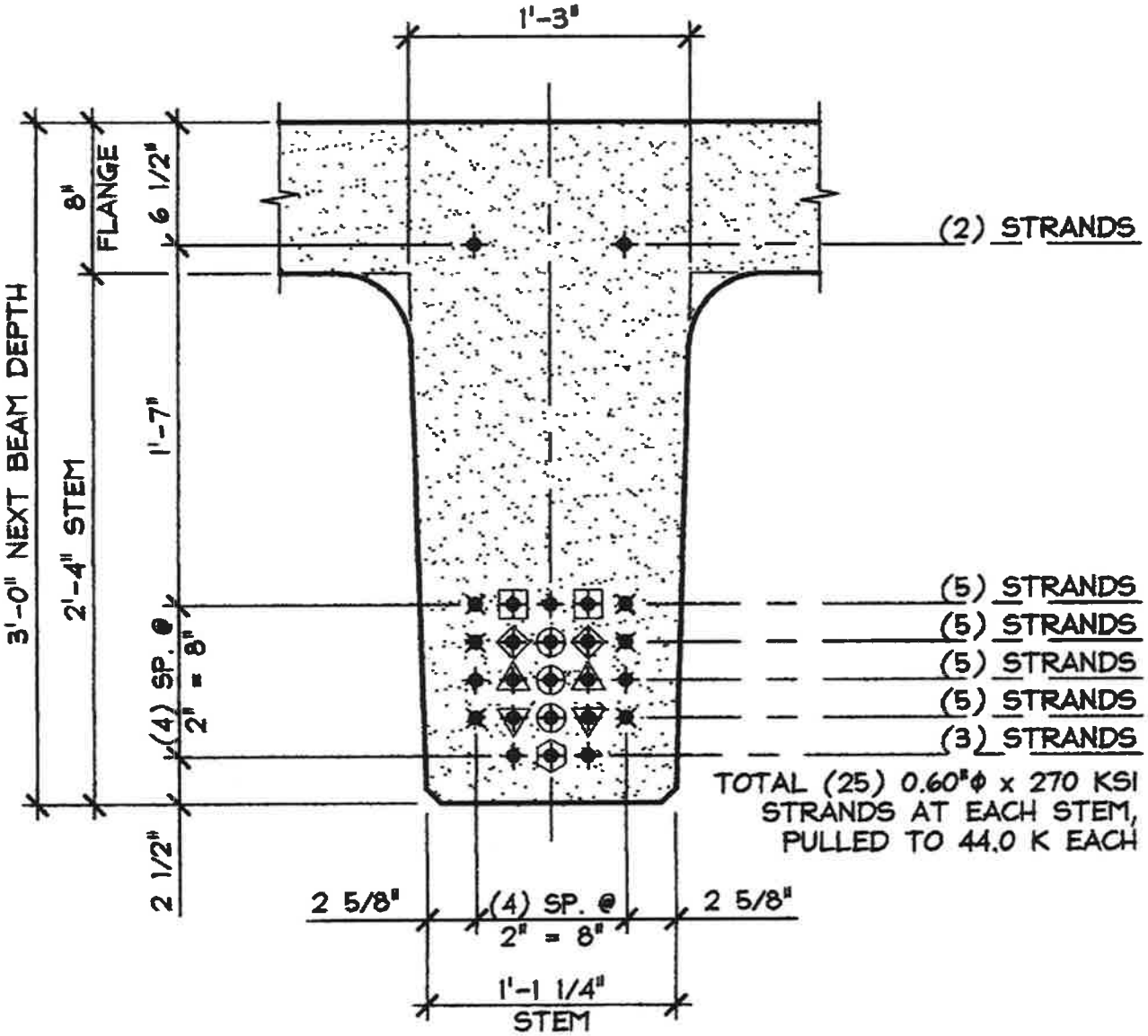
3/16" = 1'-0"



2 / NB1 REINFORCING PLAN VIEW IN FORM

ALL DIMENSIONS INDICATED ARE PARALLEL OR PERPENDICULAR TO ℄ OF STEMS (U.N.O.)

3/16" = 1'-0"

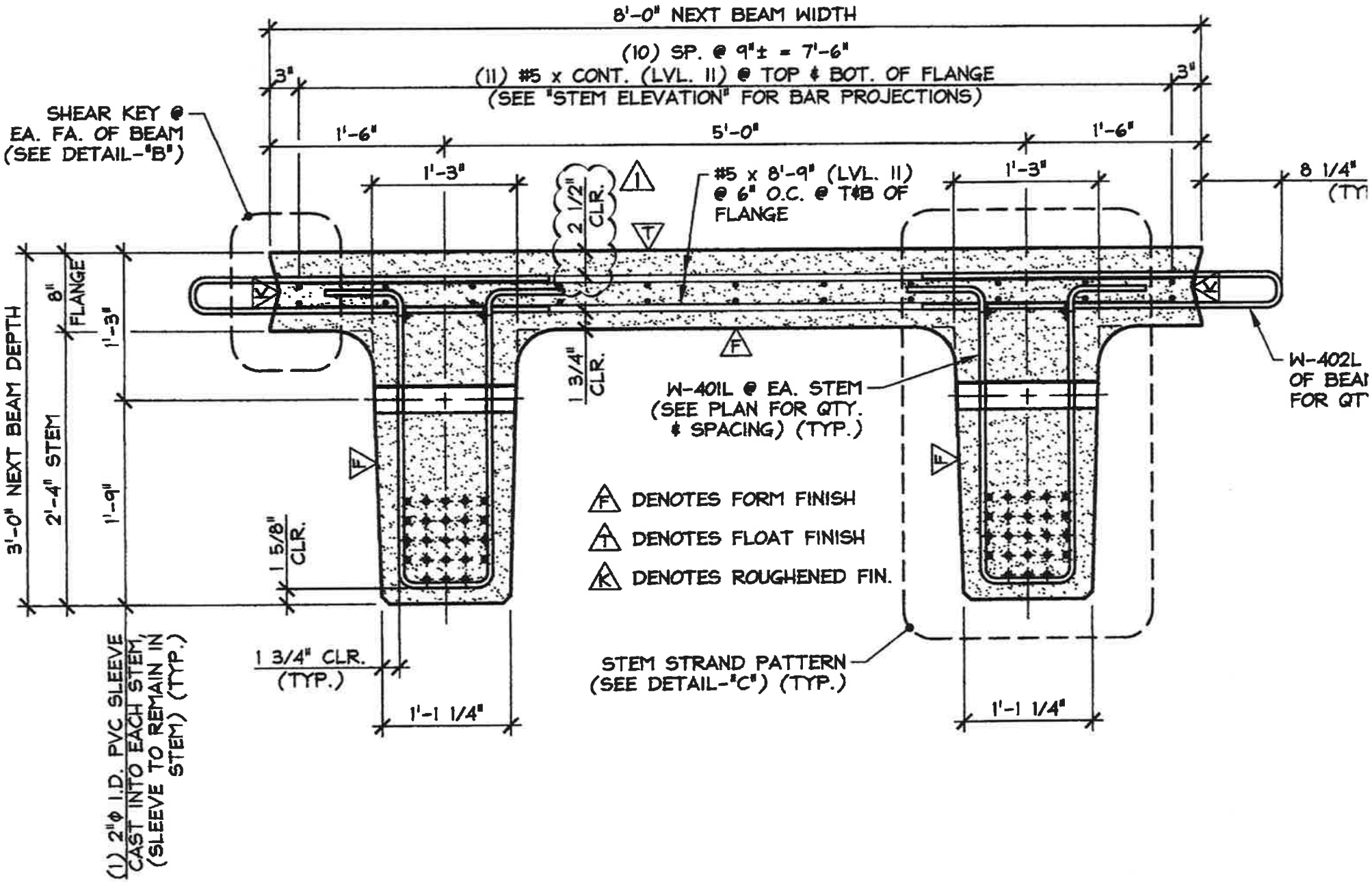


PRESTRESSING NOTATIONS

- DENOTES STRAIGHT STRANDS TO BE CUT FLUSH WITH EA. END OF EA. STEM
- DENOTES STRAIGHT STRANDS TO PROJECT 1'-6" FROM EA. END OF EA. STEM
- DENOTES STRAIGHT STRANDS TO BE DEBONDED 6" FROM EA. END OF EA. STEM
- DENOTES STRAIGHT STRANDS TO BE DEBONDED 10'-0" FROM EA. END OF EA. STEM
- DENOTES STRAIGHT STRANDS TO BE DEBONDED 14'-0" FROM EA. END OF EA. STEM
- DENOTES STRAIGHT STRANDS TO BE DEBONDED 16'-0" FROM EA. END OF EA. STEM
- DENOTES STRAIGHT STRANDS TO BE DEBONDED 18'-0" FROM EA. END OF EA. STEM
- DENOTES STRAIGHT STRANDS TO BE DEBONDED 20'-0" FROM EA. END OF EA. STEM

DETAIL - "C" (STEM STRAND PATTERN)

1" = 1'-0"



A
NB1

DIMENSIONAL & REINFORCING SECTION

3/4" = 1'-0"

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Project:
Problem:

SUMMARY REPORT

Design Code Used: ACI 318-08

CONCRETE MATERIAL PROPERTIES

CASE 1 & CASE 2

	Precast Beam			
Concrete Density	Wt	=	142	lb/ft^3
Compressive Strength	f'c	=	10000.0	psi
Modulus of Elasticity	Ec	=	3.646E+6	psi (user defined)
Strength at Transfer	f'c	=	9545.0	psi
Modulus of Elast. at Transfer	Ec	=	3.646E+6	psi
Strength at Lifting	f'c	=	9545.0	psi
Modulus of Elast. at Lifting	Ec	=	3.646E+6	psi

MEASURED f'ci & CALCULATED Eci

Cement Content = 691 lb/yd^3
Air Content = 7.00 %
Slump = 1.97 in
Aggregate Mix = 0.40 (fine to total aggregate ratio)
Aggregate Size = 0.79 in
Basic Shrinkage Strain = 780.000E-6

Construction Schedule
Age at Transfer = 3.00 days
Age at Erection = 40 days
Age at Cast-in-Place Pour = 50 days
Age Cast-in-Place is Composite = 53 days
Age Construction is Complete = 143 days

Curing Method = Moist
Relative Humidity in Service = 70 %
Ambient Temperature in Service = 20 deg C
Precast concrete is flowable

PRECAST BEAM LAYOUT

Segment/Length No	From ft	To ft	Length ft	Section Identification: Folder Name	Section Name	Section Type	Offset Z in	Y in
1	0.00	86.16	86.16	Topped NEXT	NEXT 8 36D	Double Tee	0.00	0.00

Span Length at Transfer = 86.16 ft, Centre of Supports, Left @ 0.00 ft, Right @ 86.16 ft
Span Length in Service = 85.00 ft, Centre of Supports, Left @ 0.58 ft, Right @ 85.58 ft
Total Beam Length = 86.16 ft, Bearing Length, Left = 4.00 in, Right = 4.00 in

GROSS PRECAST SECTION PROPERTIES (NON-COMPOSITE)
(based on Ec of the precast beam - transformed area of rebar and strand NOT included)

Seg. No.	Section Properties A in^2	I in^4	yb in	Section Height in	Section Width in	Shear Width in	Volume / Surface in	Section Moduli Sb in^3	St in^3
1	1562.0	176674	23.03	36.00	96.00	28.25	5.11	-7671	13622

UNCRACKED SECTION PROPERTIES SUMMARY

x ft	Net Precast Section at Transfer (based on Eci) (include rebar, deduct strand) A in^2	I in^4	yb in	Transformed Precast Section at Transfer (based on Eci) (include rebar and strand) A in^2	I in^4	yb in	Transformed Precast Section in Service (based on Ec) (include rebar and strand) A in^2	I in^4	yb in
0.00	1556	175763	23.08	1562	176683	23.03	1562	176683	23.03
0.58	1571	176584	23.17	1586	179900	23.04	1586	179900	23.04
8.65	1602	178378	23.34	1658	191897	22.89	1658	191897	22.89
17.58	1600	177829	23.37	1673	194993	22.75	1673	194993	22.75
26.08	1599	177299	23.38	1685	198876	22.63	1685	198876	22.63
34.58	1599	177299	23.38	1685	198876	22.63	1685	198876	22.63
43.08	1599	177299	23.38	1685	198876	22.63	1685	198876	22.63
52.01	1599	177299	23.38	1685	198876	22.63	1685	198876	22.63
60.51	1599	177299	23.38	1685	198876	22.63	1685	198876	22.63
69.00	1600	177842	23.37	1672	194741	22.76	1672	194741	22.76
77.93	1602	178378	23.34	1658	191897	22.89	1658	191897	22.89
85.58	1571	176584	23.17	1586	179900	23.04	1586	179900	23.04
86.16	1556	175763	23.08	1562	176683	23.03	1562	176683	23.03

These section properties can used to calculate uncracked concrete stresses using the following guidelines.

Net Precast Section at Transfer properties are used with the initial prestress after transfer (after elastic shortening loss).
Transformed Precast Section at Transfer properties are used with the precast beam self-weight.
Transformed Precast Section in Service properties are used with external loads applied to the non-composite precast beam.

PRESTRESSING STEEL TENDONS

ID	Qty	Grade ksi	Type *	Strand Size	Offsets x ft	y in	End Offset & Type Left ** ft	Right ** ft	Tendon Area in^2	Jacking Force Pj kip	%fpu
1	4	270.0	LRS	0.6" (3/5)	0.00	2.50	0.00 B	0.00 B	0.868	175.8	0.75
					86.16	2.50					
2	2	270.0	LRS	0.6" (3/5)	0.00	2.50	20.00 D	20.00 D	0.434	87.9	0.75

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Project:
Problem:

					86.16	2.50					
3	4	270.0	LRS	0.6" (3/5)	0.00	4.50	0.00 B	0.00 B	0.868	175.8	0.75
					86.16	4.50					
4	4	270.0	LRS	0.6" (3/5)	0.00	4.50	18.00 D	18.00 D	0.868	175.8	0.75
					86.16	4.50					
5	2	270.0	LRS	0.6" (3/5)	0.00	4.50	0.50 D	0.50 D	0.434	87.9	0.75
					86.16	4.50					
6	4	270.0	LRS	0.6" (3/5)	0.00	6.50	0.00 B	0.00 B	0.868	175.8	0.75
					86.16	6.50					
7	4	270.0	LRS	0.6" (3/5)	0.00	6.50	16.00 D	16.00 D	0.868	175.8	0.75
					86.16	6.50					
8	2	270.0	LRS	0.6" (3/5)	0.00	6.50	0.50 D	0.50 D	0.434	87.9	0.75
					86.16	6.50					
9	4	270.0	LRS	0.6" (3/5)	0.00	8.50	0.00 B	0.00 B	0.868	175.8	0.75
					86.16	8.50					
10	4	270.0	LRS	0.6" (3/5)	0.00	8.50	14.00 D	14.00 D	0.868	175.8	0.75
					86.16	8.50					
11	2	270.0	LRS	0.6" (3/5)	0.00	8.50	0.50 D	0.50 D	0.434	87.9	0.75
					86.16	8.50					
12	6	270.0	LRS	0.6" (3/5)	0.00	10.50	0.00 B	0.00 B	1.302	263.7	0.75
					86.16	10.50					
13	4	270.0	LRS	0.6" (3/5)	0.00	10.50	10.00 D	10.00 D	0.868	175.8	0.75
					86.16	10.50					
14	4	270.0	LRS	0.6" (3/5)	0.00	29.50	0.00 B	0.00 B	0.868	175.8	0.75
					86.16	29.50					

note: * Type = LRS - Low-Relaxation Strand, SRS - Stress-Relieved Strand, PB - Plain Bar,
DB - Deformed Bar, SW - Single Wire
** End Types = B - Fully Bonded, D - Debonded, C - Cut, A - Anchored (fully developed)

Calculated Losses: Initial = 8.9%, Final = 30.6%
Maximum Total Prestress Forces: Pj(jacking) = 2197.1 kip,
Pi(transfer) = 2002.6 kip,
Pe(effective) = 1525.7 kip @ x = 43.08 ft,

8.9% CALCULATED LOSSES

See the "Development Length" text report for details of the strand transfer and development lengths

LONGITUDINAL REINFORCING STEEL

Reinforcing Steel Groups

ID	Qty	Steel Grade ksi	Bar Size	Bar Area in^2	End Location & Type From ft	*	To ft	*	Bar Spacing in	Cross Spacing in	Vertical Offset in	Offset ** Reference
1	11	60	# 5	3.4	0.25	SE	85.91	SE	9.00	-	30.69	Bottom of Precast Beam
2	11	60	# 5	3.4	0.25	SE	85.91	SE	9.00	-	32.56	Bottom of Precast Beam

* End Types: SE - Straight Embeddment, FD - Fully Developed, SH - Standard Hook, HB - Headed Bar
** Offsets are measured up from the bottom or down from the top

See the "Development Length" text report for details of the bar and wire development lengths

SHEAR STIRRUPS

From ft	To ft	Stirrup Grade ksi	Stirrup Size	Number of Legs Stirrup in Beam	Number of Legs Interface Ties	Total Stirrup Area Stirrup in^2	Total Stirrup Area Interface in^2	Stirrup Spacing Stirrup in	Stirrup Spacing Interface in
0.00	86.16	58.0	15M	0	0	0.00	0.00	0.00	0.00

TORSION PARAMETERS

Seg. Torsion Parameters

No.	Aoh in^2	Ph in
1	0.00	0.00

Aoh is the area enclosed by the centerline of the outermost closed transverse torsional reinforcement.
Ph is the perimeter of the area defined as Aoh.

PRECAST BEAM AND CAST-IN-PLACE POUR SELF-WEIGHT

Segment/Length No.	From ft	To ft	Linear Weight Beam kip/ft	Linear Weight Cast-in-Place kip/ft
1	0.00	86.16	1.5414	0.0000

EXTERNALLY APPLIED LOADS

Load Case	Type	Label	Description	Distribution