PRESTRESSED CONCRETE I-GIRDER LOAD AND RESISTANCE FACTOR RATING (LRFR) ANALYSIS BRIDGE NO. 00596 ROUTE 68 OVER NAUGATUCK RIVER, ROUTE 8, METRO-NORTH RR, SR 710 NAUGATUCK, CONNECTICUT

PROJECT NO. 87-142
MARCH 2011
JOHN H. MILLER

STATE OF CONNECTICUT
JOHN H. MILLER
NO. 4142
LICENSED
PROFESSIONAL ENGINEER

MARCH 31, 2011

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CONNECTICUT DEPARTMENT OF TRANSPORTATION

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BRIDGE NO.00596
ROUTE 68 OVER NAUGATUCK RIVER, ROUTES 8, 710 AND METRO NORTH TRACKS
NAUGATUCK, CT

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BRIDGE NO.00596

ROUTE 68 OVER NAUGATTUCK RIVER, ROUTES 8, 710 AND METRO NORTH TRACKS

NAUGATUCK, CT

INTERIOR GIRDER "E"

BY: B.A.
CHKD.BY: DATE: 3/08/2010

BRIDGE NO.00596
ROUTE 68 OVER NAUGATUCK RIVER, ROUTES 8 & 710 & METRO NORTH RAILROAD, NAUGATUCK, CT

STRUCTURE TYPE: POST-TENSIONED CONCRETE I GIRDERS
YEAR BUILD:1958, 1960
1963, 1987, 1993 (REHAB.)
DECK WIDTH OUT TO OUT: 64' - 6" DECK WIDTH CURB TO CURB: 50' - 0"
DECK THICKNESS AND TYPE: 8" CONCRETE, CAST BETWEEN BEAMS WITH 2 1/2" BITUMNOUS OVERLAY
CONCRETE COMPRESSIVE STRENGTH: f'c= 5000 psi (P/S CONC. GIRDERS)
f's= 250,000 psi (PRE-STRESSING STEEL) f's= 200,000 psi (POST-TENSIONING STEEL)
BEAM SPACING: 5' - 11½"
SPAN LENGTHS: 75.54' (SPAN 1 & 6)
97.5' (SPANS 2- 5)

LOAD RESISTANCE FACTOR RATING SUMMARY (LRFR)
HL-93, L73.0 (4 Axle), L3S2 (5 Axle), P76.5 (4 Axle), P204 (8 Axle), P380 (19 Axle), TLC (9 Axle)

LRFR STRENGTH I LIMIT STATE				INVENTORY Flexure FACTOR	OPERATING Flexure FACTOR	INVENTORY Shear FACTOR	OPERATING Shear FACTOR
SPAN(S)	MEMBER(S)		LOCATION				
2-5	Interior Girder (As Built)	HL-93	Flexural @ Midspan Shear @ .25L	1.00	1.30	*	***0.53***
		L73.0		*	1.66	*	***0.88***
		L3S2		*	2.00	*	1.00
		P76.5		*	*	*	*
		P204		*	*	*	*
		P380		*	*	*	*
		TLC		*	*	*	*
5	Span 5 Interior Girder E4 (As Inspected)	HL-93	Flexural @ Midspan Shear @ .25L	***0.71***	***0.92***	*	***0.37***
		L73.0		*	1.20	*	***0.61***
		L3S2		*	1.50	*	***0.72***
		P76.5		*	*	*	*
		P204		*	*	*	*
		P380		*	*	*	*
		TLC		*	*	*	*

LRFR STRENGTH II LIMIT STATE				INVENTORY Flexure FACTOR	OPERATING Flexure FACTOR	INVENTORY Shear FACTOR	OPERATING Shear FACTOR
SPAN(S)	MEMBER(S)		LOCATION				
2-5	Interior Girder (As Built)	HL-93	Flexural @ Midspan Shear @ .25L	*	*	*	*
		L73.0		*	*	*	*
		L3S2		*	*	*	*
		P76.5		*	1.30	*	***0.92***
		P204		*	1.10	*	***0.68***
		P380		*	1.30	*	***0.94***
		TLC		*	***0.84***	*	***0.57***
5	Span 5 Interior Girder E4 (As Inspected)	HL-93	Flexural @ Midspan Shear @ .25L	*	*	*	*
		L73.0		*	*	*	*
		L3S2		*	*	*	*
		P76.5		*	1.10	*	***0.57***
		P204		*	***0.99***	*	***0.42***
		P380		*	1.20	*	***0.58***
		TLC		*	***0.76***	*	***0.36***

BY: B.A.
CHKD.BY: DATE: 3/15/2010

BRIDGE NO.00596
ROUTE 68 OVER NAUGATUCK RIVER, ROUTES 8 & 710 & METRO NORTH RAILROAD, NAUGATUCK, CT

STRUCTURE TYPE: POST-TENSIONED CONCRETE I GIRDERS
YEAR BUILD:1958, 1960
1963, 1987, 1993 (REHAB.)
DECK WIDTH OUT TO OUT: 64' - 6" DECK WIDTH CURB TO CURB: 50' - 0"
DECK THICKNESS AND TYPE: 8" CONCRETE, CAST BETWEEN BEAMS WITH 2 1/2" BITUMNOUS OVERLAY
CONCRETE COMPRESSIVE STRENGTH: f'C= 5000 psi (P/S CONC. GIRDERS)
f's= 250,000 psi (PRE-STRESSING STEEL) f's= 200,000 psi (POST-TENSIONING STEEL)
BEAM SPACING: 5' - 11½"
SPAN LENGTHS: 75.54' (SPAN 1 & 6)
97.5' (SPANS 2- 5)

LOAD RESISTANCE FACTOR RATING SUMMARY (LRFR)
HL-93, L73.0 (4 Axle), L3S2 (5 Axle), P76.5 (4 Axle), P204 (8 Axle), P380 (19 Axle), TLC (9 Axle)

LRFR STRENGTH I LIMIT STATE				INVENTORY Flexure FACTOR	OPERATING Flexure FACTOR	INVENTORY Shear FACTOR	OPERATING Shear FACTOR
SPAN(S)	MEMBER(S)		LOCATION				
1 & 6	Interior Girder (As Built)	HL-93	Flexural @ Midspan Shear @ .05L	1.30	1.60	*	***0.30***
		L73.0		*	2.90	*	***0.65***
		L3S2		*	4.00	*	***0.81***
		P76.5		*	*	*	*
		P204		*	*	*	*
		P380		*	*	*	*
		TLC		*	*	*	*

LRFR STRENGTH II LIMIT STATE				INVENTORY Flexure FACTOR	OPERATING Flexure FACTOR	INVENTORY Shear FACTOR	OPERATING Shear FACTOR
SPAN(S)	MEMBER(S)		LOCATION				
1 & 6	Interior Girder (As Built)	HL-93	Flexural @ Midspan Shear @ .05L	*	*	*	*
		L73.0		*	*	*	*
		L3S2		*	*	*	*
		P76.5		*	2.70	*	***0.69***
		P204		*	2.10	*	***0.56***
		P380		*	2.70	*	***0.82***
		TLC		*	1.60	*	***0.46***

BY: B.A.
CHKD.BY: DATE: 3/10/2010

BRIDGE NO.00596
ROUTE 68 OVER NAUGATUCK RIVER, ROUTES 8 & 710 & METRO NORTH TRACKS, NAUGATUCK, CT

STRUCTURE TYPE: POST-TENSIONED CONCRETE I GIRDERS
YEAR BUILD:1958, 1960
1963, 1987, 1993 (REHAB.)
DECK WIDTH OUT TO OUT: 64' - 6" DECK WIDTH CURB TO CURB: 50' - 0"
DECK THICKNESS AND TYPE: 8" CONCRETE, CAST BETWEEN BEAMS WITH 2 1/2" BITUMNOUS OVERLAY
CONCRETE COMPRESSIVE STRENGTH: f'C= 5000 psi (P/S CONC. GIRDERS)
f's= 250,000 psi (PRE-STRESSING STEEL) f's= 200,000 psi (POST-TENSIONING STEEL)
BEAM SPACING: 5' - 11½"
SPAN LENGTHS: 75.54' (SPAN 1 & 6)
97.5' (SPANS 2- 5)

LOAD RESISTANCE FACTOR RATING SUMMARY (LFR vs. LRFR)
HS-20, HL-93, L73.0 (4 Axle), L3S2 (5 Axle), P76.5 (4 Axle), P204 (8 Axle), P380 (19 Axle), TLC (9 Axle)

LRFR STRENGTH I LIMIT STATE LFR RATING				INVENTORY Flexure FACTOR	OPERATING Flexure FACTOR	INVENTORY Shear FACTOR	OPERATING Shear FACTOR
SPAN(S)	MEMBER(S)		LOCATION				
2-5	Interior Girder (As Built)	HS-20	Flexural @ Midspan Shear @ .25L	1.08	1.80	1.21	2.02
		HL-93		1.00	1.30	*	***0.53***
		L73.0		*	1.66	*	***0.88***
		L3S2		*	2.00	*	1.00
		P76.5		*	*	*	*
		P204		*	***0.83***	*	***0.80***
		P380		*	***0.89***	*	***0.93***
		TLC		*	*	*	*
5	Span 5 Interior Girder E4 (As Inspected)	HS-20	Flexural @ Midspan Shear @ .25L	***0.80***	1.56	1.15	1.92
		HL-93		***0.71***	***0.92***	*	***0.37***
		L73.0		*	1.20	*	***0.61***
		L3S2		*	1.50	*	***0.72***
		P76.5		*	*	*	*
		P204		*	***0.72***	*	***0.76***
		P380		*	***0.77***	*	***0.88***
		TLC		*	*	*	*

LRFR STRENGTH II LIMIT STATE				INVENTORY Flexure FACTOR	OPERATING Flexure FACTOR	INVENTORY Shear FACTOR	OPERATING Shear FACTOR
SPAN(S)	MEMBER(S)		LOCATION				
2-5	Interior Girder (As Built)	HL-93	Flexural @ Midspan Shear @ .25L	*	*	*	*
		L73.0		*	*	*	*
		L3S2		*	*	*	*
		P76.5		*	1.30	*	***0.92***
		P204		*	1.10	*	***0.68***
		P380		*	1.30	*	***0.94***
		TLC		*	***0.84***	*	***0.57***
5	Span 5 Interior Girder E4 (As Inspected)	HL-93	Flexural @ Midspan Shear @ .25L	*	*	*	*
		L73.0		*	*	*	*
		L3S2		*	*	*	*
		P76.5		*	1.10	*	***0.57***
		P204		*	***0.99***	*	***0.42***
		P380		*	1.20	*	***0.58***
		TLC		*	***0.76***	*	***0.36***

BY: B.A.
CHKD.BY: DATE: 3/08/2010

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BRIDGE NO.00596
ROUTE 68 OVER NAUGATUCK RIVER, ROUTES 8 & 710 & METRO NORTH TRACKS, NAUGATUCK, CT

STRUCTURE TYPE: POST-TENSIONED CONCRETE I GIRDERS
YEAR BUILD:1958, 1960
1963, 1987, 1993 (REHAB.)
DECK WIDTH OUT TO OUT: 64' - 6" DECK WIDTH CURB TO CURB: 50' - 0"
DECK THICKNESS AND TYPE: 8" CONCRETE, CAST BETWEEN BEAMS WITH 2 1/2" BITUMNOUS OVERLAY
CONCRETE COMPRESSIVE STRENGTH: f'c= 5000 psi (P/S CONC. GIRDERS)
f's= 250,000 psi (PRE-STRESSING STEEL) f's= 200,000 psi (POST-TENSIONING STEEL)
BEAM SPACING: 5' - 11½"
SPAN LENGTHS: 75.54' (SPAN 1 & 6)
97.5' (SPANS 2- 5)

LOAD RESISTANCE FACTOR RATING SUMMARY (LRFR)
HL-93, L73.0 (4 Axle), L3S2 (5 Axle), P76.5 (4 Axle), P204 (8 Axle), P380 (19 Axle), TLC (9 Axle)

LRFR STRENGTH I LIMIT STATE				INVENTORY Flexure FACTOR	OPERATING Flexure FACTOR	INVENTORY Shear FACTOR	OPERATING Shear FACTOR
SPAN(S)	MEMBER(S)		LOCATION				
2-5	Interior Girder (As Built)	HL-93	Flexural @ Midspan Shear @ .25L	1.00	1.30	*	***0.53***
		L73.0		*	1.66	*	***0.88***
		L3S2		*	2.00	*	1.00
		P76.5		*	*	*	*
		P204		*	*	*	*
		P380		*	*	*	*
		TLC		*	*	*	*
5	Span 5 Interior Girder E4 (As Inspected)	HL-93	Flexural @ Midspan Shear @ .25L	***0.71***	***0.92***	*	***0.37***
		L73.0		*	1.20	*	***0.61***
		L3S2		*	1.50	*	***0.72***
		P76.5		*	*	*	*
		P204		*	*	*	*
		P380		*	*	*	*
		TLC		*	*	*	*

LRFR STRENGTH II LIMIT STATE				INVENTORY Flexure FACTOR	OPERATING Flexure FACTOR	INVENTORY Shear FACTOR	OPERATING Shear FACTOR
SPAN(S)	MEMBER(S)		LOCATION				
2-5	Interior Girder (As Built)	HL-93	Flexural @ Midspan Shear @ .25L	*	*	*	*
		L73.0		*	*	*	*
		L3S2		*	*	*	*
		P76.5		*	1.30	*	***0.92***
		P204		*	1.10	*	***0.68***
		P380		*	1.30	*	***0.94***
		TLC		*	***0.84***	*	***0.57***
5	Span 5 Interior Girder E4 (As Inspected)	HL-93	Flexural @ Midspan Shear @ .25L	*	*	*	*
		L73.0		*	*	*	*
		L3S2		*	*	*	*
		P76.5		*	1.10	*	***0.57***
		P204		*	***0.99***	*	***0.42***
		P380		*	1.20	*	***0.58***
		TLC		*	***0.76***	*	***0.36***

Close, Jensen and Miller, P.C.

BY: BA	DATE: ##	SUBJECT: BR. 596	SHEET NO.: 1E OF
CHKD. BY:	DATE: 12/6/10	RATING	JOB NO.:

BR. 00596:
ROUTE 68 OVER NAUGATUCK RIVER, ROUTES 8 & 710 & METRO NORTH RR TRACKS
NAUGAUCK , CT

STRUCTURE TYPE: PRESTRESSED CONCRETE I GIRDERS
YEAR BUILT: 1958 WITH REHABILITATIONS ON 1963, 1987, 1993
SPAN LENGTHS: 75.54' (SPANS 1 & 6), 97.5' (SPANS 2-5)
BEAM SPACING: 5'-11 1/2"
DECK WIDTH OUT TO OUT: 64'-6"
DECK THICKNESS: 8"
CONCRETE COMPRESSIVE STRENGTH: 5000 PSI (P/S CONCRETE GIRDERS)

REFERENCES

1. AASHTO Standard Specifications for Highway Bridges, 16th Edition, 1996 (with interim specifications up to 1998) **(AASHTO)** 17th Edition, 2002
2. AASHTO Manual for Condition Evaluation of Bridges, 1994 (with interim specifications up to 1998) **(MCEB)** 1998 2007
3. User's Manual for Computer Program P4353030 Prestressed Concrete Girder Design and Rating, Pennsylvania Department of Transportation, Version 3.4, November 1996 **(PS3.4)** PS3.5
4. AISC Manual of Steel Construction, 5th Edition, 1957.
5. AISC Manual of Steel Construction, 8th Edition, 1980. 9th Edition, 1989
6. Original Construction Plans for Route 68 Extension over Naugatuck River, Naugatuck, CT, 1958.
7. Rehabilitation Plans for Route 68 over Naugatuck River, Metro North Tracks, Route 8, and North Main Street, Naugatuck, CT, 1987.
8. McNichols Master Catalog, 1999.
9. Design of Prestressed Concrete Structures, by T.Y. Lin, 1955.
10. Engineering Formulas, by Gieck & Gieck, 6th Edition, 1990.
11. Bridge Safety Inspection Report, CDOT Bridge No. 00596, 2000 Routine Inspection.
12. Bridge Safety Inspection Report, CDOT Bridge No. 00596, 2009 Routine Inspection.

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BY BA DATE 12/6/10 SUBJECT BR 596 SHEET NO. 3E OF
CHKD. BY DATE Ford 68 of NAVGATUK JOB NO.
FMR, ATR 8, MNRR, SR 710 NAVGATUK

GENERAL NOTES AND ASSUMPTIONS

1. Span nomenclature was the same as that used in the latest inspection field notes. Girder nomenclature was the same as that used in the1958 original construction plans.

2. An overlay thickness of 2½", as shown in the 1958 original construction plans, was used for dead loads. All superimposed dead loads were distributed evenly to all girders.

3. For all spans, the exterior girders (A in spans 1 & 6, C in spans 2 & 5, and F in spans 3 & 4) were not rated, since they will not be subjected to any vehicular live load. Only the typical interior girders (B in spans 1 & 6 and E in spans 2-5) were rated. Interior girder D (adjacent to the curb) in spans 2-5 was not rated since it has a larger cross-section, greater prestress force and lower live load shear distribution factor than the typical interior girder E.

4. A review of the 1963, 1987, and 1993 rehabilitation plans indicates that, except for the additional dead load from a 6" diameter gas main (1987 Rehab), the rated members were not affected by the rehabilitation.

5. A review of the latest inspection field notes indicates concrete spalls, which do affect the bridge rating.

(SEE NEXT PAGE)

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BY BA DATE 12/6/6 SUBJECT FR 576 SHEET NO. 4E OF

CHKD. BY DATE FRONT 68 & NAUGATUCK JOB NO. NAUGATUCK

FWOC, RTE 8, NWCK, CT 710

GENERAL NOTES (FROM 1958 ORIG. CONSTN. PLANS)

SPECIFICATIONS. Connecticut State Highway Department Form 808-January 1955 as supplemented by Special Provisions
Standard Specifications for Highway Bridges (AASHO-1953) except as supplemented by Connecticut State Highway Department Standard Bridge Details for Contracting Engineers (February 1956).
U.S. Department of Commerce, Bureau of Public Roads Criteria for Prestressed Concrete Bridges 1954.
American Welding Society Specifications for Welded Highway and Railroad Bridges incl. latest revisions.

LIVE LOAD: H20-S16-44

DEAD LOAD. Allowance for future pavement 25 lbs per sq ft of roadway.

CONCRETE. Class "A" Concrete shall be used throughout (see Special Provisions); except for 1) Prestressed Girders, (see Spec. Prov.) & 2) Conc. Filled Grid floor (see Spec. Prov.)

CAST-IN-PLACE CONCRETE shall have a 28-day cylinder strength of 3000 psi (see Special Provisions.).

PRECAST CONCRETE shall have a 28-day cylinder strength of 5000 psi. The minimum compressive strength of concrete at the transfer of prestress shall be 4000 psi (see Special Provisions).

DEFORMED STEEL BARS. Deformations to conform to ASTM. A-305.

PRETENSIONING STEEL: Individual tendons for pre-tensioning shall consist of seven-wire cable strands which have a nominal diameter of $\frac{3}{8}$ inch (see Special Provisions).

TAR PAPER: The cost of furnishing and placing 2 layers of 3-ply tar paper at the backwalls shall be included in item for Class "A" Concrete.

PRESTRESSED GIRDERS. TABLE OF STRESSES
(Notation according to B.P.R. "Criteria for Prestressed Concrete Girders")

Concrete.
f'_c = 5000 psi, f'_{ci} = 4000 psi
f_c = 2000 psi
f_c = 200 psi (tension due to temporary loads)
f_c = 0 psi (tension under dead, live and impact loads)

Steel. $\frac{3}{8}$" Pretensioning strands
f'_s = 250,000 psi (min ultimate stress)
f_s = 140,000 psi (allowable)

Post-tensioning Strands:
f'_s = 200,000 psi (Min. ultimate stress)
$0.6\ f'_s$ = allowable stress

POST-TENSIONING STEEL: The proposed type of tendons to be used for post-tensioning, all necessary additional details, including those for end-anchorages, methods to be employed and procedures to be followed shall be approved by the Engineer.
After the securing of the end-anchorage all tendons shall be pressure grouted in their conduits in accordance with the "Criteria for Prestressed Bridges" (see Special Provisions).

HANDLING PRESTRESSED CONCRETE BEAMS: When the pre-tensioned beam sections or the post-tensioned girders are handled, they shall be lifted by the devices provided in the top flanges of the ends of the sections or girders. The lifting forces shall be applied in a vertical direction only (see Special Provisions)

PAINTING: For shop and field painting of Structural Steel and Metal Bridge Rail, see Special Provisions.

JOINT SEAL: Joint Seal shall be included in the item for Class "A" Concrete (see Special Provisions for Class "A" Concrete)

EXPOSED EDGES: Exposed edges shall be beveled 1½" unless otherwise dimensioned.

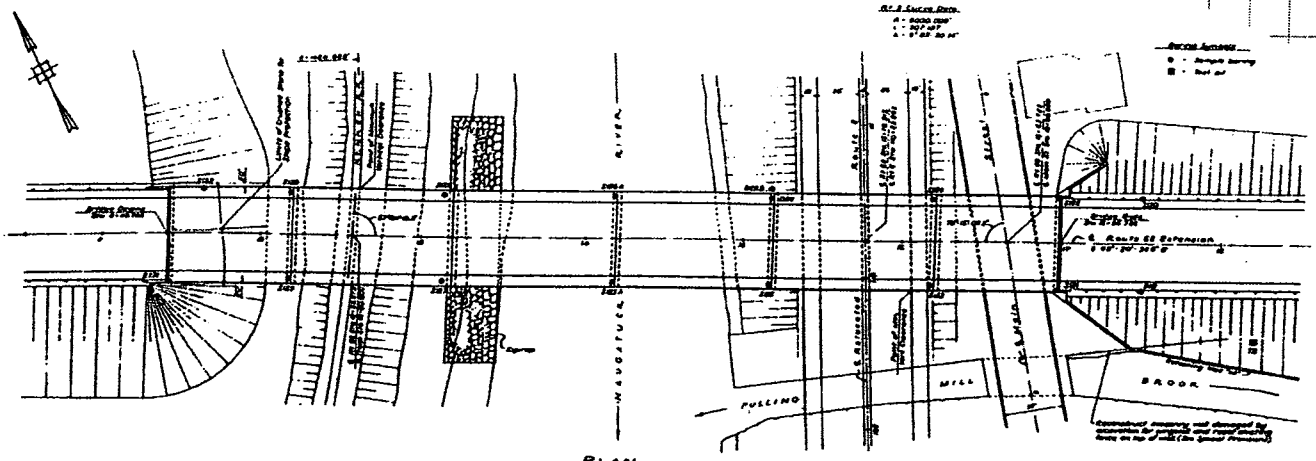
QUANTITIES: Quantities are approximate only and do not relieve the Contractor of the responsibility of checking them in preparing his bid.
The item "Structure Excavation (Complete)" applies to Abutments #1 & 2 and Piers #1 & #5
The items "Cofferdam and Pumping" and "Structure Excavation" (excluding Cofferdam and Pumping) apply to Piers #2, #3 and #4

Close, Jensen and Miller, P.C.

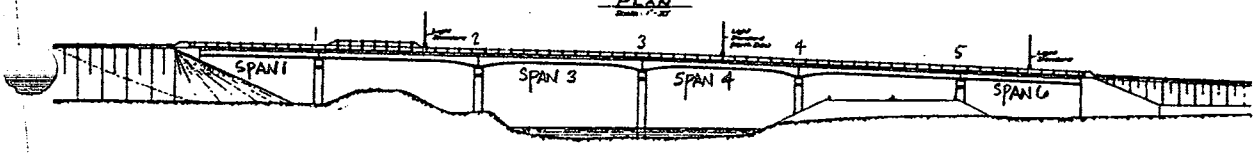
BY BA DATE 12/2/10 SUBJECT BR. 596 SHEET NO. 5E OF

CHKD. BY DATE Route 68 of NAVGATUK JOB NO.

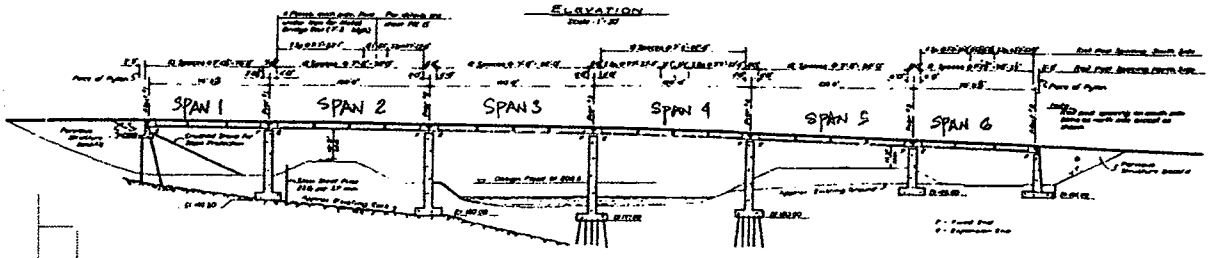
Fuller, Rge 8, SWRR, SR 710. NAVGATUK



PLAN



ELEVATION



LONGITUDINAL SECTION

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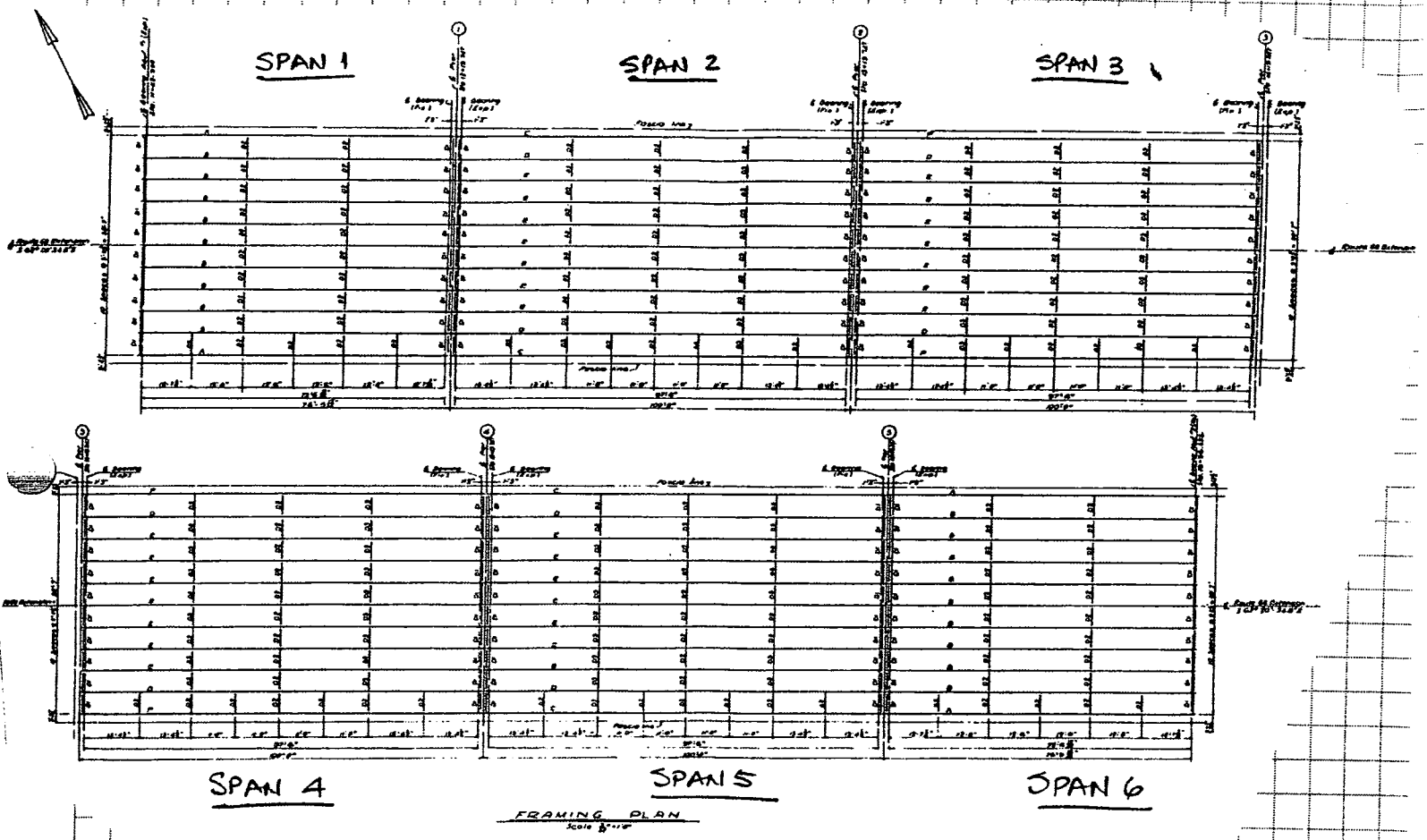
BY BA DATE 12/2/10 SUBJECT BR. 596 SHEET NO. 6E OF

CHKD. BY DATE ROUTE 6B O/ NAVIGATOR JOB NO.

FLAT, KTE 8, MNRR, SR 710 NAVIGATOR



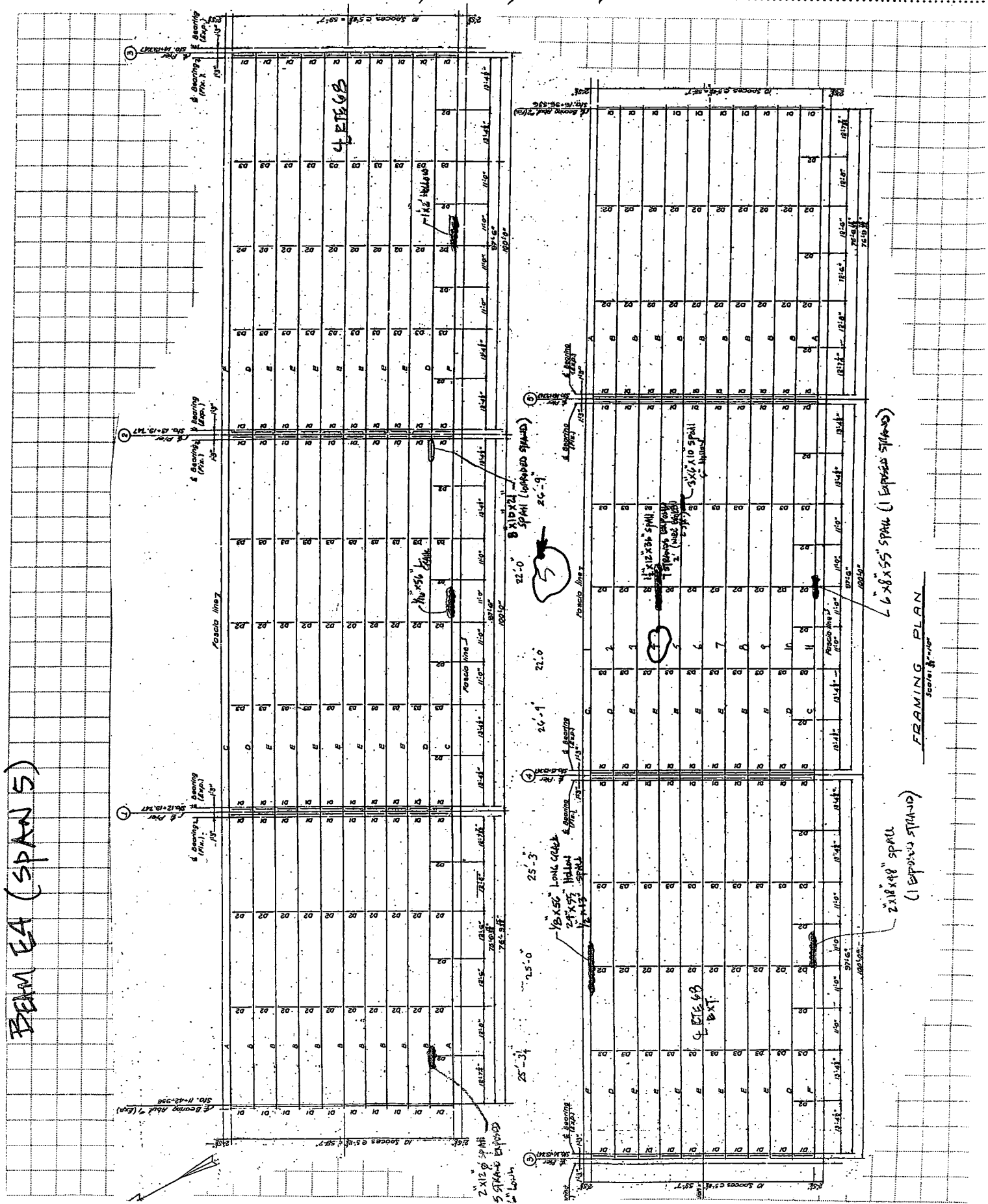
FRAMING PLAN
Scale 1/8"=1'-0"

Close, Jensen and Miller, P.C.

BY ....BA.... DATE 12/2/16 SUBJECT ....BR. 596.... SHEET NO. ....7E.... OF ....

CHKD. BY .... DATE .... ROUTE 48 O/ NAVGATUK .... JOB NO. ....

.... FORM, RTE 8, MNRR, SR 710 .... NAVGATUK ....



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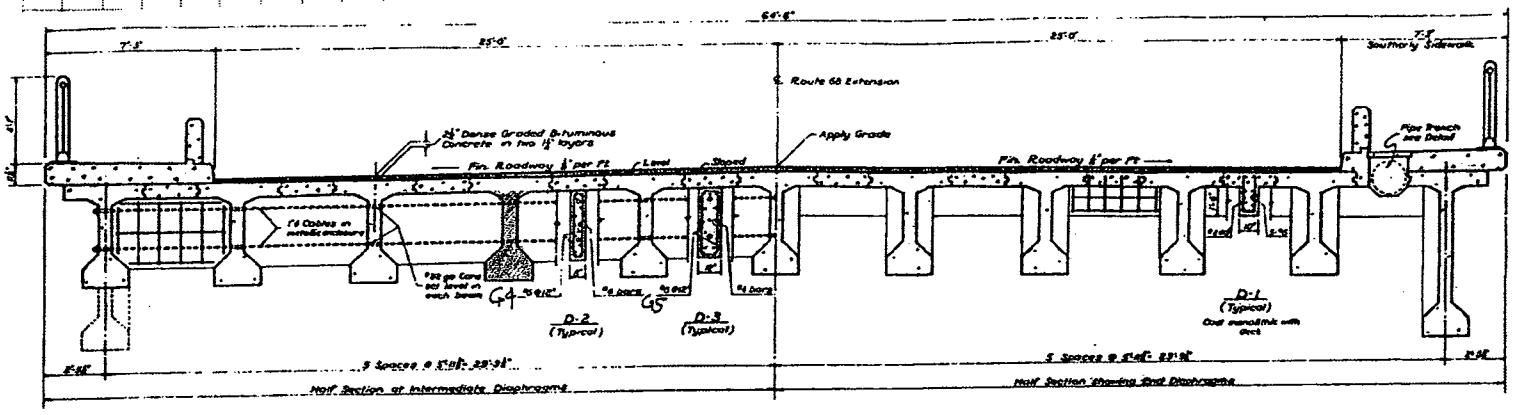
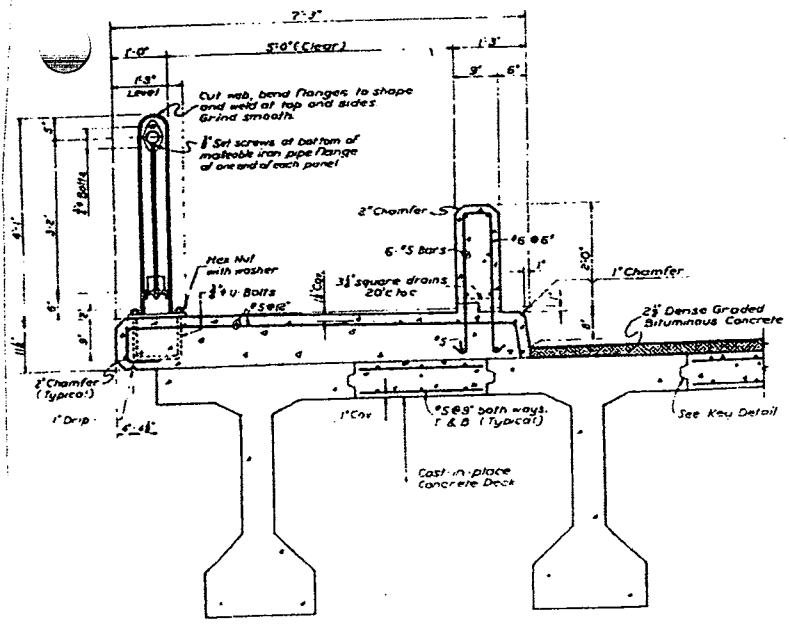
BY BA DATE 12/2/10 SUBJECT BR. 596 SHEET NO. 8E OF

CHKD. BY DATE ROUTE 6B, O/ NANGATUCK JOB NO. NANGATUCK

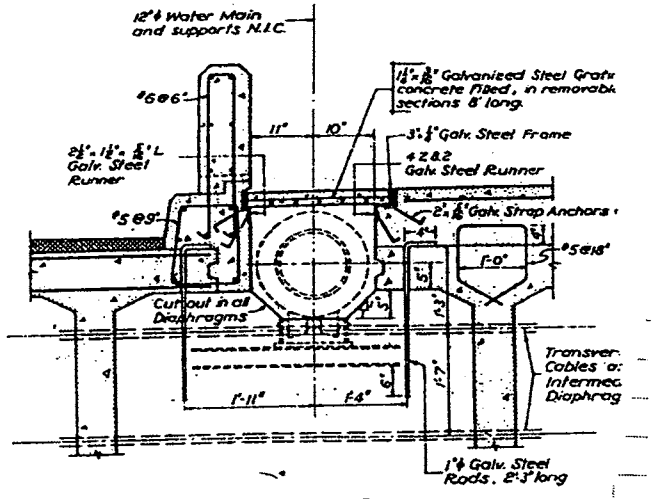
RIVER, RTE 8, MNRR, SR 710



TRANSVERSE SECTION
N.T.S.



SIDEWALK DETAIL
N.T.S.



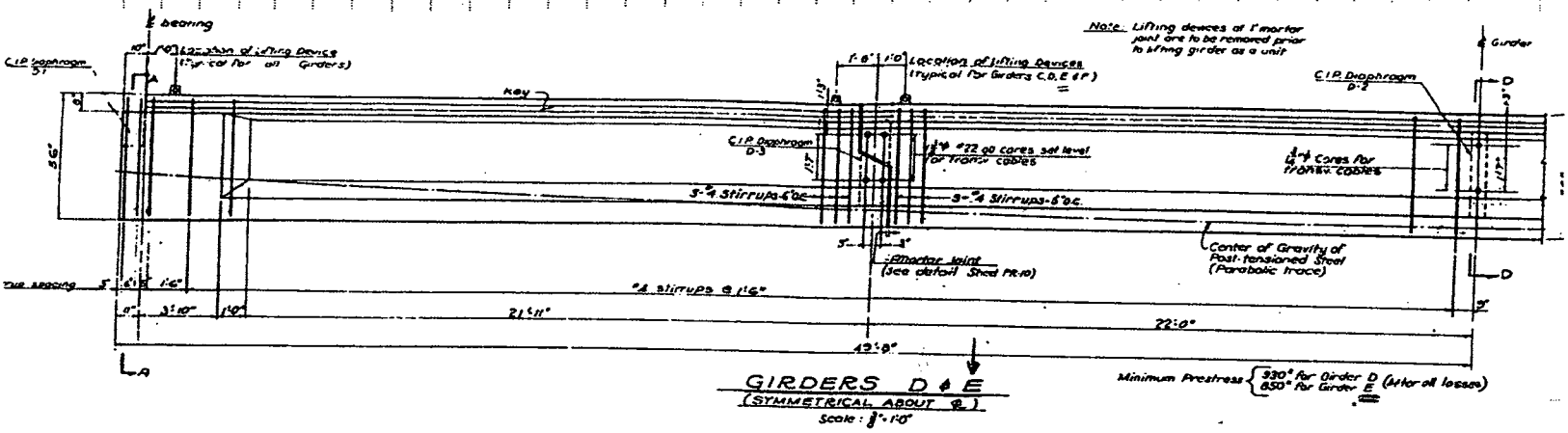
PIPE TRENCH DETAIL
N.T.S.

Close, Jensen and Miller, P.C.

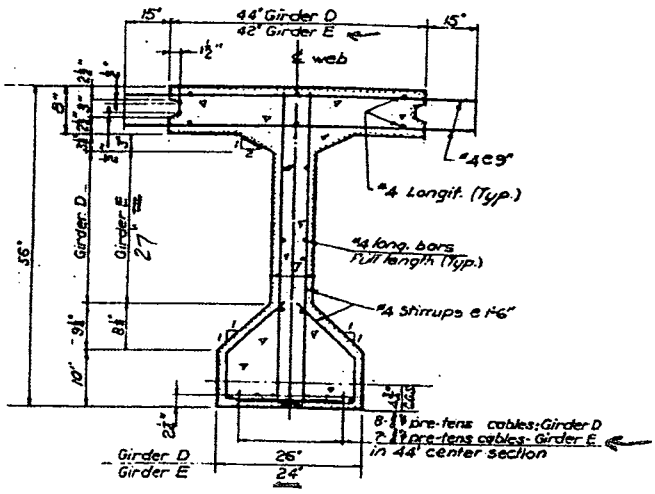
BY BA DATE 12/2/10 SUBJECT BR. 596 SHEET NO. 9E OF

CHKD. BY DATE ROUTE 6B, O/ NAUGATUCK JOB NO.

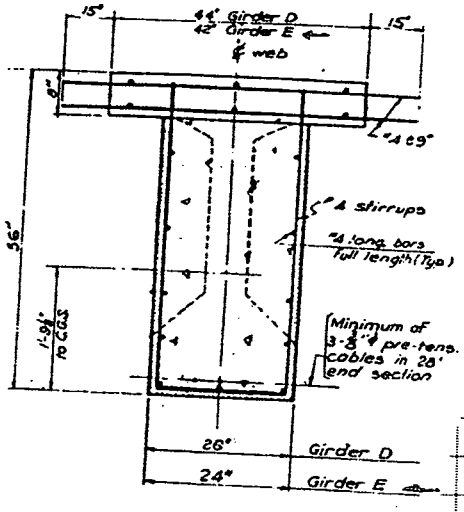
RIVER, RTE 8, MNRR, SR 710 NAUGATUCK



GIRDERS D & E
(SYMMETRICAL ABOUT ℄)
Scale: 3/8" = 1'-0"



SECTION D-D
Scale: 3/4" = 1'-0"



SECTION A-A
Scale: 3/4" = 1'-0"

INTERIOR "E"

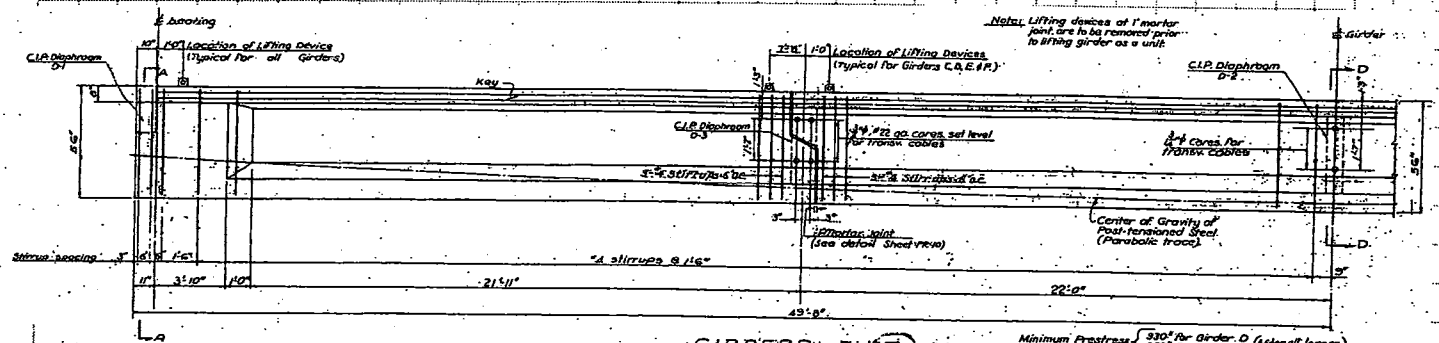
97.5' SPAN

Close, Jensen and Miller, P.C.

BY BK DATE 4/22/10 SUBJECT BR-596 SHEET NO. 10E OF

CHKD. BY DATE ROUTE 68 O/ NAUGATUCK RIVER JOB NO.

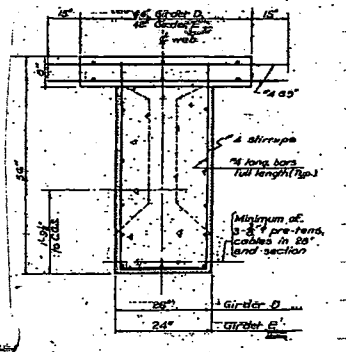
RTE 8, MNRR, SR 110 NAUGATUCK, CT



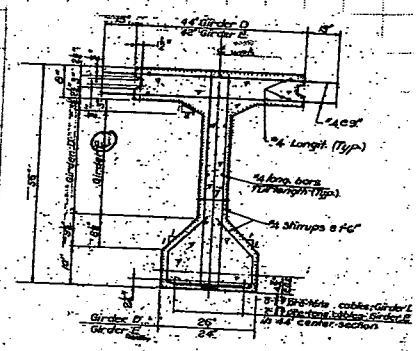
GIRDERS D & E
(SYMMETRICAL ABOUT ℄)
Scale: 3/8"=1'-0"

INTERIOR

Minimum Prestress { 930# for Girder D, 850# for Girder E (after all losses)



SECTION A-A
Scale: 3/8"=1'-0"



SECTION D-D
Scale: 3/8"=1'-0"

Close, Jensen and Miller, P.C.

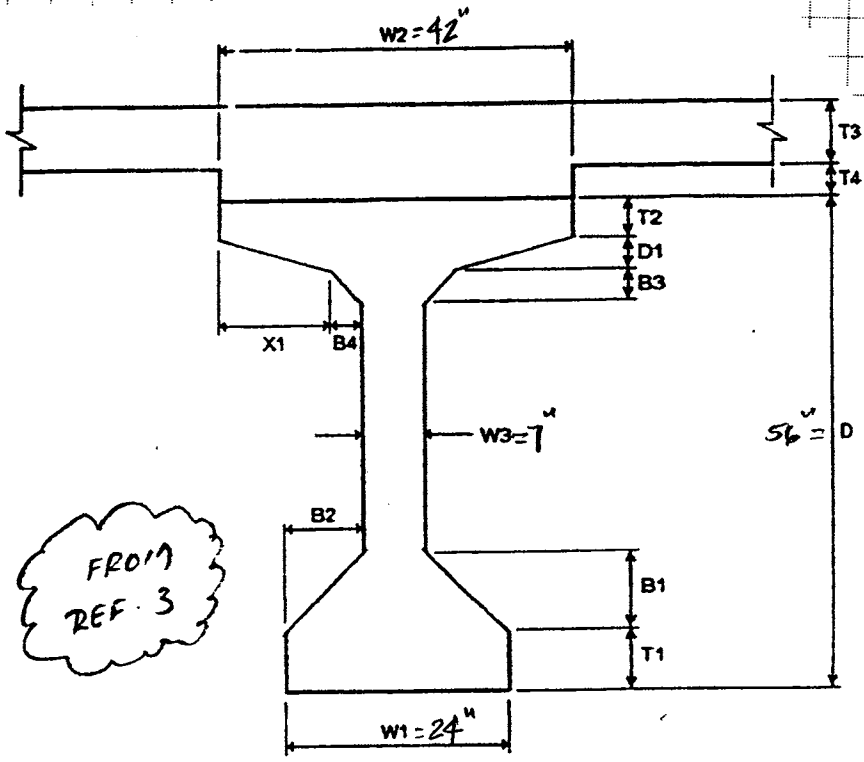
BY BA DATE 12/2/10 SUBJECT BR. 596 SHEET NO. 11E OF
CHKD. BY DATE ROUTE 68 O/ NAVGATUK JOB NO.
RIVER, RTE 8, MINN, STE 710 NAVGATUK

BEAM DIMENSIONS

TYPE I (girder E)
COMP N

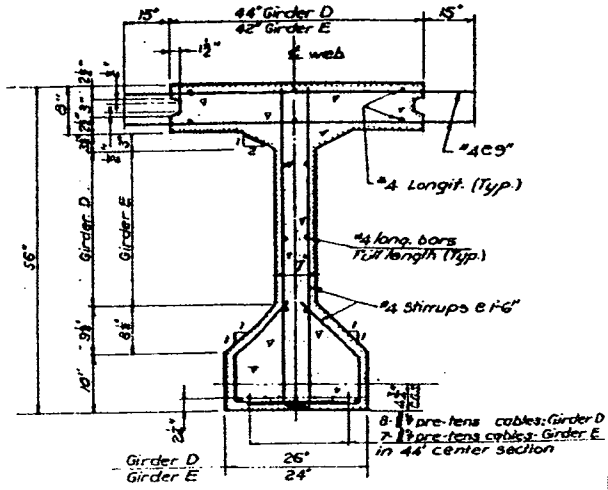
D = 56"
W1 = 24"
W2 = 42"
W3 = 7"
T1 = 10"
T2 = 8"
B1 = 8½"
B2 = 8½"
B3 = 3"
B4 = 6"
D1 = 0
D2 = 0
X1 = 0
X2 = 0

SLAB THICK - BLANK
HAUNCH - BLANK



FROM REF. 3

AASHTO Type 5 I beam



SECTION D-D
Scale: ¾" = 1'-0"

GIRDERS D & E

Close, Jensen and Miller, P.C.

BY BA DATE 11/19/00 SUBJECT BR. 596 SHEET NO. 12E OF
CHKD. BY DATE ROUTE 68 O/ NAVIGATION RIVER JOB NO.
RTE 8, M.N.R.R., SR 710 NAVIGATION

CONCRETE BEAM RATING:

SPALLS & EXPOSED REBAR/STRANDS:

G1 - SPAN 4: 1/8" x 56" CRACK LONG.
24" x 55" HOLLOW
1/2" x 13" SPALL
} MID-SPAN / BOTT. FLG.

G4 - SPAN 5: 1 1/2" x 12" x 36" SPALL (7 STRANDS EXPOSED 23" LONG)
MID-SPAN / BOTT. FLG.

G5 - SPAN 5: 3" x 6" x 10" SPALL (EXPOSED STRANDS 10" LONG)
6" ø HOLLOW
NEAR THIRD DIAPH. FROM PIER 4 / BOTT. FLG.

G10 - SPAN 1: 2" x 12" ø SPALL (5 STRANDS EXPOSED 6" LONG)
12' FROM W. ABUT. / BOTT. FLG.

G10 - SPAN 2: 8" x 10" x 21" SPALL (CORRODED STRANDS)
NEAR PIER 2 / BOTT. FLG.

G11 - SPANS 2, 3, 4
1/16" x 56" CRACK LONG.
2' x 8' HOLLOW
2" x 18" x 4' SPALL (1 EXPOSED STRANDS)
1' x 2' HOLLOW (SPAN 3)
} MIDDLE 1/3 / BOTT. FLG.

G11 - SPAN 5: 6" x 8" x 55" SPALL (1 EXPOSED STRAND)
MID-SPAN / BOTT. FLG.

Close, Jensen and Miller, P.C.

BY BA DATE 11/22/10 SUBJECT BR. 596 SHEET NO. 13 E OF
CHKD. BY DATE ROUTE 68 O/ NAUGATUCK RIVER JOB NO.
RTE 8, MNRR, SR 110 NAUGATUCK, CT

5.

All of the concrete girders have areas of hairline cracks and mapcracks with and without efflorescence as well as spalls with and without exposed strands and hollow areas in random locations. Five of the girders have more advanced spalls that are up to 55" long and 6" deep that have exposed corroded strands. Consider analyzing this structure with a reduced capacity for the beams with large spalls and/or broken prestressing strands. Clean and paint the exposed strands and patch the spalls (+/- 10 CF).

GIRDERS 4

Prestressed Concrete I-Beams with closed horizontal hairline cracks at the intersection of the girder webs and top flanges in Span 1 and random vertical, horizontal, diagonal hairline cracks and mapcracks with and without efflorescence. Some cracks at the ends have been epoxy injected. There are also spalls with and without exposed rebar and hollow areas in the webs, typically at girder ends beyond the bearings. The underside of the girder bottom flanges have closed hairline cracks and small spalls at random locations, plus the following:

INT. G10 in Span 1 - 12" diameter x 2" deep spall with five strands exposed 6" long in the underside of the bottom flange located 12' from the West Abutment.

G10 in Span 2 - 21" x 10" x 8" deep new spall with corroded strands near Pier 2.

INT. WORST CASE G4 in Span 5 - 36" x 12" x 1½" deep spall with seven strands exposed up to 23" long and heavy rust with several wires broken on two strands on the underside of the bottom flange at approximately midspan.

G5 in Span 5 - 10" x 6" x 3" deep spall with strands exposed up to 10" long and a 6" diameter hollow area on the underside of the bottom flange near the third diaphragm from Pier 4.

G11 in Span 5 - 8" x 55" x 6" epoxy coated spall with one exposed strand with some light rust beginning to show through on the underside of the bottom flange at midspan.

G11 in Spans 2, 3 & 4 - The girders have longitudinal hairline cracks up to 56" long x up to 1/16" wide in the bottom flange with hollow areas up to 2' x 8' and a 18" x 4' x 2" deep spall (1 exposed strand) with a 1' x 2' hollow area in Span 3. All are on the bottom flange in the middle 1/3 of the span. In addition, some of these areas appear to have been patched.

G1 in Span 4 - longitudinal cracks open to 1/8" x 56" long with a 24" x 55" hollow area and a 13" x ½" deep spall located along the bottom flange at midspan.

Exterior post tensioning is present along G11 in Spans 2, 3 and 4 with no deficiencies. Random cast-in-place diaphragms (and pipe supports in Bay 10) have open cracks, spalls up to 3" deep with exposed rusted rebar and hollow areas. See sheets 25-39 and photos 10, 19-20.

(REF. 12)

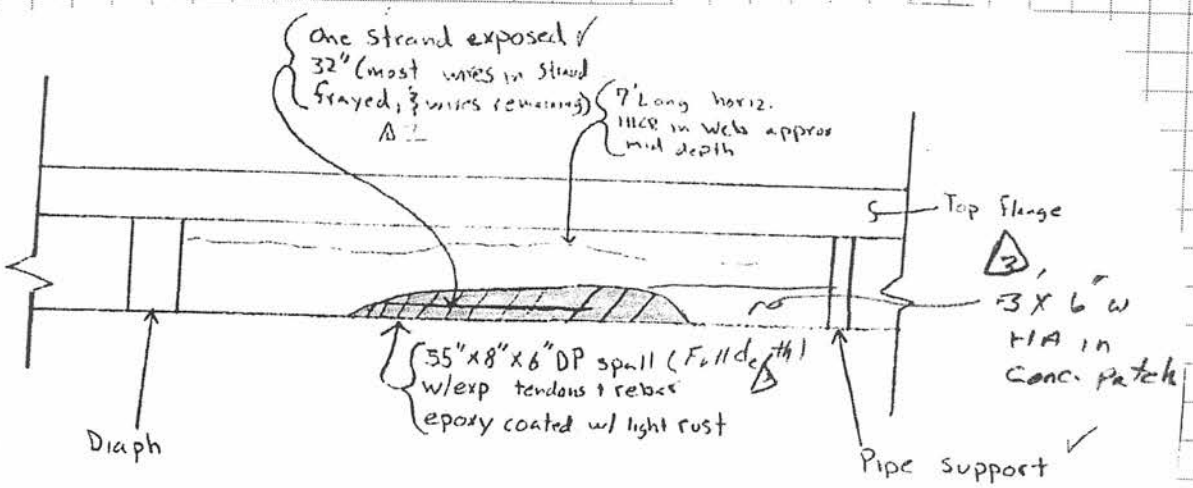
4. There is a spall with a few exposed and rusted through strands on the underside of the bottom flange of G4 and G5 in Span 5.
5. There are large spalls and hollow areas on the underside of the bottom flange of post tensioned G11 in Spans 2, 3 and 4 and prestressed G1 in Span 4.

Bridge Safety and Evaluation believes that these repairs are structurally important and should be addressed.

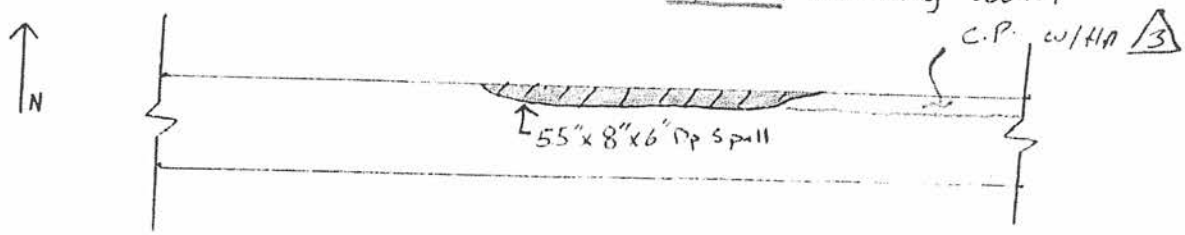
Close, Jensen and Miller, P.C.

BY BA DATE 11/22/10 SUBJECT BR. 596 SHEET NO. 14 E OF
CHKD. BY DATE ROUTE 68 O/ NAUGATUCK RIVER JOB NO.
RTE 8, MNRR, SR 710 NAUGATUCK

"AS-BUILT / AS-INSPECTED" CONDITION RATING: GIRDER E



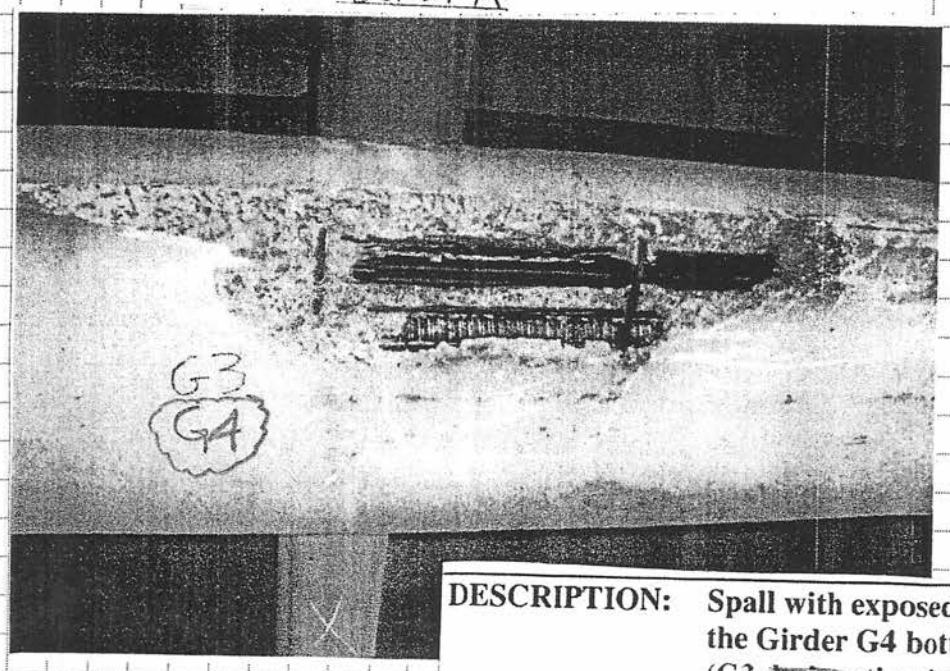
North Face Span 5, Looking South



Bottom of Bottom Flange Span 5

Detail A

G4



DESCRIPTION: **Spall with exposed rebar and strands along the Girder G4 bottom flange in Span 5. (G3 ~~designation~~ in photo is incorrect)**

GRAFFITI

PHOTO: 00596P22.JPG

Close, Jensen and Miller, P.C.

BY DA DATE 11/22/10 SUBJECT BR. 596 SHEET NO. 15 E OF
CHKD. BY DATE ROUTE 6 B O/ NAUGATUCK JOB NO.
FMR, RTE 8, MNRR, SR 710 NAUGATUCK

GIRDER E

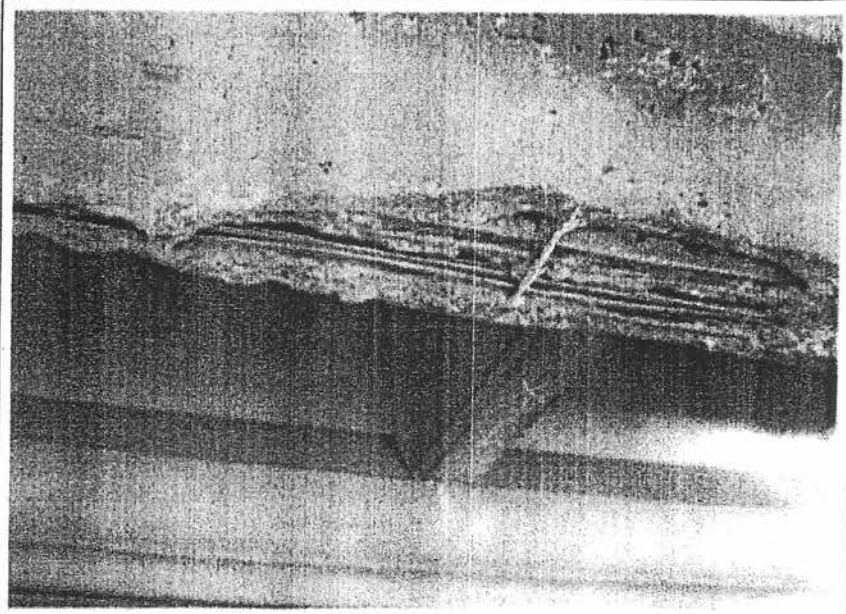
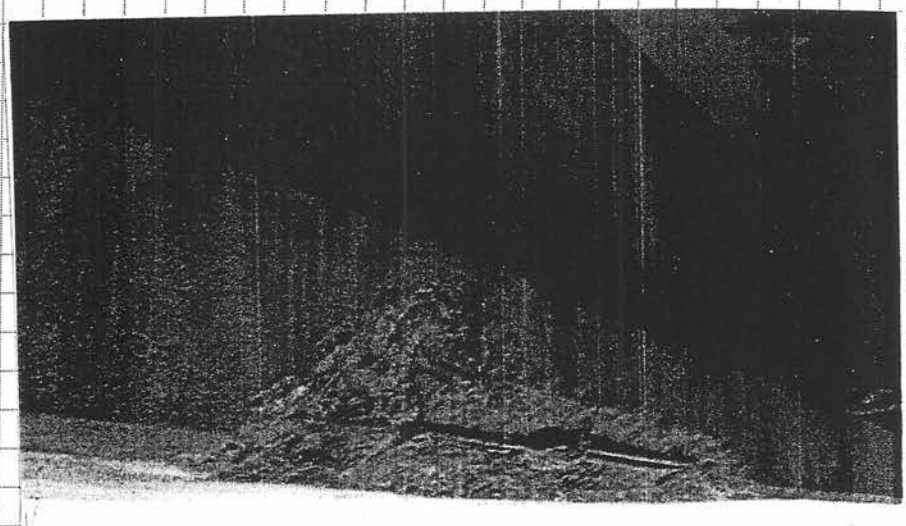


Photo # 19: Typical spall with exposed strands in I-beams (Span 5, G4)



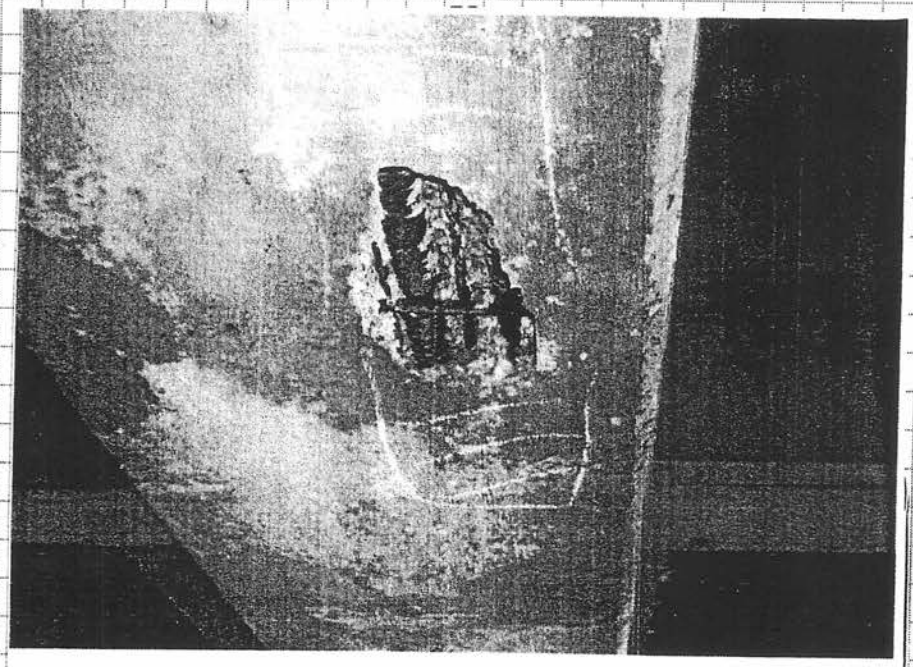
DESCRIPTION: **Spall with exposed strand along the Girder G11 bottom flange in Span 5.**

PHOTO: 00596P23.JPG

Close, Jensen and Miller, P.C.

BY BA DATE 11/22/10 SUBJECT BR. 596 SHEET NO. 16 E OF
CHKD. BY DATE ROUTE 68 O/ NAVGATIVK JOB NO.
FWY, RTE B, MNRR, SR 710 NAVGATIVK

GIRDER E



DESCRIPTION: **Spall with exposed rebar and strand along the Girder G5 bottom flange in Span 5.**

PHOTO: 00596P21.JPG

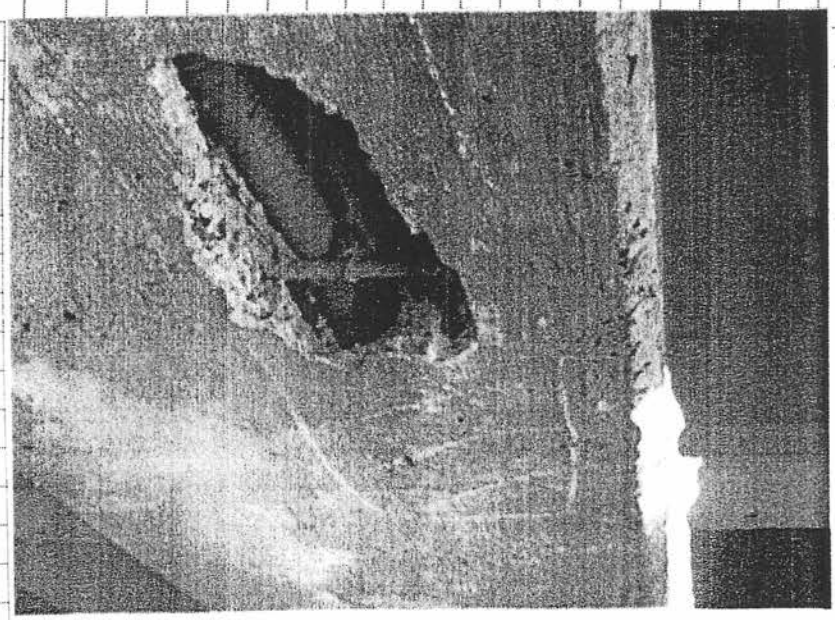


Photo # 10: Typical spall with exposed strands and hollow area on underside of I-beam (Span 5, G5)

Close, Jensen and Miller, P.C.

BY. BA DATE 12/2/10 SUBJECT BR. 596 SHEET NO. 17E OF

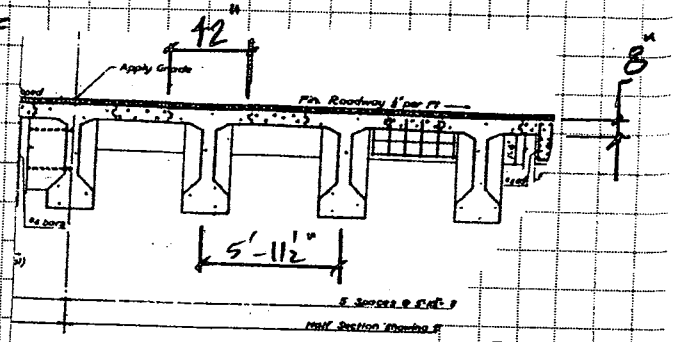
CHKD. BY DATE ROUTE 68 O/ NAUGATUCK JOB NO.

RIVER, RTE 8, MNPR, SR 710 NAUGATUCK

DEADLOAD 1 = DL1 CALCULATION FOR INTERIOR GIRDER:

$$\text{SLAB DL} = \left(\frac{71.5'' - 42''}{12}\right) \times \left(\frac{8''}{12}\right) \times .15^{\text{KCF}}$$

$$= .246 \text{ K/FT}$$



INTERIOR GIRDERS

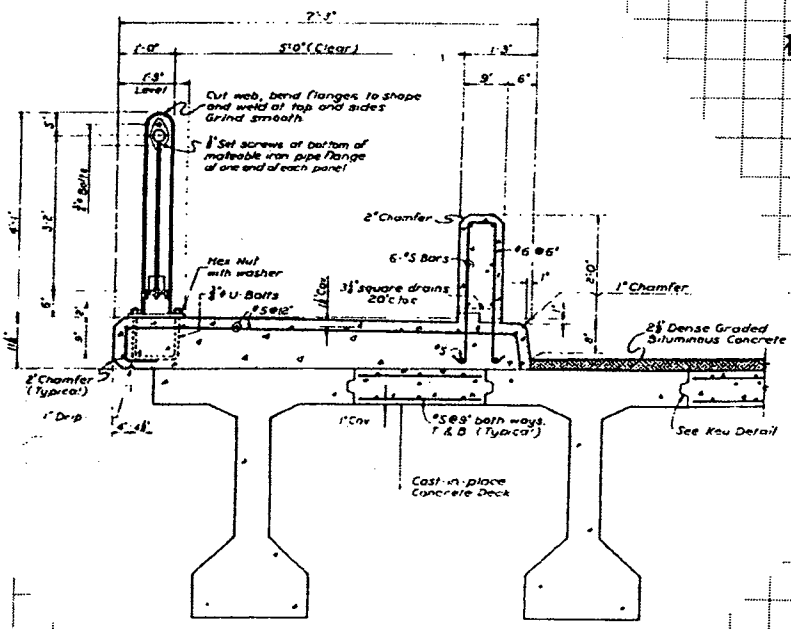
DL1 = 0.246 K/FT WT OF SLAB

(CAST-IN-PLACE BETWEEN BEAM FLANGES)

Close, Jensen and Miller, P.C.

BY EA DATE 12/2/10 SUBJECT BR. 596 SHEET NO. 18E OF
CHKD. BY DATE PONTE 68 O/ NAUGATUCK JOB NO.
RIVER, RTE 8, MNRR, SR710 NAUGATUCK

DEADLOAD 2 = DL2 (PARAPET & SIDEWALK @ NORTH SIDE)



EXTERIOR INTERIOR

SIDEWALK DETAIL
NTS

PARAPET & SIDEWALK:

$$.15^{kcf}\left[\left(\frac{9''}{12}\times 2\right)+\left(\frac{11.5''}{12}\times 7.25\right)-\left(\frac{6}{2}\times\frac{1}{12}\right)\right]$$

$= 1.23$ K/FT

RAILING:
(WT OF RAILING O/ MNRR)

SPACING = 4.5"
AREA OF SPINDLE = .875" x .875"
= .766 in²

HEIGHT OF HIGH RAIL SPINDLES
= 87" - 6" - 5" = 76"
NO. OF SPINDLES IN ONE PANEL = 17

WT_{TOTAL} (SPINDLES PER PANEL) =

$$\left(\frac{76''\times .766\,in^2}{1728}\right)\times .49^{kcf}\times 17^{EA.}$$

$= .281$ K/PANEL

WT. OF POST RAILING $= \left(W_{(X25\ POST)}\right) = 0.025\ K/FT \times \frac{87''}{12} = .181$ K/PANEL

Close, Jensen and Miller, P.C.

BY BA DATE 12/2/10 SUBJECT BR. 596 SHEET NO. 19E OF
CHKD. BY DATE RTE 68 o/ NAUGATUCK JOB NO.
RIVER, RTE 8, MNRR, SR 710 NAUGATUCK

WEIGHT OF TOP TWO RAILS ($2\frac{1}{2}$" ϕ X-STRONG PIPE)

$= 2 \times 7.83 / 1000 = .0157$ K/FT

WEIGHT OF BOTTOM RAIL PER PANEL ($9/1000$)

BOTT. CHANNEL C5X9

$= .009$ K/FT

TOTAL WT. OF RAILING PER PANEL PER FOOT:

PANEL = 7'-2 3/4" EACH

$\frac{0.281 + 0.181}{7.229} + .0157 + .009 = .0886$ K/ft

(15% FOR MISC CONNECTIONS)

TOTAL WEIGHT $= .0886 + (.0886 \times .15) = .102$ K/ft

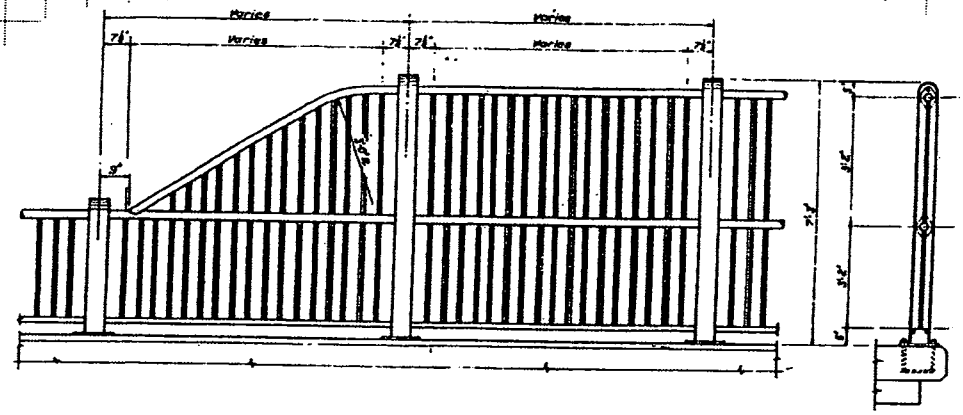
TOTAL WEIGHT/FT $= .102 \times 2$ (RAILING BOTH SIDES) $= .204$ K/ft

Close, Jensen and Miller, P.C.

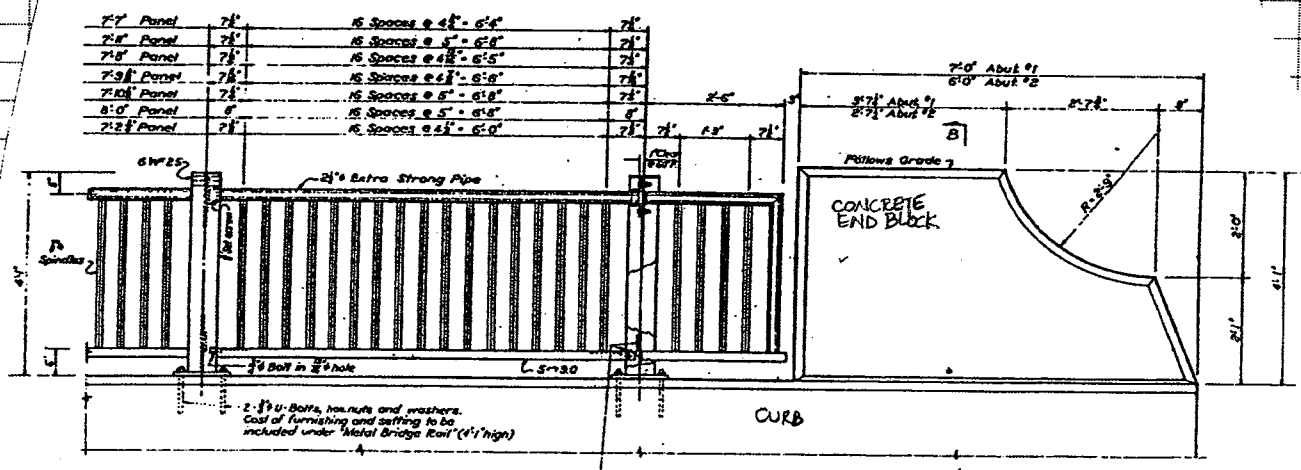
BY BA DATE 12/2/10 SUBJECT BR-596 SHEET NO. 20E OF

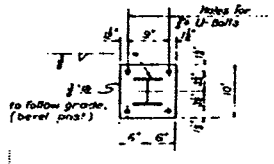
CHKD. BY DATE ROUTE 68 O/ NAUGATUCK JOB NO.

RIVER, RTE 8, MNRR, SR 710 NAUGATUCK



HIGH RAILING DETAIL
AT N.Y. N.H. & H. R.R.
N.T.S





BASE PL DETAIL

4"x4"x⅜"x0'-3½" clip angles welded to post.
⅜" Bolt in ⅞"x⅞" slotted hole in channel.

Railing Notes:

Posts and Spindles to be truly vertical, rails to follow grade.
⅜" U-Bolts to be included in price bid for Metal Bridge Rail. When shimming is necessary, posts to be shimmed with lead wool and caulked "Mithulon" compound, or as directed by the Engineer. Cost to be included in price bid for Metal Bridge Rail. Malleable iron or cast steel pipe flanges at all posts, ⅜" set screw at outer side of each. Use ⅜" bolts at all connections. In end panel all horizontal members to be welded with continuous welds to web of 6"WF25.
See sheet PR-1 for railing layout.
See sheet PR-15 for spacing at light poles.
Post and Base Plate to conform to ASTM-A7

RAILING DETAILS
N.T.S

Close, Jensen and Miller, P.C.

BY BA DATE 12/2/10 SUBJECT BR. 596 SHEET NO. 21 E OF

CHKD. BY DATE PTE 6B, NAUGATUCK RIVER JOB NO.

PTE 8, MNRR, SR 710 NAUGATUCK

(REF. 4)

PIPE

Nom. Dia. In.	Outside Dia. In.	Inside Dia. In.	Thickness In.	Weight per Foot Lb. Plain Ends	Weight per Foot Lb. Thread & Cplg.	Threads per Inch	Couplings Outside Dia. In.	Couplings Length In.	Couplings Weight Lb.	Properties I In.⁴	Properties A In.²	Properties r In.
STANDARD												
1/8	.405	.269	.068	.24	.25	27	.562	7/8	.03	.001	.072	.12
1/4	.540	.364	.088	.42	.43	18	.685	1	.04	.003	.125	.16
3/8	.675	.493	.091	.57	.57	18	.848	1 1/8	.07	.007	.167	.21
1/2	.840	.622	.109	.85	.85	14	1.024	1 3/8	.12	.017	.250	.26
3/4	1.050	.824	.113	1.13	1.13	14	1.281	1 5/8	.21	.037	.333	.33
1	1.315	1.049	.133	1.68	1.68	11 1/2	1.576	1 7/8	.35	.087	.494	.42
1 1/4	1.660	1.380	.140	2.27	2.28	11 1/2	1.950	2 1/8	.55	.195	.669	.54
1 1/2	1.900	1.610	.145	2.72	2.73	11 1/2	2.218	2 3/8	.76	.310	.799	.62
2	2.375	2.067	.154	3.65	3.68	11 1/2	2.760	2 5/8	1.23	.666	1.075	.79
2 1/2	2.875	2.469	.203	5.79	5.82	8	3.276	2 7/8	1.76	1.530	1.704	.95
3	3.500	3.068	.216	7.58	7.62	8	3.948	3 1/8	2.55	3.017	2.228	1.16
3 1/2	4.000	3.548	.226	9.11	9.20	8	4.591	3 5/8	4.33	4.788	2.680	1.34
4	4.500	4.026	.237	10.79	10.89	8	5.091	3 5/8	5.41	7.233	3.174	1.51
5	5.563	5.047	.258	14.62	14.81	8	6.296	4 1/8	9.16	15.16	4.300	1.88
6	6.625	6.065	.280	18.97	19.19	8	7.358	4 1/8	10.82	28.14	5.581	2.25
8	8.625	8.071	.277	24.70	25.00	8	9.420	4 5/8	15.84	63.35	7.265	2.95
8	8.625	7.981	.322	28.55	28.81	8	9.420	4 5/8	15.84	72.49	8.399	2.94
10	10.750	10.192	.279	31.20	32.00	8	11.721	6 1/8	33.92	125.9	9.178	3.70
10	10.750	10.136	.307	34.24	35.00	8	11.721	6 1/8	33.92	137.4	10.07	3.69
10	10.750	10.020	.365	40.48	41.13	8	11.721	6 1/8	33.92	160.7	11.91	3.67
12	12.750	12.090	.330	43.77	45.00	8	13.958	6 1/8	48.27	248.5	12.88	4.39
12	12.750	12.000	.375	49.56	50.71	8	13.958	6 1/8	48.27	279.3	14.58	4.38
EXTRA STRONG												
1/8	.405	.215	.095	.31	.32	27	.582	1 1/8	.05	.001	.093	.11
1/4	.540	.302	.119	.54	.54	18	.724	1 3/8	.07	.004	.157	.15
3/8	.675	.423	.126	.74	.75	18	.898	1 5/8	.13	.009	.217	.20
1/2	.840	.546	.147	1.09	1.10	14	1.085	1 7/8	.22	.020	.320	.25
3/4	1.050	.742	.154	1.47	1.49	14	1.316	2 1/8	.33	.045	.433	.32
1	1.315	.957	.179	2.17	2.20	11 1/2	1.575	2 3/8	.47	.106	.639	.41
1 1/4	1.660	1.278	.191	3.00	3.05	11 1/2	2.054	2 7/8	1.04	.242	.881	.52
1 1/2	1.900	1.500	.200	3.63	3.69	11 1/2	2.294	2 7/8	1.17	.391	1.068	.61
2	2.375	1.939	.218	5.02	5.13	11 1/2	2.870	3 5/8	2.17	.868	1.477	.77
2 1/2	2.875	2.323	.276	7.66	7.83	8	3.389	4 1/8	3.43	1.924	2.254	.92
3	3.500	2.900	.300	10.25	10.46	8	4.014	4 1/8	4.13	3.894	3.016	1.14
3 1/2	4.000	3.364	.318	12.51	12.82	8	4.628	4 5/8	6.29	6.280	3.678	1.31
4	4.500	3.826	.337	14.98	15.39	8	5.233	4 5/8	8.16	9.610	4.407	1.48
5	5.563	4.813	.375	20.78	21.42	8	6.420	5 1/8	12.87	20.67	6.112	1.84
6	6.625	5.761	.432	28.57	29.33	8	7.482	5 1/8	15.18	40.49	8.405	2.20
8	8.625	7.625	.500	43.39	44.72	8	9.596	6 1/8	26.63	105.7	12.76	2.88
10	10.750	9.750	.500	54.74	56.94	8	11.958	6 5/8	44.16	211.9	16.10	3.63
12	12.750	11.750	.500	65.42	68.02	8	13.958	6 5/8	51.99	361.5	19.24	4.34
DOUBLE—EXTRA STRONG												
1/2	.840	.252	.294	1.71	1.73	14	1.085	1 7/8	.22	.024	.504	.22
3/4	1.050	.434	.308	2.44	2.46	14	1.316	2 1/8	.33	.058	.718	.28
1	1.315	.599	.358	3.66	3.68	11 1/2	1.575	2 3/8	.47	.140	1.076	.36
1 1/4	1.660	.896	.382	5.21	5.27	11 1/2	2.054	2 7/8	1.04	.341	1.534	.47
1 1/2	1.900	1.100	.400	6.41	6.47	11 1/2	2.294	2 7/8	1.17	.568	1.885	.55
2	2.375	1.503	.436	9.03	9.14	11 1/2	2.870	3 5/8	2.17	1.311	2.656	.70
2 1/2	2.875	1.771	.552	13.70	13.87	8	3.389	4 1/8	3.43	2.871	4.028	.84
3	3.500	2.300	.600	18.58	18.79	8	4.014	4 1/8	4.13	5.992	5.466	1.05
3 1/2	4.000	2.728	.636	22.85	23.16	8	4.628	4 5/8	6.29	9.848	6.721	1.21
4	4.500	3.152	.674	27.54	27.95	8	5.233	4 5/8	8.16	15.28	8.101	1.37
5	5.563	4.063	.750	38.55	39.20	8	6.420	5 1/8	12.87	33.64	11.34	1.72
6	6.625	4.897	.864	53.16	53.92	8	7.482	5 1/8	15.18	66.33	15.64	2.06
8	8.625	6.875	.875	72.42	73.76	8	9.596	6 1/8	26.63	162.0	21.30	2.76

LARGE O. D. PIPE

Pipe 14" and larger is sold by actual O. S. diameter and thickness.
Sizes, 14", 15", and 16" are available regularly in thicknesses varying by 1/16" from 1/4" to 1", inclusive.

All pipe is furnished random length unless otherwise ordered, viz: 12 to 22 feet with privilege of furnishing 5 per cent in 6 to 12 feet lengths. Pipe railing is most economically detailed with slip joints and random lengths between couplings.

AMERICAN INSTITUTE OF STEEL CONSTRUCTION

Pipe used for handrail of DL2

2 1/2" ø

12" ø

Pipe used for water main of DL2

68.02
7.83
75.85 lb

Close, Jensen and Miller, P.C.

BY BA DATE 12/2/10 SUBJECT BR. 596 SHEET NO. 22 E OF
CHKD. BY DATE ROUTE 68 O/ NAUGATUCK RIVER, RTE 8, MNRR, SR 710 JOB NO. NAUGATUCK

DL2 CONTINUED:

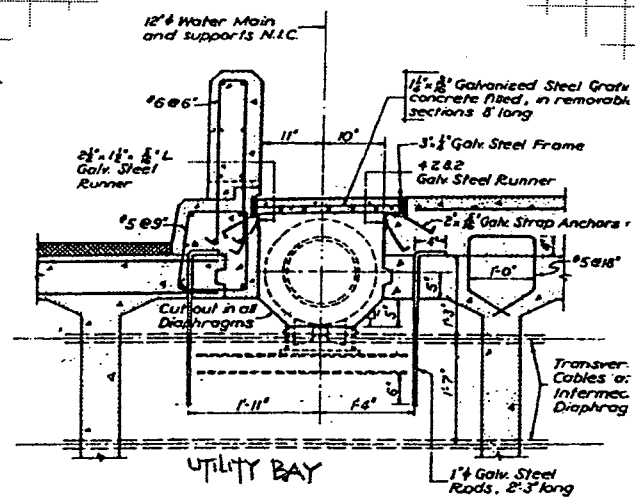
BITUMINOUS CONCRETE WEIGHT

$\frac{2.5''}{12}$ MIN. $\times$ 50' WIDTH $\times$ .15 KCF $= 1.563$ K/LF

WEIGHT OF 12" ø WATERMAIN & MISC. HARDWARE ASSUME 15%
(REF. 4)

$= 68.02 + (.15 \times 68.02) + \frac{\pi/4 (11.75)^2 (62.43)}{12^2}$

$= 125.23$ lb/FT $= .125$ K/FT



PIPE TRENCH DETAIL
N.T.S.

WEIGHT OF $1\frac{1}{4}'' \times \frac{3}{16}''$ GALV. STEEL GRATING CONCRETE FILLED IN REMOVABLE SECTION 8' LONG (REF. 8)

WT. = 12.2 lb/SF

WIDTH = 24" = 2' GRATING

WT/FT = 12.2 x 2' = 24.4 = .0244 K/FT

VOL. OF STEEL = $2' \times 1' \times \frac{24.4}{2 \times 49 \text{ lb/cf}} = .05$ CF

VOL. OF CONC. = $2' \times 1' \times 1.25/12 - .05 = .159$ CF

WT. OF CONC = .159 x .15 = .024 K/FT

TOTAL GRATING WEIGHT = .0244 + .024 = .0484 K/FT

Welded

GW, SGW Series

- **CONSTRUCTION:**
  Bearing bars and cross bars welded together
- **MATERIAL:**
  Plain Steel (ASTM A569)
  HD Galvanized Steel
  Painted Black Steel
  Stainless Steel Type 304 (mill finish)
- **HEIGHTS:**
  3/4" to 2-1/2" available
- **BAR THICKNESS:**
  1/8" or 3/16"
- **WIDTHS:**
  Please see panel width chart
- **LENGTHS:**
  20' stock or cut-to-size

SERIES	GW		GW-2		SGW		SGW-2	
Bar Spacing	4" x 1-3/16"		2" 2" x 1-3/16"		4" x 15/16"		2" 2" x 15/16"	
Bearing Bar Size	Item No.	#/SF	Item No.	#/SF	Item No.	#/SF	Item No.	#/SF
3/4" x 1/8"	GW-75A	4.1	GW-75A-2	4.8	SGW-75A	5.0	SGW-75A-2	5.7
3/4" x 3/16"	GW-75	5.7	GW-75-2	6.4	SGW-75	7.2	SGW-75-2	7.9
1" x 1/8"	GW-100A	5.2	GW-100A-2	5.9	SGW-100A	6.4	SGW-100A-2	7.1
1" x 3/16"	GW-100	7.4	GW-100-2	8.1	SGW-100	9.3	SGW-100-2	10.0
1-1/4" x 1/8"	GW-125A	6.3	GW-125A-2	7.0	SGW-125A	7.9	SGW-125A-2	8.6
1-1/4" x 3/16"	GW-125	9.1	GW-125-2	9.8	SGW-125	11.5	SGW-125-2	12.2
1-1/2" x 1/8"	GW-150A	7.4	GW-150A-2	8.1	SGW-150A	9.3	SGW-150A-2	10.0
1-1/2" x 3/16"	GW-150	10.8	GW-150-2	11.5	SGW-150	13.7	SGW-150-2	14.4
1-3/4" x 3/16"	GW-175	12.5	GW-175-2	13.2	SGW-175	15.8	SGW-175-2	16.5
2" x 3/16"	GW-200	14.1	GW-200-2	14.8	SGW-200	18.0	SGW-200-2	18.7
2-1/4" x 3/16"	GW-225	15.7	GW-225-2	16.4	SGW-225	20.0	SGW-225-2	20.7
2-1/2" x 3/16"	GW-250	17.4	GW-250-2	18.1	SGW-250	22.2	SGW-250-2	22.9

Panel Widths—1-3/16" CTC Bearing Bars

No. Bars	GW, GW-2 GAA, GBB	SGW, SGW-2 GCC, GDD	No. Bars	GW, GW-2 GAA, GBB	SGW, SGW-2 GCC, GDD
2	1-3/8"	1-1/8"	27	31-1/16"	24-9/16"
3	2-9/16"	2-1/16"	28	32-1/4"	25-1/2"
4	3-3/4"	3"	29	33-7/16"	26-7/16"
5	4-15/16"	3-15/16"	30	34-5/8"	27-3/8"
6	6-1/8"	4-7/8"	31	35-13/16"	28-5/16"
7	7-5/16"	5-13/16"	32		29-1/4"
8	8-1/2"	6-3/4"	33		30-3/16"
9	9-11/16"	7-11/16"	34		31-1/8"
10	10-7/8"	8-5/8"	35		32-1/16"
11	12-1/16"	9-9/16"	36		33"
12	13-1/4"	10-1/2"	37		33-15/16"
13	14-7/16"	11-7/16"	38		34-7/8"
14	15-5/8"	12-3/8"	39		35-13/16"
15	16-13/16"	13-5/16"			
16	18"	14-1/4"			
17	19-3/16"	15-3/16"			
18	20-3/8"	16-1/8"			
19	21-9/16"	17-1/16"			
20	22-3/4"	18"			
21	23-15/16"	18-15/16"			
22	25-1/8"	19-7/8"			
23	26-5/16"	20-13/16"			
24	27-1/2"	21-3/4"			
25	28-11/16"	22-11/16"			
26	29-7/8"	23-5/8"			

Maximum width indicated. Wider areas will be made in two or more panels. GW & SGW panels are available up to 48" wide—please inquire!

Deduct 1/16" from width for 1/8" bearing bars. NOTE: WIDTH AND LENGTH TOLERANCE ±1/4"

■ STOCK

GW, GW-2, GAA & GBB Series Steel LOAD TABLE

SPAN (1-3/16" Center to Center Bar Spacings)

Bearing Bar Size		2'-0"	2'-6"	3'-0"	3'-6"	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	8'-0"
3/4" x 1/8"	U	386	247	172	126	96	76						
	D	.096	.150	.216	.294	.382	.485						
	C	386	309	257	221	193	172						
	D	.077	.120	.173	.235	.307	.388						
3/4" x 3/16"	U	581	372	258	190	145	115						
	D	.096	.150	.216	.294	.382	.485						
	C	581	465	387	332	290	258						
	D	.077	.120	.173	.235	.307	.388						
1" x 1/8"	U	686	439	305	224	172	136	110	91	76			
	D	.072	.112	.162	.220	.289	.365	.451	.545	.646			
	C	686	549	458	392	343	305	272	250	229			
	D	.058	.090	.130	.176	.230	.292	.360	.436	.519			
1" x 3/16"	U	1030	659	458	336	257	203	165	136	114			
	D	.072	.112	.162	.220	.289	.365	.451	.545	.646			
	C	1030	824	686	588	515	458	412	374	342			
	D	.058	.090	.130	.176	.230	.292	.360	.436	.519			
1-1/4" x 1/8"	U	1072	686	477	350	268	212	172	142	119	102	88	
	D	.058	.090	.130	.176	.230	.292	.360	.435	.516	.607	.704	
	C	1072	858	715	613	536	477	429	390	358	330	306	
	D	.046	.072	.104	.141	.184	.233	.288	.348	.415	.486	.562	
1-1/4" x 3/16"	U	1610	1031	716	526	403	318	258	213	179	152	131	
	D	.058	.090	.130	.176	.230	.292	.360	.435	.516	.607	.704	
	C	1610	1288	1074	920	805	716	644	586	537	496	460	
	D	.046	.072	.104	.141	.184	.233	.288	.348	.415	.486	.562	
1-1/2" x 1/8"	U	1544	988	686	504	386	305	247	204	172	146	126	96
	D	.048	.075	.108	.147	.192	.243	.300	.363	.432	.506	.587	.765
	C	1544	1236	1030	882	772	686	618	562	515	475	441	386
	D	.038	.060	.086	.118	.154	.194	.240	.291	.346	.405	.470	.614
1-1/2" x 3/16"	U	2320	1485	1031	758	580	458	371	307	258	220	189	145
	D	.048	.075	.108	.147	.192	.243	.300	.363	.432	.506	.587	.765
	C	2320	1856	1547	1326	1160	1031	928	844	773	714	663	580
	D	.060	.060	.086	.118	.154	.194	.240	.291	.346	.405	.470	.614
1-3/4" x 3/16"	U	3158	2021	1404	1031	790	624	505	418	351	299	258	197
	D	.041	.064	.093	.126	.165	.208	.257	.312	.370	.435	.505	.657
	C	3158	2526	2105	1805	1579	1404	1263	1148	1053	972	902	790
	D	.033	.051	.074	.101	.132	.167	.206	.249	.296	.348	.403	.527
2" x 3/16"	U	4125	2640	1833	1347	1031	815	660	545	458	390	337	258
	D	.036	.056	.081	.110	.144	.182	.225	.272	.324	.380	.441	.576
	C	4125	3300	2750	2357	2062	1833	1650	1500	1375	1269	1178	1031
	D	.029	.045	.065	.088	.115	.146	.180	.218	.259	.304	.353	.461
2-1/4" x 3/16"	U	5221	3341	2320	1704	1305	1031	835	690	580	494	426	326
	D	.032	.050	.072	.098	.128	.162	.200	.242	.288	.338	.392	.512
	C	5221	4176	3480	2983	2610	2320	2088	1898	1740	1606	1492	1305
	D	.026	.040	.058	.078	.102	.130	.160	.194	.230	.270	.314	.410
2-1/2" x 3/16"	U	6445	4125	2864	2104	1611	1273	1031	852	716	610	526	403
	D	.029	.045	.065	.088	.115	.146	.180	.218	.259	.304	.353	.461
	C	6445	5156	4297	3683	3222	2864	2578	2344	2148	1983	1841	1611
	D	.023	.036	.052	.070	.092	.117	.144	.174	.207	.243	.282	.389

Unit Stress 18,000 lbs per sq. inch
U - Uniform Load-Pounds per Sq. Ft.
C - Concentrated Load-Pounds per Ft. width at mid span
D - Deflection-Inches

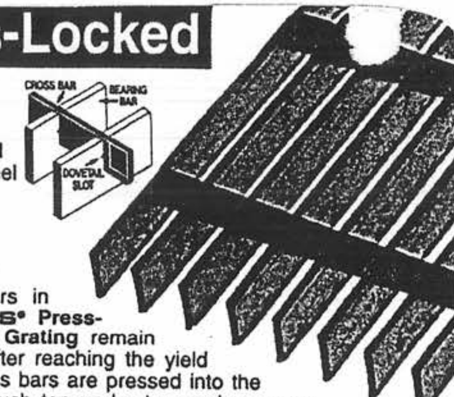
GAA & GBB conform to RRG-661E Type 1 Class II
GW & SGW conform to RRG-661E Type 1 Class I

Spans in shaded area produce a deflection of 1/4" or less under a uniform load of 100 pounds per square foot. This deflection is recommended as the maximum to provide pedestrian comfort. It can be exceeded at the discretion of the engineer.

CONVERSION TABLE- To determine load for types shown below, multiply value above by the corresponding load factor. Deflection under the factored loads will be same as shown in load table.

Series	SGW, SGW-2, GCC, GDD	GCM-1	GCM-2	GCM-3	GCM-4	GCM-5	GM GO	GO GR	GWH	GV
Load Factor	1.27	2.70	2.35	1.90	1.72	1.45	1.15	1.61	.82	.58

Press-Locked



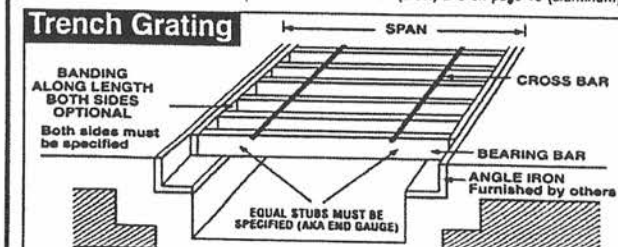
- **MATERIAL:**
  Plain or HD Galvanized
  Painted Steel
  Stainless Steel
  or
  Mill Finish Aluminum

The cross bars in **McNICHOLS® Press-Locked Steel Grating** remain locked even after reaching the yield point. The cross bars are pressed into the bearing bars flush top under tremendous pressure laterally displacing 1/16 of an inch of cross bar material into the "dovetail" slot, assuring firm, rigid connections. Deep cross bars are used for lateral support without removing excessive material from either member. The main bars are not cut, punched or otherwise deformed below the neutral axis and therefore can resist up to the yield stress for the full cross-section of the bars. **Not recommended for wheel traffic or barefoot pedestrian.** GAA & GBB conform to Fed. Spec. RRG-661E Type 1 Class II. Available by special order.

TYPE	GAA		GBB		GCC		GDD	
Bar Spacing	4" x 1-3/16"		2" 2" x 1-3/16"		4" x 15/16"		2" 2" x 15/16"	
Bearing Bar Size	Item No.	#/SF	Item No.	#/SF	Item No.	#/SF	Item No.	#/SF
3/4" x 1/8"	GAA-75A	4.4	GBB-75A	4.6	GCC-75A	4.8	GDD-75A	5.5
3/4" x 3/16"	GAA-75	8.0	GBB-75	8.5	GCC-75	10.4	GDD-75	9.7
1" x 1/8"	GAA-100A	7.5	GBB-100A	8.0	GCC-100A	10.5	GDD-100A	11.1
1" x 3/16"	GAA-100	9.0	GBB-100	9.5	GCC-100	12.5	GDD-100	13.2
1-1/4" x 1/8"	GAA-125A	6.4	GBB-125A	9.0	GCC-125A	12.0	GDD-125A	12.6
1-1.4" x 3/16"	GAA-125	9.2	GBB-125	11.1	GCC-125	14.7	GDD-125	15.3
1-1/2" x 1/8"	GAA-150A	9.5	GBB-150A	10.1	GCC-150A	13.5	GDD-150A	14.2
1-1/2" x 3/16"	GAA-150	12.0	GBB-150	12.5	GCC-150	16.8	GDD-150	17.4
1-3/4" x 3/16"	GAA-175	13.5	GBB-175	14.0	GCC-175	18.8	GDD-175	19.4
2" x 3/16"	GAA-200	16.0	GBB-200	17.0	GCC-200	22.9	GDD-200	23.3
2-1/4" x 3/16"	GAA-225	17.5	GBB-225	18.5	GCC-225	25.0	GDD-225	25.4
2-1/2" x 3/16"	GAA-250	19.0	GBB-250	20.0	GCC-250	27.1	GDD-250	27.8

Loading information and panel widths can be found at left (steel) and on page 19 (aluminum).

Trench Grating



McNICHOLS® Trench Grating is bar grating cut with bearing bars running parallel to the span of trench. It may be cut with or without equal stubs. Equal stubs and banding must be specified. Banding may be welded to the grating along the length of the trench to prevent bearing bars from turning. Drawing illustrates that bearing bars must span the width of the trench for maximum strength.

Close, Jensen and Miller, P.C.

BY BA DATE 12/2/10 SUBJECT BR. 596 SHEET NO. 24E OF
CHKD. BY DATE ROUTE 6B, NANGATUCK JOB NO.
RIVER, RTE 8, MNRR, SR 710 NANGATUCK

1-89 (REF. 5)

PIPE
Dimensions and properties

Dimensions				Weight per Foot Lbs. Plain Ends	Properties			
Nominal Diameter In.	Outside Diameter In.	Inside Diameter In.	Wall Thickness In.		A In.^{2}	I In.^{4}	S In.^{3}	r In.
Standard Weight								
½	.840	.622	.109	.85	.250	.017	.041	.261
¾	1.050	.824	.113	1.13	.333	.037	.071	.334
1	1.315	1.049	.133	1.68	.494	.087	.133	.421
1¼	1.660	1.380	.140	2.27	.669	.195	.235	.540
1½	1.900	1.610	.145	2.72	.799	.310	.326	.623
2	2.375	2.067	.154	3.65	1.07	.666	.561	.787
2½	2.875	2.469	.203	5.79	1.70	1.53	1.06	.947
3	3.500	3.068	.216	7.58	2.23	3.02	1.72	1.16
3½	4.000	3.548	.226	9.11	2.68	4.79	2.39	1.34
4	4.500	4.026	.237	10.79	3.17	7.23	3.21	1.51
5	5.563	5.047	.258	14.62	4.30	15.2	5.45	1.88
6	6.625	6.065	.280	18.97	5.58	28.1	8.50	2.25
8	8.625	7.981	.322	28.55	8.40	72.5	16.8	2.94
10	10.750	10.020	.365	40.48	11.9	161	29.9	3.67
12	12.750	12.000	.375	49.56	14.6	279	43.8	4.38
Extra Strong								
½	.840	.546	.147	1.09	.320	.020	.048	.250
¾	1.050	.742	.154	1.47	.433	.045	.085	.321
1	1.315	.957	.179	2.17	.639	.106	.161	.407
1¼	1.660	1.278	.191	3.00	.881	.242	.291	.524
1½	1.900	1.500	.200	3.63	1.07	.391	.412	.605
2	2.375	1.939	.218	5.02	1.48	.868	.731	.766
2½	2.875	2.323	.276	7.66	2.25	1.92	1.34	.924
3	3.500	2.900	.300	10.25	3.02	3.89	2.23	1.14
3½	4.000	3.364	.318	12.50	3.68	6.28	3.14	1.31
4	4.500	3.826	.337	14.98	4.41	9.61	4.27	1.48
5	5.563	4.813	.375	20.78	6.11	20.7	7.43	1.84
6	6.625	5.761	.432	28.57	8.40	40.5	12.2	2.19
8	8.625	7.625	.500	43.39	12.8	106	24.5	2.88
10	10.750	9.750	.500	54.74	16.1	212	39.4	3.63
12	12.750	11.750	.500	65.42	19.2	362	56.7	4.33
Double-Extra Strong								
2	2.375	1.503	.436	9.03	2.66	1.31	1.10	.703
2½	2.875	1.771	.552	13.69	4.03	2.87	2.00	.844
3	3.500	2.300	.600	18.58	5.47	5.99	3.42	1.05
4	4.500	3.152	.674	27.54	8.10	15.3	6.79	1.37
5	5.563	4.063	.750	38.55	11.3	33.6	12.1	1.72
6	6.625	4.897	.864	53.16	15.6	66.3	20.0	2.06
8	8.625	6.875	.875	72.42	21.3	162	37.6	2.76

The listed sections are available in conformance with ASTM Specification A53 Grade B or A501. Other sections are made to these specifications. Consult with pipe manufacturers or distributors for availability.

AMERICAN INSTITUTE OF STEEL CONSTRUCTION

Pipe used for gas main of AL2

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BY BA DATE 12/2/10 SUBJECT BR. 596 SHEET NO. 25 E OF
CHKD. BY DATE ROUTE 68, NAUGATUCK JOB NO.
RIVER, RTE 8, MNRR, SR710 NAUGATUCK

DL2 CONTINUED:

WEIGHT OF CONCRETE OVER GRATING = $1\frac{3}{4}$" CONC.

$$\text{WEIGHT} = \frac{1.75''}{12} \times 2 \times .15 = .0438 \text{ K/ft}$$

WEIGHT OF SIDEWALK & PARAPET @ SOUTH SIDE

$$\text{WEIGHT} = .15^{\text{KCF}}\left[\left(\frac{9''}{12} \times 2\right) + \left(\frac{15''}{12}\right)\left(\frac{8''+25''+8''}{12}\right) + \left(\frac{81''-15''-21''}{12} \times \frac{11.5''}{12}\right)\right]$$

$$= 1.13 \text{ K/ft}$$

GAS MAIN 6"Ø PLUS 15% MISC. HARDWARE WEIGHT (REF. 5)

$$\text{PIPE} = 28.57 + (.15 \times 28.57) = .033 \text{ K/ft}$$

$$\text{TOTAL DL2} = \underbrace{\overset{\text{PARAPET, SIDEWALK}}{1.23} + \overset{\text{RAILING}}{.204} + \overset{\text{BIT.}}{1.563} + \overset{\text{WATER MAIN}}{.125} + \overset{\text{GRATE}}{.0484} + \overset{\text{CONC O/GRATE}}{.0438} + \overset{\text{S\&P (S. SIDE)}}{1.13} + \overset{\text{GAS}}{.033}}_{\text{11 GIRDERS}}$$

$$\text{DL2}_{\text{TOTAL}} = .398 \text{ K/ft}$$

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BY [illegible] DATE 12/2/10 SUBJECT BR. 596 SHEET NO. 25AE OF
CHKD. BY DATE ROUTE 68 O/ NAUGATUCK JOB NO.
RIVER, RTE 8, MNRR, SR 710 NAUGATUCK

DIAPHRAGM DETAILS FOR GIRDER E

EXTERIOR DIAPHRAGM

12" THK. USED

$$\text{WEIGHT} = .15\left[\frac{(38)(12)(71.5''-7'')}{1728} - \frac{(3)(6)(12)}{1728} - \frac{(8.5\times 8.5\times 12)}{1728}\right]$$

WEIGHT OF DIAPH. D3 = 2.459 K

THICKNESS OF DIAPHRAGM AT MIDSPAN = 8"

THICKNESS AT OTHER DIAPHRAGMS = 12"

DISTANCE	DIAPHRAGM	1	D3	26'-9"
		2	D2	26'-9" + 22' = 48'-9"
		3	D3	48'-9" + 22' = 70'-9"

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BY BA DATE 12/2/10 SUBJECT BR-596 SHEET NO. 24E OF

CHKD. BY DATE ROUTE 6B O/ NAUGATUCK JOB NO.

FINAL, RTE. 8, YNRR, SR710 NAUGATUCK

PRESTRESS CRITERIA: (ALL BEAMS) ("AS-INSPECTED")

BEAM CONCRETE	f'_{cB} =	5000 psi	
SLAB CONCRETE	f'_{cS} =	3000 psi	
CONCRETE INITIAL	f'_{cI} =	4000 psi	
STEEL INITIAL	f_{SI} =	$\frac{200}{1-.2} = 160$ ksi	20% LOSS
STEEL YIELD	f_y =		
STEEL ULTIMATE	f'_s =	200 ksi	

INITIAL ALLOWABLE:

COMPRESSION	f_{cI} =	$.55 f'_{ci} = .55 \times 4 = 2.2$ ksi	AASHTO 9.15.2.1
TENSION	f_{TI} =	$3\sqrt{f'_{ci}} = 3\sqrt{4000} = .19$ ksi	
DRP/DBD	f_{TD} =	$3\sqrt{f'_{ci}} = 3\sqrt{4000} = .19$ ksi	

FINAL ALLOWABLE:

COMPRESSION	f_c =	$.4 f'_{cB} = .4 \times 5 = 2.0$ ksi	AASHTO 9.15.2.2
TENSION	f_T =	$3\sqrt{f'_{cb}} = 3\sqrt{5000} = .212$ ksi	
STEEL E	E =	25000 ksi	

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CHKD. BY DATE FONTE 68 O/ NAVGATUK JOB NO.
FINAL, RTE 8, MNRR, SK 710 NAVGATUK

GIRDER E

PRESTRESSING STEEL (CONTD.)

FROM GIRDER B CALCS, POST-TENSIONING STEEL CONSISTS OF STRANDS WITH 19 OR MORE GALVANIZED WIRES.

TOTAL POST-TENSION P/S FORCE (AFTER LOSSES) = 850^k (MIN.)

THE FOLL. COMBINATION GIVES THE TOTAL POST-TENSIONED FORCE CLOSE TO THE REQD. FORCE ABOVE.

$9 - 1\frac{1}{8}''\ \phi$ STRANDS $\Rightarrow$ $9 \times 90^k = 810^k$
$1 - 0.835''\ \phi$ STRANDS $\Rightarrow$ $1 \times 49^k = 49^k$
$859^k > 850^k$ (MIN) REQD.

HOWEVER, SINCE ONLY ONE STRAND SIZE & TYPE CAN BE INPUT INTO THE PS3 PROGRAM, USE AN EQUIVALENT DIA. AND AREA OF A FICTITIOUS CABLE CLOSEST TO THE $1\frac{1}{8}''\ \phi$ CABLE

USE 9 CABLES. $\Rightarrow$ PS3 INPUT ITEMS: R1 = 9

FORCE / CABLE REQD. = $850/9 = 94.4^k$

EQUIVALENT AREA = $\frac{94.4^k}{90} \times 0.751 = 0.788\ in^2$ $\Rightarrow$ STRAND AREA = $0.788\ in^2$

EQUIVALENT $\phi = 1\frac{1}{8} \times \sqrt{\frac{0.788}{0.751}} = 1.152''$ $\Rightarrow$ STRAND DIA = $1.152''$

Galvanized Strands for Post-Tensioning (FROM REF. 9)

Diameter, in.	Weight per Foot, lb	Area, sq in.	Minimum Guaranteed Ultimate Strength, lb	Design Load, lb
0.600	0.737	0.215	46,000	26,000
0.835	1.412	0.409	86,000	49,000
1	2.00	0.577	122,000	69,000
1⅛	2.61	0.751 ←	156,000	90,000
1¼	3.22	0.931	192,000	112,000
1⅜	3.89	1.12	232,000	134,000
1½	4.70	1.36	276,000	163,000
1 9/16	5.11	1.48	300,000	177,000
1⅝	5.52	1.60	324,000	192,000
1 11/16	5.98	1.73	352,000	208,000

The average modulus of elasticity of the strands in the above table is 25,000,000 psi.

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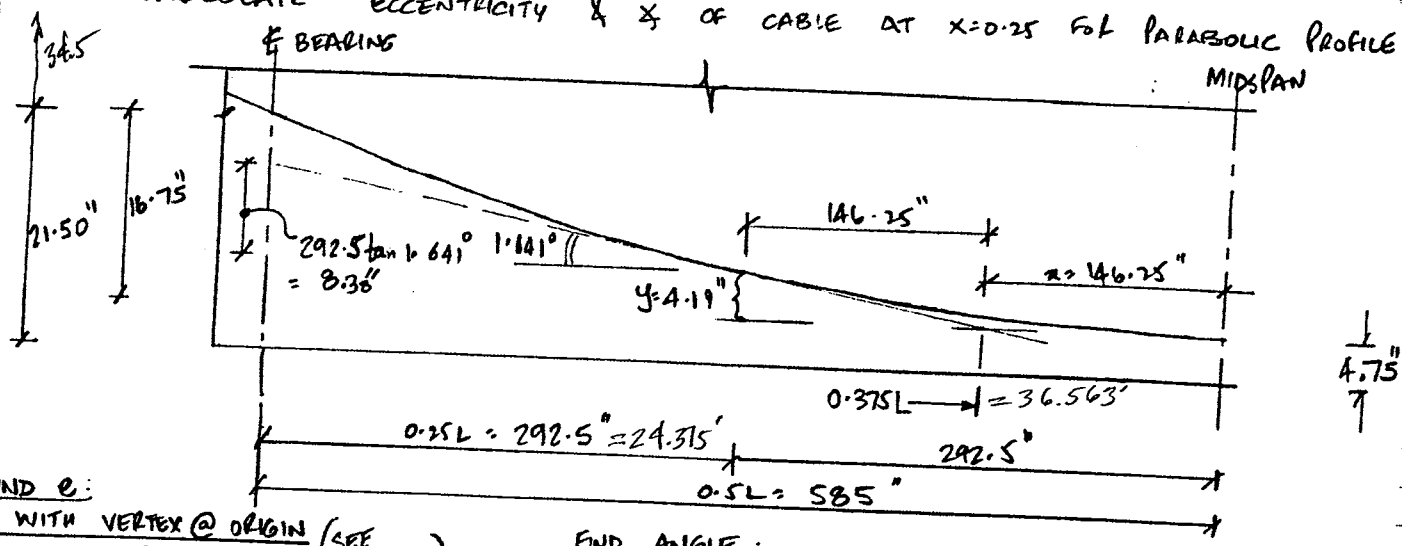
SHEAR RATING @ X = 0.25L: GIRDER E

CALCULATE ECCENTRICITY & ∡ OF CABLE AT X = 0.25 FOR PARABOLIC PROFILE



FIND e:

WITH VERTEX @ ORIGIN (SEE BELOW)

$x^2 = 2py$

$(585)^2 = 2p(16.75")$

$\therefore p = 10215.6"$

$\therefore$ FOR $x = 292.5"$

$y = \dfrac{292.5^2}{2(10215.6)}$

$= \underline{\underline{4.19"}}$

FIND ANGLE: (SEE BELOW)

$x_0 = y_0 = 0$

$x_1 = 292.5"$

$y_1 = 4.19"$

$y = 0$

x: $0 = \dfrac{2(4.19-0)(x-292.5)}{(292.5-0)} + 4.19$

$\therefore x = 146.25"$

$\measuredangle = \tan^{-1}\left(\dfrac{4.19}{146.25}\right) = 1.641°$

$\therefore e_{END} = 30.21" - 8.38" - 4.19" - 4.75" = 12.89"$ ← RERUN P53 WITH THIS VALUE. TO PROVIDE CORRECT e & ∡ @ X = 0.25L.

Parabola (FROM REF. 10)

Parabola equation (by converting to this equation the vertex and parameter p may be ascertained)

	vertex at the origin	vertex elsewhere	parabola open at
f 19	$x^2 = 2py$	$(x-x_0)^2 = 2p(y-y_0)$	top
f 20	$x^2 = -2py$	$(x-x_0)^2 = -2p(y-y_0)$	bottom

F: focus
L: directrix
S: tangent at the vertex

Basic equation

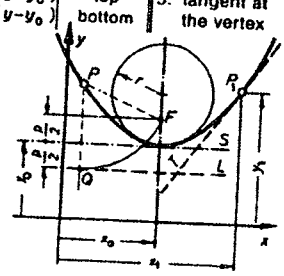
f 21 $y = ax^2 + bx + c$

f 22 **Vertex radius** $r = p$

f 23 **Basic property** $\overline{PF} = \overline{PQ}$

Tangent T **at point** P_1 (x_1, y_1)

f 24 $y = \dfrac{2(y_1-y_0)(x-x_1)}{x_1-x_0} + y_1$



.375L = 36.56

16.75 / 12 | .038
36.56

Sin 1.641 = .03

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BY FA DATE 12/2/10 SUBJECT BR. 596 SHEET NO. 28AE OF

CHKD. BY DATE ROUTE 68 O/ NAUGATUCK JOB NO.

RIVER, RTE 8, MNRR, SR 710 NAUGATUCK

STRAND DETAILS

GIRDER E

STRAND DIAMETER = 1.152"

STRAND AREA = .788 in²

G1 2"

G2 4.75"

F1 9

STIRRUP DETAILS

SPEC A

STIRRUP AREA .2 in²

f_{sy} 40 ksi

STIRRUP LOCATION 0

SPACING 6"

LOCATION .33 ← 4"

SPACING 18"

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BY BA DATE 3/1/11 SUBJECT BR. 596 SHEET NO. 29E OF
CHKD. BY DATE ROUTE 68 O/ NAUGATUCK JOB NO.
LRFR RATING RIVER, RTE 8, MNRR, SR 710 NAUGATUCK, CT

RATING THE INTERIOR GIRDER E4 (SPAN 5) PRESTRESSED CONCRETE GIRDER
AT MIDSPAN FOR MOMENT
AT CRITICAL SECTION FOR SHEAR
AT CHANGE IN STIRRUP SPACING FOR SHEAR

BASED ON "AS-BUILT" / "AS-INSPECTED".

SPAN: 97.5'

YEAR BUILT: 1963 (REHAB 1987, 1993)

MATERIALS:

CONCRETE: $f'_c = 5$ ksi (P/S BEAM)

$f'_{c_i} = 4$ ksi (P/S BEAM AT TRANSFER)

PRESTRESSING STEEL: 3/8" ø STRESS RELIEVED STRANDS

$A_{ps} = .788$ in^2 TOTAL (STRAND ø = 1.152")

850^k POST-TENSIONING P/S FORCE AFTER LOSS

EQUIVALENT:

9 - 1 1/8" ø Strand } 9 x 90^k = 810^k
1 - .835" ø Strand } 1 x 49^k = 49^k = 859^k > 850^k MIN. REQ.

1 1/8" ø A = .751 in^2

DESIGN LOAD = 90^k

850^k/9 = 94.4^k ⟹ $\frac{94.4^k}{90^k} \times .751 = .788$ in^2

EQUIVA. 9 - 1.152" ø STRANDS

STIRRUPS: #4 @ 12" A = .2 in^2
#4 @ 18" A = .13 in^2

COMPRESSION STEEL: 3 - #4 @ 6" GRADE 40 ksi

CONDITION: DETERIORATED, SPALLS, EXPOSED REBAR, EXPOSED STRANDS
NBI ITEM 59 CODE = 4

RIDING SURFACE: SOME SURFACE DEVIATIONS (FIELD DOCUMENTED)

ADTT (ONE DIRECTION): 2000 USE 5000 ADTT

SKEW: 0°

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BY BA DATE 3/1/11 SUBJECT BR. 596 SHEET NO. 30E OF
CHKD. BY DATE ROUTE 68 O/ NAUGATUCK JOB NO.
FWOR., RTE 8, MONR., SEC 710 NAUGATUCK, CT

LRFD 4.6.2.6.1

EFFECTIVE FLANGE WIDTH: b_e

MINIMUM of:

1) $\frac{1}{4}L = \frac{1}{4}(97.5) = 24.38 \times 12 = 292.5$ in
2) $12t_s + \frac{1}{2}b_{f_{TOP}} = 12 \times 8" + \frac{1}{2} \times 42" = 117$ in
3) $S = 5.958' \times 12 = 71.5$ in ← GOVERNS

EFFECTIVE FLANGE WIDTH $b_e = 71.5$ in

LRFD EQ. 5.4.2.4-1

$E_c = 33000\, W_c^{1.5} \sqrt{f'_c} = 33000 \times (.145)^{1.5} \sqrt{3} = 3.16 \times 10^3$ ksi

$E_c = 33000 \times (.145)^{1.5} \sqrt{5} = 4.07 \times 10^3$ ksi P/S BEAM

MODULAR RATIO: $n = \frac{E_{DECK}}{E_{BEAM}} = \frac{3.16 \times 10^3}{4.07 \times 10^3} = .78$

TRANSFORMED WIDTH, $b_{trans} = 71.5^{in} \times .78 = 55.77$ in

SUMMARY OF SECTION PROPERTIES:

$h = 56"$
$A = 932.2$ in^2
$I = 375443.9$ in^4

$Y_b = 30.21$ in
$S_b = 12429.6$ in^3

$S_t = 14555.3$ in^3
$Y_T = 25.79$ in

* BR.596 RATING OF AN INTERIOR BEAM *

****

BASIC BEAM SECTION PROPERTIES

DEPTH IN	AREA IN.2	WEIGHT LBS/FT	M OF I IN.4	N.A. TO TOP YT IN.	N.A. TO BOT YB IN	Z TOP IN.3	Z BOT IN.3
56.00	932.2	971.09	375443.9	25.79	30.21	14555.3	12429.6

UNIFORM DEAD LOADS ACTING ON GIRDER (KIPS/FT)

GIRDER WEIGHT	FORMWORK WEIGHT	INPUT DL1	FUTURE WEARING SURFACE	INPUT DL2	TOTAL DL1	TOTAL DL2
0.9711	0.0000	0.2460	0.0000	0.3980	1.2171	0.3980

DEAD LOAD AND LIVE LOAD REACTIONS

DL1 REACTION	DL2 REACTION	IMPACT FACTOR	LL+I H20 REACTION	LL+I HS20 REACTION	LL+I ML80 REACTION	LL+I TK527 REACTION
63.0	19.4	1.225	41.9 L	48.0 T	49.8 T	52.2 T

LL+I P-82 REACTION
107.4 T

PRESTRESSING FORCE (STRAND PATTERN UNKNOWN)

INITIAL	LOSS %	EFFECTIVE	NO. OF STRANDS
1008.640	20.00	806.912	8

	ECCENTRICITY	C.G.S (GM)
AT MID SPAN:	25.460	4.746

	ECCENTRICITY	C.G.S (GE)
AT CL BRG.:	8.710	21.496

****

* RATING DATA *

****

LIVE LOAD TYPE: H20 GROSS WEIGHT: 20.00 TONS

UNFACTORED MOMENTS AND SHEARS

* BR.596 RATING OF AN INTERIOR BEAM *

****

BASIC BEAM SECTION PROPERTIES

DEPTH IN	AREA IN.2	WEIGHT LBS/FT	M OF I IN.4	N.A. TO TOP YT IN.	N.A. TO BOT YB IN	Z TOP IN.3	Z BOT IN.3
56.00	932.2	971.09	375443.9	25.79	30.21	14555.3	12429.6

UNIFORM DEAD LOADS ACTING ON GIRDER (KIPS/FT)

GIRDER WEIGHT	FORMWORK WEIGHT	INPUT DL1	FUTURE WEARING SURFACE	INPUT DL2	TOTAL DL1	TOTAL DL2
0.9711	0.0000	0.2460	0.0000	0.3980	1.2171	0.3980

DEAD LOAD AND LIVE LOAD REACTIONS

DL1 REACTION	DL2 REACTION	IMPACT FACTOR	LL+I H20 REACTION	LL+I HS20 REACTION	LL+I ML80 REACTION	LL+I TK527 REACTION
63.0	19.4	1.225	41.9 L	48.0 T	49.8 T	52.2 T

LL+I P-82 REACTION
107.4 T

I_{YY} =

PRESTRESSING FORCE (STRAND PATTERN UNKNOWN)

INITIAL	LOSS %	EFFECTIVE	NO. OF STRANDS
1008.640	20.00	806.912	8

	ECCENTRICITY	C.G.S (GM)
AT MID SPAN:	25.460	4.746

	ECCENTRICITY	C.G.S (GE)
AT CL BRG.:	12.890	17.316

****

* RATING DATA *

****

LIVE LOAD TYPE: H20 GROSS WEIGHT: 20.00 TONS

UNFACTORED MOMENTS AND SHEARS

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BY BA DATE 3/1/11 SUBJECT BR 596 SHEET NO. 33 E OF
CHKD. BY DATE ROUTE 68 O/ NAUGATUCK JOB NO.
RIVER, RTE 8, MNEL, SR 710 NAUGATUCK, CT

DEAD LOAD ANALYSIS (INTERIOR GIRDER)

DL1 : .246 + .9711 = 1.217 k/' ≃ 1.22 k/'

DL2 : = .398 k/' ≃ .4 k/'

$V_{DL1} = 1.22^{k/'} \times 97.5'/2 = 59.5$ k AT SUPPORT COMPUTOR 63 k

$M_{DL1} = 1.22 \times 97.5^2/8 = 1450$ k-FT AT MIDSPAN 1572 k-FT

$V_{DL2} = .398^{k/'} \times 97.5'/2 = 19.4$ k AT SUPPORT ✓

$M_{DL2} = .398 \times 97.5^2/8 = 472.9$ k-FT AT MIDSPAN ✓

$V_{DLW} = .142^{k/'} \times 97.5/2 = 6.93$ k

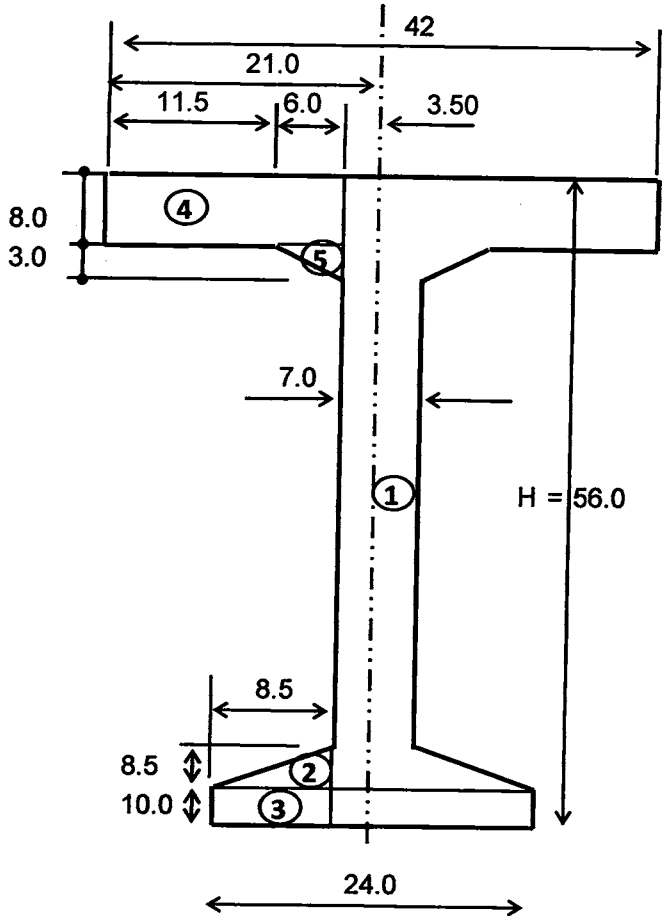
$M_{DLW} = .142 \times 97.5^2/8 = 168.7$ k-FT

Close, Jensen and Miller, P.C

3/23/2011

BY:
CHKD.BY: DATE

34AE



DECKED BULB TEE GIRDER

MOMENT OF INERTIA OF GIRDER CROSS SECTION ABOUT X-X AXIS

Io :

						(in²)
1 =	1/12 *	7.0	*	56.0^3	=	102443
2 =	1/36 *	8.5	*	8.5^3	=	145.0
3 =	1/12 *	8.5	*	10.0^3	=	708.3
4 =	1/12 *	17.5	*	8.0^3	=	746.7
5 =	1/36 *	6.0	*	3.0^3	=	4.5

NON-COMPOSITE SECTION PROPERTIES :

	A (in²)	Y (in)	AY (in²)	AY² (in³)	Io (in⁴)
1	392.0	28.0	10976	307328	102443
2	72.3	12.8	927.21	11899.2	290
3	170.0	5.0	850	4250	1417
4	280.0	52.0	14560	757120	1493
5	18.0	47.0	846	39762	9
Σ =	932.3		28159	1120359	105652

$$Y = \frac{28159}{932.3} = 30.21 \text{ in}$$

$$I_{xx} = 1120359 + 105652 - 932.3 * 30.21^2 = \mathbf{375{,}444} \text{ in}^4$$

$$S_t = \frac{375444}{25.79} \qquad S_b = \frac{375444}{30.21}$$

$$S_t = 14555 \text{ in}^3 \qquad S_b = 12430 \text{ in}^3$$

LIVELOAD ANALYSIS:

COMPUTE LL DISTRIBUTION FACTORS, g

LRFD TABLE 4.4.6.2.2.1-1

AASHTO LRFD TYPE (j) CROSS-SECTION

LONGITUDINAL STIFFNESS PARAMETER, k_g:

$$k_g = n\left(I + Ae_g^2\right)$$

$$n = \frac{E_B}{E_D} = \frac{4.07\times10^3}{3.16\times10^3} = 1.288$$

$A = 932.2 \text{ in}^2$

$I = 375443.9 \text{ in}^4$

$L = 97.5'$

$t_s = 8 \text{ in}$

$e_g = \text{girder depth} - Y_b + \text{haunch} + t_s/2 = 56 - 30.21 + 0 + 0 = 25.79 \text{ in}$

$k_g = 1.288\left(375443.9 + 932.2 \times 25.79^2\right) = 1{,}282{,}169 \text{ in}$

$$k_g / 12Lt_s^3 = \frac{1282169}{12\times97.5\times8^3} = 2.14$$

DISTRIBUTION FACTOR FOR MOMENT, g_m (LRFD DESIGN TABLE 4.6.2.2.2b-1)

ONE LANE LOADED:

$$g_{m_1} = .06 + \left(\frac{S}{14}\right)^{.4}\left(\frac{S}{L}\right)^{.3}\left(\frac{k_g}{12Lt_s^3}\right)^{.1} = .06 + \left(\frac{5.958}{14}\right)^{.4}\left(\frac{5.958}{97.5}\right)^{.3}(2.14)^{.1} = .391$$

TWO OR MORE LANES LOADED:

$$g_{m_2} = .075 + \left(\frac{S}{9.5}\right)^{.6}\left(\frac{S}{L}\right)^{.2}\left(\frac{k_g}{12Lt_s^3}\right)^{.1} = .075 + \left(\frac{5.958}{9.5}\right)^{.6}\left(\frac{5.958}{97.5}\right)^{.2}(2.14)^{.1} = .541$$

USE $g_m = .541$

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RIVER, RTE 8, MAKE, SR 710 NAUGATUCK, CT JOB NO.

DISTRIBUTION FACTOR FOR SHEAR, g_v (LRFD DESIGN TABLE 4.6.2.2.3a-1)

ONE LANE LOADED:

$$g_{v_1} = .36 + \frac{S}{25} = .36 + \frac{5.958}{25} = .598$$

TWO OR MORE LANE LOADED:

$$g_{v_2} = .2 + \left(\frac{S}{12}\right) - \left(\frac{S}{35}\right)^2 = .2 + \left(\frac{5.958}{12}\right) - \left(\frac{5.958}{35}\right)^2 = .668$$

$$.668 > .598$$

USE $g_v = .668$

HL-93 DESIGN LANE LOAD: (MAXIMUM LL EFFECT)
MAX. DESIGN LL (HL-93) - MOMENT @ MIDSPAN

Note: The general rule for simple spans carrying moving concentrated loads states that the maximum bending moment produced by moving concentrated loads occurs under one of the loads when that load is as far from one support as the center of gravity of all the moving loads on the beam is from the other support. It should be understood that locating the precise critical section and load position for rating depends on the combined influence of dead load, live load, member capacity and load factors that make up the general Rating Factor equation. For simplicity and illustrative purposes only, the moment at midspan is used to closely approximate the maximum moment. See also Example A1, which illustrates that for a beam with a constant section capacity throughout the maximum moment region and a long span, the resulting rating factor obtained by a refined analysis yields only a small difference compared to the rating factor obtained from the maximum moment approximated at midspan.

Calculated by statics with the load centered at midspan:

LRFD TABLE 3.6.2.1-1

DESIGN LANE LOAD MOMENT $= .64^{k}/_{ft} \times \frac{(97.5')^2}{8} = 760.5 \approx 761$ K-FT

DESIGN TRUCK MOMENT $= 1475$ K-FT

TOTAL $= 761 + 1475 \times 1.33 = 2723$ K-FT M_{LL+IM}

DISTRIBUTION OF LL MOMENT AT MIDSPAN:

$$M_{LL+IM} = 2723 \times g_m = 2723 \times .541 = 1473 \text{ K-FT}$$

LRFD

Table of Maximum Moments, Shears, and Reactions Simple Spans, One Lane **Without** Dynamic Load Allowance (cont.)

Span(ft)	Moment (k-ft)		End Shear and End Reaction (k)	
42	617.1	a	69.4	a
44	666.9	a	70.8	a
46	717.3	a	72.1	a
48	768.3	a	73.4	a
50	820.0	a	74.6	a
52	872.3	a	75.7	a
54	925.3	a	76.8	a
56	978.9	a	77.9	a
58	1033.1	a	79.0	a
60	1088.0	a	80.0	a
62	1143.5	a	81.0	a
64	1199.7	a	82.0	a
66	1256.5	a	82.9	a
68	1313.9	a	83.9	a
70	1372.0	a	84.8	a
75	1520.0	a	87.0	a
80	1672.0	a	89.2	a
85	1828.0	a	91.3	a
90	1988.0	a	93.3	a
95	2152.0	a	95.3	a
100	2320.0	a	97.3	a
110	2668.0	a	101.1	a
120	3032.0	a	104.8	a
130	3412.0	a	108.4	a
140	3808.0	a	112.0	a
150	4220.0	a	115.5	a
160	4648.0	a	119.0	a
170	5092.0	a	122.4	a
180	5552.0	a	125.9	a
190	6028.0	a	129.3	a
200	6520.0	a	132.6	a
220	7552.0	a	139.3	a
240	8648.0	a	146.0	a
260	9808.0	a	152.6	a
280	11032.0	a	159.2	a
300	12320.0	a	165.8	a

	TRUCK	TANDUM	LANE	TOTAL	MOM. K-FT
95'	1430	1137.5	722	2152	
100'	1520	1200	800	2320	
97.5'	1475	1168.8	761	2236	
95'	64.9	48.9	30.4	95.3	SHEAR K
100'	65.3	49.0	32	97.3	
97.5'	65.1	48.95	31.2	96.3	

a controlled by Design Truck + Lane Loading
b controlled by Design Tandem + Lane Loading

COMPUTE NOMINAL FLEXURAL RESISTANCE AT MIDSPAN:

$$f_{ps} = f_{pu}\left(1 - k\frac{c}{d_p}\right)$$ LRFD EQ. 5.7.3.1.1-1

$k = .38$ for STRESS RELIEVED

$f_{pu} = 200$ ksi

d_p = DISTANCE FROM EXTREME COMPRESSION FIBER TO THE CENTROID OF THE PRESTRESSING TENDONS

			STRAND xY
LAYER 1	9	4.75	42.75

$$\bar{y} = \frac{\text{Strand } xy}{\text{Strands}} = \frac{42.75}{9} = 4.75''$$

$\bar{y} = 4.75''$ DISTANCE FROM BOTTOM OF GIRDER TO CENTROID OF PRESTRESSING STRANDS

$d_p = 56'' - 4.75'' = 51.25''$

c = DISTANCE FROM THE NEUTRAL AXIS TO THE COMPRESSIVE FACE

TO COMPUTE C, ASSUME RECTANGULAR SECTION BEHAVIOR. (NEGLECT ANY NONPRESTRESSED REINFORCEMENT)

GIVEN $A_{ps} = .788\ in^2$ FOR 1.152" STRAND
STRESS RELIEVED STRANDS

$$c = \frac{A_{ps} f_{pu}}{.85 f'_c \beta_1 b + k A_{ps}\frac{f_{pu}}{d_p}} = \frac{7.092\ in^2 \times 200\ ksi}{.85 \times 3 \times .85 \times 7.5 + .38 \times 7.092 \times \frac{200}{51.25}} = 8.57$$ LRFD 5.7.3.1.1-4

$a = \beta_1 c = .85 \times 8.57 = 7.29 < 8''$ LRFD 5.7.2.2

Therefore, THE RECTANGULAR SECTION BEHAVIOR ASSUMPTION IS VALID.

$$f_{ps} = 200\left(1 - .38 \times \frac{8.57}{51.25}\right) = 187.3\ ksi$$

NOMINAL FLEXURAL RESISTANCE (MIDSPAN): LRFD EQ. 5.7.3.2.2-1

$$M_n = A_{ps} f_{ps}\left(d_p - \frac{a}{2}\right) = 7.092 \times 187.3\left(51.25 - \frac{7.29}{2}\right)\left(\frac{1}{12}\right) = 5270 \text{ K-FT}$$

$$6.304 \times 187.3\left(51.25 - \frac{5.84}{2}\right)\left(\frac{1}{12}\right) = 4755.6 \text{ K-FT}$$ "AS-INSPECTED"

MAXIMUM REINFORCEMENT: 6A.5.5 (CGA.5.5)

THE FACTORED RESISTANCE (ϕ FACTOR) OF COMPRESSION CONTROLLED SECTION SHALL BE REDUCED IN ACCORDANCE WITH LRFD DESIGN ARTICLE 5.5.4.2.1

THIS APPROACH LIMITS THE CAPACITY OF OVER-REINFORCED (COMPRESSION CONTROLLED) SECTIONS. LRFD C5.7.2.1

THE NET-TENSILE STRAIN, ε_t, IS THE TENSILE STRAIN AT NOMINAL STRENGTH AND DETERMINED BY STRAIN COMPATIBILITY USING SIMILAR TRIANGLES

$\varepsilon_c = .003$ $c = 8.57$ DEPTH TO NUTRAL AXIS

$d_p = 51.25$ DEPTH FROM THE EXTREME CONCRETE COMPRESSION FIBER TO THE CENTER OF GRAVITY OF THE PRESTRESSED STRANDS

$$\frac{\varepsilon_c}{c} = \frac{\varepsilon_t}{d-c} \Rightarrow \frac{.003}{8.57} = \frac{\varepsilon_t}{51.25 - 8.57} \rightarrow \varepsilon_t = .015$$

$\varepsilon_t = .015 > .005$ THE SECTION IS TENSION CONTROLLED AND RESISTANCE FACTOR ϕ SHALL BE TAKEN AS 1.0

LRFD 5.7.2.1, 5.5.4.2

$$P_{pe} = A_{ps} f_{pe}$$

LRFD 5.9.5.1-1

TOTAL PRESTRESS LOSSES $\Delta f_{pT} = \Delta f_{pES} + \Delta f_{pLT}$ IMMEDIATELY BEFORE TRANSFER

EFFECTIVE PRESTRESS f_{pe} = INITIAL PRESTRESS − TOTAL PRESTRESS LOSS

MINIMUM REINFORCEMENT 6A.5.6

AMOUNT OF REINFORCEMENT MUST BE SUFFICIENT TO DEVELOP M_r EQUAL TO THE LESSER OF: $1.2 M_{cr}$ OR $1.33 M_n$ LRFD 5.7.3.3.2

LOAD	LOAD FACTOR γ
DC	1.25
DW	1.50
LL	1.75

LRFD TABLE 3.4.1-1, 3.4.1-2

1) $M_R = \phi M_n = (1.0)(5270) = 5270$ k-FT

$1.33 M_n = 1.33\left[1.75(1473) + 1.25(1450 + 304.2) + 1.5(168.7)\right] = 6681.3$ k-FT

6681.3 k-FT > 5270 k-FT NG.

2) $M_{cr} = S_c\left(f_r + f_{cpe}\right) - M_{dnc}\left(\frac{S_c}{S_{nc}} - 1\right) \geq S_c f_r$ 6A.5.6 LRFD EQ. 5.7.3.3.2-1

$M_{dnc} = M_{DC1} = 1450$ k-FT

$S_c = 14555.3$ in^3

$S_{nc} = 12429.6$ in^3

MODULUS OF RUPTURE $f_r = .37\sqrt{f'_c} = .37\sqrt{5} = .827$ ksi LRFD DESIGN 5.4.2.6

f_{cpe} = COMPRESSIVE STRESS IN CONCRETE DUE TO EFFECTIVE PRESTRESS FORCE (AFTER ALLOWANCE FOR ALL PRESTRESS LOSSES) AT EXTREME FIBER OF SECTION WHERE TENSILE STRESS IS CAUSED BY EXTERNALLY APPLIED LOADS

$f_{cpe} = \frac{P_{pe}}{A} + \frac{P_{pe}\,e}{S_b}$ P_{pe} = EFFECTIVE PRESTRESS FORCE

DETERMINE EFFECTIVE PRESTRESS FORCE, P_{pe}

$P_{pe} = A_{ps} f_{pe}$ LRFD EQ. 5.9.5.1-1

TOTAL PRESTRESS LOSSES $\Delta f_{pT} = \Delta f_{pES} + \Delta f_{pLT}$ IMMEDIATELY BEFORE TRANSFER

EFFECTIVE PRESTRESS f_{pe} = INITIAL PRESTRESS − TOTAL PRESTRESS LOSSES

A3.7.1.1 – LOSS DUE TO ELASTIC SHORTENING AND/OR EXTERNAL LOADS, Δf_{pES} LRFD 5.9.5.2.3a

$$\Delta f_{pES} = \frac{E_p}{E_{ci}} f_{cgp}$$ TABLE 5.9.3-1

$$f_{cgp} = \frac{P_i}{A} + \frac{P_i e^2}{I} - \frac{M_D e}{I}$$

INITIAL PRESTRESS IMMEDIATELY PRIOR TO TRANSFER $= .70 f_{pu}$ FOR STRESS RELIEVED PRESTRESSING STRANDS

FOR ESTIMATING P_i IMMEDIATELY AFTER TRANSFER USE $.9(.7 f_{pu})$ LRFD 5.9.5.2.3a

$.85(.7 f_{pu})$

$P_i = .9(.7 \times 200 \text{ ksi}) \times 9 \times .788 = 893.6$ k

M_D = MOMENT DUE TO SELF WEIGHT OF MEMBER AT SECTION OF MAX. MOMENT (MIDSPAN)

$= \frac{1}{8} \times .971 \times 97.5^2 = 1153.8$ k-FT

$Y_p = 30.21$ BASIC BEAM SECTION

$\bar{Y} = 4.75$ in DISTANCE FROM BOTTOM OF GIRDER TO CENTROID OF PRESTRESSING STRANDS

$e = 30.21 - 4.75 = 25.46$ in

$P_i = .9(.7 \times 200) \times 9 \times .788 = 893.6$ K

ECCENTRICITY OF P/S STRANDS FROM CG OF BEAM

Close, Jensen and Miller, P.C.

BY BA DATE 3/2/11 SUBJECT BR. 596 SHEET NO. 41 E OF
CHKD. BY DATE ROUTE 68 O/ NAUGATUCK JOB NO.
RWBC, RTE 8, MWRR, SK710 NAUGATUCK, CT

$$f_{cgp} = \frac{893.6}{932.2} + \frac{893.6 \times 25.46^2}{375443.9} - \frac{1153.8 \times 25.46}{375443.9} = 2.42 \text{ ksi}$$

(.959, 1.543, .078 X12) LRFD 5.4.4.2

→ 1.57 ksi

$E_p = 25000$ ksi

$E_{ct} = 33000(w_c)^{1.5}\sqrt{f'_c} = 33000(.145)^{1.5}\sqrt{4} = 3644$ ksi LRFD 5.4.2.4-1

$\Delta f_{pES} = \frac{25000}{3644} \times 2.42 = 16.6$ ksi LRFD C5.9.5.2.3a-1

(↓ 1.57, ↓ 10.77)

APPROXIMATE LUMP SUM ESTIMATE OF TIME-DEPENDENT LOSSES, Δf_{pLT}

TIME DEPENDENT LOSSES INCLUDE SHRINKAGE OF CONCRETE, CREEP OF CONCRETE, AND RELAXATION OF STEEL. LRFD 5.9.5.4.1-1

$$\Delta f_{pLT} = (\Delta f_{pSR} + \Delta f_{pCR} + \Delta f_{pR1})_{id} + (\Delta f_{pSD} + \Delta f_{pCD} + \Delta f_{pR} - \Delta f_{pSS})_{df}$$

LRFD 5.9.5.3

FOR I-GIRDERS, TIME DEPENDENT LOSSES CAN BE APPROXI. BY:

$$\Delta f_{pLT} = 10.0 \frac{f_{pi} A_{ps}}{A_g} \gamma_h \gamma_{st} + 12 \gamma_h \gamma_{st} + \Delta f_{pR}$$ LRFD 5.9.5.3-1

$$\gamma_h = 1.7 - .01H$$ LRFD 5.9.5.3-2

ASSUMING A RELATIVE HUMIDITY H RANGING BETWEEN 40 to 100 PERCENT.

$H = 70\%$ FROM FIG. 5.4.2.3.3-1

$\gamma_h = 1.7 - .01(70) = 1.0$

$\gamma_{st} = \frac{5}{1 + f'_{ci}} = \frac{5}{1+4} = 1.0$

$\Delta f_{pR} = 10$ ksi FOR RELAXATION LOSS (STRESS RELIEVED STRANDS)

$\Delta f_{pi} = .75 \times 200 = 150$ ksi

$$\Delta f_{PLT} = 10 \times \frac{150 \times (9 \times .788)}{932.2} \times 1.0 \times 1.0 + 12 \times 1 \times 1 + 10 = 33.41 \text{ ksi}$$

(7.09 in²)

TOTAL PRESTRESS LOSSES, Δf_{pT} LRFD 5.9.5.1-1

$$\Delta f_{pT} = \Delta f_{pES} + \Delta f_{pLT} = \cancel{16.6}\ 10.77 + 33.41 = \cancel{50.01}\ 44.2 \text{ ksi}$$

f_{pe} = INITIAL PRESTRESS − TOTAL PRESTRESS LOSSES

$$= .75 \times 200 - \cancel{50.01}\ 44.2 = 100 \text{ ksi} \quad (106 \text{ ksi})$$

$$P_{pe} = 100 \times 9 \times .788 = 709.2 \text{ kips} \quad (751.8 \text{ kips})$$

$$f_{pb} = \frac{P_{pe}}{A} + \frac{P_{pe} e}{S_b} = \frac{709.2}{932.2} + \frac{709.2 \times 25.46}{12429.6} = 1.45 \text{ ksi} \quad (2.35)$$

$$M_{cr} = S_c (f_r + f_{cpe}) - M_{dnc} \left(\frac{S_c}{S_{nc}} - 1 \right) \geq S_c f_r$$

LRFD EQ. 5.7.3.3.2-1

$$S_c (f_r + f_{cpe}) - M_{dnc} \left(\frac{S_c}{S_{nc}} - 1 \right) = \frac{14555.3}{12} (.827 + 1.45) - 1450 \left(\frac{14555.3}{12429.6} - 1 \right)$$

(2761.87)

$$= 2513.89 \text{ k-FT}$$

$$S_c f_r = \frac{14555.3}{12} \times .827 = 1003.1 \text{ k-FT}$$

THEREFORE, $M_{cr} = 2513.89$ k-FT

$$1.2 \times M_{cr} = 1.2 \times 2513.89 \text{ k-FT} = 3016.67 \text{ k-FT} \leftarrow$$

$$1.33\, M_u = 6681.3 \text{ k-FT}$$

$1.2\, M_{cr} < 1.33\, M_u \Rightarrow 1.2 M_{cr}$ GOVERNS

MINIMUM REINF CK SATISFIED

$M_r = 5270$ k-FT

$M_r = 5270$ k-FT > 3016.67 k-FT OK

6A.5.6

Close, Jensen and Miller, P.C.

BY BA DATE 3/2/11 SUBJECT BR. 596 SHEET NO. 43 E OF
CHKD. BY DATE ROUTE 68 O/ NAUGATUCK JOB NO.
RIVER, RTE 8, MNDR, SR 710 NAUGATUCK, CT

COMPUTE NOMINAL SHEAR RESISTANCE AT FIRST CRITICAL SECTION

NOTE: ARTICLE 6A.5.8 OF BRIDGE EVALUATION MANUAL DOES NOT REQUIRE A SHEAR EVALUATION FOR THE DESIGN LOAD AND LEGAL LOADS IF THE BRIDGE SHOWS NO VISIBLE SIGN OF SHEAR DISTRESS. HOWEVER THIS BRIDGE (SPAN 5, E4) EXHIBIT SHEAR CRACKS AT END THEREFORE SHEAR CALCULATIONS FOR HL-93 ARE CALCULATED.

SHEAR LOCATION:

CRITICAL SECTION FOR SHEAR NEAR SUPPORTS IS THE GREATER OF d_v OR $0.5 d_v \cot\theta$ FROM THE FACE OF SUPPORT

LRFD 5.8.3.2
LRFD 5.8.2.9

EFFECTIVE SHEAR DEPTH, d_v:

MAXIMUM OF:

i) DISTANCE BETWEEN RESULTANTS OF THE TENSILE AND COMPRESSIVE FORCES

ii) $0.9 d_e$

iii) $0.72 h$

THE FIRST CRITICAL SECTION WILL, BE INSPECTION, BE WITHIN THE 24-FT DRAPPED END REGION.

$$c = \frac{A_{ps} f_{pu}}{.85 f'_c \beta_1 b + k A_{ps} \frac{f_{pu}}{d_p}}$$

EQ. 5.7.3.1.1-4

$A_{ps} = 8 \times .788 = 6.3 \text{ in}^2$

$b = b_e$ = EFFECTIVE FLANGE WIDTH = 71.5 in

Close, Jensen and Miller, P.C.

BY B.A. DATE 3/2/11 SUBJECT BR. 596 SHEET NO. 44E OF
CHKD. BY DATE ROUTE 68 O/ NAUGATUCK JOB NO.
RIVER, RTE 8, MNNR, SR710 NAUGATUCK, CT

$\beta_1 = .85$

$f'_c = 4$ ksi

$k = .38$ for STRESS RELIEVED

$f_{pu} = 200$ ksi TOTAL STRANDS 8 $\overset{\bar{y}}{12.89} = 103.12$

$$\bar{y} = \frac{103.12}{8} = 12.89 \text{ in}$$

$$d_p = (56 - \overset{\text{DRAPED}}{12.89}) = 43.11 \text{ in}$$

$$c = \frac{6.3^{in^2} \times 200^{ksi}}{.85 \times 4 \times .85 \times 71.5 + .38 \times 6.3 \times \frac{200}{43.11}} = 5.78 \text{ in}$$

$$a = \beta_1 c = .85 \times 5.78 = 4.92 \text{ in}$$

$$d_v = 43.11 - \frac{4.92}{2} = 40.65 \text{ in}$$

FOR ESTABLISHING THE CRITICAL SHEAR SECTION ASSUME:

$\theta = 30°$ A HIGH ASSUMPTION IS CONSERVATIVE

$$0.5 d_v \cot\theta = (0.5)(d_v)(\cot 30°) = .87 d_v < d_v$$

DISTANCE FROM FACE OF SUPPORT TO CENTERLINE OF BEARING = 6 in

DISTANCE FROM CENTERLINE OF BEARING TO CRITICAL SHEAR SECTION:

$= 40.65 + 6 = 46.65$ in $= 3.88$ ft LRFD 5.11.4

Close, Jensen and Miller, P.C.

BY BA DATE 3/3/11 SUBJECT BR. 596 SHEET NO. 45 E OF
CHKD. BY DATE RAMP 68 O/ NAVIGATOR JOB NO.
FIVE, RTE 8, MNRR, SR710 NAUGATUCK, CT

MAXIMUM SHEAR AT CRITICAL SECTION NEAR SUPPORTS

CALCULATED BY STATICS WITH THE LOADS APPLIED NO CLOSER THAN 3.88' FROM THE SUPPORTS

$$V_{TANDEM} = 25^k \times \left(\frac{93.62' + 89.62'}{97.5'}\right) = 47^k$$

$$V_{TRUCK} = \frac{32^k(93.62' + 79.62') + 8^k(65.62')}{97.5'} = 62.24^k \leftarrow \text{GOVERNS}$$

$$V_{LANE} = \frac{.64^{k/'}(93.62)^2}{2 \times 97.5'} = 28.77^k$$

IM = 33%

TOTAL SHEAR $= V_{LANE} + V_{TRUCK} \times 1.33 = 111.55^k$

DISTRIBUTED $V_{LL+IM} = 111.55^k \times .668 = 74.5^k$

DL SHEAR: $DC_1 = 1.22^{k/'}$

$DC_2 = .4^{k/'}$

$DW = .142^{k/'}$

$$V_{DL} = (1.22 + .4)(.5 \times 97.5 - 3.88) = 72.69^k$$

$$V_{DW} = (.142)(.5 \times 97.5 - 3.88) = 6.37^k$$

COMPUTE NOMINAL SHEAR RESISTANCE

THE NOMINAL SHEAR RESISTANCE V_n SHALL BE LESSER OF

$$V_n = V_s + V_c + V_p$$

$$V_n = 0.25 f'_c b_v d_v + V_p$$

LRFD EQS. 5.8.3.3-1, 5.8.3.3-2

V_p: FOR DRAPED TENDON:

$V_p = V \times B \times \sin 1.7°$ (PER STRAND)

$.7854 \times 8 \times 100^{ksi} \times .030 = 18.9^k$

CRITICAL SECTION FOR SHEAR NEAR THE SUPPORT IS AT 46.65 in FROM CENTERLINE OF BEARING (WITHIN THE DRAPPED LENGTH) TRANSVERSE REINFORCEMENT PROVIDED AT CRITICAL SECTION = #4 VERTICAL STIRRUPS @ 12" SPAC.

MINIMUM TRANSVERSE REINFORCEMENT LRFD 5.8.2.5

EFFECTIVE WEB WIDTH, $b_v = 7''$

STIRRUP SPACING, $s = 12''$

GRADE 40 REBAR, $f_y = 40$ ksi

$$A_v = .0316\sqrt{f'_c}\,\frac{b_v s}{f_y} = .0316\sqrt{5}\cdot\frac{7\times 12}{40} = .148 \text{ in}^2$$

AREA PROVIDED = 2 legs $\times .2 \text{ in}^2 = .4 \text{ in}^2 > .148 \text{ in}^2$ ok

$$V_c = .0316\beta\sqrt{f'_c}\,b_v d_v$$ LRFD 5.8.3.3-3

$$V_s = \frac{A_v f_y d_v \cot\theta}{s} \quad \text{for } \alpha = 90^\circ$$ 5.8.3.3-4 5.8.3.3-2

$$.25 f'_c b_v d_v + V_p = .25\times 5\times 7\times 40.65 + 18.9 = 374.6 \text{ k}$$ ✓ SEE PREVIOUS SHT.

THESE EQUATIONS ARE BASED ON THE MODIFIED COMPRESSION FIELD THEORY (MCFT) AND REQUIRE THE DETERMINATION OF β AND θ BY DETAILED ANALYSIS. A SIMPLIFIED ANALYSIS USING $\theta = 45^\circ$ & $\beta = 2$ MAY BE UTILIZED FOR AN INITIAL EVALUATION BEFORE RESORTING TO THE MCFT, IF NECESSARY, FOR LIKELY IMPROVED SHEAR CAPACITY

Close, Jensen and Miller, P.C.

BY BA DATE 3/3/11 SUBJECT B.R. 596 SHEET NO. 47 E OF
CHKD. BY DATE ROUTE 68 OVER NAUGATUCK JOB NO.
BRIDGE, RTE 8, MARK, SR710 NAUGATUCK, CT

SIMPLIFIED APPROACH

$\theta = 45^\circ \quad \beta = 2.0$

CONCRETE $V_c = .0316\beta\sqrt{f'_c}\, b_v d_v = .0316 \times 2 \times \sqrt{5} \times 7 \times 40.65 = 40.2^k$

STEEL $V_s = \dfrac{A_v f_y d_v \cot\theta}{s} = \dfrac{.4 \times 40 \times 40.65 \times \cot 45}{12} = 54.2^k$

TOTAL NOMINAL SHEAR RESISTANCE $= 40.2 + 54.2 + (78.8 \times 8 \times \sin 1.7^\circ) = 107.3^k$
$V_n = V_c + V_s + V_p$ $\quad V_n$ $\quad 113.1^k$

$107.3^k < 374.6^k \quad \therefore V_n = 107.3^k$

$\phi V_n = .9 \times 107.3^k = 96.5^k$

MAXIMUM DISTRIBUTED SHEARS AT CRITICAL SECTION (HL-93 INVENTORY LOADING)

$V_{LL+I} = 74.5^k \qquad \gamma_{LL+I} = 1.75$

$V_{DC} = 72.69^k \qquad \gamma_{DC} = 1.25$

$V_{DW} = 6.37^k \qquad \gamma_{DW} = 1.5$

LRFD TABLES 3.4.1-1, 3.4.1-2

FACTORED SHEAR:

$V_u = (1.75)(74.5) + (1.25)(72.69) + (1.5)(6.37) = 230.8^k > 96.5^k < 230.8^k$ NG

TRY MCFT APPROACH

Close, Jensen and Miller, P.C.

BY BA DATE 3/3/11 SUBJECT BR. 596 SHEET NO. 48E OF
CHKD. BY DATE ROUTE 68 O/ NAUGATUCK JOB NO.
RIVER, RTE 8, MNRR, SR710 NAUGATUCK, CT

MCFT APPROACH

SHEAR STRESS ON THE CONCRETE:

$$v = \frac{V_u - \varphi V_p}{\varphi b_v d_v} = \frac{230.8}{.9 \times 7 \times 40.65} = .9 \text{ ksi}$$

$$\frac{v}{f'_c} = \frac{.9}{5} = .18 < .25 \quad \text{ok}$$

AT FIRST CRITICAL SECTION FOR SHEAR (3.88' = 46.56" FROM ℄ OF BRG.)

LIVE LOAD MOMENTS AT FIRST CRITICAL SECTION DETERMINED BY STATICS:

$$M_{TRUCK} = \frac{32^k \times 3.88'(93.62 + 79.62) + 8^k \times 3.88(65.62')}{97.5} = 241.1 \text{ k-FT}$$

$$M_{LANE} = .64^{k/'} \times \frac{(93.62)^2}{2 \times 97.5} \times 3.88 = 111.61$$

$$M_{LL+I} = 111.61^{k\text{-}FT} + 1.33 \times 241.1^{k\text{-}FT} = 432.2 \text{ k-FT}$$

DISTRIBUTED MOMENT $= g_m \times M_{LL+IM} = .541 \times 432.2 = 233.84$ k-FT

DEAD LOAD MOMENT AT FIRST CRITICAL SECTION FOR SHEAR

$$M_{DC} = .5(1.22 + .4)(3.88)(97.5 - 3.88) = 294.2 \text{ k-FT}$$

$$M_{DW} = .5(.142)(3.88)(97.5 - 3.88) = 25.79 \text{ k-FT}$$

FACTORED MOMENT $= M_u = (1.75 \times 233.84) + (1.25)(294.2) + (1.5)(25.79) = 815.66^{k\text{-}FT}$

FOLLOWING THE APPROACH IN THE LRFD SHEAR DESIGN FLOWCHART AND LRFD DESIGN TABLE 5.8.3.4.2-1

TRANSFER LENGTH 60 STRAND DIAMETER $= 30^{in} < 46.56^{in}$

AS THE SECTION IS OUTSIDE THE TRANSFER LENGTH, THE FULL VALUE OF f_{po} IS USED IN CALCULATING THE SHEAR RESISTANCE

THE MODIFIED COMPRESSION FIELD THEORY (MCFT) FOLLOWS AN ITERATIVE PROCESS:

$\frac{v}{f'_c} = .12$ ($\leq .125$, ROW 3 OF LRFD DESIGN TABLE 5.8.3.4.2-1)

LRFD FIG. C5.8.3.4.2-5

ASSUME $\varepsilon_x \leq -0.10 \times 10^{-3}$ ($\varepsilon_x \times 1000 \leq -0.10$) TABLE 5.8.3.4.2-1

FROM LRFD DESIGN TABLE 5.8.3.4.2-1 (ROW 3, COLUMN 2):

$\theta = 21.9°$ $\beta = 2.99$

EQ. 5.8.3.4.2-1

ε_x:

$$\varepsilon_x = \frac{\frac{|M_u|}{d_v} + .5N_u + .5|V_u - V_p|\cot\theta - A_{ps}f_{po}}{2(E_sA_s + E_pA_{ps})} \leq .001$$

$A_{ps} = 8 \times .788 = 6.304 \text{ in}^2$

$f_{po} = .7 f_{pu} = .7 \times 200 = 140 \text{ ksi}$

$$\varepsilon_x = \frac{\frac{|12 \times 815.66|}{40.65} + 0.5|230.8|(\cot 21.9) - (6.304)(140)}{2(0 + 25000 \times 6.304)} = -1.125 \times 10^{-3}$$

IF ε_x IS NEGATIVE, IT MUST BE RECALCULATED INCLUDING CONCRETE STIFFNESS

A_c = Area below $h/2$ $= 7 \times 24 + \frac{1}{2}(7 + 24)(8) + (8)(10) = 372 \text{ in}^2$

FIG. 5.8.3.4.2-1

Close, Jensen and Miller, P.C.

BY BA DATE 3/3/11 SUBJECT BR. 596 SHEET NO. 50 E OF

CHKD. BY DATE ROUTE 68 O/ NAUGATUCK JOB NO.

RIVER, RTE 8, MARK, SK710 NAUGATUCK, CT

EQ. 5.8.3.4.2-3

$$\varepsilon_x = \frac{\frac{|M_u|}{d_v} + .5N_u + .5|V_u - V_p|\cot\theta - A_{ps}f_{po}}{2(E_cA_c + E_sA_s + E_pA_{ps})}$$

$$\varepsilon_x = \frac{\frac{12\times|815.66|}{40.65} + .5(230.8)(\cot 21.9) - \overset{-59.505}{(6.304)(140)}}{2\left[(4070)(372) + 0 + (25000\times 6.304)\right]} = -1.78\times10^{-5}$$

$-.016\times10^{-3} >$ ASSUMED $\varepsilon_x \leq -0.10\times10^{-3}$

ASSUME $\varepsilon_x \leq 0$

FROM LRFD DESIGN TABLE 5.8.3.4.2-1 (ROW 3, COLUMN 4):

$\theta = 23.7°$ $\beta = 2.87$

$$\varepsilon_x = \frac{\frac{12\times|815.66|}{40.65} + .5(230.8)(\cot 23.7) - \overset{-41.84}{(6.304)(140)}}{2\left[(4070)(372) + (25000)(6.304)\right]} = -2.5\times10^{-5}$$

$-2.5\times10^{-5} <$ ASSUMED $\varepsilon_x \leq 0$ ok

NOTE $-2.5\times10^{-5} < -.05\times10^{-3}$ LRFD 5.8.3.3-3

CALCULATE V_n: EQ. 5.8.3.3-3

$$V_c = .0316\beta\sqrt{f'_c}\, b_v d_v = .0316(2.87)\sqrt{5} \times 7 \times 40.65 = 57.7^k$$

$$V_s = \frac{A_v f_y d_v \cot\theta}{s} = \frac{.2 \times 40 \times 40.65 \times \cot 23.7}{12} = 61.74^k$$

TOTAL NOMINAL SHEAR RESISTANCE: $V_n = V_c + V_s = 57.7 + 61.74 = 119.4^k$

VERSUS 107.3^k BY SIMPLIFIED METHOD

$$.25 f'_c b_v d_v + V_p = 355.7^k$$

EQ. 5.8.3.3-1

$119.4^k < 355.7^k$ $V_n = 119.4^k$

$\phi V_n = .9 \times 119.4 = 107.5^k$

$V_n = V_c + V_s + V_p = 138.3^k$ (18.9)

$\phi V_n = 124.5^k$

CHECK LONGITUDINAL REINFORCEMENT (LRFD 5.8.3.5)

TENSILE CAPACITY OF THE LONGITUDINAL REINFORCEMENT ON THE FLEXURAL TENSION SIDE OF THE MEMBER SHALL BE PROPORTIONED TO SATISFY LRFD DESIGN EQ. 5.8.3.5-1 "ANY LACK OF FULL DEVELOPMENT SHALL BE ACCOUNTED FOR".

EQ. 5.8.3.5-1

$$A_{ps} f_{ps} + A_s f_y \geq \frac{|M_u|}{d_v \phi_f} + .5\frac{N_u}{\phi_c} + \left[\left|\frac{V_u}{\phi_v} - V_p\right| - .5 V_s\right]\cot\theta$$

CALCULATE MINIMUM REQUIRED TENSILE CAPACITY:

$$V_s = 61.74^k < \frac{V_u}{\phi} = \frac{230.8^k}{.9} = 256.44^k \quad \text{USE } 256.44^k$$

THE RIGHT SIDE OF LRFD EQ. 5.8.3.5-1 YIELDS:

$$= \frac{\left|\frac{815.66 \times 12}{40.65 \times 1.0}\right|}{} + \left(\left|\frac{230.8^{k}}{.9}\right| - .5(256.44)\right) \cot 23.7^\circ = 828.1 \quad k$$

TRANSFER LENGTH: LRFD 5.11.4.1

$\ell_t = 60$ Strand diameter $= 60 \times .5 \quad 30$ in

DEVELOPMENT LENGTH: LRFD 5.11.4.2-1

$$\ell_d \geq k\left(f_{ps} - \frac{2}{3} f_{pe}\right) d_b$$

WHERE $k = 1.6$ FOR PRETENSIONED MEMBERS WITH A DEPTH OF GREATER THAN 24 in.

$$\ell_d \geq 1.6 \times \left(187.3 - \frac{2}{3} \times 100\right) \times .5 = 96.5 \text{ in}$$

LRFD 5.11.4.3
5.11.4.1

THE 8-9 EFFECTIVE STRANDS AT THE CRITICAL SHEAR SECTION ARE DRAPED OVER THE FULL LENGTH OF THE BEAM. THE SECTION AT 3.88' FROM CENTERLINE OF THE BEARING IS BETWEEN THE TRANSFER LENGTH (30 in FROM END OF BEAM, 27 in FROM CENTERLINE OF BEARING) AND THE DEVELOPMENT LENGTH (96.5 in FROM END OF BEAM, 90.5 in FROM CENTERLINE OF BEARING). USE A LINEAR GROWTH IN STRAND CAPACITY FROM f_{pe} AT THE TRANSFER LENGTH TO f_{ps} AT THE DEVELOPMENT LENGTH.

LRFD EQ. 5.11.4.2-3

$\ell_{px} = 46.65$ in

$$f_{px} = f_{pe} + \frac{\ell_{px} - 60 d_b}{\ell_d - 60 d_b}\left(f_{ps} - f_{pe}\right) = 100 + \frac{46.65 - 30}{96.5 - 30}(187.3 - 100) = 121.86$$

Close, Jensen and Miller, P.C.

BY FA DATE 3/3/11 SUBJECT BR. 596 SHEET NO. 53E OF
CHKD. BY DATE ROUTE 68 O/ NAUGATUCK JOB NO.
RIVER, RTE 8, MNRR, SR710 NAUGATUCK, CT

THE LEFT SIDE OF LRFD DESIGN EQ. 5.8.3.5-1 YIELDS:

$= f_{px} \times A_{ps} = 121.86 \text{ ksi} \times 7.092 \text{ in}^2 = 864.23$ kips

$$A_{ps} f_{ps} + A_s f_y \geq \frac{|M_u|}{d_v Q_f} + 0.5 \frac{N_u}{Q_c} + \left[\left|\frac{V_u}{\phi Q_v} - V_p\right| - 0.5 V_s\right] \cot\theta$$ reduces to

$864.23^k > 828.1^k$ ok

COMPUTE NOMINAL SHEAR RESISTANCE AT STIRRUP CHANGE / QUARTER POINT C6A.5.8

MULTIPLE LOCATIONS NEED TO BE CHECKED FOR SHEAR. TYPICALLY, LOCATIONS NEAR THE QUARTER POINT COULD BE CRITICAL BECAUSE THE CORRESPONDING MOMENT MAY BE QUITE LOW.

$97.5'/4 = 24.38'$ AT DRAPPOINT $.375L = .375 \times 97.5' = 36.56'$

EFFECTIVE SHEAR DEPTH, d_v BASED ON 9 STRANDS

CHECK TRANSFER LENGTH LRFD 5.11.4

60 STRAND DIAMETER $= 60 \times 1.152'' = 69.12''$
$60 \times .5 = 30$ in REBAR

$d_v = d_e - \frac{a}{2}$ LRFD 5.8.2.9

$d_e = h - \bar{y} = 56 - 4.75'' = 51.25$
$56 - 12.89'' = 43.11$

$a = 7.29$ in

d_v NEED NOT BE LESS THAN GREATER OF MINIMUM EFFECTIVE SHEAR DEPTH LIMITS $.9d_e$ OR $.72h$

$d_v = 51.25 - \frac{7.29}{2} = 47.61$ in $> .9d_e = .9 \times 51.25 = 46.13$ in
$> .72h = .72 \times 56 = 40.32$ in

IF WE BASE d_v ON:

$$d_v = \frac{M_n}{A_s f_y + A_{ps} f_{ps}}$$ INCLUDING THE EFFECTS OF DEVELOPMENT LENGTH

$$d_v = \frac{5270^{k\text{-}ft} \times 12^{in/ft}}{0 + (8 \times \underbrace{1.152}_{.768\ in^2}) \times 187.3} = 36.64\ in$$

MAXIMUM SHEAR AT STIRRUP CHANGE

FOR HL-93 LOADING @ 24.38' FROM ℄ OF BRG.

CALCULATED BY STATICS WITH THE LOADS APPLIED NO CLOSER THAN 3.88' FROM THE SUPPORT

$$V_{TANDEM} = \frac{25^k (73.13' + 69.13')}{97.5'} = 36.48\ k$$

$$V_{TRUCK} = \frac{32^k (73.13' + 59.13') + 8 (45.13')}{97.5'} = 47.11^k \leftarrow$$

$$V_{LANE} = \frac{.64^{k/'} (73.13')^2}{2 \times 97.5} = 17.55^k$$

IM = 33%

$$V_{LL+IM} = 17.55^k + 1.33 \times 47.11 = 80.21\ k$$

DISTRIBUTED $g_V = .668$

$$g_V V_{LL+IM} = .668 \times 80.21 = 53.58^k$$

DEAD LOAD SHEARS $DC_1 = 1.22\ k/'$
$DC_2 = .4$
$DW = .142$

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BY BA DATE 3/3/11 SUBJECT BR. 596 SHEET NO. 55 E OF
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RIVER, RTE 8, MNRR, STATION NAUGATUCK, CT

$V_{DL} = (1.22^{k/'} + .4^{k/'})(.5 \times 97.5' - 24.38') = 39.48^k$

$V_{DW} = .142^{k/'}(.5 \times 97.5 - 24.38) = 3.46^k$

MINIMUM TRANSVERSE REINFORCEMENT: LRFD EQ. 5.8.2.5-1

EFFECTIVE WEB WIDTH $= b_v = 7$ in

SPACING OF TRANSVERSE REINFORCEMENT:

$S = 18$ in

$A_v = .0316\sqrt{f'_c}\,\frac{b_v s}{f_y} = .0316\sqrt{5}\,\frac{(7)(18)}{40} = .22 \text{ in}^2$

AREA PROVIDED $2\#4 = 2(.13) = .26 \text{ in}^2 > .22 \text{ in}^2$ ok (#4 @ 18)

SIMPLIFIED APPROACH

$\theta = 45°$

$\beta = 2$

LRFD EQ. 5.8.3.3-3

Concrete: $V_c = .0316\beta\sqrt{f'_c}\,b_v d_v$

EFFECTIVE SHEAR DEPTH $d_v = 47.61$ in

$V_c = .0316 \times 2 \times \sqrt{5} \times 7 \times 47.61 = 47.1^k$

STEEL:

$V_s = \frac{A_v f_y d_v \cot\theta}{S} = \frac{.26 \times 40 \times 47.61 \times \cot 45}{18}$

#4 @ 18"
$A = 2 \times .13 = .26 \text{ in}^2$

$V_s = 27.5^k$

TOTAL NOMINAL SHEAR RESISTANCE:

$V_n = V_c + V_s = 47.1 + 27.5 = 74.6^k$

$V_n = V_c + V_s + V_p = 74.6 + 18.9^k = 93.5^k$

LRFD EQ. 5.8.3.3-2

$.25 f'_c b_v d_v + V_p = .25 \times 5 \times 7 \times 47.61 = 416.6^k$

$74.6^k < 416.6^k \quad \therefore \quad V_n = 74.6^k$

$\phi V_n = .9 \times 74.6 = 67.14^k$

FACTORED SHEAR V_u?

$V_u = 1.75(27.5) + 1.25(39.48) + 1.5(3.46) = 102.7^k$

$67.14^k < 102.7^k$ N.G.

TRY MCFT Approach

MCFT Approach

SHEAR STRESS ON THE CONCRETE

LRFD EQ. 5.8.2.9-1

$v = \dfrac{V_u - \phi V_p}{\phi b_v d_v} = \dfrac{102.7^k}{.9 \times 7 \times 47.61} = .34$ ksi

$\dfrac{v}{f'_c} = \dfrac{.34}{5} = .068 < .25$ OK

AT STIRRUP CHANGE:

$M_{TRUCK} = \dfrac{32^k \times 24.38' (73.13 + 69.13) + 8^k \times 24.38 (55.13')}{97.5'} = 1248.6$ k-FT

$M_{LANE} = \dfrac{.64^{k/'} \times 73.13^2}{2 \times 97.5} \times 24.38' = 427.93$

$M_{LL+I} = 427.93 + 1.33 \times 1248.6 = 2088.6$

$\gamma_m M_{LL+I} = .541 \times 2088.6 = 1130$ k-FT

$M_{DC} = .5(1.22 + .4)(24.38)(97.5 - 24.38) = 1493.96$ k-ft

$M_{DW} = .5(.142^{k/ft})(24.38)(97.5 - 24.38) = 126.6$ k-ft

$M_u = 1.75(1130) + 1.25(1494) + 1.5(126.6) = 3972.4$ k-ft

Following the approach in the LRFD shear design flowchart and LRFD design table 5.8.3.4.2-1
5.8.3.4.2

Check upper limit of shear V_n

LRFD eq. 5.8.3.3-2

$.25 f'_c b_v d_v + V_p = .25 \times 5 \times 7 \times 47.61 = 416.6$ k

$\frac{v}{f'_c} = .068 \leq .100$

LRFD
Fig. C5.8.3.4.2-5
Table 5.8.3.4.2-1
5.8.3.4.2

$A_{ps} = 8 \times .788 = 6.3$ in^2

$f_{po} = .7 f_{pu} = .7 \times 200 = 140$ ksi

$$\varepsilon_x = \frac{\frac{|M_u|}{d_v} + .5N_u + .5|V_u - V_p|\cot\theta - A_{ps} f_{po}}{2(E_s A_s + E_p A_{ps})} \leq .001$$

$$\varepsilon_x = \frac{\frac{12 \times 3972.4}{47.61} + .5(102.7)\cot\theta - (6.3)(140)}{2(25000 \times 6.3)} = 3.785 \times 10^{-4} + 1.63 \times 10^{-4} \cot\theta$$

Assume $\varepsilon_x \leq .125 \times 10^{-3}$ $(\varepsilon_x \times 1000 \leq .125)$

From LRFD design table 5.8.3.4.2-1

$\theta = 24.9°$ $\beta = 2.91$

$\varepsilon_x = 3.785 \times 10^{-4} + 1.63 \times 10^{-4} \cot 24.9 = .73 \times 10^{-3}$

THE CALCULATED ε_x IS LESS THAN THE ASSUMED BUT NOT LESS THAN THE ADJACENT ε_x VALUE 0.0, ∴ THE ASSUMPTION WAS NOT TOO CONSERVATIVE

CALCULATE V_n: LRFD 5.8.3.3-3

$V_c = .0316\beta\sqrt{f'_c}\, b_v d_v = .0316(2.38)\sqrt{5} \times 7 \times 47.61 = 56.05^k$

$V_s = \frac{A_v f_y d_v \cot\theta}{s} = \frac{.24 \times 40 \times 47.61 \times \cot 33.7}{18} = 41.25^k$

LRFD 5.8.3.3-4

$V_n = V_c + V_s = 56.05 + 41.25 = 97.3^k$

$V_s = \frac{.24 \times 40 \times 47.61 \times \cot 21.9}{18} = 59.3^k$

$.25 f'_c b_v d_v + V_p = 416.6^k$

LRFD EQ. 5.8.3.3-1

$97.3^k < 416.6^k$ USE 97.3^k

$\phi V_n = .9 \times 97.3 = 87.57^k$

CHECK LONGITUDINAL REINFORCEMENT (LRFD 5.8.3.5)

EQ. 5.8.3.5-1

$$A_{ps} f_{ps} + A_s f_y \geq \frac{|M_u|}{d_v \phi_f} + .5\frac{N_u}{\phi_c} + \left[\left|\frac{V_u}{\phi_v} - V_p\right| - .5 V_s\right]\cot\theta$$

$V_s = 41.25^k < \frac{V_u}{\phi} = \frac{102.7^k}{.9} = 114.1^k$ USE 41.25^k

THE RIGHT SIDE OF LRFD DESIGN EQ. 5.8.3.5-1 YIELDS:

$$= \frac{12 \times 3972.4}{47.61 \times 1} + \left(\frac{102.7}{.9} - .5 \times 41.25\right)\cot 33.7 = 1141.41 \text{ kips}$$

THE STRANDS ARE FULLY DEVELOPED AT THIS LOCATION $f_{ps} = 187.3$ ksi

AS A PORTION OF THE REMAINING DEVELOPMENT LENGTH FROM THE END

LRFD EQ. 5.11.4.2-1 W/ $k=2$ $\kappa = 1.6$

$\ell_d \geq k\left(f_{ps} - \frac{2}{3} f_{pe}\right) d_b$ $\qquad f_{pe} = 100$ ksi

$\ell_d \geq 2\left(187.3 - \frac{2}{3} \times 100\right) .5 = 120.63$ in

CHECK TO SEE THAT THE STRANDS ARE FULLY DEVELOPED AT THE STIRRUP CHANGE LOCATION:

$120.63^{in} + .375L > .25L$

CALCULATE f_{px}

$\ell_{px} = (24.38 - 10.05) \times 12 = 171.93$ in

$f_{px} = 100 + \frac{171.93 - 30}{120.63 - 30}(187.3 - 100) = 236.72$ ksi

THEN THE LEFT SIDE OF LRFD EQ. 5.8.3.5-1 YIELDS

$= 187.3 \times 8 \times .788 = 1180.7$ k OK

LRFD 5.8.3.5-1

$$A_{ps} f_{ps} + A_s f_y \geq \frac{|M_u|}{d_v \varphi_f} + .5\frac{N_u}{\varphi} + \left[\left|\frac{V_u}{\varphi_v} - V_p\right| - .5V_s\right] \cot\theta$$

REDUCES TO $1180.7^k \geq 1141.41^k$ OK

Close, Jensen and Miller, P.C.

BY BA DATE 3/3/11 SUBJECT BR. 596 SHEET NO. 60E OF

CHKD. BY DATE ROUTE 68 O/ NAUGATUCK JOB NO.

RIVER, RTE 8, MNRR, SR20 NAUGATUCK, CT

SUMMARY TABLE: (MOMENTS & SHEARS)

LOCATION	SUPPORT	CRITICAL SHEAR	STIRRUP CHANGE	MIDSPAN
x/L	0	.04	.25	.5
x	0	3.88	24.38	48.75
V_{DC1} (kips)	59.5	54.74	29.73	–
V_{DC2} (kips)	19.4	17.95	9.75	–
V_{DW} (kips)	6.93	6.37	3.46	–
$\gamma_m V_{LLI}$ (kips)	–	74.5	53.58	–
V_n (kips) SIMPLIFIED	–	107.3 (126.2)	74.6 (93.5)	–
V_n (kips) MCEFT	–	119.4 (138.3)	97.3 (116.2)	–
M_{DC1} (k-FT)	–	221.58	1087.4	1450
M_{DC2} (k-FT)	–	72.62	356.5	472.9
M_{DW} (k-FT)	–	25.79	126.6	168.7
$\gamma_m M_{LLI}$ (k-FT)	–	233.84	1130	1473
M_n (k-FT)	–	–	–	5270

Close, Jensen and Miller, P.C.

BY BA DATE 3/4/11 SUBJECT BR. 596 SHEET NO. 61E OF
CHKD. BY DATE ROUTE 6B O/ NAUGATUCK JOB NO.
FLOR., RTE 8, MARK SR710 NAUGATUCK, CT

GENERAL LOAD RATING EQUATION EQ. 6A.4.2.1-1

$$RF = \frac{C - (\gamma_{DC})(DC) - (\gamma_{DW})(DW) \pm (\gamma_P)(P)}{(\gamma_L)(LL + IM)}$$

EVALUATION FACTORS (FOR STRENGTH LIMIT STATE)

RESISTANCE FACTOR, φ (LRFD 5.5.4.2.1)

$\varphi = 1.0$ FOR FLEXURE (TENSION-CONTROLLED SECTION) SEE SHEET 7

$\varphi = .9$ FOR SHEAR

$\varphi_c = .85$ NBI RATING = 4 (POOR) CONDITION FACTOR φ_c 6A.4.2.3

$\varphi_s = 1.0$ REDUNDANT STRUCTURE GIRDER SPACING > 4 ft SYSTEM FACTOR φ_s 6A.4.2.4

DESIGN LOAD RATING 6A.4.3
STRENGTH I LIMIT STATE 6A.5.4.1

$$RF = \frac{(\varphi_c)(\varphi_s)(\varphi)R_n - (\gamma_{DC})(DC) - (\gamma_{DW})(DW)}{(\gamma_L)(LL + IM)}$$

INVENTORY LEVEL TABLE 6A.4.2.2-1 (HL-93)

LOAD	LOAD FACTOR
DC	1.25
DW	1.5
LL	1.75

FLEXURE AT MIDSPAN: $RF = \frac{(1.0)(1.0)(.85)(5270) - [(1.25)(1450 + 472.9)] + (1.5)(168.7)}{(1.75)(1473)}$ 2454.7

RF = .707

WITHOUT DETERIORATION RF = 1.01

Close, Jensen and Miller, P.C.

BY BA DATE 3/4/11 SUBJECT BR. 596 SHEET NO. 62E OF
CHKD. BY DATE PONTE 68 OF NAUGATUCK JOB NO.
FINAL, AFE 8, MNRR, SR710 NAUGATUCK, CT

THE SHEAR RATING FACTORS FOR DESIGN LOAD RATING ARE CALCULATED FOR ILLUSTRATION PURPOSE ONLY. IN-SERVICE CONCRETE BRIDGES THAT SHOW VISIBLE SIGNS OF SHEAR DISTRESS NEED BE CHECKED FOR SHEAR DURING DESIGN LOAD & LEGAL LOAD RATINGS.

SHEAR AT FIRST CRITICAL SHEAR SECTION (3.88' FROM ℄ OF BEARING):

1. SIMPLIFIED APPROACH

$$RF = \frac{(1.0)(1.0)(.9)(126.2) - [(1.25)(54.74 + 17.95) + (1.5)(6.37)]}{(1.75)(74.5)}$$

100.4

$RF = 0.1$

2. MCFT

$$RF = \frac{(1.0)(1.0)(.9)(138.3) - [(1.25)(54.74 + 17.95) + (1.5)(6.37)]}{(1.75)(74.5)}$$

100.4

$RF = 0.2$

SHEAR AT STIRRUP CHANGE (.25L FROM ℄ OF BEARING):

1. SIMPLIFIED APPROACH

$$RF = \frac{(1.0)(.85)(.9)(93.5) - [(1.25)(29.73 + 9.75) + (1.5)(3.46)]}{(1.75)(53.58)}$$

54.54

$RF = 0.2$

2. MCFT

$$RF = \frac{(1.0)(.85)(.9)(116.2) - [(1.25)(29.73 + 9.75) + (1.5)(3.46)]}{(1.75)(53.58)}$$

$RF = .31$

Close, Jensen and Miller, P.C.

BY BA DATE 3/4/11 SUBJECT BR. 596 SHEET NO. 63 E OF
CHKD. BY DATE ROUTE 68 O/ NAUGATUCK JOB NO.
FINAL, RTE 8, MNRR, SR 710 NAUGATUCK, CT

OPERATING LEVEL (HL-93)

FOR STRENGTH I OPERATING LEVEL ONLY THE LIVE LOAD FACTOR CHANGES; THEREFORE THE RATING FACTOR CAN BE CALCULATED BY DIRECT PROPORTIONS.

TABLE 6A.4.2.2-1

LOAD	LOAD FACTOR, γ
DC	1.25
DW	1.5
LL	1.35

FLEXURE AT MIDSPAN:

$$RF = .707 \times \frac{1.75}{1.35} = .92$$ W/ DETERIORATION

$$RF = 1.01 \times \frac{1.75}{1.35} = 1.3$$ W/OUT DETERIORATION

Shear: Prestressed concrete shear capacity is load-dependent. Therefore, the change in the rating factor using MCFT will not be linear with the change in the live-load factor. The Operating Design Load Rating for shear is not illustrated here.

This example has illustrated the calculation for the shear rating factor with the longitudinal yield check at the first critical section for shear and at a stirrup change. Due to the variation of resistances for shear along the length of this prestressed concrete I-beam, it is not certain that these two locations govern for the Strength I limit state. A systematic evaluation of the shear and longitudinal yield criteria based on shear-moment interaction should be performed along the length of the beam.

Flexure rating should be checked at maximum moment sections and at sections where there are changes in flexural resistance.

The checks performed for minimum and maximum reinforcement will also vary along the length; these checks are required to be satisfied at each cross section in the LRFD Design specification.

Close, Jensen and Miller, P.C.

BY BA DATE 3/4/11 SUBJECT M. 596 SHEET NO. 65 E OF

CHKD. BY DATE ROUTE 68 O/ NAUGATUCK JOB NO.

RIVER, RTE 8, MARR, SHEW NAUGATUCK, CT

SERVICE III LIMIT STATE (INVENTORY LEVEL) (6A.5.4.1)

$$RF = \frac{f_R - (\gamma_D)(f_D)}{(\gamma_L)(f_{LL+I})}$$

FLEXURAL RESISTANCE $f_R = f_{pb}$ + ALLOWABLE TENSILE STRESS

f_{pb} = COMPRESSION STRESS DUE TO EFFECTIVE PRESTRESS

= 1.45 ksi

ALLOWABLE TENSILE STRESS $= .19\sqrt{f'_c} = .19\sqrt{5} = .425$ ksi

LRFD 5.9.4.2.2

$f_R = f_{pb} + .425 = 1.45 + .425 = 1.875$ ksi

DETERMINE DEAD LOAD STRESSES AT MIDSPAN:

$M_{DC1} = 1450$ k-FT

$M_{DC2} = 472.9$ k-FT

$M_{DW} = 168.7$ k-FT

$S_{b(NC)} = S_{b(comp.)} = 12429.6$ in^3

$$f_{DC} = \frac{1450 \times 12}{12429.6} + \frac{472.9 \times 12}{14555.3} = 1.43$$

$$f_{DW} = \frac{168.7 \times 12}{14555.3} = .14$$

TOTAL f_D = 1.57 ksi 1.37

LIVE LOAD STRESS AT MIDSPAN:

$$M_{LL+IM} = \frac{1473 \times 12}{12429.6} = 1.42$$

$$\frac{1473 \times 12}{14555.3} = 1.21$$

BR. 596

66E

NUMBER OF ROWS	NUMBER OF Lx	STIRRUP DETAILS
0	0	Y

PRESTRESSED CONCRETE BEAM DIMENSIONS

TYPE	COMP	D	W1	W2	W3	T1	T2
I	N	56.000	24.000	42.000	7.000	10.000	8.000

B1	B2	B3	B4	D1	D2	X1	X2	SLAB THICK	HAUNCH
8.50	8.50	3.00	6.00	0.00	0.00	0.000	0.000	0.00	0.00

STRAND DETAILS

AREA	G1	G2	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
0.788	2.00	4.750	8									

STIRRUP DETAILS

SPEC. FOR ANAL/RATE	STIRRUP AREA	FSY	LOCATION	SPACING	LOCATION	SPACING	LOCATION	SPACING
A	0.200	40	0.00	6.000	0.33	18.000	0.00	0.000
			0.00	0.000	0.00	0.000	0.00	0.000

WARNING ---- INPUT P/S LOSS LESS THAN MINIMUM BY PENNDOT CRITERIA

SPECIAL LIVE LOADING 1 (CT-L73)

LANE LOADING

NUMBER OF AXLES	3% INCR	UNIFORM LANE LOAD	CONC LOAD MOMENT	CONC LOAD SHEAR	GAGE DISTANCE	PASSING DISTANCE	VARY LAST	MAX AXLE DIST
4	N	0.000	0.000	0.000	6.0	4.0		0.0

TRUCK LOAD

AXLE NO.	LOAD	DIST	AXLE NO.	LOAD	DIST	AXLE NO.	LOAD	DIST	AXLE NO.	LOAD	DIST
1	19.00	11.00	2	18.00	4.00	3	18.00	4.00	4	18.00	0.00

SPECIAL LIVE LOADING 2 (CT-L3S2)

LANE LOADING

NUMBER OF AXLES	3% INCR	UNIFORM LANE LOAD	CONC LOAD MOMENT	CONC LOAD SHEAR	GAGE DISTANCE	PASSING DISTANCE	VARY LAST	MAX AXLE DIST
5	N	0.000	0.000	0.000	6.0	4.0		0.0

TRUCK LOAD

AXLE NO.	LOAD	DIST	AXLE NO.	LOAD	DIST	AXLE NO.	LOAD	DIST	AXLE NO.	LOAD	DIST
1	12.00	11.00	2	18.00	4.00	3	18.00	32.00	4	16.00	4.00

5 16.00 0.00

SPECIAL LIVE LOADING 3 (CT-P76.5)

LANE LOADING

NUMBER OF AXLES	3% INCR	UNIFORM LANE LOAD	CONC LOAD MOMENT	CONC LOAD SHEAR	GAGE DISTANCE	PASSING DISTANCE	VARY LAST	MAX AXLE DIST
4	N	0.000	0.000	0.000	6.0	4.0		0.0

TRUCK LOAD

AXLE NO.	LOAD	DIST	AXLE NO.	LOAD	DIST	AXLE NO.	LOAD	DIST	AXLE NO.	LOAD	DIST
1	13.50	9.60	2	18.00	4.10	3	22.50	4.50	4	22.50	0.00

SPECIAL LIVE LOADING 4 (CT-P204)

LANE LOADING

NUMBER OF AXLES	3% INCR	UNIFORM LANE LOAD	CONC LOAD MOMENT	CONC LOAD SHEAR	GAGE DISTANCE	PASSING DISTANCE	VARY LAST	MAX AXLE DIST
8	N	0.000	0.000	0.000	6.0	4.0		0.0

TRUCK LOAD

AXLE NO.	LOAD	DIST	AXLE NO.	LOAD	DIST	AXLE NO.	LOAD	DIST	AXLE NO.	LOAD	DIST
1	15.00	11.00	2	27.00	4.00	3	27.00	4.00	4	27.00	24.00
5	27.00	4.00	6	27.00	4.00	7	27.00	4.00	8	27.00	0.00

SPECIAL LIVE LOADING 5 (CT-P380)

LANE LOADING

NUMBER OF AXLES	3% INCR	UNIFORM LANE LOAD	CONC LOAD MOMENT	CONC LOAD SHEAR	GAGE DISTANCE	PASSING DISTANCE	VARY LAST	MAX AXLE DIST
19	N	0.000	0.000	0.000	6.0	4.0		0.0

TRUCK LOAD

AXLE NO.	LOAD	DIST	AXLE NO.	LOAD	DIST	AXLE NO.	LOAD	DIST	AXLE NO.	LOAD	DIST
1	12.80	14.00	2	20.30	5.00	3	20.30	5.00	4	20.30	14.00
5	21.00	5.00	6	21.00	5.00	7	21.00	14.00	8	20.30	5.00
9	20.30	5.00	10	20.30	47.00	11	20.55	5.00	12	20.55	5.00
13	20.55	14.00	14	19.70	5.00	15	19.70	5.00	16	19.70	14.00
17	20.55	5.00	18	20.55	5.00	19	20.55	0.00			

SPECIAL LIVE LOADING 6 (CT-TLC)

LANE LOADING

NUMBER OF AXLES	3% INCR	UNIFORM LANE LOAD	CONC LOAD MOMENT	CONC LOAD SHEAR	GAGE DISTANCE	PASSING DISTANCE	VARY LAST	MAX AXLE DIST
9	N	0.000	0.000	0.000	6.0	4.0		0.0

TRUCK LOAD

AXLE NO.	LOAD	DIST	AXLE NO.	LOAD	DIST	AXLE NO.	LOAD	DIST	AXLE NO.	LOAD	DIST
1	13.50	9.60	2	18.00	4.10	3	22.50	4.50	4	22.50	18.00
5	63.70	14.30	6	64.90	24.80	7	18.00	3.00	8	18.00	6.50
9	36.50	0.00									

DEFAULT VALUES

GAGE DIST	PASS DIST	DLF	LLF	SKEW C.F.	UNIT WT DK CONC	ST YLD Fy	AASHTO FC
6.0	4.0	1.30	2.17	1.000	0.150	170.0	N

ALLOW SHR-VHA	OR STR LEVEL	IR STR LEVEL	CREEP FACTOR
0.300	0.900	0.800	1.6

WARNING - THE MIDSPAN ECCENTRICITY ENTERED IN THE CROSS SECTION & LOAD DATA LINE DOES NOT MATCH THE COMPUTED ECCENTRICITY BASED ON THE INPUT CGS AND TOTAL NUMBER OF STRANDS.

INPUT ECC = 25.460 IN.
COMPUTED ECC = 25.456 IN.

THE PROGRAM WILL CONTINUE WITH ECC = 25.460 IN.
(BASED ON INPUT ECCENTRICITY)

****
* RATING OF AN INTERIOR BEAM *
****

BASIC BEAM SECTION PROPERTIES

DEPTH IN	AREA IN.2	WEIGHT LBS/FT	M OF I IN.4	N.A. TO TOP YT IN.	N.A. TO BOT YB IN	Z TOP IN.3	Z BOT IN.3
56.00	932.2	971.09	375443.9	25.79	30.21	14555.3	12429.6

UNIFORM DEAD LOADS ACTING ON GIRDER (KIPS/FT)

GIRDER WEIGHT	FORMWORK WEIGHT	INPUT DL1	FUTURE WEARING SURFACE	INPUT DL2	TOTAL DL1	TOTAL DL2
0.9711	0.0000	0.2460	0.0000	0.3980	1.2171	0.3980

DEAD LOAD AND LIVE LOAD REACTIONS

Br. 596 (69) E

DL1 REACTION	DL2 REACTION	IMPACT FACTOR	LL+I SP-1 REACTION	LL+I SP-2 REACTION	LL+I SP-3 REACTION	LL+I SP-4 REACTION
63.0	19.4	1.330	51.3 T	45.2 T	55.1 T	116.6 T

LL+I SP-5 REACTION	LL+I SP-6 REACTION
99.3 T	129.7 T

PRESTRESSING FORCE (STRAND PATTERN UNKNOWN)

INITIAL	LOSS %	EFFECTIVE	NO. OF STRANDS
1008.640	20.00	806.912	8

	ECCENTRICITY	C.G.S (GM)
AT MID SPAN:	25.460	4.746

	ECCENTRICITY	C.G.S (GE)
AT CL BRG.:	8.710	21.496

****
* RATING DATA *
****

LIVE LOAD TYPE: SP-1 (CT-L73.0) GROSS WEIGHT: 36.50 TONS

UNFACTORED MOMENTS AND SHEARS

X	LOCATION FROM CL BRG	DL1 MOMENT	DL2 MOMENT	LL+I MOMENT	DL1 SHEAR	DL2 SHEAR	LL+I SHEAR
H/2	2.333	143.7	44.2	109.9	60.2	18.5	47.1
0.05	4.875	292.8	89.9	222.9	57.1	17.5	45.7
0.10	9.750	556.6	170.3	420.2	51.2	15.5	43.1
0.15	14.625	791.5	241.2	591.8	45.2	13.6	40.5
0.20	19.500	997.5	302.7	737.7	39.3	11.6	37.8
0.25	24.375	1174.6	354.7	858.7	33.4	9.7	35.2
0.30	29.250	1290.3	397.3	963.9	25.0	7.8	32.6
0.35	34.125	1404.1	430.4	1043.4	19.0	5.8	29.9
0.40	39.000	1489.0	454.0	1097.3	13.1	3.9	27.3
0.45	43.875	1544.9	468.2	1125.5	7.2	1.9	24.7
0.50	48.750	1572.0	472.9	1129.5	1.2	0.0	22.0

STRENGTHS AND RATINGS

	MOMENT STRENGTHS				MOMENT RATINGS			SHEAR RATINGS	
X	phi*Mn	CRACKING Mcr	IR Mfy	OR Mfy	IR	OR	SHEAR STRENGTH	IR	OR
H/2	1046.7	2103.4	33712.8	1204.0	3.365U	5.617U	174.1	0.703	1.173
0.05	1937.7	2181.7	60077.9	2145.6	2.978U	4.970U	206.7	1.106	1.847
0.10	2841.6	2331.9	82203.4	2935.8	2.080U	3.472U	206.7	1.283	2.142

BR. 596 (70) E

0.15	3653.8	2482.1	99059.7	3537.8	1.800U	3.004U	182.1	1.204	2.009
0.20	3920.5	2632.2	99059.7	3571.4	1.359B	2.325U	150.1	1.022	1.705
0.25	4152.7	2782.4	99059.7	3571.4	1.075B	1.939U	116.6	0.794	1.326
0.30	4385.2	2932.6	99059.7	3571.4	0.950B	1.749U	104.1	0.871	1.453
0.35	4617.9	3082.8	99059.7	3571.4	0.880B	1.646U	95.5	0.972	1.623
0.40	4734.3	3157.9	99999.9	3571.4	0.807B	1.484F	86.2	1.082	1.806
0.45	4734.3	3157.9	99999.9	3571.4	0.724B	1.384F	79.8	1.270	2.119
0.50	4734.3	3157.9	99999.9	3571.4	0.693B	1.351F	79.8	1.635	2.729

CODES: MOMENT STRENGTH CODE:
= MOMENT STRENGTH REDUCED BY phi*Mn/MIN(1.2Mcr or 4/3Mu)

INVENTORY RATING CODES:
IF SERVICEABILITY GOVERNS INVENTORY RATING:
B = BOTTOM STRESS GOVERNS
T = TOP STRESS GOVERNS
S = SLAB STRESS GOVERNS

U = phi*Mn GOVERNS
F = Mfy GOVERNS

OPERATING RATING CODES:
U = phi*Mn GOVERNS
F = Mfy GOVERNS

GOVERNING RATINGS

STRESSES AT 48.750 FROM CL BRG (TENSION + COMPRESSION -)

	TOP FIBER SLAB	TOP FIBER BEAM	BOT FIBER BEAM
P/S	0.000	0.546	-2.518
DL1	0.000	-1.296	1.518
DL2	0.000	-0.390	0.457
	---	---	---
P/S + DL	0.000	-1.140	-0.544
LL + I	0.000	-0.931	1.090
	---	---	---
TOTAL	0.000	-2.071	0.546
IR ALLOW	0.000	-2.000	0.212

FLEXURAL RATINGS (BASED ON MOMENT)

	FACTOR	TONS	LOCATION FROM CL BRG
IR	0.693	25.31	48.750
OR	1.351	49.33	48.750

SHEAR RATINGS (AASHTO)

	FACTOR	TONS	LOCATION FROM CL BRG
IR	0.703	25.65	2.333
OR	1.173	42.81	2.333

LIVE LOAD TYPE: SP-2 (CT-L352) GROSS WEIGHT: 40.00 TONS

UNFACTORED MOMENTS AND SHEARS

X	LOCATION FROM CL BRG	DL1 MOMENT	DL2 MOMENT	LL+I MOMENT	DL1 SHEAR	DL2 SHEAR	LL+I SHEAR
H/2	2.333	143.7	44.2	96.2	60.2	18.5	41.2

BR. 596 (71) E

0.05	4.875	292.8	89.9	193.7	57.1	17.5	39.7
0.10	9.750	556.6	170.3	359.3	51.2	15.5	36.8
0.15	14.625	791.5	241.2	496.7	45.2	13.6	34.0
0.20	19.500	997.5	302.7	637.8	39.3	11.6	31.1
0.25	24.375	1174.6	354.7	750.8	33.4	9.7	28.2
0.30	29.250	1290.3	397.3	835.6	25.0	7.8	25.3
0.35	34.125	1404.1	430.4	892.4	19.0	5.8	22.4
0.40	39.000	1489.0	454.0	926.7	13.1	3.9	19.5
0.45	43.875	1544.9	468.2	938.8	7.2	1.9	16.7
0.50	48.750	1572.0	472.9	922.7	1.2	0.0	14.0

STRENGTHS AND RATINGS

	MOMENT STRENGTHS				MOMENT RATINGS			SHEAR RATINGS	
X	phi*Mn	CRACKING Mcr	IR Mfy	OR Mfy	IR	OR	SHEAR STRENGTH	IR	OR
H/2	1046.7	2103.4	33712.8	1204.0	3.843U	6.415U	174.1	0.803	1.340
0.05	1937.7	2181.7	60077.9	2145.6	3.427U	5.720U	206.7	1.273	2.125
0.10	2841.6	2331.9	82203.4	2935.8	2.433U	4.061U	206.7	1.501	2.505
0.15	3653.8	2482.1	99059.7	3537.8	2.144U	3.579U	177.0	1.364	2.276
0.20	3920.5	2632.2	99059.7	3571.4	1.571B	2.690U	143.3	1.143	1.908
0.25	4152.7	2782.4	99059.7	3571.4	1.230B	2.218U	123.4	1.102	1.839
0.30	4385.2	2932.6	99059.7	3571.4	1.095B	2.017U	109.6	1.220	2.037
0.35	4617.9	3082.8	99059.7	3571.4	1.029B	1.925U	100.2	1.394	2.327
0.40	4734.3	3157.9	99999.9	3571.4	0.955B	1.757F	79.8	1.361	2.272
0.45	4734.3	3157.9	99999.9	3571.4	0.868B	1.660F	79.8	1.880	3.138
0.50	4734.3	3157.9	99999.9	3571.4	0.849B	1.654F	79.8	2.566	4.283

CODES: MOMENT STRENGTH CODE:
= MOMENT STRENGTH REDUCED BY phi*Mn/MIN(1.2Mcr or 4/3Mu)

INVENTORY RATING CODES:
IF SERVICEABILITY GOVERNS INVENTORY RATING:
B = BOTTOM STRESS GOVERNS
T = TOP STRESS GOVERNS
S = SLAB STRESS GOVERNS

U = phi*Mn GOVERNS
F = Mfy GOVERNS

OPERATING RATING CODES:
U = phi*Mn GOVERNS
F = Mfy GOVERNS

GOVERNING RATINGS

STRESSES AT 48.750 FROM CL BRG (TENSION + COMPRESSION -)

	TOP FIBER SLAB	TOP FIBER BEAM	BOT FIBER BEAM
P/S	0.000	0.546	-2.518
DL1	0.000	-1.296	1.518
DL2	0.000	-0.390	0.457
	---	---	---
P/S + DL	0.000	-1.140	-0.544

Bk 596 (72) E

LL + I	0.000	-0.761	0.891
TOTAL	0.000	-1.901	0.347
IR ALLOW	0.000	-2.000	0.212

FLEXURAL RATINGS (BASED ON MOMENT)

	FACTOR	TONS	LOCATION FROM CL BRG
IR	0.849	33.95	48.750
OR	1.654	66.17	48.750

SHEAR RATINGS (AASHTO)

	FACTOR	TONS	LOCATION FROM CL BRG
IR	0.803	32.10	2.333
OR	1.340	53.59	2.333

LIVE LOAD TYPE: SP-3 (CT-P76.5) GROSS WEIGHT: 38.25 TONS

UNFACTORED MOMENTS AND SHEARS

X	LOCATION FROM CL BRG	DL1 MOMENT	DL2 MOMENT	LL+I MOMENT	DL1 SHEAR	DL2 SHEAR	LL+I SHEAR
H/2	2.333	143.7	44.2	116.9	60.2	18.5	50.1
0.05	4.875	292.8	89.9	237.3	57.1	17.5	48.7
0.10	9.750	556.6	170.3	447.7	51.2	15.5	45.9
0.15	14.625	791.5	241.2	631.3	45.2	13.6	43.2
0.20	19.500	997.5	302.7	787.9	39.3	11.6	40.4
0.25	24.375	1174.6	354.7	917.7	33.4	9.7	37.6
0.30	29.250	1290.3	397.3	1022.1	25.0	7.8	34.9
0.35	34.125	1404.1	430.4	1110.5	19.0	5.8	32.1
0.40	39.000	1489.0	454.0	1172.0	13.1	3.9	29.4
0.45	43.875	1544.9	468.2	1206.7	7.2	1.9	26.6
0.50	48.750	1572.0	472.9	1214.4	1.2	0.0	23.9

STRENGTHS AND RATINGS

X	MOMENT STRENGTHS phi*Mn	CRACKING Mcr	IR Mfy	OR Mfy	MOMENT RATINGS IR	OR	SHEAR STRENGTH	SHEAR RATINGS IR	OR
H/2	1046.7	2103.4	33712.8	1204.0	3.162U	5.278U	174.1	0.660	1.102
0.05	1937.7	2181.7	60077.9	2145.6	2.797U	4.669U	206.7	1.039	1.735
0.10	2841.6	2331.9	82203.4	2935.8	1.952U	3.258U	206.7	1.204	2.010
0.15	3653.8	2482.1	99059.7	3537.8	1.687U	2.816U	182.4	1.131	1.887
0.20	3920.5	2632.2	99059.7	3571.4	1.272B	2.177U	150.3	0.959	1.602
0.25	4152.7	2782.4	99059.7	3571.4	1.006B	1.814U	131.0	0.918	1.532
0.30	4385.2	2932.6	99059.7	3571.4	0.896B	1.649U	102.0	0.786	1.311
0.35	4617.9	3082.8	99059.7	3571.4	0.827B	1.547U	93.5	0.877	1.465
0.40	4734.3	3157.9	99999.9	3571.4	0.755B	1.389F	84.3	0.976	1.630
0.45	4734.3	3157.9	99999.9	3571.4	0.675B	1.291F	79.8	1.177	1.965
0.50	4734.3	3157.9	99999.9	3571.4	0.645B	1.257F	79.8	1.511	2.521

CODES: MOMENT STRENGTH CODE:
= MOMENT STRENGTH REDUCED BY phi*Mn/MIN(1.2Mcr or 4/3Mu)

INVENTORY RATING CODES:
IF SERVICEABILITY GOVERNS INVENTORY RATING:
B = BOTTOM STRESS GOVERNS

BR. 596 (73) E

T = TOP STRESS GOVERNS
S = SLAB STRESS GOVERNS

U = phi*Mn GOVERNS
F = Mfy GOVERNS

OPERATING RATING CODES:
U = phi*Mn GOVERNS
F = Mfy GOVERNS

GOVERNING RATINGS

STRESSES AT 48.750 FROM CL BRG (TENSION + COMPRESSION -)

	TOP FIBER SLAB	TOP FIBER BEAM	BOT FIBER BEAM
P/S	0.000	0.546	-2.518
DL1	0.000	-1.296	1.518
DL2	0.000	-0.390	0.457
	---	---	---
P/S + DL	0.000	-1.140	-0.544
LL + I	0.000	-1.001	1.172
	---	---	---
TOTAL	0.000	-2.141	0.628
IR ALLOW	0.000	-2.000	0.212

FLEXURAL RATINGS (BASED ON MOMENT)

	FACTOR	TONS	LOCATION FROM CL BRG
IR	0.645	24.67	48.750
OR	1.257	48.08	48.750

SHEAR RATINGS (AASHTO)

	FACTOR	TONS	LOCATION FROM CL BRG
IR	0.660	25.26	2.333
OR	1.102	42.16	2.333

LIVE LOAD TYPE: SP-4 (P204) GROSS WEIGHT: 102.00 TONS

UNFACTORED MOMENTS AND SHEARS

X	LOCATION FROM CL BRG	DL1 MOMENT	DL2 MOMENT	LL+I MOMENT	DL1 SHEAR	DL2 SHEAR	LL+I SHEAR
H/2	2.333	143.7	44.2	253.6	60.2	18.5	108.7
0.05	4.875	292.8	89.9	511.2	57.1	17.5	104.9
0.10	9.750	556.6	170.3	950.7	51.2	15.5	97.5
0.15	14.625	791.5	241.2	1328.9	45.2	13.6	90.2
0.20	19.500	997.5	302.7	1654.4	39.3	11.6	82.8
0.25	24.375	1174.6	354.7	1908.2	33.4	9.7	75.4
0.30	29.250	1290.3	397.3	2111.1	25.0	7.8	68.1
0.35	34.125	1404.1	430.4	2251.0	19.0	5.8	60.7
0.40	39.000	1489.0	454.0	2320.9	13.1	3.9	53.4
0.45	43.875	1544.9	468.2	2346.8	7.2	1.9	46.2
0.50	48.750	1572.0	472.9	2301.0	1.2	0.0	39.4

STRENGTHS AND RATINGS

MOMENT STRENGTHS MOMENT SHEAR

Br. 596 (74) E

X	phi*Mn	CRACKING Mcr	IR Mfy	OR Mfy	RATINGS IR	RATINGS OR	SHEAR STRENGTH	RATINGS IR	RATINGS OR
H/2	1034.1#	2103.4	33712.8	1204.0	1.435U	2.396U	174.1	0.304	0.508
0.05	1752.7#	2181.7	60077.9	2145.6	1.132U	1.889U	206.7	0.482	0.805
0.10	2841.6	2331.9	82203.4	2935.8	0.919U	1.535U	206.7	0.567	0.947
0.15	3653.8	2482.1	99059.7	3537.8	0.802U	1.338U	170.3	0.480	0.801
0.20	3920.5	2632.2	99059.7	3571.4	0.606B	1.037U	140.2	0.412	0.687
0.25	4152.7	2782.4	99059.7	3571.4	0.484B	0.873U	122.0	0.403	0.673
0.30	4385.2	2932.6	99059.7	3571.4	0.434B	0.798U	100.7	0.393	0.657
0.35	4617.9	3082.8	99059.7	3571.4	0.408B	0.763U	91.9	0.452	0.755
0.40	4734.3	3157.9	99999.9	3571.4	0.381B	0.702F	79.8	0.498	0.832
0.45	4734.3	3157.9	99999.9	3571.4	0.347B	0.664F	79.8	0.678	1.132
0.50	4734.3	3157.9	99999.9	3571.4	0.340B	0.663F	79.8	0.915	1.528

CODES: MOMENT STRENGTH CODE:
= MOMENT STRENGTH REDUCED BY phi*Mn/MIN(1.2Mcr or 4/3Mu)

INVENTORY RATING CODES:
IF SERVICEABILITY GOVERNS INVENTORY RATING:
B = BOTTOM STRESS GOVERNS
T = TOP STRESS GOVERNS
S = SLAB STRESS GOVERNS

U = phi*Mn GOVERNS
F = Mfy GOVERNS

OPERATING RATING CODES:
U = phi*Mn GOVERNS
F = Mfy GOVERNS

GOVERNING RATINGS

STRESSES AT 48.750 FROM CL BRG (TENSION + COMPRESSION -)

	TOP FIBER SLAB	TOP FIBER BEAM	BOT FIBER BEAM
P/S	0.000	0.546	-2.518
DL1	0.000	-1.296	1.518
DL2	0.000	-0.390	0.457
	---	---	---
P/S + DL	0.000	-1.140	-0.544
LL + I	0.000	-1.897	2.221
	---	---	---
TOTAL	0.000	-3.037	1.677
IR ALLOW	0.000	-2.000	0.212

FLEXURAL RATINGS (BASED ON MOMENT)

	FACTOR	TONS	LOCATION FROM CL BRG
IR	0.340	34.72	48.750
OR	0.663	67.67	48.750

SHEAR RATINGS (AASHTO)

	FACTOR	TONS	LOCATION FROM CL BRG
IR	0.304	31.06	2.333
OR	0.508	51.84	2.333

LIVE LOAD TYPE: SP-5 (P380) GROSS WEIGHT: 190.00 TONS

BR.596 (75) E

UNFACTORED MOMENTS AND SHEARS

X	LOCATION FROM CL BRG	DL1 MOMENT	DL2 MOMENT	LL+I MOMENT	DL1 SHEAR	DL2 SHEAR	LL+I SHEAR
H/2	2.333	143.7	44.2	216.1	60.2	18.5	92.6
0.05	4.875	292.8	89.9	433.3	57.1	17.5	88.9
0.10	9.750	556.6	170.3	797.2	51.2	15.5	81.8
0.15	14.625	791.5	241.2	1125.3	45.2	13.6	74.6
0.20	19.500	997.5	302.7	1385.9	39.3	11.6	67.5
0.25	24.375	1174.6	354.7	1608.7	33.4	9.7	60.4
0.30	29.250	1290.3	397.3	1782.7	25.0	7.8	53.6
0.35	34.125	1404.1	430.4	1937.3	19.0	5.8	47.0
0.40	39.000	1489.0	454.0	2055.4	13.1	3.9	40.3
0.45	43.875	1544.9	468.2	2129.5	7.2	1.9	34.3
0.50	48.750	1572.0	472.9	2144.3	1.2	0.0	28.7

STRENGTHS AND RATINGS

X	MOMENT STRENGTHS phi*Mn	CRACKING Mcr	IR Mfy	OR Mfy	MOMENT RATINGS IR	OR	SHEAR STRENGTH	SHEAR RATINGS IR	OR
H/2	1046.7	2103.4	33712.8	1204.0	1.712U	2.857U	174.1	0.357	0.597
0.05	1937.7	2181.7	60077.9	2145.6	1.532U	2.557U	206.7	0.569	0.950
0.10	2841.6	2331.9	82203.4	2935.8	1.096U	1.830U	206.7	0.676	1.129
0.15	3653.8	2482.1	99059.7	3537.8	0.947U	1.580U	173.0	0.596	0.996
0.20	3920.5	2632.2	99059.7	3571.4	0.723B	1.238U	142.1	0.518	0.864
0.25	4152.7	2782.4	99059.7	3571.4	0.574B	1.035U	116.5	0.462	0.771
0.30	4385.2	2932.6	99059.7	3571.4	0.513B	0.946U	102.7	0.517	0.863
0.35	4617.9	3082.8	99059.7	3571.4	0.474B	0.887U	97.7	0.642	1.071
0.40	4734.3	3157.9	99999.9	3571.4	0.431B	0.792F	86.9	0.742	1.238
0.45	4734.3	3157.9	99999.9	3571.4	0.383B	0.732F	79.8	0.913	1.525
0.50	4734.3	3157.9	99999.9	3571.4	0.365B	0.712F	79.8	1.254	2.093

CODES: MOMENT STRENGTH CODE:
= MOMENT STRENGTH REDUCED BY phi*Mn/MIN(1.2Mcr or 4/3Mu)

INVENTORY RATING CODES:
IF SERVICEABILITY GOVERNS INVENTORY RATING:
B = BOTTOM STRESS GOVERNS
T = TOP STRESS GOVERNS
S = SLAB STRESS GOVERNS

U = phi*Mn GOVERNS
F = Mfy GOVERNS

OPERATING RATING CODES:
U = phi*Mn GOVERNS
F = Mfy GOVERNS

GOVERNING RATINGS

STRESSES AT 48.750 FROM CL BRG (TENSION + COMPRESSION -)
TOP FIBER TOP FIBER BOT FIBER

BR.596 (76) E

	SLAB	BEAM	BEAM
P/S	0.000	0.546	-2.518
DL1	0.000	-1.296	1.518
DL2	0.000	-0.390	0.457
	---	---	---
P/S + DL	0.000	-1.140	-0.544
LL + I	0.000	-1.768	2.070
	---	---	---
TOTAL	0.000	-2.908	1.526
IR ALLOW	0.000	-2.000	0.212

FLEXURAL RATINGS (BASED ON MOMENT)

	FACTOR	TONS	LOCATION FROM CL BRG
IR	0.365	69.40	48.750
OR	0.712	135.25	48.750

SHEAR RATINGS (AASHTO)

	FACTOR	TONS	LOCATION FROM CL BRG
IR	0.357	67.91	2.333
OR	0.597	113.36	2.333

LIVE LOAD TYPE: SP-6 (CT-TLC) GROSS WEIGHT: 138.80 TONS

UNFACTORED MOMENTS AND SHEARS

X	LOCATION FROM CL BRG	DL1 MOMENT	DL2 MOMENT	LL+I MOMENT	DL1 SHEAR	DL2 SHEAR	LL+I SHEAR
H/2	2.333	143.7	44.2	269.7	60.2	18.5	115.6
0.05	4.875	292.8	89.9	544.7	57.1	17.5	111.7
0.10	9.750	556.6	170.3	1017.4	51.2	15.5	104.4
0.15	14.625	791.5	241.2	1418.0	45.2	13.6	97.0
0.20	19.500	997.5	302.7	1746.5	39.3	11.6	89.6
0.25	24.375	1174.6	354.7	2003.0	33.4	9.7	82.2
0.30	29.250	1290.3	397.3	2296.2	25.0	7.8	74.0
0.35	34.125	1404.1	430.4	2521.1	19.0	5.8	65.3
0.40	39.000	1489.0	454.0	2669.5	13.1	3.9	55.3
0.45	43.875	1544.9	468.2	2733.4	7.2	1.9	45.3
0.50	48.750	1572.0	472.9	2699.9	1.2	0.0	35.5

STRENGTHS AND RATINGS

X	MOMENT STRENGTHS phi*Mn	CRACKING Mcr	IR Mfy	OR Mfy	MOMENT RATINGS IR	OR	SHEAR STRENGTH	SHEAR RATINGS IR	OR
H/2	990.5#	2103.4	33712.8	1204.0	1.275U	2.128U	174.1	0.286	0.478
0.05	1676.7#	2181.7	60077.9	2145.6	0.998U	1.665U	206.7	0.453	0.756
0.10	2841.6	2331.9	82203.4	2935.8	0.859U	1.434U	206.7	0.530	0.885
0.15	3653.8	2482.1	99059.7	3537.8	0.751U	1.254U	184.7	0.515	0.859
0.20	3920.5	2632.2	99059.7	3571.4	0.574B	0.982U	152.8	0.446	0.744
0.25	4152.7	2782.4	99059.7	3571.4	0.461B	0.831U	133.6	0.435	0.727
0.30	4385.2	2932.6	99059.7	3571.4	0.399B	0.734U	114.4	0.448	0.747
0.35	4617.9	3082.8	99059.7	3571.4	0.364B	0.681U	103.4	0.502	0.838
0.40	4734.3	3157.9	99999.9	3571.4	0.332B	0.610F	92.2	0.584	0.974
0.45	4734.3	3157.9	99999.9	3571.4	0.298B	0.570F	80.4	0.697	1.163
0.50	4734.3	3157.9	99999.9	3571.4	0.290B	0.565F	79.8	1.015	1.694

Close, Jensen and Miller, P.C.

BY BA DATE 3/4/11 SUBJECT BR. 596 SHEET NO. 77E OF
CHKD. BY DATE ROUTE 68 O/ NAUGATUCK JOB NO.
RIVER, RTE 8, MNRR, SR 710 NAUGATUCK, CT

$$RF = \frac{1.875 - (1)(1.57)}{.8(1.42)} = .3 \qquad \frac{1.875 - (1)(1.367)}{.8(1.42)} = .52$$

.508

LEGAL LOAD RATING STRENGTH I 6A.4.3.1

INVENTORY DESIGN LOAD RATING RF < 1.0, THEREFORE THE LEGAL LOAD RATINGS NEED TO BE PERFORMED AND POSTING MAY BE REQUIRED.

LEGAL LOAD RATING:

LEGAL TYPE: CT-L73.0 (73K ON 4 AXLES)
(CONSTRUCTION VEHICLE DESCRIBED IN SECTION 14-269(d) OF THE CT GENERAL STATUTES)

$M_{LL} = 1129.5$ k-FT

$V_{LL} = 47.1$ k

2656.7

$$RF = \frac{(1.0)(1.0)(.85)(4755) - [(1.25)(1450+472.9) + (1.5)(168.7)]}{1.8(1129.5)(.541)} = 1.2 > 1.0$$

SHEAR $RF = \frac{34.35}{1.8(47.1)(.668)} = .61$

$\frac{50}{1.8(47.1)(.668)} = .88$

LEGAL TYPE: CT-L382 (80K ON 5 AXLES)

$M_{LL} = 922.7$ k-FT

$V_{LL} = 39.7$ k

2656.7

$$RF = \frac{(1.0)(1.0)(.85)(4755) - [(1.25)(1450+472.9) + (1.5)(168.7)]}{1.8(922.7)(.541)} = 1.5 > 1.0$$

MLFT: $(.9)(.85)(1)(1162) - 5454 = 34.35$ $RF = \frac{34.35}{1.8 \times 39.7 \times .668} = .72$

$(.9)(1)(1)(1162) - 5454 = 50$ $\frac{50}{47.1} = 1.0$

Close, Jensen and Miller, P.C.

BY BA DATE 3/7/11 SUBJECT BR. 596 SHEET NO. 10 E OF

CHKD. BY DATE ROUTE 68 O/ NAUGATUCK JOB NO.

RIVER, RTE 8, MARK, SECTION NAUGATUCK, CT

PERMIT LOAD RATING

LRFD
TABLES 3.4.1-1 ; 3.4.1-2
TABLES 6A.4.5.4.2a-1

PERMIT TYPE: CT-P 76.5 (76.5k ON 4 AXLE)

FREQUENCY: ROUTINE OR ANNUAL
LOADING CONDITION: UNLIMITED CROSSINGS
DISTRIBUTION FACTOR: MIX WITH TRAFFIC
ADTT: TWO OR MORE LANES $\gamma_{LL} = 1.8$
>5000

$M_{LL} = 1214.4$ k-ft

STRENGTH II

$V_{LL} = 50.1$ k

FLEXURE: $RF = \dfrac{(1.0)(1.0)(.85)(4755) - [(1.25)(1450 + 472.9) + (1.5)(168.7)]}{1.8(1214.4)(.541)}$ (2656.7)

$RF = 1.1$

SHEAR $RF = \dfrac{34.35}{1.8(50.1)(.668)} = .57$

$RF = \dfrac{50}{1.8(50.1)(.668)} = .83$

Close, Jensen and Miller, P.C.

BY BA DATE 3/7/11 SUBJECT BR. 596 SHEET NO. 79E OF
CHKD. BY DATE ROUTE 68 O/ NAUGATUCK JOB NO.
FINAL, ATT 8, MNRR, SR 710 NAUGATUCK, CT

PERMIT LOAD RATING

PERMIT TYPE: CT-P204 (204 K ON 8 AXLE)

ROUTINE ON ANNUAL
FREQUENCY: UNLIMITED CROSSING
LOADING CONDITION: MIX WITH TRAFFIC
DISTRIBUTION FACTOR: TWO OR MORE LANES
ADTT ≥ 5000
MINIMUM LOAD FACTOR: 1.35 $\gamma_{LL} = 1.35$

$M_{LL} = 2301.0$ K-FT

$V_{LL} = 108.7$ K

$$RF = \frac{1385}{1.35(2301.0)\left(\frac{.541}{1.2}\right)} = .99 > 1$$ STRENGTH II

$$\text{SHEAR } RF = \frac{34.35}{1.35 \times 108.7 \times .668/1.2} = .42$$

$$RF = \frac{50}{98.0} = .51 \quad (.41)$$

Close, Jensen and Miller, P.C.

BY BA DATE 3/1/11 SUBJECT BR. 596 SHEET NO. 80 E OF
CHKD. BY DATE ROUTE 68 O/ NAUGATUCK JOB NO.
RUDR, RTE 8, MNRR, SR 710 NAUGATUCK, CT

PERMIT LOAD RATING

PERMIT TYPE: CT-P380 (380k ON 19 AXLE)

SPECIAL OR LIMITED CROSSING

FREQUENCY: SINGLE TRIP
LOADING CONDITION: ESCORTED WITH NO OTHER VEHICLES ON THE BRIDGE
DISTRIBUTION FACTOR: ONE LANE
ADTT: N/A

$\gamma_{LL} = 1.15$

$g_{m_1} = .541 \times \frac{1}{1.2} = .451$ USE ONE LANE DISTRIBUTION FACTOR AND DIVIDE OUT THE 1.2 MULTIPLE PRESENCE FACTOR

6A.4.5.4.2b
6A.4.5.5

STRENGTH II LIMIT STATE:

$M_{LL} = 2144.3$ k-ft

$V_{LL} = 92.6$ k

$$RF = \frac{1385}{1.15(2144.3)(.451)} = 1.2 > 1.0$$

$$RF_{STRUT} = \frac{34.35}{1.15(92.6)\left(\frac{.668}{1.2}\right)} = .58$$

$$RF = \frac{50}{59.28} = .84 \ (.94)$$

Close, Jensen and Miller, P.C.

BY BA DATE 3/7/11 SUBJECT B1.596 SHEET NO. B1E OF
CHKD. BY DATE ROUTE 68 O/ NAUGATUCK JOB NO.
RIVER, RTE 8, MAP, SR710 NAUGATUCK, CT

PERMIT LOAD RATING

PERMIT TYPE: CT-TLC

SPECIAL OR LIMITED CROSSING

FREQUENCY: SINGLE TRIP
LOADING CONDITION: MIX WITH TRAFFIC
DISTRIBUTION FACTOR: ONE LANE
ADTT > 5000
DYNAMIC LOAD ALLOWANCE: 0 $\gamma_{LL} = 1.5$

STRENGTH II LIMIT STATE:

$M_{LL} = 2699.9$ K-FT

$V_{LL} = 115.6$ K

$$RF = \frac{1385}{1.5(2699.9)(.451)} = .76 < 1$$

$$RF_{SHEAR} = \frac{34.35}{1.5 \times 115.6 \times \frac{.668}{1.2}} = .36$$

$$RF = \frac{50}{96.53} = .52$$

SERVICE I LIMIT STATE

6A.5.4.2-2b
TABLE 6A.4.2.2-1

$\gamma_L = \gamma_{DC} = \gamma_{DW} = 1$

LRFD DISTRIBUTION ANALYSIS METHODS AS DESCRIBED IN LRFD DESIGN ARTICLE 4.6.2 SHOULD BE USED.

$g_m = .541$

DISTRIBUTED LIVE-LOAD EFFECT:

DEAD LOAD MOMENTS AT MIDSPAN:

$M_{DC_1} = 1450$ k-FT

$M_{DC_2} = 472.9$ k-FT

$M_{DW} = 168.7$ k-FT

$M_{LL+IM} = (2699.9)(.541) = 1460.6$ k-FT (WORST CASE) IM = 1.3 =1.2 IF MINOR DEVIATION

$M_{DC} + M_{DW} + M_{LL+IM} = 1450 + 472.9 + 168.7 + 1460.6 = 3552.2$ k-FT

SIMPLIFIED CHECK USING $.75 M_n$ 6A.4.2.2

NOMINAL FLEXURAL RESISTANCE $M_n = 5270$ k-FT USE NOMINAL, NOT FACTORED RESISTANCE

$.75 M_n = .75 \times 5270 = 3952.5$ k-FT > 3552.2 k-FT OK

MOMENT RATIO: $\dfrac{.75 M_n}{M_{DL} + M_{DW} + M_{LL+I}} = \dfrac{3952.5}{3552.2} = 1.1 > 1$ OK

REFINED CHECK USING $.9 f_y$

CALCULATE STRESS IN OUTER REINFORCEMENT AT MIDSPAN. STRESS DUE TO MOMENTS IN EXCESS OF THE CRACKING MOMENT ACTS UPON THE CRACKED SECTION. THE MOMENTS UP TO THE CRACKING MOMENT CAUSE STRESS IN THE REINFORCEMENT EQUAL TO THE EFFECTIVE PRESTRESS.

$f_R = .9 f_y = .9(.9 F_u) = .9(.9 \times 200) = 162$ ksi

6A.5.4.2.2b
TABLE 6A.5.4.2.2b-1

$M_{cr} = 2513.89$ k-FT

EFFECTIVE PRESTRESS: $(.75 \times 200 - 50.01) = 100$ ksi

$M_{DC} + M_{DW} + M_{LL+I} - M_{cr} = 3552.2 - 2513.89 = 1038.3$ k-FT

SECTION PROPERTIES FOR THE CRACKED COMPOSITE SECTION:

$b_{trans} = 71.5 \times .78 = 55.77$ in

$h = 56$ in

$A_{ps} = 8 \times .788 = 6.3$ in^2

$n = \frac{E_{ps}}{E_{beam}} = \frac{25 \times 10^3}{4.07 \times 10^3} = 6.1$

$A_{trans} = 6.3^{in^2} \times 6.1 = 38.7$ in^2

$Y = 4.75$ in

OUTER STRAND $Y = 2.25$ in

ASSUME NEUTRAL AXIS IS IN THE BEAM

$$c = \frac{\left(\frac{c}{2}\right)(b_{trans} \times c) + (h-Y)(A_{trans})}{(b_{trans} \times c) + (A_{trans})} = \frac{\left(\frac{c}{2}\right)(55.77)c + (56-4.75)(38.7)}{55.77c + 38.7}$$

$27.89c^2 + 38.7c - 1983.4 = 0$

Close, Jensen and Miller, P.C.

BY BA DATE 3/7/11 SUBJECT BR. 596 SHEET NO. 84 E OF

CHKD. BY DATE FOUTE 6.8 O/ NAUGATUCK JOB NO.

RIVER, RTE 8, NWDR, SECTION NAUGATUCK, CT

SOLVING FOR C: $c = \frac{-38.7 \pm \sqrt{38.7^2 - 4(27.89)(-1983.4)}}{2(27.89)} = \frac{-38.7 \pm 472}{55.78}$

$c = 7.77$ in

$I_{cr} = \frac{1}{12}(55.77)(7.77)^3 + (55.77)(7.77)\left(\frac{7.77}{2}\right)^2 + (38.7)(56 - 4.75 - 7.77)^2$

$= 2180.1 + 6540.4 + 73162.8 = 81{,}883.3 \text{ in}^4$

STRESS BEYOND THE EFFECTIVE PRESTRESS (INCREASE IN STRESS AFTER CRACKING):

$f_s = n\frac{My}{I} = \frac{6.1 \times 1038.3 \times 12 \times (56 - 2 - 7.77)}{81883.3} = 42.7$ ksi

STRESS IN THE REINFORCEMENT AT PERMIT CROSSING SERVICE II

$f_s = 100 + 42.7 = 142.7$ ksi $< f_R = .9F_y = 162$ ksi OK

STRESS RATIO $= \frac{.9f_y}{f_s} = \frac{162}{142.7} = 1.13$ OK

Close, Jensen and Miller, P.C.

BY BA DATE 3/7/11 SUBJECT BR. 596 SHEET NO. 85 E OF
CHKD. BY DATE ROUTE 68 O/ NAUGATUCK JOB NO.
RIVER, RTE 8, MAIN, SECTION NAUGATUCK, CT

SUMMARY OF RATING FACTORS:

INTERIOR GIRDER EA @ SPAN 5

LIMIT STATE	HL-93 DESIGN LOAD RATING INV.	OPER.	RATING LEGAL LOADS	RATING PERMIT LOAD
STRENGTH I				
FLEXURE (@ MIDSPAN)	.71 (1.0)	.92 (1.3)	{1.2 / 1.5}	
SHEAR @ 3.86'				
SHEAR @ .25L	.52		{.58 / .69}	
STRENGTH II				
FLEXURE (@ MID SPAN)			{(1.3) (.9) / 1.1 .99}	(1.3) (1.4) / 1.2 .76
SHEAR				.55 .42 / .56 .34
SERVICE III (CRACKING)				(.92) (.57) / (.94) (.57)
FLEXURE (@ MID SPAN)	.30 (.8)			
SERVICE I			STRESS RATIO = 1.1 (1.3)	

PERMANENT YIELDING OF REINF.

Close, Jensen and Miller, P.C.

BY BA DATE 3/8/11 SUBJECT BR. 596 SHEET NO. 86 E OF
CHKD. BY DATE ROUTE 68 O/ NAUGATUCK JOB NO.
RIVER, RTE 8, MAURA, SR710 NAUGATUCK, CT

PERMIT LOAD RATING (I = 1.2)

PERMIT: CT-P76.5

$M_{LL} = 1095.7$ k-FT

$V_{LL} = 45.2$ k

$$RF_{FLEXURAL} = \frac{1385}{1.8(1095.7)(.541)} = 1.3$$

$$RF_{SHEAR} = \frac{50}{1.8(45.2)(.668)} = .92$$

CT-P204

$M_{LL} = 2076.1$ k-FT

$V_{LL} = 98.1$ k

$$RF_F = \frac{1385}{1.35(2076.1)\left(\frac{.541}{1.2}\right)} = 1.1 \quad (2098/1526 = 1.3)$$

$$RF_S = \frac{50}{1.35(98.1)\left(\frac{.668}{1.2}\right)} = .68$$

CT-P380

$M_{LL} = 1934.7$ k-FT

$V_{LL} = 83.5$ k

$$RF_F = \frac{1385}{1.15(1934.7)(.451)} = 1.3$$

$$RF_S = \frac{50}{1.15(83.5)\left(\frac{.668}{1.2}\right)} = .94$$

CT-TLC

$M_{LL} = 2436$ k-FT

$V_{LL} = 104.3$ k

$$RF_F = \frac{1385}{1.5(2436)(.451)} = .84 \quad (2098/1648 = 1.2)$$

$$RF_S = \frac{50}{1.5(104.3)\left(\frac{.668}{1.2}\right)} = .57$$

BR.00596

87 E

UNIFORM DEAD LOADS ACTING ON GIRDER (KIPS/FT)

GIRDER WEIGHT	FORMWORK WEIGHT	INPUT DL1	FUTURE WEARING SURFACE	INPUT DL2	TOTAL DL1	TOTAL DL2
0.9711	0.0000	0.2460	0.0000	0.3980	1.2171	0.3980

DEAD LOAD AND LIVE LOAD REACTIONS

DL1 REACTION	DL2 REACTION	IMPACT FACTOR	LL+I SP-1 REACTION	LL+I SP-2 REACTION	LL+I SP-3 REACTION	LL+I SP-4 REACTION
63.0	19.4	1.200	46.3 T	40.7 T	49.7 T	105.2 T

LL+I SP-5 REACTION	LL+I SP-6 REACTION
89.6 T	117.0 T

PRESTRESSING FORCE (STRAND PATTERN UNKNOWN)

INITIAL	LOSS %	EFFECTIVE	NO. OF STRANDS
1008.640	20.00	806.912	8

	ECCENTRICITY	C.G.S (GM)
AT MID SPAN:	25.460	4.746

	ECCENTRICITY	C.G.S (GE)
AT CL BRG.:	8.710	21.496

****
* RATING DATA *
****

LIVE LOAD TYPE: SP-1 (CT-L73.0) GROSS WEIGHT: 36.50 TONS

UNFACTORED MOMENTS AND SHEARS

X	LOCATION FROM CL BRG	DL1 MOMENT	DL2 MOMENT	LL+I MOMENT	DL1 SHEAR	DL2 SHEAR	LL+I SHEAR
H/2	2.333	143.7	44.2	99.2	60.2	18.5	42.5
0.05	4.875	292.8	89.9	201.1	57.1	17.5	41.3
0.10	9.750	556.6	170.3	379.1	51.2	15.5	38.9
0.15	14.625	791.5	241.2	533.9	45.2	13.6	36.5
0.20	19.500	997.5	302.7	665.6	39.3	11.6	34.1
0.25	24.375	1174.6	354.7	774.8	33.4	9.7	31.8
0.30	29.250	1290.3	397.3	869.7	25.0	7.8	29.4
0.35	34.125	1404.1	430.4	941.4	19.0	5.8	27.0
0.40	39.000	1489.0	454.0	990.0	13.1	3.9	24.6
0.45	43.875	1544.9	468.2	1015.5	7.2	1.9	22.3
0.50	48.750	1572.0	472.9	1019.1	1.2	0.0	19.9

	FACTOR	TONS	LOCATION FROM CL BRG		FACTOR	TONS	LOCATION FROM CL BRG
IR	0.769	28.05	48.750	IR	0.779	28.43	2.333
OR	1.498	54.67	48.750	OR	1.300	47.45	2.333

LIVE LOAD TYPE: SP-2 (CT-L352) GROSS WEIGHT: 40.00 TONS

UNFACTORED MOMENTS AND SHEARS

X	LOCATION FROM CL BRG	DL1 MOMENT	DL2 MOMENT	LL+I MOMENT	DL1 SHEAR	DL2 SHEAR	LL+I SHEAR
H/2	2.333	143.7	44.2	86.8	60.2	18.5	37.2
0.05	4.875	292.8	89.9	174.8	57.1	17.5	35.8
0.10	9.750	556.6	170.3	324.2	51.2	15.5	33.2
0.15	14.625	791.5	241.2	448.2	45.2	13.6	30.6
0.20	19.500	997.5	302.7	575.5	39.3	11.6	28.0
0.25	24.375	1174.6	354.7	677.4	33.4	9.7	25.4
0.30	29.250	1290.3	397.3	753.9	25.0	7.8	22.8
0.35	34.125	1404.1	430.4	805.1	19.0	5.8	20.2
0.40	39.000	1489.0	454.0	836.2	13.1	3.9	17.6
0.45	43.875	1544.9	468.2	847.0	7.2	1.9	15.0
0.50	48.750	1572.0	472.9	832.5	1.2	0.0	12.7

STRENGTHS AND RATINGS

	MOMENT STRENGTHS				MOMENT RATINGS			SHEAR RATINGS	
X	phi*Mn	CRACKING Mcr	IR Mfy	OR Mfy	IR	OR	SHEAR STRENGTH	IR	OR
H/2	1046.7	2103.4	33712.8	1204.0	4.260U	7.110U	174.1	0.890	1.485
0.05	1937.7	2181.7	60077.9	2145.6	3.798U	6.340U	206.7	1.411	2.355
0.10	2841.6	2331.9	82203.4	2935.8	2.696U	4.501U	206.7	1.663	2.776
0.15	3653.8	2482.1	99059.7	3537.8	2.376U	3.967U	176.7	1.508	2.517
0.20	3920.5	2632.2	99059.7	3571.4	1.742B	2.981U	143.1	1.263	2.109
0.25	4152.7	2782.4	99059.7	3571.4	1.363B	2.458U	123.2	1.217	2.032
0.30	4385.2	2932.6	99059.7	3571.4	1.214B	2.236U	109.3	1.346	2.247
0.35	4617.9	3082.8	99059.7	3571.4	1.141B	2.134U	99.8	1.537	2.565
0.40	4734.3	3157.9	99999.9	3571.4	1.059B	1.947F	79.8	1.509	2.519
0.45	4734.3	3157.9	99999.9	3571.4	0.962B	1.840F	79.8	2.084	3.478
0.50	4734.3	3157.9	99999.9	3571.4	0.941B	1.834F	79.8	2.844	4.747

CODES: MOMENT STRENGTH CODE:

= MOMENT STRENGTH REDUCED BY phi*Mn/MIN(1.2Mcr or 4/3Mu)

INVENTORY RATING CODES:

IF SERVICEABILITY GOVERNS INVENTORY RATING:

B = BOTTOM STRESS GOVERNS
T = TOP STRESS GOVERNS
S = SLAB STRESS GOVERNS

U = phi*Mn GOVERNS
F = Mfy GOVERNS

BR.00596 (89) E

OPERATING RATING CODES:
U = phi*Mn GOVERNS
F = Mfy GOVERNS

GOVERNING RATINGS

STRESSES AT 48.750 FROM CL BRG (TENSION + COMPRESSION -)

	TOP FIBER SLAB	TOP FIBER BEAM	BOT FIBER BEAM
P/S	0.000	0.546	-2.518
DL1	0.000	-1.296	1.518
DL2	0.000	-0.390	0.457
	---	---	---
P/S + DL	0.000	-1.140	-0.544
LL + I	0.000	-0.686	0.804
	---	---	---
TOTAL	0.000	-1.826	0.260
IR ALLOW	0.000	-2.000	0.212

FLEXURAL RATINGS (BASED ON MOMENT)

	FACTOR	TONS	LOCATION FROM CL BRG
IR	0.941	37.63	48.750
OR	1.834	73.34	48.750

SHEAR RATINGS (AASHTO)

	FACTOR	TONS	LOCATION FROM CL BRG
IR	0.890	35.58	2.333
OR	1.485	59.40	2.333

PERMIT

LIVE LOAD TYPE: SP-3 (CT-P76.5) GROSS WEIGHT: 38.25 TONS

UNFACTORED MOMENTS AND SHEARS

X	LOCATION FROM CL BRG	DL1 MOMENT	DL2 MOMENT	LL+I MOMENT	DL1 SHEAR	DL2 SHEAR	LL+I SHEAR
H/2	2.333	143.7	44.2	105.5	60.2	18.5	45.2
0.05	4.875	292.8	89.9	214.1	57.1	17.5	43.9
0.10	9.750	556.6	170.3	404.0	51.2	15.5	41.4
0.15	14.625	791.5	241.2	569.6	45.2	13.6	38.9
0.20	19.500	997.5	302.7	710.9	39.3	11.6	36.5
0.25	24.375	1174.6	354.7	828.0	33.4	9.7	34.0
0.30	29.250	1290.3	397.3	922.2	25.0	7.8	31.5
0.35	34.125	1404.1	430.4	1001.9	19.0	5.8	29.0
0.40	39.000	1489.0	454.0	1057.5	13.1	3.9	26.5
0.45	43.875	1544.9	468.2	1088.7	7.2	1.9	24.0
0.50	48.750	1572.0	472.9	1095.7	1.2	0.0	21.5

STRENGTHS AND RATINGS

MOMENT STRENGTHS			MOMENT RATINGS	SHEAR RATINGS
CRACKING	IR	OR		SHEAR

BR.00596 (90) E

LIVE LOAD TYPE: SP-4 (P204) GROSS WEIGHT: 102.00 TONS

UNFACTORED MOMENTS AND SHEARS

X	LOCATION FROM CL BRG	DL1 MOMENT	DL2 MOMENT	LL+I MOMENT	DL1 SHEAR	DL2 SHEAR	LL+I SHEAR
H/2	2.333	143.7	44.2	228.8	60.2	18.5	98.1
0.05	4.875	292.8	89.9	461.2	57.1	17.5	94.6
0.10	9.750	556.6	170.3	857.7	51.2	15.5	88.0
0.15	14.625	791.5	241.2	1199.0	45.2	13.6	81.3
0.20	19.500	997.5	302.7	1492.7	39.3	11.6	74.7
0.25	24.375	1174.6	354.7	1721.7	33.4	9.7	68.1
0.30	29.250	1290.3	397.3	1904.8	25.0	7.8	61.4
0.35	34.125	1404.1	430.4	2031.0	19.0	5.8	54.8
0.40	39.000	1489.0	454.0	2094.0	13.1	3.9	48.2
0.45	43.875	1544.9	468.2	2117.4	7.2	1.9	41.7
0.50	48.750	1572.0	472.9	2076.1	1.2	0.0	35.5

STRENGTHS AND RATINGS

	MOMENT STRENGTHS				MOMENT RATINGS			SHEAR RATINGS	
X	phi*Mn	CRACKING Mcr	IR Mfy	OR Mfy	IR	OR	SHEAR STRENGTH	IR	OR
H/2	1046.7	2103.4	33712.8	1204.0	1.616U	2.698U	174.1	0.337	0.563
0.05	1879.6#	2181.7	60077.9	2145.6	1.381U	2.305U	206.7	0.535	0.892
0.10	2841.6	2331.9	82203.4	2935.8	1.019U	1.701U	206.7	0.629	1.049
0.15	3653.8	2482.1	99059.7	3537.8	0.888U	1.483U	170.3	0.532	0.888
0.20	3920.5	2632.2	99059.7	3571.4	0.671B	1.149U	140.2	0.456	0.761
0.25	4152.7	2782.4	99059.7	3571.4	0.536B	0.967U	121.9	0.446	0.745
0.30	4385.2	2932.6	99059.7	3571.4	0.481B	0.885U	100.6	0.436	0.728
0.35	4617.9	3082.8	99059.7	3571.4	0.452B	0.846U	91.9	0.501	0.836
0.40	4734.3	3157.9	99999.9	3571.4	0.423B	0.778F	79.8	0.552	0.922
0.45	4734.3	3157.9	99999.9	3571.4	0.385B	0.736F	79.8	0.752	1.255
0.50	4734.3	3157.9	99999.9	3571.4	0.377B	0.735F	79.8	1.015	1.694

CODES: MOMENT STRENGTH CODE:

= MOMENT STRENGTH REDUCED BY phi*Mn/MIN(1.2Mcr or 4/3Mu)

INVENTORY RATING CODES:

IF SERVICEABILITY GOVERNS INVENTORY RATING:

B = BOTTOM STRESS GOVERNS
T = TOP STRESS GOVERNS
S = SLAB STRESS GOVERNS

U = phi*Mn GOVERNS
F = Mfy GOVERNS

OPERATING RATING CODES:

U = phi*Mn GOVERNS
F = Mfy GOVERNS

GOVERNING RATINGS

STRESSES AT 48.750 FROM CL BRG (TENSION + COMPRESSION -)

	TOP FIBER SLAB	TOP FIBER BEAM	BOT FIBER BEAM
P/S	0.000	0.546	-2.518
DL1	0.000	-1.296	1.518
DL2	0.000	-0.390	0.457
	---	---	---
P/S + DL	0.000	-1.140	-0.544
LL + I	0.000	-1.712	2.004
	---	---	---
TOTAL	0.000	-2.852	1.460
IR ALLOW	0.000	-2.000	0.212

FLEXURAL RATINGS (BASED ON MOMENT)

	FACTOR	TONS	LOCATION FROM CL BRG
IR	0.377	38.48	48.750
OR	0.735	75.00	48.750

SHEAR RATINGS (AASHTO)

	FACTOR	TONS	LOCATION FROM CL BRG
IR	0.337	34.42	2.333
OR	0.563	57.46	2.333

LIVE LOAD TYPE: SP-5 (P380) GROSS WEIGHT: 190.00 TONS

UNFACTORED MOMENTS AND SHEARS

X	LOCATION FROM CL BRG	DL1 MOMENT	DL2 MOMENT	LL+I MOMENT	DL1 SHEAR	DL2 SHEAR	LL+I SHEAR
H/2	2.333	143.7	44.2	194.9	60.2	18.5	83.5
0.05	4.875	292.8	89.9	391.0	57.1	17.5	80.2
0.10	9.750	556.6	170.3	719.3	51.2	15.5	73.8
0.15	14.625	791.5	241.2	1015.3	45.2	13.6	67.3
0.20	19.500	997.5	302.7	1250.4	39.3	11.6	60.9
0.25	24.375	1174.6	354.7	1451.5	33.4	9.7	54.5
0.30	29.250	1290.3	397.3	1608.4	25.0	7.8	48.4
0.35	34.125	1404.1	430.4	1747.9	19.0	5.8	42.4
0.40	39.000	1489.0	454.0	1854.5	13.1	3.9	36.4
0.45	43.875	1544.9	468.2	1921.3	7.2	1.9	30.9
0.50	48.750	1572.0	472.9	1934.7	1.2	0.0	25.9

STRENGTHS AND RATINGS

X	MOMENT STRENGTHS phi*Mn	CRACKING Mcr	IR Mfy	OR Mfy	MOMENT RATINGS IR	MOMENT RATINGS OR	SHEAR STRENGTH	SHEAR RATINGS IR	SHEAR RATINGS OR
H/2	1046.7	2103.4	33712.8	1204.0	1.897U	3.166U	174.1	0.396	0.661
0.05	1937.7	2181.7	60077.9	2145.6	1.698U	2.834U	206.7	0.631	1.053
0.10	2841.6	2331.9	82203.4	2935.8	1.215U	2.028U	206.7	0.750	1.251
0.15	3653.8	2482.1	99059.7	3537.8	1.049U	1.751U	173.0	0.661	1.103
0.20	3920.5	2632.2	99059.7	3571.4	0.802B	1.372U	142.0	0.573	0.957
0.25	4152.7	2782.4	99059.7	3571.4	0.636B	1.147U	116.6	0.512	0.855

LIVE LOAD TYPE: SP-6 (CT-TLC) GROSS WEIGHT: 138.80 TONS

UNFACTORED MOMENTS AND SHEARS

X	LOCATION FROM CL BRG	DL1 MOMENT	DL2 MOMENT	LL+I MOMENT	DL1 SHEAR	DL2 SHEAR	LL+I SHEAR
H/2	2.333	143.7	44.2	243.4	60.2	18.5	104.3
0.05	4.875	292.8	89.9	491.5	57.1	17.5	100.8
0.10	9.750	556.6	170.3	918.0	51.2	15.5	94.2
0.15	14.625	791.5	241.2	1279.4	45.2	13.6	87.5
0.20	19.500	997.5	302.7	1575.8	39.3	11.6	80.8
0.25	24.375	1174.6	354.7	1807.2	33.4	9.7	74.1
0.30	29.250	1290.3	397.3	2071.7	25.0	7.8	66.8
0.35	34.125	1404.1	430.4	2274.6	19.0	5.8	58.9
0.40	39.000	1489.0	454.0	2408.5	13.1	3.9	49.9
0.45	43.875	1544.9	468.2	2466.3	7.2	1.9	40.9
0.50	48.750	1572.0	472.9	2436.0	1.2	0.0	32.0

STRENGTHS AND RATINGS

	MOMENT STRENGTHS				MOMENT RATINGS			SHEAR RATINGS	
X	phi*Mn	CRACKING Mcr	IR Mfy	OR Mfy	IR	OR	SHEAR STRENGTH	IR	OR
H/2	1046.7	2103.4	33712.8	1204.0	1.519U	2.536U	174.1	0.317	0.530
0.05	1800.6#	2181.7	60077.9	2145.6	1.222U	2.040U	206.7	0.502	0.837
0.10	2841.6	2331.9	82203.4	2935.8	0.952U	1.589U	206.7	0.587	0.980
0.15	3653.8	2482.1	99059.7	3537.8	0.832U	1.390U	184.5	0.569	0.950
0.20	3920.5	2632.2	99059.7	3571.4	0.636B	1.089U	152.6	0.492	0.822
0.25	4152.7	2782.4	99059.7	3571.4	0.511B	0.921U	133.3	0.481	0.802
0.30	4385.2	2932.6	99059.7	3571.4	0.442B	0.814U	114.2	0.495	0.825
0.35	4617.9	3082.8	99059.7	3571.4	0.404B	0.755U	103.2	0.555	0.926
0.40	4734.3	3157.9	99999.9	3571.4	0.367B	0.676F	91.9	0.645	1.076
0.45	4734.3	3157.9	99999.9	3571.4	0.330B	0.632F	80.2	0.770	1.285
0.50	4734.3	3157.9	99999.9	3571.4	0.322B	0.627F	79.8	1.125	1.878

CODES: MOMENT STRENGTH CODE:

= MOMENT STRENGTH REDUCED BY phi*Mn/MIN(1.2Mcr or 4/3Mu)

INVENTORY RATING CODES:

IF SERVICEABILITY GOVERNS INVENTORY RATING:

B = BOTTOM STRESS GOVERNS
T = TOP STRESS GOVERNS
S = SLAB STRESS GOVERNS

U = phi*Mn GOVERNS
F = Mfy GOVERNS

OPERATING RATING CODES:

U = phi*Mn GOVERNS
F = Mfy GOVERNS

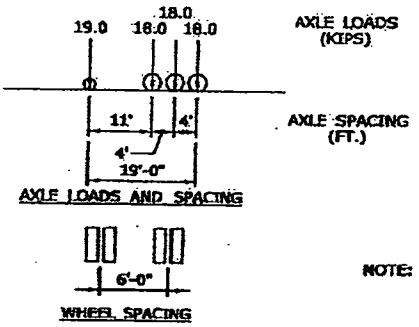
Live load ratings for existing structures that undergo minor rehabilitation, such as increased overlay thickness, shall be prepared for the live loads, and the load factor criteria and analysis parameters shown in Table 1.3. The minimum acceptable rating factors shall be no less the values shown in Table 1.3.

TABLE 1.3

Rating Procedure	Live Load Vehicle	Load factor criteria and analysis parameters	Minimum Acceptable Rating Factor (RF)
Design Load Rating	HL-93	Evaluation Level - inventory	Report value
Design Load Rating	HL-93	Evaluation Level - operating	1.00
Legal Load Rating	CT-L73.0	Load factor = 1.80	1.00
Legal Load Rating	CT-L3S2	Load factor = 1.80	1.00
Permit Load Rating	CT-P76.5	Permit Type: Routine or Annual Frequency: Unlimited Crossings Loading Condition: Mix with traffic Distribution Factor: Two or more lanes ADTT: > 5000	Report value, may be less than 1.00
Permit Load Rating	CT-P204	Permit Type: Routine or Annual Frequency: Unlimited Crossings Loading Condition: Mix with traffic Distribution Factor: Two or more lanes ADTT: > 5000 Minimum Load Factor: 1.35	Report value, may be less than 1.00
Permit Load Rating	CT-P380	Permit Type: Special or Limited Crossing Frequency: Single Trip Loading Condition: Escorted with no other vehicles on the bridge Distribution Factor: One lane ADTT: N/A	Report value, may be less than 1.00
Permit Load Rating	CT-TLC	Permit Type: Special or Limited Crossing Frequency: Single trip Loading Condition: Mix with traffic Distribution Factor: One lane ADTT: > 5000 Dynamic Load Allowance: 0.00	Report value, may be less than 1.00

Br. 596

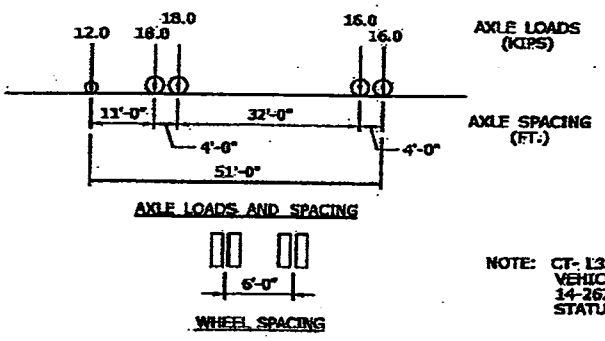
(94) E



NOTE: CT- L73.0 REPRESENTS THE CONSTRUCTION VEHICLE DESCRIBED IN SECTION 14-269(d) OF THE CT GENERAL STATUTES

CT-L73.0 LEGAL LIVE LOAD VEHICLE

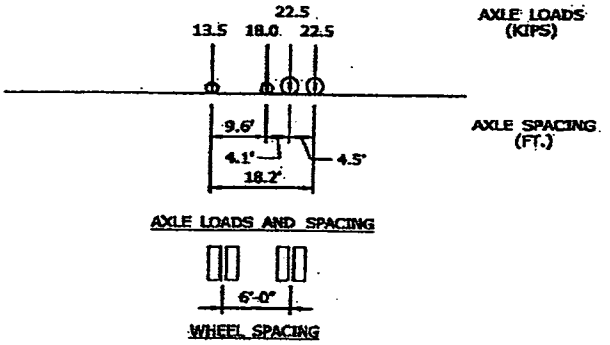
73 KIPS ON 4 AXLES



NOTE: CT- L3S2 REPRESENTS THE VEHICLE DESCRIBED IN SECTION 14-267A(b)(8) OF THE CT GENERAL STATUTES

CT-L3S2 LEGAL LIVE LOAD VEHICLE

80 KIPS ON 5 AXLES

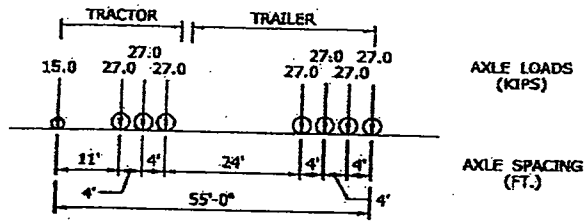


CT-P76.5 PERMIT LIVE LOAD VEHICLE

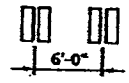
76.5 KIPS ON 4 AXLES

FIGURE 3.1

BR.596 (95) E



AXLE LOADS AND SPACING

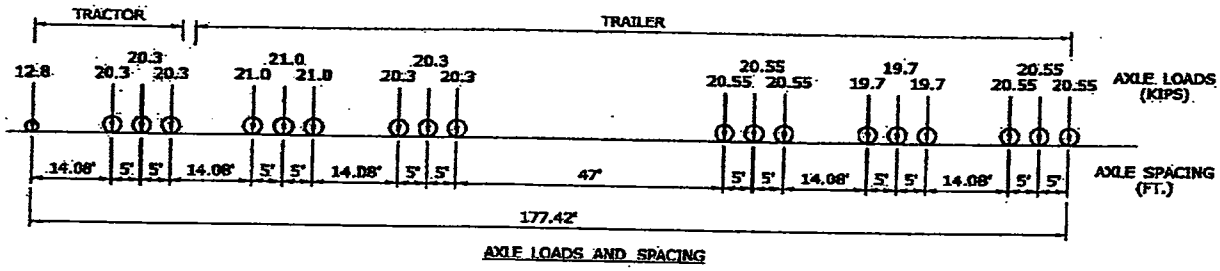


WHEEL SPACING

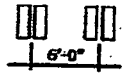
NOTE: CT-P204 IS A NOTIONAL VEHICLE

CT-P204 PERMIT LIVE LOAD VEHICLE

204 KIPS ON 8 AXLES



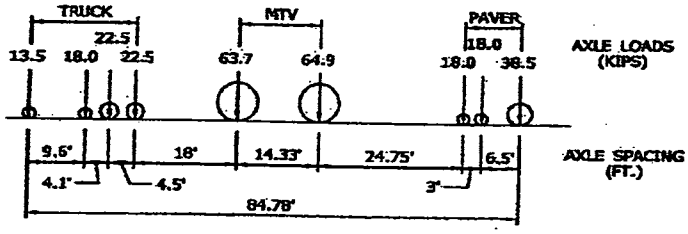
AXLE LOADS AND SPACING



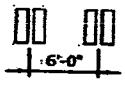
WHEEL SPACING

CT-P380 PERMIT LIVE LOAD VEHICLE

380 KIPS ON 19 AXLES



AXLE LOADS AND SPACING



WHEEL SPACING

NOTE: TLC = TRI-LOAD COMBINATION OF VEHICLES IN PAVING TRAIN

CT-TLC PERMIT LIVE LOAD VEHICLE

279.6 KIPS ON 9 AXLES

FIGURE 3.1

BRIDGE NO.00596

ROUTE 68 OVER NAUGATTUCK RIVER, ROUTES 8, 710 AND METRO NORTH TRACKS

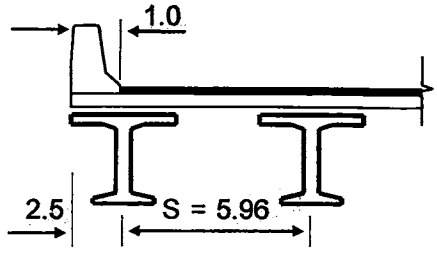
NAUGATUCK, CT

INTERIOR GIRDER "E" - CHECK

Br. 596, Span 5 Interior Girder E4

I - GIRDER BRIDGE (INTERIOR GIRDER)

BRIDGE DATA



SPAN : L = 97.50 ft

L_{total} = 99.33 ft

BRIDGE WIDTH = 50.00 ft (CURB-TO-CURB)

SLAB THICKNESS, t_s = 8 in

BITUMINOUS = 2.5 in

HAUNCH = 0.0 in

NUMBER OF BEAMS = 11 ea.

BEAM, TYPE: DBT

YEAR BUILT : 1985

BRIDGE WIDTH = 64.50 ft (OUT-TO-OUT)

MATERIALS :

CONCRETE : f'_c = 3.0 ksi (DECK)

f'_c = 5.0 ksi (P/S BEAM)

f'_{ci} = 4.0 ksi (P/S BEAM AT TRANSFER)

PRESTRESSING STEEL :

DIAMETER, d_b = 1.152 in STRESS-RELIEVED STRANDS

f'_s = 4.0 ksi

A_{ps} = 0.788 in² (AREA OF ONE STRAND)

ULTIMATE STRENGHT : f_{pu} = 200 ksi

STRANDS : 9 ea. PRESTRESSING STRANDS

0 ea. DEBONDED ON EACH END, OVER THE LAST : 0 ft

STIRRUPS : # 4 @ 12 in OVER END : 2 ft

4 @ 18 in OVER CENTER : 48.75 ft

COMPRESSION STEEL : 3 - # 4

YIELD STRENGTH : f_y = 40 ksi

ADTT = 5000 ACTUAL ADTT = 2000

SKEW = 0 °

MODULUS OF ELASTICITY OF CONCRETE, E_c : $E_c = (33000)(w_c)^{1.5}\sqrt{f'_c}$

CONCRETE UNIT WEIGHT : w_c = 0.145 kcf

DECK CONCRETE : E_c = 3156 ksi

P/S BEAM : E_c = 4074 ksi

MODULAR RATIO, $n = \frac{E_{deck}}{E_{beam}} = \frac{3156}{4074} = 0.775$

EFFECTIVE FLANGE WIDTH, b_e : LRFD Design 4.6.2.6.1

MINIMUM OF :

¼L = 292.5 in

$12t_s$ + GREATER OF EITHER t_w OR 1/2 $b_{f\,top}$ = 12 * 8 + 0.5 * 42 = 117 in

$b_{f\,top}$ = 42 in

t_w = 7 in

S = 71.52 in ← GOVERNS

EFFECTIVE FLANGE WIDTH b_e = 71.52 in

TRANSFORMED FLANGE WIDTH, b_{trans} : $b_{trans.}$ = 71.52 * 0.77 = 55.4 in

BY: m.g.
CHKD.BY: BA DATE 3/17/11

BRIDGE NO.00596

I - GIRDER BRIDGE (INTERIOR GIRDER)

CROSS-SECTION PROPERTIES:

BEAM, TYPE: DBT

$h = 56$ in PCI DESIGN MANUAL

$A = 932.2$ in²

$I_o = 375444$ in⁴

$y_{bot.} = 30.21$ in

$y_{top} = 25.79$ in

$$S_b = \frac{375444}{30.21}$$

$S_b = 12428$ in³ SECTION MODULUS FOR THE EXTREME BOTTOM FIBER OF THE NON-COMPOSITE PRECAST BEAM

$S_t = 14558$ in³ SECTION MODULUS FOR THE EXTREME TOP FIBER OF THE NON-COMPOSITE PRECAST BEAM

COMPOSITE SECTION :

	AREA, (in²)	y, (in)	A·y	d, (in)	Ad² (in⁴)	Io (in⁴)
P/S BEAM	932.2	30.21	28161.8	0.00	0	375444
SLAB, As	0	60	0	29.79	0	2364
TOTALS	932		28161.8		0	377808

AREA SLAB: (btrans.)

$A_s = 0 * 55.4 = 0$ in²

$y_{slab} = 56 + 0.0 + (0.5 * 8) = 60$ in

$$\bar{y} = \frac{28162}{932} = 30.21 \text{ in}$$

$y_{bot.c} = 30.21$ in

$y_{top\,c} = 56 - 30.21 = 25.79$ in²

$$I_{o,slab} = \frac{55.4 * (8)^3}{12} = 2364 \text{ in}^4$$

$I_{comp.} = 377808$ in⁴

$$S_b = \frac{377808}{30.21}$$

COMPOSITE SECTION MODULUS FOR THE EXTREME BOTTOM FIBER OF THE NON-COMPOSITE PRECAST BEAM

$S_b = 12506$ in³

COMPOSITE SECTION MODULUS FOR THE EXTREME TOP FIBER OF THE NON-COMPOSITE PRECAST BEAM

$S_t = 14649$ in³

(3EC)

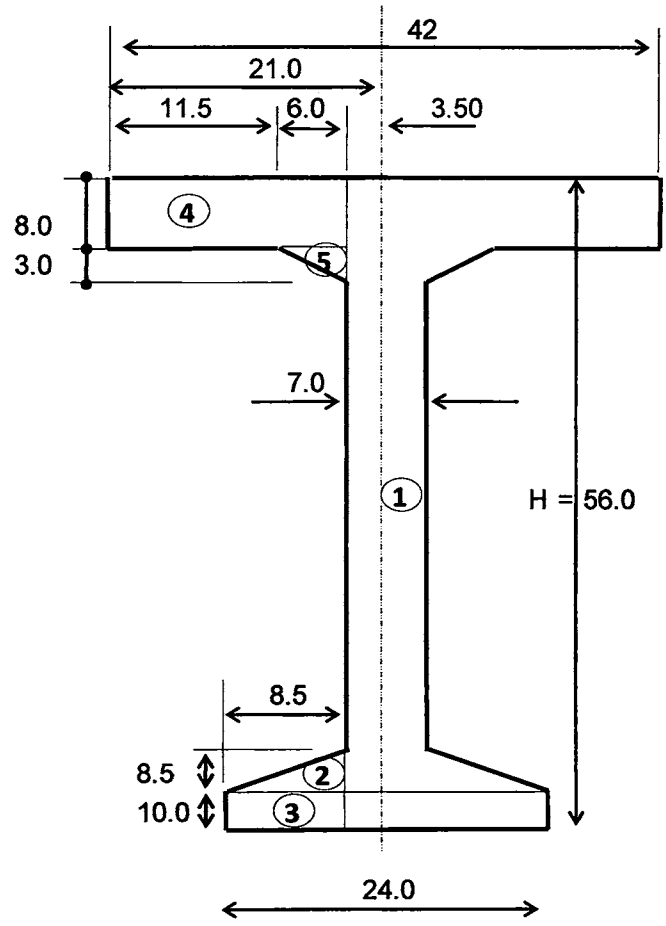
Close, Jensen and Miller, P.C

3/25/2011

BY:
CHKD.BY: DATE

DECKED BULB TEE GIRDER

MOMENT OF INERTIA OF GIRDER CROSS SECTION ABOUT X-X AXIS



Io : (in²)

1 = 1/12 * 7.0 * 56.0^3 = 102443
2 = 1/36 * 8.5 * 8.5^3 = 145.0
3 = 1/12 * 8.5 * 10.0^3 = 708.3
4 = 1/12 * 17.5 * 8.0^3 = 746.7
5 = 1/36 * 6.0 * 3.0^3 = 4.5

NON-COMPOSITE SECTION PROPERTIES :

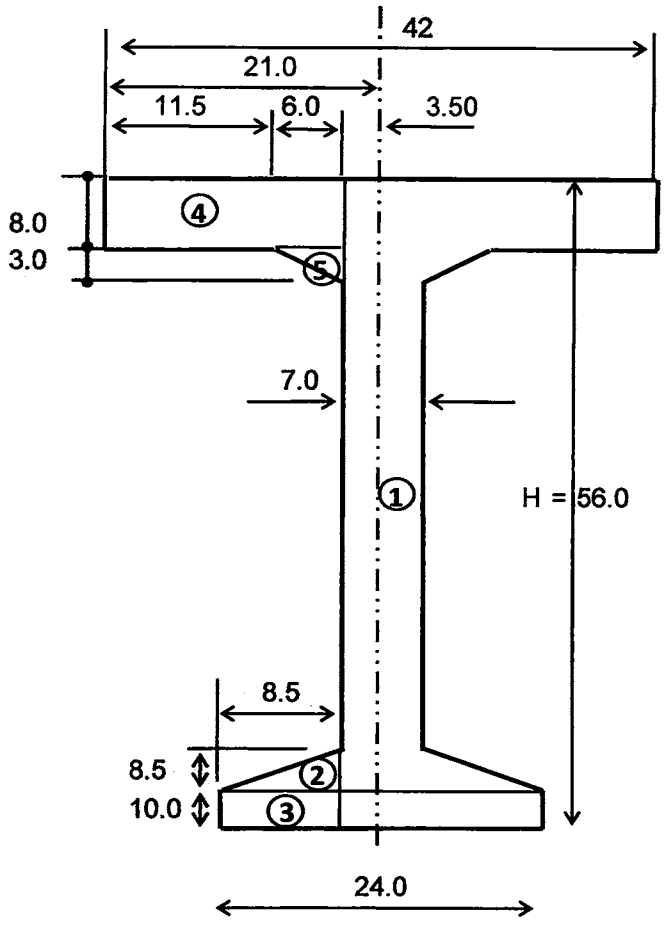
	A (in²)	Y (in)	AY (in²)	AY^2 (in³)	Io (in⁴)
1	392.0	28.0	10976	307328	102443
2	72.3	12.8	927.21	11899.2	290
3	170.0	5.0	850	4250	1417
4	280.0	52.0	14560	757120	1493
5	18.0	47.0	846	39762	9
∑ =	932.3		28159	1120359	105652

$$Y = \frac{28159}{932.3} = 30.21 \text{ in}$$

$$I_{xx} = 1120359 + 105652 - 932.3 * 30.21^2 = \mathbf{375,444} \text{ in}^4$$

$$S_t = \frac{375444}{25.79} \qquad S_b = \frac{375444}{30.21}$$

S_t = 14555 in³ S_b = 12430 in³



DECKED BULB TEE GIRDER

MOMENT OF INERTIA OF GIRDER CROSS SECTION ABOUT Y-Y AXIS

Io: (in²)

1 = 1/12 * 56.0 * 3.5^3 = 200.083
2 = 1/36 * 8.5 * 8.5^3 = 145.0
3 = 1/12 * 10.0 * 8.5^3 = 511.8
4 = 1/12 * 8.0 * 17.5^3 = 3572.9
5 = 1/36 * 3.0 * 6.0^3 = 18.0

NON-COMPOSITE SECTION PROPERTIES :

	A (in²)	Y (in)	AY (in²)	AY² (in³)	Io (in⁴)
1	196.0	1.8	343	600.25	200
2	36.1	6.3	228.79	1449.01	145
3	85.0	7.8	658.75	5105.31	512
4	140.0	12.3	1715	21008.8	3573
5	9.0	5.5	49.5	272.3	18
Σ =	466		2995	28436	4448

I_{yy} = 28436 + 4448 =

I_{yy} = 32883 * 2 (ea.) = **65,767** in⁴

BY: m.g.
CHKD.BY: BA DATE 3/17/11

BRIDGE NO.00596

I - GIRDER BRIDGE (INTERIOR GIRDER)

NONCOMPOSITE DEAD LOAD, DC1 :

PCI DESIGN MANUAL

BEAM SELF WEIGHT : = 0.375 kip/ft

DIAPHRAGMS : = 0.246 kip/ft

SLAB + HAUNCH : $\left[\underset{(ts.\ ft)}{0.667} * \underset{(S,ft)}{5.96} + \left(\underset{(HAUNCH,in)}{0.0} * \underset{(in)}{42}\right)\right] * \underset{(k/ft^3)}{0.150} = 0.596$ kip/ft

$\sum DC_1 = 1.22$ kip/ft

$V_{DC1} = 1.22 * \frac{97.5}{2} = 59.3$ kip AT SUPPORT

$M_{DC1} = \frac{1.22 * 97.5^2}{8} = 1446$ kip-ft AT MIDSPAN

COMPOSITE DEAD LOAD, DC2 :

LRFD Design 4.6.2.2.1

Wparapet= 2.20 kip/ft

$DC_2 = \left[\underset{(ea.)}{2} * 2.200\right] / \underset{(BEAMS,ea.)}{11} = 0.4$ kip/ft

$V_{DC2} = 0.40 * \frac{97.5}{2} = 19.5$ kip AT SUPPORT

$M_{DC2} = \frac{0.40 * (97.5)^2}{8} = 475.3$ kip-ft AT MIDSPAN

WEARING SURFACE, DW :

ROADWAY WIDTH : $50.00 - \left(1.0 * \underset{(ea.PARAPET)}{0}\right) = 50.0$ ft

$DW = \left[\underset{(thick.,\ ft)}{0.208} * 50.0 * \underset{(k/ft^3)}{0.150}\right] / \underset{(BEAMS,ea.)}{11} = 0.142$ kip/ft

$V_{DW} = 0.142 * \frac{97.5}{2} = 6.9$ kip AT SUPPORT

$M_{DW} = \frac{0.142 * (97.5)^2}{8} = 168.8$ kip-ft AT MIDSPAN

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BRIDGE NO.00596

I - GIRDER BRIDGE (INTERIOR GIRDER)

LIVE LOAD ANALYSIS : LRFD Design, Table 4.6.2.2.1-1

LIVE LOAD DISTRIBUTION FACTORS, g :

LONGITUDINAL STIFFNESS PARAMETER, Kg : AASHTO LRFD TYPE (J) CROSS-SECTION

$$K_g = (I + Ae_g^2)n$$

$$n = \frac{E_{beam}}{E_{deck}} = \frac{4074}{3156} = 1.29$$

$A = 932.2$ in²

$I_0 = 375444$ in⁴

$L = 97.50$ ft

$t_s = 0$ in

e_g = GIRDER DEPTH - y_b + HAUNCH + $t_s/2$

$e_g = (56 - 30.21) + 0.0 + (0 / 2)$

$e_g = 25.79$ in

$$K_g = (375444 + 932.2 * 25.79^2) * 1.29$$

$K_g = 1285150$ in

DISTRIBUTION FACTOR FOR MOMENT, gm : LRFD Design, Table 4.6.2.2.2b-1

ONE LANE LOADED :

$$\frac{K_g}{12Lt_s^3} = \frac{1285150}{12 * 97.50 * 8^3} = 2.15$$

$$g_{m1} = 0.06 + \left(\frac{S}{14}\right)^{0.4} * \left(\frac{S}{L}\right)^{0.3} * \left(\frac{K_g}{12Lt_s^3}\right)^{0.1}$$

$$g_{m1} = 0.06 + \left(\frac{5.96}{14}\right)^{0.4} * \left(\frac{5.96}{97.50}\right)^{0.3} * (2.15)^{0.1}$$

$g_{m1} = 0.392$

TWO OR MORE LANES LOADED :

$$g_{m2} = 0.075 + \left(\frac{S}{9.5}\right)^{0.6} * \left(\frac{S}{L}\right)^{0.2} * \left(\frac{K_g}{12Lt_s^3}\right)^{0.1}$$

$$g_{m2} = 0.075 + \left(\frac{5.96}{9.5}\right)^{0.6} * \left(\frac{5.96}{97.50}\right)^{0.2} * (2.15)^{0.1}$$

$g_{m2} = 0.542$ $g_{m2} > g_{m1}$ USE, g_m = **0.572**

DISTRIBUTION FACTOR FOR SHEAR, gv : LRFD Design, Table 4.6.2.2.3a-1

ONE LANE LOADED :

$$g_{v1} = 0.36 + \frac{S}{25} = 0.36 + \frac{5.96}{25} = 0.60$$

TWO OR MORE LANES LOADED :

$$g_{v2} = 0.2 + \left(\frac{S}{12}\right) - \left(\frac{S}{35}\right)^2 = 0.2 + \left(\frac{5.96}{12}\right) - \left(\frac{5.96}{35}\right)^2 = 0.668$$

$g_{v2} > g_{v1}$

USE, g_v = **0.668**

BY: m.g.
CHKD.BY: BA DATE 3/17/11

BRIDGE NO.00596

I - GIRDER BRIDGE (INTERIOR GIRDER)

LIVE LOAD ANALYSIS : LRFD Design, Table 4.6.2.2.1-1

LIVE LOAD DISTRIBUTION FACTORFOR MOMENT, g_m : LRFD Design, Table 4.6.2.2.2b-1

BRIDGE TYPE (j), IF CONNECTED ONLY ENOUGH TO PREVENT RELATIVE DISPLACEMENT AT INTERFACE

ST.VENANT'S TORSIONAL INERTIA, J :

$$J = \frac{A^4}{40\, I_p} = \frac{932.2^4}{40 * 441210} \longrightarrow J = 42789 \text{ in}^4$$

LRFD Design, Table 4.6.2.2.2b-1

POLAR MOMENT OF INERTIA, I_p :

$I_p = I + I_{yy} = 441210 \text{ in}^4$

GROSS MOMENT OF INERTIA OF GIRDER CROSS SECTION ABOUT CENTROIDAL X-X AXIS: $I = 375444 \text{ in}^4$

GROSS MOMENT OF INERTIA OF GIRDER CROSS SECTION ABOUT CENTROIDAL Y-Y AXIS: $I_{yy} = 65766 \text{ in}^4$

$A = 932.2 \text{ in}^2$

$\mu = 0.20$ (POISSON'S RATIO) LRFD Design, 5.4.2.5

$$K = \left(\frac{(1 + \mu) * I}{J} \right)^{1/2} \qquad K = \sqrt{10.5} = 3.245$$

$$C = K * \left(\frac{W_{overall}}{L} \right) \qquad C = 2.147$$

OVERALL WIDTH OF BRIDGE, $W_{overall} = 64.50$ ft

$L = 97.5$ ft

WHEN $C \leq 5$

WIDTH OF DISTRIBUTION PER LINE, D:

$$D = 11.5 - N_L + 1.4 * N_L * (1 - 0.2 * C)^2$$

NUMBER OF DESIGN LANES, N_L :

$N_L = 1$

$$D = 11.5 - 1 + 1.4 * 1 * (1 - 0.2 * 2.147)^2$$

$D = 10.96$

$$g_{m1} = \frac{S}{D} = \frac{5.96}{10.96} = 0.544$$

$S = 5.96$ ft

$N_L = 2$

$$D = 11.5 - 2 + 1.4 * 2 * (1 - 0.2 * 2.147)^2$$

$D = 10.41$

$g_{m2} = 0.572$

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BRIDGE NO.00596

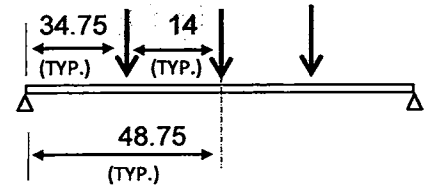
I - GIRDER BRIDGE (INTERIOR GIRDER)

COMPUTE MAXIMUM LIVE LOAD EFFECTS

MAXIMUM DESIGN LIVE LOAD (HL-93) MOMENT AT MIDSPAN

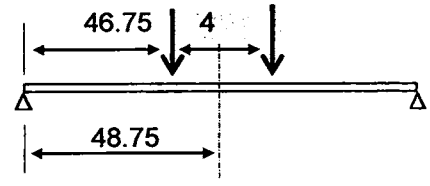
$$\text{DESIGN LANE LOAD MOMENT} = \overset{(klf)}{0.64} * \frac{97.50^2}{8} = 760.5 \text{ kip-ft}$$

DESIGN TRUCK MOMENT WITH THE MIDDLE AXLE LOCATED AT MIDSPAN:



$$\text{DESIGN TRUCK MOMENT} = \frac{\left[\overset{(kip)}{8} + \overset{(kip)}{32}\right] * \overset{(ft)}{48.75} * \overset{(ft)}{34.75}}{97.50} + \frac{\overset{(kip)}{32} * 97.50}{4} = 1475 \text{ kip-ft} \leftarrow \text{GOVERNS}$$

TANDEM AXLES MOMENT WITH TANDEM AXLES LOCATED EQUIDISTANT FROM MIDSPAN:



$$\text{TANDEM AXLES MOMENT} = \overset{(kip)}{25} * \overset{(ft)}{38} = 950 \text{ kip-ft}$$

IM = 33 %

LRFD Design, Table 3.6.2.1-1

$M_{LL+I} = 760.5 + (1475 * 1.33)$

$M_{LL+I} = 2722$ kip-ft

DISTRIBUTED LIVE LOAD MOMENT AT MID SPAN:

$g_m M_{LL+I} = 2722 * g_m = 2722 * 0.572 = 1558$ kip-ft

I - GIRDER BRIDGE (INTERIOR GIRDER)

NOMINAL FLEXURAL RESISTANCE AT MIDSPAN :

AVERAGE STRESS IN PRESTRESSING STEEL, f_{ps} :

$f_{ps} = f_{pu}\,(1 - k\,(c / d_p))$ LRFD Design, Eq. 5.7.3.1.1-1

$k = 0.38$ STRESS-RELIEVED STRANDS LRFD Design, Table C5.7.3.1.1-1

$f_{pu} = 200$ ksi SPECIFIED TENSILE STRENGTH OF PRESTRESSING STEEL

d_p = DISTANCE FROM EXTREME COMPRESSION FIBER TO THE CENTROID OF THE PRESTRESSING TENDONS

	STRANDS	y	STRANDS · y
LAYER 1	9	4.75	42.75
LAYER 2	0	0	0
LAYER 3	0	0	0
TOTAL	9		42.75

$\bar{y} = \dfrac{42.75}{9} = 4.75$ DISTANCE FROM BOTTOM OF GIRDER TO CENTROID OF PRESTRESSING STRANDS

$d_p = \left[\, 56 + 0.0 + 0 \,\right] - 4.75 = 51.25$ in

DISTANCE FROM THE NEUTRAL AXIS TO THE COMPRESSIVE FACE, c :

RECTANGULAR SECTION : LRFD Design, Eq. 5.7.3.1.1-4

$$c = \frac{A_{ps}\, f_{pu}}{0.85 f'_c \beta_1 b + k A_{ps}(f_{pu}/d_p)}$$

AREA OF PRESTRESSING STEEL : (PER STRAND) $A_{ps} = 0.788$ in² LOW-RELAXATION STRANDS

$\sum A_{ps} = 9 * 0.788 = 7.092$ in²

$b = b_e = 71.52$ in (EFFECTIVE FLANGE WIDTH OF DECK)

$f'_c = 3.0$ ksi (DECK)

$\beta_1 = 0.85$ LRFD Design, 5.7.2.2

$A_{ps} f_{pu} = 7.092 * 200 = 1418$ kip

$0.85 f'_c \beta_1 b = 0.85 * 3.0 * 0.85 * 71.52 = 155$ k/in

$k A_{ps} (f_{pu}/d_p) = 0.38 * 7.1 * \left[\, 200 / 51.25 \,\right] = 10.52$ k/in

$c = 1418 / \left[\, 155 + 10.52 \,\right] = 8.57$ in

DEPTH OF THE EQUIVALENT STRESS BLOCK, a :

$a = \beta_1 c = 0.85 * 8.57 = 7.28$ in LRFD Design, 5.7.2.2

$a < t_s = 8$ in ASSUMPTION OF THE SECTION BEHAVING AS A RECTANGULAR SECTION IS CORRECT

AVERAGE STRESS IN PRESTRESSING STEEL, f_{ps} : LRFD Design, Eq. 5.7.3.1.1-1

$f_{ps} = 200 * \left[\, 1 - 0.38 * \left[\, 8.57 / 51.25 \,\right] \right] = 187.3$ ksi

NOMINAL FLEXURAL RESISTANCE, M_n (AT MIDSPAN) : LRFD Design, Eq. 5.7.3.2.2-1

$M_n = A_{ps} f_{ps} (d_p - a/2) = 7.092 * 187.3 * \left[\, 51.25 - \left[\, 7.28 / 2 \,\right] \right] = 5270$ kip-ft

I - GIRDER BRIDGE (INTERIOR GIRDER)

MAXIMUM REINFORCEMENT

CONCRETE STRAIN, ε_c : LRFD Design, C5.7.2.1

$\varepsilon_c = 0.003$

NET TENSILE STRAIN, ε_t :

$$\frac{\varepsilon_c}{c} = \frac{\varepsilon_t}{d_p - c}$$

$\varepsilon_t = [0.003 * [51.25 - 8.57]] / 8.57 = 0.0149 > 0.005$ LRFD Design, 5.7.2.1

SECTION IS TENSION CONTROLLED

RESISTANCE FACTOR : $\varphi = 1.0$ LRFD Design, 5.5.4.2

MINIMUM REINFORCEMENT LRFD Design, 5.7.3.3.2

AMOUNT OF REINFORCEMENT MUST BE SUFFICIENT TO DEVELOP M_r EQUAL TO THE LESSER OF :

$1.2\ M_{cr}$ OR $1.33\ M_u$

LOAD	LOAD FACTOR, γ
DC	1.25
DW	1.50
LL	1.75

LRFD Design, Table 3.4.1-1
LRFD Design, Table 3.4.1-2

FACTORED FLUXURAL RESISTANCE, M_r : $M_r = \varphi M_n = 1.0 * 5270 = 5270$ kip-ft

FACTORED MOMENT, $1.33\ M_u$:

$1.33\ M_u = 1.33 * [1.25 * [1446 + 475.3] + 1.50 * 168.8 + 1.75 * 1558]$

$= 7158$ kip-ft $>$ 5270 kip-ft

NO GOOD

CRACKING MOMENT, $1.2\ M_{cr}$: THE MANUAL FOR BRIDGE EVALUATION 6A.5.6

$1.2\ M_{cr} = S_c (f_r + f_{cpe}) - M_{dnc} ((S_c/S_{nc}) - 1) \geq S_c f_r$ LRFD Design, Eq. 5.7.3.3.2-1

UNFACTORED DEAD LOAD MOMENT (NONCOMPOSITE SECTION), M_{dnc}

$M_{dnc} = 1446$ kip-ft

$S_c = 14649$ in³

$S_{nc} = 12428$ in³

MODULUS OF RUPTURE, f_r : $f_r = 0.37\sqrt{f'_c}$ LRFD Design, 5.4.2.6

$= 0.37 * \sqrt{5.0} = 0.827$ ksi

LRFD Design, 5.7.3.3.2

COMPRESSIVE STRESS IN CONCRETE DUE TO EFFECTIVE PRESTRESS FORCE (AFTER ALLOWANCE FOR ALL PRESTRESS LOSSES) AT EXTREME FIBER OF SECTION WHERE TENSILE STRESS IS CAUSED BY EXTERNALLY APPLIED LOADS, f_{cpe} :

$$f_{cpe} = \frac{P_{pe}}{A} + \frac{P_{pe}\, e}{S_b}$$

I - GIRDER BRIDGE (INTERIOR GIRDER)

DETERMINE EFFECTIVE PRESTRESS FORCE, P_{pe} :

$P_{pe} = A_{ps} * f_{pe}$

EFFECTIVE PRESTRESS f_{pe} = INITIAL PRESTRESS - TOTAL PRESTRESS LOSSES

TOTAL PRESTRESS LOSSES IMMEDIATELY BEFORE TRANSFER, Δf_{pT} :

$\Delta f_{pT} = \Delta f_{pES} + \Delta f_{pLT}$ LRFD Design, Eq. 5.9.5.1-1

LOSS DUE TO ELASTIC SHORTENING AND/OR EXTERNAL LOADS, Δf_{pES} : LRFD Design, 5.9.5.2.3a

$$\Delta f_{pES} = \frac{E_p}{E_{ct}} f_{cgp}$$

THE CONCRETE STRESS AT THE CENTER OF GRAVITY OF PRESTRESSING TENDONS DUE TO THE PRESTRESSING FORCE IMMEDIATELY AFTER TRANSFER AND SELF-WEIGHT OF THE MEMBER AT THE SECTION OF MAXIMUM MOMENT, f_{cgp} :

$$f_{cgp} = \frac{P_i}{A} + \frac{P_i e^2}{I} - \frac{M_D e}{I}$$

INITIAL PRESTRESS IMMEDIATELY PRIOR TO TRANSFER, $f_{pbt} = 0.7 f_{pu}$: LRFD Design, Table 5.9.3-1

$f_{pbt} = 0.7 * f_{pu}$

IMMEDIATELY AFTER TRANSFER : LRFD Design, 5.9.5.2.3a

$P_i = 0.90 (0.7 f_{pu})(\#\ \text{STRANDS})\ A_{PS}$

$P_i = 0.90 * (0.7 * 200) * 9 * 0.788 = 893.6$ kips

MOMENT DUE TO SELF-WEIGHT OF MEMBER AT SECTION OF MAXIMUM MOMENT (MIDSPAN), M_D :

$$M_D = \frac{0.971 * 97.5^2}{8} = 1154 \text{ kip-ft}$$

$y_b = 30.21$ in BASIC BEAM SECTION

$\bar{y} = 4.75$ in DISTANCE FROM BOTTOM OF GIRDER TO CENTROID OF PRESTRESSING STRANDS

ECCENTRICITY OF STRANDS :

$e = 30.21 - 4.75 = 25.46$ in

$$f_{cgp} = \frac{893.6}{932.2} + \frac{893.6 * 25.46^2}{375443.9} - \frac{1154 * 12 * 25.46}{375443.9}$$

$f_{cgp} = 0.959 + 1.543 - 0.939 = 1.562$ ksi

MODULUS OF ELASTICITY OF PRESTRESSING REINFORCEMENT, E_p : LRFD Design, 5.9.5.2.3a

$E_p = 25000$ ksi

MODULUS OF ELASTICITY OF CONCRETE AT TRANSFER, E_{ct} :

$E_{ct} = (33000)(w_c)^{1.5} \sqrt{f'_c}$ $w_c = 0.145$ kcf LRFD Design, Eq. 5.4.2.4-1

$E_{ct} = 3644$ ksi

$\Delta f_{pES} = (25000 / 3644) * 1.562 = 10.72$ ksi

I - GIRDER BRIDGE (INTERIOR GIRDER)

APPROXIMATE LUMP SUM ESTIMATE OF TIME-DEPENDENT LOSESS, Δf_{pLT} :

$$\Delta f_{pLT} = \left[\Delta f_{pSR} + \Delta f_{pCR} + \Delta f_{pR1} \right]_{id} + \left[\Delta f_{pSD} + \Delta f_{pCD} + \Delta f_{pR} - \Delta f_{pSS} \right]_{df}$$ LRFD Design, Eq. 5.9.5.4.1-1

FOR I-BEAM : LRFD Design, 5.9.5.3

$$\Delta f_{pLT} = 10.0\ ((f_{pi}\ A_{ps})/A_g)\ \gamma_h \gamma_{st} + 12.0\ \gamma_h \gamma_{st} + \Delta f_{pR}$$

CORRECTION FACTOR FOR RELATIVE HUMUDITY :

$$\gamma_h = 1.7 - 0.01H$$ LRFD Design, Eq. 5.9.5.3-2

ASSUME RELATIVE HUMUDITY RANGING BETWEEN 40% - 100% : H = 70 %

$$\gamma_h = 1.7 - 0.01 * 70$$

$$\gamma_h = 1.0$$

CORRECTION FACTOR FOR SPECIFIED CONCRETE STRENGTH AT TIME OF PRESTRESS TRANSFER TO THE CONCRETE MEMBER :

$$\gamma_{st} = 5 / (1 + f'_{ci})$$

$$\gamma_{st} = 5 / [1 + 4.0] = 1.0$$

ESTIMATE OF RELAXATION LOSS :

$\Delta f_{pR} = 10.0$ ksi STRESS RELIEVED STRANDS LRFD Design, 5.9.5.3

$f_{pbt} = 0.75 * 200 = 150$ ksi

$A_{ps} = 9 * 0.788 = 7.092$ in²

$$\Delta f_{pLT} = 10.0 * \frac{150 * 7.092}{932.2} * 1.0 * 1.0 + 12.0 * 1.0 * 1.0 + 10$$

$\Delta f_{pLT} = 33.41$ ksi

TOTAL PRESTRESS LOSSES, Δf_{pT} :

$$\Delta f_{pT} = \Delta f_{pES} + \Delta f_{pLT}$$

$$\Delta f_{pT} = 10.72 + 33.41 = 44.13 \text{ ksi}$$

EFFECTIVE PRESTRESS f_{pe} = INITIAL PRESTRESS - TOTAL PRESTRESS LOSSES

$$f_{pe} = 0.75 * 200 - 44.13 = 105.9 \text{ ksi}$$

$$P_{pe} = A_{ps} * f_{pe}$$

$$P_{pe} = 7.092 * 105.9 = 750.8 \text{ kips}$$

$$f_{cpe} = \frac{P_{pe}}{A} + \frac{P_{pe}\, e}{S_b}$$

$$f_{cpe} = \frac{750.8}{932.2} + \frac{750.8 * 25.46}{12428}$$

$$f_{cpe} = 2.344 \text{ ksi}$$

I - GIRDER BRIDGE (INTERIOR GIRDER)

CRACKING MOMENT, 1.2 M_{cr} :

THE MANUAL FOR BRIDGE EVALUATION 6A.5.6

$M_{cr} = S_c (f_r + f_{cpe}) - M_{dnc} ((S_c/S_{nc}) - 1) \geq S_c f_r$

LRFD Design, Eq. 5.7.3.3.2-1

$$S_c (f_r + f_{cpe}) - M_{dnc} ((S_c/S_{nc}) - 1) = \frac{14649}{12} * \left(0.827 + 2.344 \right) - 1446 * \left(\frac{14649}{12428} - 1 \right)$$

$M_{cr} =$ 3613 kip-ft

$S_c f_r = \left(14649 / 12 \right) * 0.827 =$ 1010 kip-ft OK

1.2 M_{cr} = 1.2 * 3613 = 4335 kip-ft ← CONTROLS 1.2 M_{cr} < 1.33 M_u

1.33 M_u = 7158 kip-ft

M_r = 5270 kip-ft > 4335 kip-ft

OK

I - GIRDER BRIDGE (INTERIOR GIRDER)

NOMINAL SHEAR RESISTANCE AT FIRST CRITICAL SECTION

CRITICAL SECTION NEAR THE SUPPORTS IS THE GREATER OF: LRFD Design, 5.8.3.2

d_v OR $0.5d_v \cot\theta$

EFFECTIVE SHEAR DEPTH, d_v: LRFD Design, 5.8.2.9

d_v = DISTANCE BETWEEN RESULTANTS OF THE TENSILE AND COMPRESSIVE FORCES, $(d_e - a/2)$
BUT NOT LESS THAN $(0.9\ d_e)$ OR $(0.72h)$

d_e = DISTANCE FROM THE EXTREME COMPRESSION FIBER TO THE CENTER OF THE PRESTRESSING STEEL AT THE SECTIO

h = DEPTH OF PRECAST BEAM + STRUCTURAL SLAB THICKNESS

STRANDS: 9 ea. PRESTRESSING STRANDS
0 ea. DEBONDED ON EACH END, OVER THE LAST: 0 ft

ASSUME THAT CRITICAL SECTION WILL BE WITHIN : 0 ft

DISTANCE FROM THE NEUTRAL AXIS TO THE COMPRESSIVE FACE, c: LRFD Design, Eq. 5.7.3.1.1-4

$$c = \frac{A_{ps} f_{pu}}{0.85 f'_c \beta_1 b + k A_{ps}(f_{pu}/d_p)}$$

$A_{ps} = (9 - 0) * 0.788 = 7.092$ in²

$b = b_e = 71.52$ in (EFFECTIVE FLANGE WIDTH OF DECK)

$f'_c = 4.0$ ksi (DECK)

$\beta_1 = 0.85$ LRFD Design, 5.7.2.2

$k = 0.38$ STRESS RELIEVED STRANDS

$f_{pu} = 200$ ksi SPECIFIED TENSILE STRENGTH OF PRESTRESSING STEEL

	STRANDS	y	STRANDS · y
LAYER 1	9	12.89	116
LAYER 2	0	0	0
LAYER 3	0	0	0
TOTAL	9		116

$\bar{y} = \frac{116}{9} = 12.89$ (DISTANCE FROM BOTTOM OF GIRDER TO CENTROID OF PRESTRESSING STRANDS)

$d_p = (56 + 0.0 + 0) - 12.89 = 43.11$ in

$$c = \frac{7.092 * 200}{0.85 * 4.0 * 0.85 * 71.52 + 0.38 * 7.092 * (200 / 43.11)} = 6.47 \text{ in}$$

$a = \beta_1 c = 0.85 * 6.47 = 5.50$ in LRFD Design, 5.7.2.2

$d_v = d_e - \frac{a}{2} = 43.11 - \frac{5.50}{2} = 40.4$ in ← GOVERNS

$h = 56 + 0.0 + 0 = 56.0$ in $0.72h = 40.32$ in 3.36 ft

$d_e = 43.11$ in $0.9d_e = 38.8$ in 3.233 ft

ASSUME: $\theta = 30°$

$0.5d_v \cot\theta = 0.5 * d_v * \cot 30 = 0.87\ d_v < d_v$

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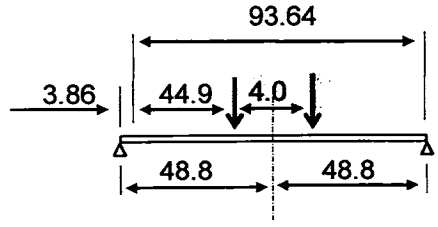
I - GIRDER BRIDGE (INTERIOR GIRDER)

DISTANCE FROM FACE OF SUPPORT TO CENTERLINE OF BEARING: 6 in LRFD Design, 5.11.4

DISTANCE FROM CENTERLINE OF BEARING TO CRITICAL SHEAR SECTION : 40.4 + 6 = 46.4 in
= 3.86 ft

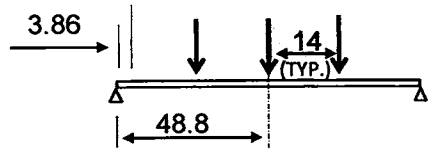
MAXIMUM SHEAR AT CRITICAL SECTION NEAR SUPPORT

L = 97.50 - 3.86 = 93.64 ft



$$V_{LANE} = \frac{0.64^{(klf)} * 93.64^2}{2 * 97.50} = 28.8 \text{ kip-ft}$$

$$V_{TANDEM} = 25^{(kip)} * \frac{93.64^{(ft)} + 89.64^{(ft)}}{97.50} = 46.99 \text{ kips}$$



$$V_{TRUCK} = \frac{32^{(kip)} * (93.64 + 79.64) + 8^{(kip)} * 65.64}{97.50}$$

V_{TRUCK} = 62.3 kips ← GOVERNS

IM = 33 % LRFD Design, Table 3.6.2.1-1

TOTAL SHEAR :

V_{LL+I} = 28.78 + 62.3 * 1.33 = 111.6 kips

DISTRIBUTION FACTOR FOR SHEAR, g_v = 0.668

DISTRIBUTED TOTAL SHEAR :

V_{LL+I} = 111.6 * 0.668 = 74.5 kips

DEAD LOAD SHEARS : $\sum DC_1$ = 1.22 kip/ft
DC_2 = 0.4 kip/ft
DW = 0.142 kip/ft

V_{DC} = (1.22 + 0.4) * (0.5 * 97.50 - 3.86)

V_{DC} = 54.6 + 18.0 = 72.6 kips

V_{DW} = 0.142 * (0.5 * 97.50 - 3.86) = 6.38 kips

I - GIRDER BRIDGE (INTERIOR GIRDER)

NOMINAL SHEAR RESISTANCE, V_n : LRFD Design, Eq. 5.8.3.3-1

SHALL BE LESSER OF: LRFD Design, Eq. 5.8.3.3-2

$V_n = V_s + V_c + V_p$

$V_n = 0.25 f'_c b_v d_v + V_p$

MINIMUM TRANSVERSE REINFORCEMENT, A_v : LRFD Design, Eq. 5.8.2.5-1

$$A_v = 0.0316 \sqrt{f'_c} \frac{b_v s}{f_y}$$

b_v = 7.0 in WEB WIDTH

s = 18.0 in

$$A_v = 0.0316 * \sqrt{5.0} * \frac{7 * 18}{40} = 0.223 \text{ in}^2$$

STIRRUPS AREA PROVIDED : # 4 A = 0.13 in²
(2 LEGS)

A_v = 2 * 0.13 = 0.26 in² > 0.223 in² OK

CONCRETE : $V_c = 0.0316\beta\sqrt{f'_c} b_v d_v$ LRFD Design, Eq. 5.8.3.3-3

STEEL : $V_s = \frac{A_v f_y d_v \cot\theta}{s}$ LRFD Design, Eq. C5.8.3.3-1

$V_n = 0.25 f'_c b_v d_v + V_p$ LRFD Design, Eq. 5.8.3.3-2

$V_p = A_{PS} * N_s * f_{pe} * SIN(\theta)$ V_p = 22.52 kip

V_n = 0.25 * 5.0 * 7 * 40.4 + 22.52 = 376 kips

NOMINAL SHEAR RESISTANCE, V_n (SIMPLIFIED APPROACH) : LRFD Design, Eq. 5.8.3.4.1

ASSUME : θ = 45 °

β = 2.0

CONCRETE : $V_c = 0.0316\beta\sqrt{f'_c} b_v d_v$ LRFD Design, Eq. 5.8.3.3-3

b_v = 7 in

d_v = 40.4 in

V_c = 0.0316 * 2.0 * √ 5.0 * 7 * 40.4 = 39.9 kips

STEEL : $V_s = \frac{A_v f_y d_v \cot\theta}{s}$ α = 90 °

STIRRUPS : # 4 @ 18 in

A_v = 0.26 in²

$$V_s = \frac{0.26 * 40 * 40.4 * \cot 45}{18} = 23.32 \text{ kips}$$

NOMINAL SHEAR RESISTANCE, V_n :

$V_n = V_s + V_c + V_p$ LRFD Design, C5.8.3.3-1

= 23.32 + 39.9 + 22.5 = 85.8 kips

V_n = 85.8 kips < 376 kips

φV_n = 0.90 * 85.8 = 77.19 kips LRFD Design, 5.5.4.2.1

RESISTANCE FACTOR FOR SHEAR, φ = 0.90

I - GIRDER BRIDGE (INTERIOR GIRDER)

MAXIMUM DISTRIBUTED SHEARS AT CRITICAL SECTION (HL-93 INVENTORY LOADING) :

V_{LL+I} = 74.5 kips

V_{DC} = 72.6 kips

V_{DW} = 6.38 kips

LOAD	LOAD FACTOR, γ
DC	1.25
DW	1.50
LL	1.75

LRFD Design, Table 3.4.1-1

LRFD Design, Table 3.4.1-2

FACTORED SHEAR :

V_u = 1.25 * 72.6 + 1.50 * 6.38 + 1.75 * 74.5

V_u = 230.7 kips > 77.19 kips NO GOOD

NOMINAL SHEAR RESISTANCE, V_n (MCFT APPROACH) : LRFD Design, Eq.5.8.2.9-1

SHEAR STRESS ON THE CONCRETE :

$$v_u = \frac{V_u - \varphi V_p}{\varphi b_v d_v}$$

$$v_u = \frac{230.7 - 20.27}{0.90 * 7.0 * 40.4} = 0.907 \text{ ksi}$$

LRFD Design, C5.8.2.9

LRFD Design, 5.5.4.2.1

RATIO OF THE APPLIED FACTORED SHEAR STRESS TO THE CONCRETE COMPRESSIVE STRENGTH :

$$\frac{v_u}{f'_c} = \frac{0.907}{5.0} = 0.181 \quad < 0.25$$

DISTANCE FROM CENTERLINE OF BEARING TO CRITICAL SHEAR SECTION = 3.86 ft

DEAD LOAD MOMENTS AT FIRST CRITICAL SECTION FOR SHEAR :

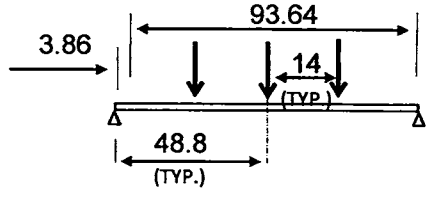
$$M_{DC} = 0.5 * \left[\overset{(k/ft)}{1.22} + \overset{(k/ft)}{0.4}\right] * 3.86 * \left[\overset{(L,\ ft)}{97.50 - 3.86}\right]$$

M_{DC} = 220.1 + 72.35 = 292.5 kip-ft

M_{DW} = 0.5 * 0.142 * 3.86 * 97.50 - 3.86 = 25.7 kip-ft

LIVE LOAD MOMENTS AT FIRST CRITICAL SECTION FOR SHEAR :

$$M_{TRUCK} = \frac{\overset{(k)}{32} * 3.86 * \left[93.64 + 79.64\right] + \overset{(k)}{8} * 3.86 * 65.64}{97.50}$$



M_{TRUCK} = 240.5 kip-ft

$$M_{LANE} = \frac{\overset{(klf)}{0.64} * 93.64^2}{2 * 97.50} * 3.86 = 111.2 \text{ kip-ft}$$

$$M_{LL+I} = \overset{(IM)}{1.33} * 240.5 + 111.2 = 431.1 \text{ kip-ft}$$

DISTRIBUTED MOMENT :

$g_m * M_{LL+I}$ = 0.572 * 431.1 = 246.7 kip-ft

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BRIDGE NO.00596

I - GIRDER BRIDGE (INTERIOR GIRDER)

NOMINAL SHEAR RESISTANCE, V_n (MCFT APPROACH) :

LOAD	LOAD FACTOR, γ
DC	1.25
DW	1.50
LL	1.75

LRFD Design, Table 3.4.1-1
LRFD Design, Table 3.4.1-2

FACTORED MOMENT :

M_u = 1.25 * 292.5 + 1.50 * 25.7 + 1.75 * 246.7 = 836 kip-ft

STRAIN IN THE REINFORCEMENT, ε_x :

LRFD Design, 5.8.3.4.2

$N_u = 0$
$V_p = 0$
$E_sA_s = 0$

$$\varepsilon_x = \frac{\frac{M_u}{d_v} + 0.5N_u + 0.5(V_u - V_p)\cot\theta - A_{ps} f_{po}}{2(E_sA_s + E_pA_{ps})} \leq 0.001$$

A_{ps} = 9 * 0.788 = 7.092 in²
$f_{po} = 0.7f_{pu}$ = 0.7 * 200 = 140 ksi
E_p = 25000 ksi
V_u = 230.7 kips
d_v = 40.4 in

ASSUME CRACK INCINATION ANGLE, θ :

V_u/f'_c = 0.181 ⟶ $\varepsilon_x \times 1000 \leq -0.10$ ε_x = -0.0001 LRFD Design, Table B5.2-1

θ = 21.9 ° cot 21.9 = 2.488

$$\varepsilon_x = \frac{\frac{836 * 12}{40.4} + 0.5 * 230.7 * 2.488 - 7.092 * 140}{2 * (0 + 25000 * 7.092)}$$

ε_x = -0.001290

RECALCULATE ε_x, INCLUDE AREA OF CONCRETE ON THE TENSION SIDE OF THE BEAM WITHIN HALF THE TOTAL DEPTH OF THE BEA

A_c = AREA BELOW * h/2

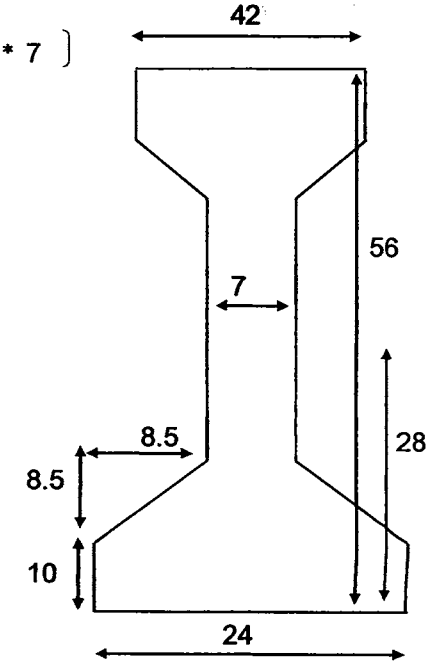
A_c = (10 * 24) + (0.5 * 8.5 * 8.5 * 2) + (8.5 * 7) + 9.5 * 7

A_c = 438.3 in²

E_c = 4074 ksi

$$\varepsilon_x = \frac{\frac{836 * 12}{40.4} + 0.5 * 230.7 * 2.488 - 7.092 * 140}{2 * (4074 * 438.3 + 25000 * 7.092)}$$

ε_x = -0.000117 ≥ -0.00010



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BRIDGE NO.00596

I - GIRDER BRIDGE (INTERIOR GIRDER)

NOMINAL SHEAR RESISTANCE, V_n (MCFT APPROACH) :

ASSUME :

$\varepsilon_x \leq 0$ LRFD Design, Table B5.2-1

$v_u / f'_c = 0.181$

$\theta = 23.7°$ cot 23.7 = 2.278

$\beta = 2.87$

$$\varepsilon_x = \frac{\frac{836 * 12}{40.4} + 0.5 * 230.7 * 2.278 - 7.092 * 140}{2 * [4074 * 438.3 + 25000 * 7.092]}$$

$\varepsilon_x = -0.000123 \leq 0$

CONCRETE : $V_c = 0.0316\beta\sqrt{f'_c}\, b_v\, d_v$ LRFD Design, Eq. 5.8.3.3-3

$V_c = 0.0316 * 2.87 * \sqrt{5.0} * 7.0 * 40.4 = 57.3$ kips

SHEAR RESISTANCE PROVIDED BY THE TRANSVERSE REINFORCEMENT (STIRRUPS), V_s :

$V_s = \frac{A_v f_y d_v \cot\theta}{s}$ LRFD Design, Eq. C5.8.3.3-1

STIRRUPS : # 4 @ 18 in $A_v = 0.26$ in²

$V_s = \frac{0.26 * 40 * 40.4 * 2.278}{18} = 53$ kips

NOMINAL SHEAR RESISTANCE, V_n :

$V_n = V_s + V_c + V_p$ LRFD Design, C5.3.3-1

$= 53.12 + 57.3 + 22.5 = 132.9$ kips

$V_n = 0.25 f'_c b_v d_v + V_p$ LRFD Design, Eq. 5.8.3.3-2

$= 0.25 * 5.0 * 7.0 * 40.4 + 22.52 = 376$ kips

$V_n = 133$ kips < 376 kips

$V_n = 133$ kips

$\varphi V_n = 0.90 * 133 = 120$ kips LRFD Design, 5.5.4.2.1

RESISTANCE FACTOR FOR SHEAR, $\varphi = 0.90$

I - GIRDER BRIDGE (INTERIOR GIRDER)

LONGITUDINAL REINFORCEMENT : LRFD Design, 5.8.3.5

$N_u = 0$

$$A_{ps}f_{ps} + A_s f_y \geq \frac{|M_u|}{d_v \varphi_f} + \cancel{0.5 * \frac{N_u}{\varphi_c}} + \left(\left|\frac{V_u}{\varphi_v} - V_p\right| - 0.5V_s\right) * \cot\theta$$ LRFD Design, Eq. 5.8.3.5-1

MINIMUM REQUIRED TENSILE CAPACITY, V_s :

$V_s = 53$ kips

$$\frac{V_u}{\varphi} = \frac{230.7}{0.90} = 256.3 \text{ kips}$$

$V_s = 256.3$ kips

$\varphi_c = 0$ LRFD Design, 5.5.4.2

$\varphi_f = 1.0$

$\varphi_v = 0.9$

$$A_{ps}f_{ps} + A_s f_y \geq \frac{|836 * 12|}{40.4 * 1.0} + \left(\left|\frac{230.7}{0.9}\right| - 0.5 * 256.3\right) * \cot 23.7$$

$A_{ps}f_{ps} + A_s f_y \geq 489.2$ kips

TRANSFER LENGTH, ℓ_t : LRFD Design, 5.11.4.1

$\ell_t = 60 \times$ STRAND DIAMETERS

$\ell_t = 60 * 1.152 = 69.12$ in

DEVELOPMENT LENGTH, ℓ_d : LRFD Design, 5.11.4.2-1

$\ell_d \geq k\,(f_{ps} - \frac{2}{3} f_{pe})d_b$ $k = 1.6$

$$\ell_d \geq 1.6 * \left(187.3 - \frac{2}{3} * 105.9\right) * 1.152$$

$\ell_d \geq 215.1$ in

DISTANCE FROMM FREE END OF PRETENSIONED STRAND TO SECTION OF MEMBER UNDER CONSIDERATION, ℓ_{px} :

$\ell_{px} = 46.4$ in LRFD Design, 5.11.4.3

LRFD Design, 5.11.4.1

DESIGN STRESS, f_{px} : LRFD Design, 5.11.4.2-3

$$f_{px} = f_{pe} + \frac{\ell_{px} - 60d_b}{\ell_d - 60d_b} * (f_{ps} - f_{pe})$$

$$f_{px} = 105.9 + \frac{46.4 - 69.12}{215.1 - 69.12} * (187.3 - 105.9) = 93.18 \text{ ksi}$$

$A_{ps}f_{ps} + A_s f_y = f_{px} * A_{ps} = 93.18 * 7.092 = 660.8$ kips

$$A_{ps}f_{ps} + A_s f_y \geq \frac{|M_u|}{d_v \varphi_f} + 0.5 * \frac{N_u}{\varphi_c} + \left(\left|\frac{V_u}{\varphi_v} - V_p\right| - 0.5V_s\right) * \cot\theta$$

660.8 kips $\geq$ 489.2 kips

OK

I - GIRDER BRIDGE (INTERIOR GIRDER)

NOMINAL SHEAR RESISTANCE AT STIRRUP CHANGE / QUARTER POINT : THE MANUAL FOR BRIDGE EVALUATION 6A.5.8

ASSUME : **24.38** ft, FROM CENTERLINE OF BEARING

CHECK TRANSFER LENGTH : LRFD Design, 5.11.4

60 * 1.152 = 69.12 in

DEBONDED LENGTH = **36.56** ft

STRANDS = 9 ea.

ALL STRANDS ARE BONDED AT : 0 + 69.12 = 5.76 ft < 24.38 ft OK

$d_v = d_e - a/2$ LRFD Design, 5.8.2.9

$h = 56 + 0.0 + 0 = 56.0$ in

$d_e = h - \overline{y} = 56.0 - 4.75 = 51.25$ in

$a = 7.28$ in

$d_v = 47.61$ in $> 0.9d_e = 0.9 * 51.25 = 46.13$ in

$> 0.72h = 0.72 * 56.0 = 40.32$ in

$d_v = M_n / (A_s f_y + A_{ps} f_{ps})$ LRFD Design, Eq. C5.8.2.9-1

$A_{ps} = 9 * 0.788 = 7.092$ in²

$d_v = 5270 * 12 / [0 + 7.092 * 187.3] = 47.61$ in

MAXIMUM SHEAR AT STIRRUP CHANGE :

24.375 ft, FROM CENTERLINE OF BEARING

MAXIMUM SHEAR AT CRITICAL SECTION NEAR SUPPORT

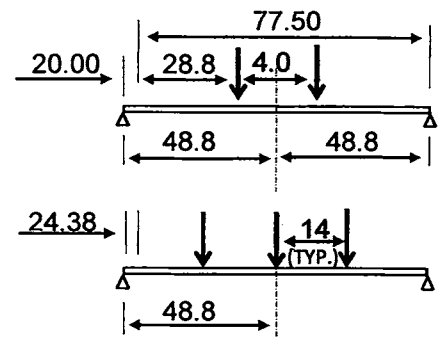
L = 97.50 - 24.38 = 73.13 ft

$$V_{LANE} = \frac{\overset{(klf)}{0.64} * 73.13^2}{2 * 97.50} = 17.6 \text{ kip-ft}$$

$$V_{TANDEM} = \overset{(kip)}{25} * \frac{\overset{(ft)}{73.13} + \overset{(ft)}{69.13}}{97.50} = 36.47 \text{ kips}$$

$$V_{TRUCK} = \frac{\overset{(kip)}{32} * [73.13 + 59.13] + \overset{(kip)}{8} * 45.13}{97.50} =$$

$V_{TRUCK} = 47.1$ kips ← GOVERNS



IM = 33 % LRFD Design, Table 3.6.2.1-1

TOTAL SHEAR :

$V_{LL+I} = 17.55 + 47.1 * 1.33 = 80.2$ kips DISTRIBUTION FACTOR FOR SHEAR, $g_v = 0.668$

DISTRIBUTED TOTAL SHEAR :

$V_{LL+I} = 80.2 * 0.668 = 53.5$ kips

I - GIRDER BRIDGE (INTERIOR GIRDER)

MAXIMUM SHEAR AT CRITICAL SECTION NEAR SUPPORT

DEAD LOAD SHEARS : $\sum DC_1 = 1.22$ kip/ft

$DC_2 = 0.4$ kip/ft

$DW = 0.142$ kip/ft

$V_{DC} = (1.22 + 0.4) * (0.5 * 97.50 - 24.38) =$

$V_{DC} = 29.67 + 9.75 = 39.4$ kips

$V_{DW} = 0.142 * (0.5 * 97.50 - 24.38) = 3.5$ kips

MINIMUM TRANSVERSE REINFORCEMENT : LRFD Design, Eq. 5.8.2.5

LRFD Design, Eq. 5.8.2.5-1

$$A_v = 0.0316 \sqrt{f'_c} \frac{b_v s}{f_y}$$

$b_v = 7.0$ in WEB WIDTH

$s = 18.0$ in

$$A_v = 0.0316 * \sqrt{5.0} * \frac{7.0 * 18}{40} = 0.223 \text{ in}^2$$

STIRRUPS AREA PROVIDED : # 4 $A = 0.13$ in²

(2 LEGS)

$A_v = 2 * 0.13 = 0.26$ in² > 0.223 in² OK

NOMINAL SHEAR RESISTANCE, V_n (SIMPLIFIED APPROACH) : LRFD Design, Eq. 5.8.3.4.1

ASSUME : $\theta = 45°$ $\cot\theta = 1.00$

$\beta = 2.0$

CONCRETE : $V_c = 0.0316\beta\sqrt{f'_c}\, b_v d_v$ LRFD Design, Eq. 5.8.3.3-3

$b_v = 7.0$ in

$d_v = 47.61$ in

$V_c = 0.0316 * 2.0 * \sqrt{5.0} * 7 * 47.61 = 47.1$ kips

STEEL : $$V_s = \frac{A_v f_y d_v \cot\theta}{s}$$

STIRRUPS : # 4 @ 18 in

$A_v = 0.26$ in²

$$V_s = \frac{0.26 * 40 * 47.61 * 1.00}{18} = 27.51 \text{ kips}$$

NOMINAL SHEAR RESISTANCE, V_n :

$V_n = V_s + V_c + V_p$ LRFD Design, C5.8.3.3-1

$= 27.51 + 47.1 + 22.5 = 97.1$ kips

$V_n = 0.25 f'_c b_v d_v + V_p$ LRFD Design, Eq. 5.8.3.3-2

$= 0.25 * 5.0 * 7.0 * 47.6 + 22.52 = 439$ kips

$V_n = 97.1$ kips < 439 kips

$\varphi V_n = 0.90 * 97.1 = 87.42$ kips LRFD Design, 5.5.4.2.1

RESISTANCE FACTOR FOR SHEAR, $\varphi = 0.90$

I - GIRDER BRIDGE (INTERIOR GIRDER)

NOMINAL SHEAR RESISTANCE, V_n (SIMPLIFIED APPROACH) :

FACTORED SHEAR :

$$V_u = 1.25 * 39.4 + 1.50 * 3.46 + 1.75 * 53.5 = 148.2 \text{ kips}$$

$$\varphi V_n = 87.42 \text{ kips} < 148.2 \text{ kips} \qquad \text{NO GOOD}$$

NOMINAL SHEAR RESISTANCE, V_n (MCFT APPROACH) : LRFD Design, Eq.5.8.2.9-1

SHEAR STRESS ON THE CONCRETE :

$$v_u = \frac{V_u - \varphi V_p}{\varphi\, b_v\, d_v}$$

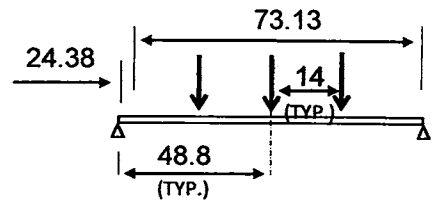
$$v_u = \frac{148.2 - 0}{0.90 * 7.0 * 47.6} = 0.494 \text{ ksi}$$ LRFD Design, C5.8.2.9 LRFD Design, 5.5.4.2.1

RATIO OF THE APPLIED FACTORED SHEAR STRESS TO THE CONCRETE COMPRESSIVE STRENGTH :

$$\frac{v_u}{f'_c} = \frac{0.494}{5.0} = 0.099 \qquad <0.25$$ LRFD Design, 5.5.4.2.1

LIVE LOAD MOMENTS AT STIRRUP CHANGE :

$$M_{TRUCK} = \frac{\overset{(kip)}{32} * 24.38 * (73.13 + 59.13) + \overset{(kip)}{8} * 24.38 * 45.13}{97.50}$$



$$M_{TRUCK} = 1148 \text{ kip-ft}$$

$$M_{LANE} = \frac{\overset{(klf)}{0.64} * 73.13^2}{2 * 97.50} * 24.38 = 427.8 \text{ kip-ft}$$

$$M_{LL+I} = \overset{(IM)}{1.33} * 1148 + 427.8 = 1955 \text{ kip-ft}$$

DISTRIBUTED MOMENT :

$$g_m * M_{LL+I} = 0.572 * 1955 = 1119 \text{ kip-ft}$$

DEAD LOAD SHEARS : $\sum DC_1 = 1.22$ kip/ft

$DC_2 = 0.4$ kip/ft

$DW = 0.142$ kip/ft

$$M_{DC} = 0.5 * (\overset{(k/ft)}{1.22} + \overset{(k/ft)}{0.4}) * 24.38 * (\overset{(L,\,ft)}{97.50 - 24.38})$$

$$M_{DC} = 1085 + 356.5 = 1441 \text{ kip-ft}$$

$$M_{DW} = 0.5 * 0.142 * 24.38 * 97.50 - 24.38 = 126.6 \text{ kip-ft}$$

FACTORED MOMENT :

$$M_u = 1.25 * 1441 + 1.50 * 126.6 + 1.75 * 1119 = 3950 \text{ kip-ft}$$

UPPER LIMIT OF SHEAR :

$$V_n = 0.25 f'_c\, b_v\, d_v + V_p = 439 \text{ kips}$$ LRFD Design, Eq. 5.8.3.3-2

I - GIRDER BRIDGE (INTERIOR GIRDER)

NOMINAL SHEAR RESISTANCE, V_n (MCFT APPROACH) :

STRAIN IN THE REINFORCEMENT, ε_x : LRFD Design, 5.8.3.4.2

$$\varepsilon_x = \frac{\frac{M_u}{d_v} + 0.5N_u + 0.5(V_u - V_p)\cot\theta - A_{ps} f_{po}}{2(E_sA_s + E_pA_{ps})} \leq 0.001$$

$N_u = 0$
$V_p = 0$
$E_sA_s = 0$

$A_{ps} = 9 * 0.788 = 7.092$ in²
$f_{po} = 0.7f_{pu} = 0.7 * 200 = 140$ ksi
$E_p = 25000$ ksi
$V_u = 148.2$ kips
$d_v = 47.61$ in

ASSUME CRACK INCINATION ANGLE, θ :

$v_u / f'_c = 0.099 \longrightarrow \varepsilon_x \times 1000 \leq -0.10$ $\varepsilon_x = -0.0001$ LRFD Design, Table B5.2-1

$\theta = 21.9°$ cot 21.9 = 2.488

$$\varepsilon_x = \frac{\frac{3950 * 12}{47.61} + 0.5 * 148.2 * 2.488 - 7.092 * 140}{2 * (0 + 25000 * 7.092)}$$

$\varepsilon_x = 0.000527$

ASSUME :

$\varepsilon_x \leq 0.125 \times 10^{-3}$ $(\varepsilon_x \times 1000 \leq 0.125)$

$\theta = 24.9°$ cot 24.9 = 2.154

$\varepsilon_x = 0.000458$ $\beta = 2.91$

CALCULATE, V_n :

CONCRETE : $V_c = 0.0316\beta\sqrt{f'_c}\, b_v d_v$ LRFD Design, Eq. 5.8.3.3-3

$V_c = 0.0316 * 2.91 * \sqrt{5.0} * 7.0 * 47.6 = 68.5$ kips

SHEAR RESISTANCE PROVIDED BY THE TRANSVERSE REINFORCEMENT (STIRRUPS), V_s :

$$V_s = \frac{A_v f_y d_v \cot\theta}{s}$$ LRFD Design, Eq. C5.8.3.3-1

STIRRUPS : # 4 @ 18 in $A_v = 0.26$ in²

$$V_s = \frac{0.26 * 40 * 47.6 * 2.154}{18} = 59 \text{ kips}$$

NOMINAL SHEAR RESISTANCE, V_n :

$V_n = V_s + V_c + V_p$ LRFD Design, C5.3.3-1

$= 59 + 68.5 + 22.5 = 128$ kips

UPPER LIMIT OF SHEAR :

$V_n = 0.25f'_c b_v d_v + V_p = 439$ kips LRFD Design, Eq. 5.8.3.3-2

$V_n = 128$ kips < 439 kips

$\varphi V_n = 0.90 * 128 = 115$ kips

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I - GIRDER BRIDGE (INTERIOR GIRDER)

LONGITUDINAL REINFORCEMENT : LRFD Design, 5.8.3.5

$N_u = 0$

$$A_{ps}f_{ps} + A_s f_y \geq \frac{|M_u|}{d_v \varphi_f} + \cancel{0.5 * \frac{N_u}{\varphi_c}} + \left(\left|\frac{V_u}{\varphi_v} - V_p\right| - 0.5V_s\right) * \cot\theta$$ LRFD Design, Eq. 5.8.3.5-1

MINIMUM REQUIRED TENSILE CAPACITY, V_s :

$V_s = 59$ kips

$\frac{V_u}{\varphi} = \frac{148.2}{0.90} = 164.6$ kips

$V_s = 164.6$ kips

$\varphi_c = 0$ LRFD Design, 5.5.4.2

$\varphi_f = 1.0$

$\varphi_v = 0.9$

$$A_{ps}f_{ps} + A_s f_s \geq \frac{|3950 * 12|}{47.61 * 1.0} + \left(\left|\frac{148.2}{0.9}\right| - 0.5 * 59\right) * \cot 24.9$$

$A_{ps}f_{ps} + A_s f_s \geq 1238$ kips

DEVELOPMENT LENGTH, ℓ_d : LRFD Design, 5.11.4.2-1

$\ell_d \geq k\,(f_{ps} - \tfrac{2}{3} f_{pe})d_b$

$k = 2.0$ LRFD Design, 5.11.4.3

$f_{ps} = 187.3$ ksi

$f_{pe} = 105.9$ ksi

$$\ell_d \geq 2.0 * \left(187.3 - \frac{2}{3} * 105.9\right) * 1.152$$

$\ell_d \geq 269$ in
(ft)

269 + 36.56 = 59.0 ft > 24.38 ft THE STRANDS ARE NOT FULLY DEVELOPED.

FROM END OF DEBONDED ZONES :

$\ell_{px} = 24.4$ (ft) $- 5.76$ (ft) $= 223.4$ in

60 * 1.152 = 69.12

DESIGN STRESS, f_{px} : LRFD Design, 5.11.4.2-3

$$f_{px} = f_{pe} + \frac{\ell_{px} - 60d_b}{\ell_d - 60d_b} * (f_{ps} - f_{pe})$$

$$f_{px} = 105.9 + \frac{223.4 - 69.12}{269 - 69.12} * (187.3 - 105.9) = 168.7 \text{ ksi}$$

$A_{ps}f_{ps} + A_s f_y = 9 * 0.788 * 187.3 + 0 * 0.788 * 168.7 = 1328$ kips

$A_{ps}f_{ps} + A_s f_y = 1328$ kips > 1238 kips

OK

I - GIRDER BRIDGE (INTERIOR GIRDER)

SUMMARY :

L = 97.50 ft

LOCATION	SUPPORT	CRITICAL SHEAR	STIRRUP CHANGE	MIDSPAN
x/L		0.04	0.25	0.5
X, ft		3.86	24.38	48.75
V_{DC1}, kips	59	55	30	
V_{DC2}, kips	20	18	10	
V_{DW}, kips	7	6	3	
$g_m V_{LL+I}$, kips		74	54	
V_n, kips, SIMPLIFIED		86	97	
V_n, kips, MCFT		133	128	
M_{DC1}, kip-ft		220	1085	1446
M_{DC2}, kip-ft		72	356	475.3
M_{DW}, kip-ft		26	127	168.8
$g_m M_{LL+I}$, kip-ft		247	1119	1558
M_n, kip-ft				5270

GENERAL LOAD RATING EQUATION : THE MANUAL FOR BRIDGE EVALUATION 6A.4.2

$$RF = \frac{C - (\gamma_{DC})(DC) - (\gamma_{DW})(DW) \pm (\gamma_P)(P)}{(\gamma_L)(LL+IM)}$$

Eq. 6A.4.2.1-1

EVALUATION FACTORS (FOR STRENGTH LIMIT STATE)

RESISTANCE FACTOR, φ : LRFD Design, 5.5.4.2.1

$\varphi = 1.0$ FLEXURE TENSION CONTROLLED SECTION

$\varphi = 0.9$ SHEAR

RESISTANCE FACTOR, φ_c :

$\varphi_c = 1.00$ GOOD CONDITION THE MANUAL FOR BRIDGE EVALUATION 6A.4.2.3

SYSTEM FACTOR, φ_s :

$\varphi_s = 1.0$ THE MANUAL FOR BRIDGE EVALUATION 6A.4.2.4

REDUNDENT STRUCTURE GIRDER SPACING > 4 FT

I - GIRDER BRIDGE (INTERIOR GIRDER)

DESIGN LOAD RATING — THE MANUAL FOR BRIDGE EVALUATION 6A.4.3

STRENGTH I LIMIT STATE :

$$RF = \frac{(\varphi_c)(\varphi_s)(\varphi)R_n - (\gamma_{DC})(DC) - (\gamma_{DW})(DW)}{(\gamma_L)(LL+IM)}$$

THE MANUAL FOR BRIDGE EVALUATION 6A.5.4.1

INVENTORY LEVEL : — TABLE 6A.4.2.2-1

LOAD	LOAD FACTOR
DC	1.25
DW	1.50
LL	1.75

FLEXURE AT MIDSPAN :

$$RF = \frac{(1.0) * (1.0) * (1.0) * (5270) - (1.25 * (1446 + 475.3) + 1.50 * 168.8)}{1.75 * 1558}$$

$$RF = 0.96$$

OPERATING LEVEL : — TABLE 6A.4.2.2-1

LOAD	LOAD FACTOR, γ
DC	1.25
DW	1.50
LL	1.35

FLEXURE AT MIDSPAN :

$$RF = 0.96 * \frac{1.75}{1.35} = 1.24$$

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I - GIRDER BRIDGE (INTERIOR GIRDER)

DESIGN LOAD RATING

SHEAR AT FIRST CRITICAL SHEAR SECTION : 46.4 in FROM CENTERLINE OF BEARING

SIMPLIFIED APPROACH :

$$RF = \frac{[1.00] * [1.0] * [0.9] * [86] - [1.25 * [55 + 18] + 1.50 * 6]}{1.75 * 74}$$

RF = -0.18

MCFT

$$RF = \frac{[1.00] * [1.0] * [0.9] * [133] - [1.25 * [55 + 18] + 1.50 * 6]}{1.75 * 74}$$

RF = 0.15

SHEAR AT STIRRUP CHANGE : 24.4 ft FROM CENTERLINE OF BEARING

SIMPLIFIED APPROACH :

$$RF = \frac{[1.00] * [1.0] * [0.9] * [97] - [1.25 * [30 + 10] + 1.50 * 3]}{1.75 * 54}$$

RF = 0.35

MCFT

$$RF = \frac{[1.0] * [1.0] * [0.9] * [128] - [1.25 * [30 + 10] + 1.50 * 3]}{1.75 * 54}$$

RF = 0.65

I - GIRDER BRIDGE (INTERIOR GIRDER)

DESIGN LOAD RATING

SERVICE III LIMIT STATE (INVENTORY LEVEL) : THE MANUAL FOR BRIDGE EVALUATION 6A.5.4.1

$$RF = \frac{f_R - (\gamma_D)(f_D)}{(\gamma_L)(LL+IM)}$$

FLEXURAL RESISTANCE, f_R :

$f_R = f_{pb}$ + ALLOWABLE TENSILE STRESS

COMPRESSIVE STRESS DUE TO EFFECTIVE PRESTRESS, f_{cpe} :

$f_{cpe} = 2.344$ ksi

ALLOWABLE TENSILE STRESS $= 0.19\sqrt{f'_c}$ LRFD Design, 5.9.4.2.2

$= 0.19 * \sqrt{5.0} = 0.425$ ksi

$f_R = 2.344 + 0.425 = 2.768$ ksi

DETERMINE DEAD LOAD STRESSES AT MIDSPAN :

$M_{DC1} = 1446$ kip-ft

$M_{DC2} = 475.3$ kip-ft

$M_{DW} = 168.8$ kip-ft

$S_{b(nc)} = 12428$ in³

$S_{b(comp)} = 14649$ in³

$$f_{DC} = \frac{1446 * 12}{12428} + \frac{475.3 * 12}{14649} = 1.79$$

$$f_{DW} = \frac{168.8 * 12}{14649} = 0.14$$

$\sum f_D = 1.92$ ksi

DETERMINE LIVE LOAD STRESSES AT MIDSPAN :

$M_{LL+I} = 1558$ kip-ft

$S_{b(comp)} = 14649$ in³

$$f_{LL+I} = \frac{1558 * 12}{14649} = 1.28$$

THE MANUAL FOR BRIDGE EVALUATION, TABLE 6A.4.2.2-1

$\gamma_{LL} = 0.8$

LRFD Design, Table 3.4.1-1

$$RF = \frac{2.768 - (1.0 * 1.92)}{0.8 * 1.28}$$

$RF = 0.83$

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I - GIRDER BRIDGE (INTERIOR GIRDER)

PERMIT LOAD RATING — THE MANUAL FOR BRIDGE EVALUATION, 6A.4.5

PERMIT VEHICLE : CT-P204

PERMIT WEIGHT : 204 kips

ADTT (ONE DIRECTION): 5000

FROM LIVE LOAD ANALYSIS (UNDISTRIBUTED MAXIMUM):

M_{LL} = 2301 kip-ft

V_{LL} = 108.7 kips

STRENGTH II LIMIT STATE : — THE MANUAL FOR BRIDGE EVALUATION, 6A.5.4.2.1

LRFD Design, Table 3.4.1-1, 3.4.1-2

THE MANUAL FOR BRIDGE EVALUATION, TABLE 6A.4.5.4.2a-1

LOAD	LOAD FACTOR, γ
DC	1.25
DW	1.50
LL	1.35

THE MANUAL FOR BRIDGE EVALUATION, 6A.4.5.4.2b

$$g_{m1} = 0.544 * \frac{1}{1.2} = 0.453$$

$$g_{v1} = 0.598 * \frac{1}{1.2} = 0.499$$

IM = 23 % — THE MANUAL FOR BRIDGE EVALUATION, 6A.4.5.5

MAXIMUM LIVE LOAD EFFECT :

M_{LL+I} = 2301 * 0.453 * 1.23 = 1283 kip-ft

V_{LL+I} = 108.7 * 0.499 * 1.23 = 67 kip-ft

FLEXURE :

$$RF = \frac{(1.0) * (1.0) * (1.0) * (5270) - (1.25 * (1446 + 475.3) + 1.50 * 168.8)}{1.35 * 1283}$$

RF = 1.51

OK

SHEAR EVALUATION (USING MCFT): — THE MANUAL FOR BRIDGE EVALUATION, 6A.5.8

$$RF = \frac{(1.0) * (1.0) * (0.9) * (133) - (1.25 * 72.6 + 1.50 * 6.38)}{1.35 * 67}$$

RF = 0.21

I - GIRDER BRIDGE (INTERIOR GIRDER)

PERMIT LOAD RATING

SERVICE I LIMIT STATE (OPTIONAL) — THE MANUAL FOR BRIDGE EVALUATION, 6A.5.4.2.2b

$\gamma_L = \gamma_{DC} = \gamma_{DW} = 1.0$ — THE MANUAL FOR BRIDGE EVALUATION, TABLE 6A.4.5.4.2a

$g_m = 0.572$

DISTRIBUTED LIVE LOAD EFFECT, MOMENTS AT MIDSPAN :

$M_{DC1} = 1446$ kip-ft

$M_{DC2} = 475.3$ kip-ft — IM = 20 %

$M_{DW} = 168.8$ kip-ft

$M_{LL+I} = 2301 * 0.572 * 1.20 = 1581$ kip-ft

$M_{DC} + M_{DW} + M_{LL+I} = 3671$ kip-ft

SIMPLIFIED CHECK USING $0.75M_n$: — THE MANUAL FOR BRIDGE EVALUATION, C6A.4.2.2

$M_n = 5270$ kip-ft

$0.75M_n = 0.75 * 5270 = 3952$ kip-ft > 3671 kip-ft OK

$$\text{MOMENT RATIO} = \frac{0.75M_n}{M_{DC} + M_{DW} + M_{LL+I}} = 1.08$$

REFINED CHECK USING $0.9f_y$:

$f_R = 0.9\ f_{py}$ — THE MANUAL FOR BRIDGE EVALUATION, 6A.5.4.2.2b

LOW RELAXATION STRAND $= 0.9f_{pu}$ — TABLE 6A.5.4.2.2b-1

STRESS RELIEVED STRAND (TYPE 1) $= 0.85f_{pu}$

STRESS RELIEVED STRAND (TYPE 2) $= 0.8f_{pu}$

$f_R = 0.9 * (0.9f_{pu}) = 0.9 * 0.9 * 200 = 162$ ksi

$M_{cr} = 3613$ kip-ft

EFFECTIVE PRESTRESS $f_{pe} = 105.9$ ksi

$M_{DC} + M_{DW} + M_{LL+I} - M_{cr} = 58.42$ kip-ft

SECTION PROPERTIES FOR THE CRACKED COMPOSITE SECTION :

TRANSFORMED FLANGE WIDTH : $b_{trans} = 55.4$ in

$h = 56 + 0.0 + 0 = 56.0$ in

$A_{ps} = 9 * 0.788 = 7.092$ in²

$$\text{MODULAR RATIO, } n = \frac{E_{ps}}{E_{beam}} = \frac{25000}{4074} = 6.14$$

$A_{trans} = 7.092 * 6.14 = 43.52$ in²

$y = 4.75$ in

OUTER STRAND, $y = 2.25$ in

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PERMIT LOAD RATING

REFINED CHECK USING $0.9f_y$:

ASSUME NEUTRAL AXIS IS IN SLAB :

$$c = \frac{\frac{c}{2}\,(b_{trans} \times c) + (h - y)\,(A_{trans})}{(b_{trans} \times c) + (A_{trans})}$$

$$c = \frac{\left(\frac{c}{2}\right) * (55.4 * c) + (56.0 - 4.75) * 43.52}{(55.4 * c) + 43.52}$$

$$(55.40 * c^2) + (43.52 * c) = (27.7 * c^2) + 2230$$

$$(27.70 * c^2) + (43.52 * c) - 2230 = 0$$

$$c = \frac{-43.52 \pm \sqrt{43.52^2 - 4 * 27.70 * -2230}}{2 * 27.70} = \frac{-43.52 \pm \sqrt{249000.6}}{55.4}$$

$$c = 8.22 \text{ in}$$

$$I_{cr} = \frac{1}{12}(55.4) * (8.22)^3 + 55.4 * 8.22 * \left(\frac{8.22}{2}\right)^2 + 43.52 * (56.0 - 4.75 - 8.22)^2$$

$$I_{cr} = 2566 + 7697 + 80568$$

$$I_{cr} = 90831 \text{ in}^4$$

STRESS BEYOND THE EFFECTIVE PRESTRESS :

$$f_s = n * \frac{My}{I} = 6.14 * \frac{58.42 * 12 * (56.0 - 2.25 - 8.22)}{90831} = 2.156 \text{ ksi}$$

STRESS IN THE REINFORCEMENT AT PERMIT CROSSING SERVICE I :

$$f_s = 105.9 + 2.156 = 108 \text{ ksi} < f_R = 162 \text{ ksi}$$

OK

$$\text{STRESS RATIO} = \frac{162}{108} = 1.50 > 1$$

OK

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I - GIRDER BRIDGE (INTERIOR GIRDER)

SUMMARY OF RATING FACTORS ("AS BUILT" CONDITION)

LIMIT STATE	DESIGN LOAD RATING (HL-93)		PERMIT LOAD RATING				
	INVERTORY	OPERATING	CT-P204	CT-L73	CT-P76.5	CT-P380	CT-TLC
STRENGTH I							
FLEXURE (AT MIDSPAN)	0.96	1.24					
SHEAR AT : 64 in	0.15						
SHEAR AT : 20 ft	0.65						
SRENGTH II							
FLEXURE (AT MIDSPAN)			1.51	2.31	2.15	1.90	1.42
SHEAR			0.21	0.37	0.35	0.30	0.22
SERVICE III							
FLEXURE (AT MIDSPAN)	0.83						
SERVICE I			1.50				

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I - GIRDER BRIDGE (INTERIOR GIRDER)

PERMIT LOAD RATING — THE MANUAL FOR BRIDGE EVALUATION, 6A.4.5

PERMIT VEHICLE : CT-L73.0

PERMIT WEIGHT : 73 kips

ADTT (ONE DIRECTION): 5000

FROM LIVE LOAD ANALYSIS (UNDISTRIBUTED MAXIMUM):

M_{LL} = 1129.5 kip-ft

V_{LL} = 47.1 kips

STRENGTH II LIMIT STATE : — THE MANUAL FOR BRIDGE EVALUATION, 6A.5.4.2.1

LRFD Design, Table 3.4.1-1, 3.4.1-2

THE MANUAL FOR BRIDGE EVALUATION, TABLE 6A.4.5.4.2a-1

LOAD	LOAD FACTOR, γ
DC	1.25
DW	1.50
LL	1.80

THE MANUAL FOR BRIDGE EVALUATION, 6A.4.5.4.2b

$$g_{m1} = 0.544 * \frac{1}{1.2} = 0.453$$

$$g_{v1} = 0.598 * \frac{1}{1.2} = 0.499$$

IM = 23 % — THE MANUAL FOR BRIDGE EVALUATION, 6A.4.5.5

MAXIMUM LIVE LOAD EFFECT :

M_{LL+I} = 1130 * 0.453 * 1.23 = 629.8 kip-ft

V_{LL+I} = 47.1 * 0.499 * 1.23 = 29 kip-ft

FLEXURE :

$$RF = \frac{(1.0) * (1.0) * (1.0) * (5270) - (1.25 * (1446 + 475.3) + 1.50 * 168.8)}{1.80 * 629.8}$$

RF = 2.31

OK

SHEAR EVALUATION (USING MCFT): — THE MANUAL FOR BRIDGE EVALUATION, 6A.5.8

$$RF = \frac{(1.0) * (1.0) * (0.9) * (133) - (1.25 * 72.6 + 1.50 * 6.38)}{1.80 * 29}$$

RF = 0.37

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I - GIRDER BRIDGE (INTERIOR GIRDER)

PERMIT LOAD RATING — THE MANUAL FOR BRIDGE EVALUATION, 6A.4.5

PERMIT VEHICLE : CT-P76.5

PERMIT WEIGHT : 76.5 kips

ADTT (ONE DIRECTION): 5000

FROM LIVE LOAD ANALYSIS (UNDISTRIBUTED MAXIMUM):

M_{LL} = 1214.4 kip-ft

V_{LL} = 50.1 kips

STRENGTH II LIMIT STATE : — THE MANUAL FOR BRIDGE EVALUATION, 6A.5.4.2.1

LRFD Design, Table 3.4.1-1, 3.4.1-2

THE MANUAL FOR BRIDGE EVALUATION, TABLE 6A.4.5.4.2a-1

LOAD	LOAD FACTOR, γ
DC	1.25
DW	1.50
LL	1.80

THE MANUAL FOR BRIDGE EVALUATION, 6A.4.5.4.2b

$$g_{m1} = 0.544 * \frac{1}{1.2} = 0.453$$

$$g_{v1} = 0.598 * \frac{1}{1.2} = 0.499$$

IM = 23 % — THE MANUAL FOR BRIDGE EVALUATION, 6A.4.5.5

MAXIMUM LIVE LOAD EFFECT :

M_{LL+I} = 1214 * 0.453 * 1.23 = 677.1 kip-ft

V_{LL+I} = 50.1 * 0.499 * 1.23 = 31 kip-ft

FLEXURE :

$$RF = \frac{(1.0) * (1.0) * (1.0) * (5270) - (1.25 * (1446 + 475.3) + 1.50 * 168.8)}{1.80 * 677.1}$$

RF = 2.15

OK

SHEAR EVALUATION (USING MCFT): — THE MANUAL FOR BRIDGE EVALUATION, 6A.5.8

$$RF = \frac{(1.0) * (1.0) * (0.9) * (133) - (1.25 * 72.6 + 1.50 * 6.38)}{1.80 * 31}$$

RF = 0.35

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I - GIRDER BRIDGE (INTERIOR GIRDER)

PERMIT LOAD RATING — THE MANUAL FOR BRIDGE EVALUATION, 6A.4.5

PERMIT VEHICLE : CT-P380

PERMIT WEIGHT : 380 kips

ADTT (ONE DIRECTION): 5000

FROM LIVE LOAD ANALYSIS (UNDISTRIBUTED MAXIMUM):

M_{LL} = 2144.3 kip-ft

V_{LL} = 92.6 kips

STRENGTH II LIMIT STATE : — THE MANUAL FOR BRIDGE EVALUATION, 6A.5.4.2.1

LOAD	LOAD FACTOR, γ
DC	1.25
DW	1.50
LL	1.15

LRFD Design, Table 3.4.1-1, 3.4.1-2
THE MANUAL FOR BRIDGE EVALUATION, TABLE 6A.4.5.4.2a-1

THE MANUAL FOR BRIDGE EVALUATION, 6A.4.5.4.2b

$$g_{m1} = 0.544 * \frac{1}{1.2} = 0.453$$

$$g_{v1} = 0.598 * \frac{1}{1.2} = 0.499$$

IM = 23 % — THE MANUAL FOR BRIDGE EVALUATION, 6A.4.5.5

MAXIMUM LIVE LOAD EFFECT :

M_{LL+I} = 2144 * 0.453 * 1.23 = 1196 kip-ft

V_{LL+I} = 92.6 * 0.499 * 1.23 = 57 kip-ft

FLEXURE :

$$RF = \frac{(1.0) * (1.0) * (1.0) * (5270) - (1.25 * (1446 + 475.3) + 1.50 * 168.8)}{1.15 * 1196}$$

RF = 1.90

OK

SHEAR EVALUATION (USING MCFT): — THE MANUAL FOR BRIDGE EVALUATION, 6A.5.8

$$RF = \frac{(1.0) * (1.0) * (0.9) * (133) - (1.25 * 72.6 + 1.50 * 6.38)}{1.15 * 57}$$

RF = 0.30

BY: m.g.
CHKD.BY: BA DATE 3/17/11

BRIDGE NO.00596

I - GIRDER BRIDGE (INTERIOR GIRDER)

PERMIT LOAD RATING — THE MANUAL FOR BRIDGE EVALUATION, 6A.4.5

PERMIT VEHICLE : CT-TLC

PERMIT WEIGHT :

ADTT (ONE DIRECTION): 5000

FROM LIVE LOAD ANALYSIS (UNDISTRIBUTED MAXIMUM):

M_{LL} = 2699.9 kip-ft

V_{LL} = 115.6 kips

STRENGTH II LIMIT STATE : — THE MANUAL FOR BRIDGE EVALUATION, 6A.5.4.2.1

LRFD Design, Table 3.4.1-1, 3.4.1-2

THE MANUAL FOR BRIDGE EVALUATION, TABLE 6A.4.5.4.2a-1

LOAD	LOAD FACTOR, γ
DC	1.25
DW	1.50
LL	1.50

THE MANUAL FOR BRIDGE EVALUATION, 6A.4.5.4.2b

$$g_{m1} = 0.544 * \frac{1}{1.2} = 0.453$$

$$g_{v1} = 0.598 * \frac{1}{1.2} = 0.499$$

IM = 0 % — THE MANUAL FOR BRIDGE EVALUATION, 6A.4.5.5

MAXIMUM LIVE LOAD EFFECT :

M_{LL+I} = 2700 * 0.453 * 1.00 = 1224 kip-ft

V_{LL+I} = 115.6 * 0.499 * 1.00 = 58 kip-ft

FLEXURE :

$$RF = \frac{(1.0) * (1.0) * (1.0) * (5270) - (1.25 * (1446 + 475.3) + 1.50 * 168.8)}{1.50 * 1224}$$

RF = 1.42

OK

SHEAR EVALUATION (USING MCFT): — THE MANUAL FOR BRIDGE EVALUATION, 6A.5.8

$$RF = \frac{(1.0) * (1.0) * (0.9) * (133) - (1.25 * 72.6 + 1.50 * 6.4)}{1.50 * 58}$$

RF = 0.22

BRIDGE NO.00596

ROUTE 68 OVER NAUGATTUCK RIVER, ROUTES 8, 710 AND METRO NORTH TRACKS

NAUGATUCK, CT

INTERIOR GIRDER "B"

BY: B.A.
CHKD.BY: DATE: 3/08/2010

iii

BRIDGE NO.00596
ROUTE 68 OVER NAUGATUCK RIVER, ROUTES 8 & 710 & METRO NORTH TRACKS, NAUGATUCK, CT

STRUCTURE TYPE: POST-TENSIONED CONCRETE I GIRDERS
YEAR BUILD:1958, 1960
1963, 1987, 1993 (REHAB.)
DECK WIDTH OUT TO OUT: 64' - 6" DECK WIDTH CURB TO CURB: 50' - 0"
DECK THICKNESS AND TYPE: 8" CONCRETE, CAST BETWEEN BEAMS WITH 2 1/2" BITUMNOUS OVERLAY
CONCRETE COMPRESSIVE STRENGTH: f'c= 5000 psi (P/S CONC. GIRDERS)
f's= 250,000 psi (PRE-STRESSING STEEL) f's= 200,000 psi (POST-TENSIONING STEEL)
BEAM SPACING: 5' - 11½"
SPAN LENGTHS: 75.54' (SPAN 1 & 6)
97.5' (SPANS 2- 5)

LOAD RESISTANCE FACTOR RATING SUMMARY (LRFR)
HL-93, L73.0 (4 Axle), L3S2 (5 Axle), P76.5 (4 Axle), P204 (8 Axle), P380 (19 Axle), TLC (9 Axle)

LRFR STRENGTH I LIMIT STATE				INVENTORY Flexure FACTOR	OPERATING Flexure FACTOR	INVENTORY Shear FACTOR	OPERATING Shear FACTOR
SPAN(S)	MEMBER(S)		LOCATION				
1 & 6	Interior Girder (As Built)	HL-93	Flexural @ Midspan Shear @ .05L	1.30	1.60	*	***0.30***
		L73.0		*	2.90	*	***0.65***
		L3S2		*	4.00	*	***0.81***
		P76.5		*	*	*	*
		P204		*	*	*	*
		P380		*	*	*	*
		TLC		*	*	*	*

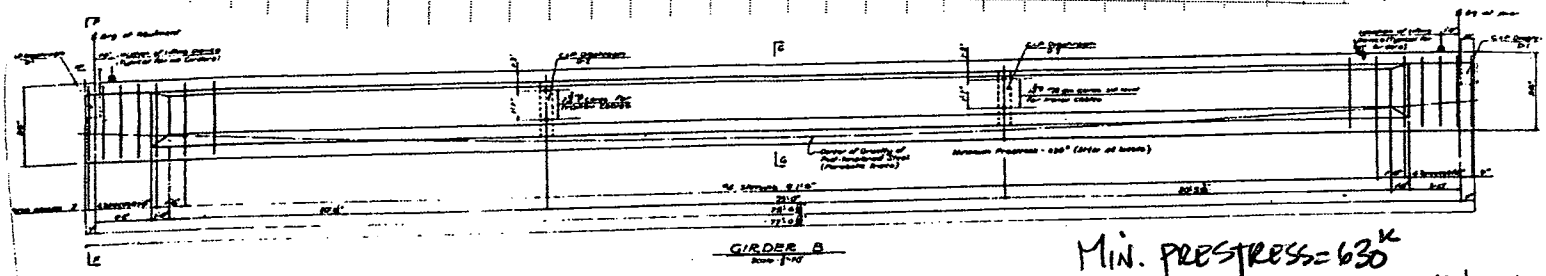
LRFR STRENGTH II LIMIT STATE				INVENTORY Flexure FACTOR	OPERATING Flexure FACTOR	INVENTORY Shear FACTOR	OPERATING Shear FACTOR
SPAN(S)	MEMBER(S)		LOCATION				
1 & 6	Interior Girder (As Built)	HL-93	Flexural @ Midspan Shear @ .05L	*	*	*	*
		L73.0		*	*	*	*
		L3S2		*	*	*	*
		P76.5		*	2.70	*	***0.69***
		P204		*	2.10	*	***0.56***
		P380		*	2.70	*	***0.82***
		TLC		*	1.60	*	***0.46***

Close, Jensen and Miller, P.C.

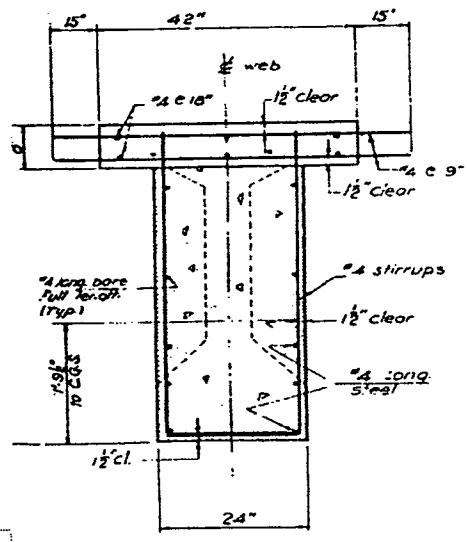
BY BA DATE 12/7/10 SUBJECT PR 596 SHEET NO. 1B OF

CHKD. BY DATE ROUTE 6B, O/NAUGATUCK JOB NO.

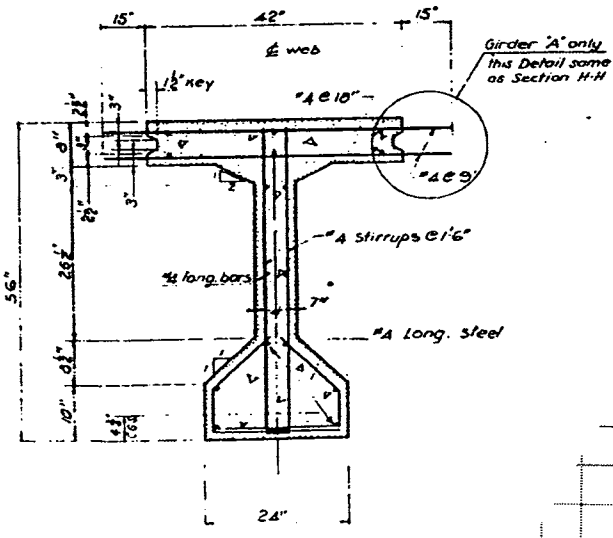
RIVER, RTE 8, MNRR, SR 710 NAUGATUCK



MIN. PRESTRESS = 630K
AFTER ALL LOSSES



SECTION F-F
Scale: ¾" = 1'-0"



SECTION G-G
Scale: ¾" = 1'-0"

GIRDER B

75.53'

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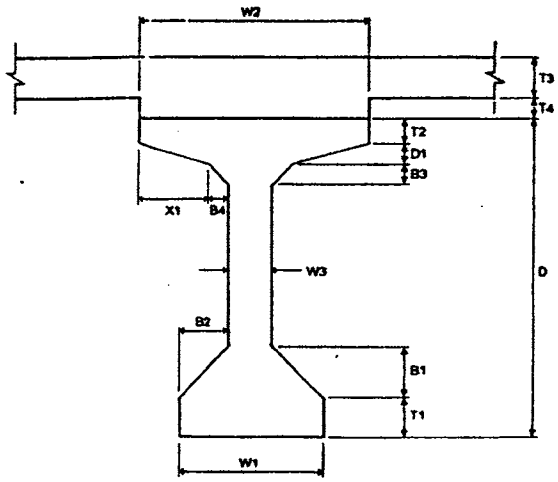
BY BA DATE 12/2/10 SUBJECT BR. 596 SHEET NO. 2B OF
CHKD. BY DATE ROUTE 68 O/ NAUGATUCK JOB NO.
RIVER, RTE 8, MNRR, SR 710 NAUGATUCK

GIRDER B

BEAM DIMENSIONS

TYPE	I
COMP	N
D	56"
W1	24"
W2	42"
W3	7"
T1	10"
T2	8"
B1	8½"
B2	8½"
B3	3"
B4	6"
D1	0
D2	0
X1	0
X2	0

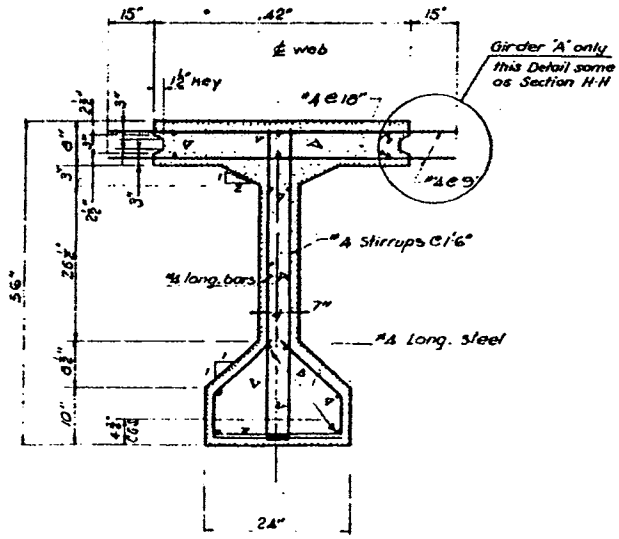


AASHTO Type 5 I beam

FROM REF. 3

Figure 4.7.3 Beam Dimensions - I Beams

- 82 -



SECTION G-G (GIRDER B)
SPAN 1 O.K.

SLAB THICK BLANK, HAUNCH - BLANK

Close, Jensen and Miller, P.C.

BY BA DATE 12/2/10 SUBJECT BR. 596 SHEET NO. 3B OF
CHKD. BY DATE ROUTE 68 O/ NAUGATUCK JOB NO.
RIVER, RTE 8, MNRR, SR 110 NAUGATUCK

GIRDER B - (DIAPHRAGM DETAILS)

$$\text{WEIGHT} = .15^{\text{KCF}} \left[\frac{38'' \times 8'' \times (71.5'' - 7'')}{1728} - \frac{3'' \times 6'' \times 8''}{1728} - \frac{8.5'' \times 8.5'' \times 8''}{1728} \right]$$

WEIGHT OF DIAPHRAGM D2 = 1.64 k

THICKNESS OF DIAPHRAGM = 8"

OF EXTERIOR DIAPHRAGM = 2

DISTANCE = 25.27' DIAPH. 1 (12'-7¼" + 12'-8") EXT.

DISTANCE = 50.27' DIAPH. 2 (25.27' + 12'-6" + 12'-6") EXT.

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BY BA DATE 12/2/10 SUBJECT BR. 596 SHEET NO. 4B OF
CHKD. BY DATE ROUTE 6B, NAUGATUCK JOB NO.
RIVER, ROUTE 8, MNRR, SR 710 NAUGATUCK

GIRDER B

DRAPE POINT:

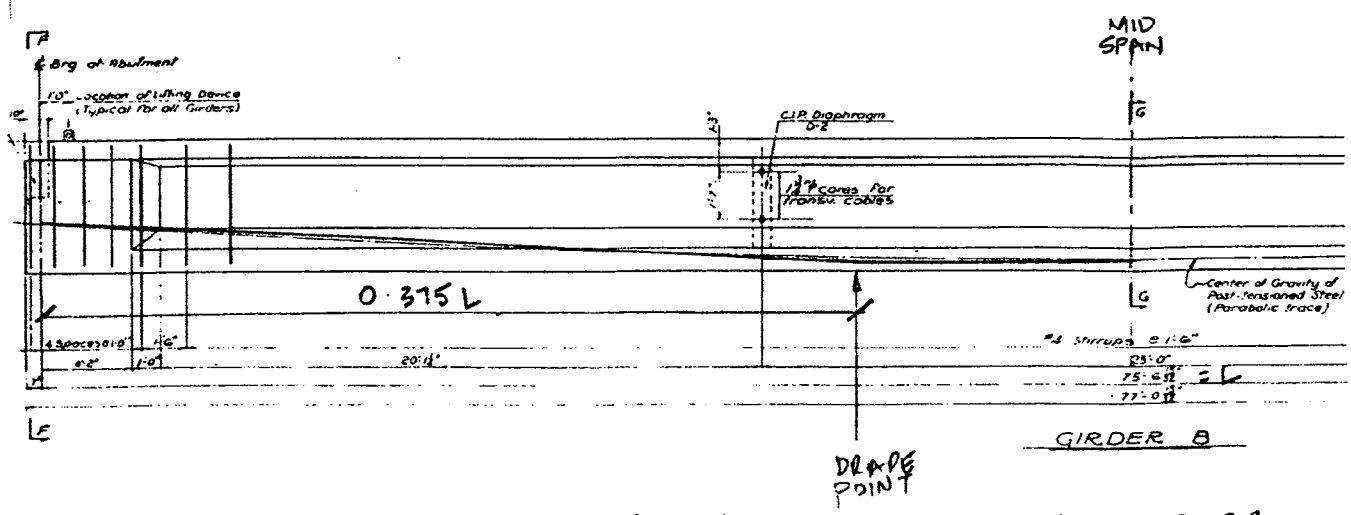
SINCE THE PS3 PROGRAM CAN ONLY RATE PRETENSIONED BEAMS, THERE IS NO PROVISION IN THE PROGRAM TO MODEL A PARABOLIC PROFILE FOR THE P/S STEEL.

∴ P/S STEEL WILL BE MODELED WITH A DRAPED PROFILE WITH MINIMAL VARIATION FROM THE PARABOLIC PROFILE

- A VALUE OF XDRAPE = 0.5 WOULD RESULT IN THE P/S STEEL BEING MODELED ABOVE THE PARABOLIC PROFILE (WITH A REDUCED e) FOR THE FULL LENGTH, WHICH WOULD BE TOO CONSERVATIVE

- A VALUE OF XDRAPE = 0.25 WOULD RESULT IN THE P/S STEEL BEING MODELED BELOW THE PARABOLIC PROFILE (WITH AN INCR. e) FOR THE FULL LENGTH, WHICH IS UNCONSERVATIVE

∴ AN INTERMEDIATE VALUE OF XDRAPE = 0.375 WAS SELECTED AS SHOWN BELOW.



Note: By modelling a parabolic profile with a draped profile at 0.375 L, conservative results will be obtained up to 0.30 L± while slightly liberal results will be obtained between 0.30 ±L ~ 0.50 ±L. See the calculated ratio of $e_{Draped}/e_{parabolic}$ on Pg 38 for comparison purposes.

Close, Jensen and Miller, P.C.

BY BA DATE 11/3/10 SUBJECT BR. 596 SHEET NO. 5B OF
CHKD. BY DATE ROUTE 68, NAUGATUCK
RIVER, RTE 8, MNRR, SR710 JOB NO. NAUGATUCK

INITIAL PRESTRESSING FORCE = 630^k AFTER ALL LOSES FOR GIRDER B

ASSUME 20% LOSSES (SHEET PR-10 OF 15)
PROJ # 87-78 (1957)

INITIAL PRESTRESSING FORCE = $\frac{630^k}{1-.2}$ = 787.5 k

ECCENTRICITY:
@ MIDSPAN = 30.21" − 4.75" = 25.46"
@ END = 30.21" − 21.5" = 8.71"

PRESTRESSING LOSS (ASSUME) = 20%

DRAPE POINT @ = .375 FOR STRESS RELIEVED STRANDS

SPAN 1 & 5 LENGTH = 75.539' ℄ BRG. TO ℄ BRG.

BEAM PROJECTION = $\frac{7+11}{2}$ = 9" AVG.

FOR BEAM B

Close, Jensen and Miller, P.C.

BY BA DATE 12/2/10 SUBJECT BR 596 SHEET NO. 6B OF
CHKD. BY DATE ROUTE 6B O/ NAUGATUCK JOB NO.
RIVER, RTE 8, MNRR, SR 710 NAUGATUCK

GIRDER B

PRESTRESSING STEEL:

PLANS GIVE THE FOLL. INFO REGARDING P/S POST-TENSIONED STEEL:

f'_s = 200,000 psi (MIN.)

MIN P/S AFTER LOSSES = 630 k

2-7 Steel, Some Practical Notes (FROM REF. 9)

Information about the available size and length of various prestressing steels can be obtained from the respective manufacturers (see Appendix B). For the purpose of design, however, it will be convenient to know in advance what sizes and lengths are available so that designs can be made accordingly. In continental Europe, smooth wires 2 and 3 (sometimes 2.5) mm in diameter and corrugated wires of 4 and 5 mm are most frequently employed in pre-tensioning work. Small wires possess higher unit strength and furnish better bond, which is often vital in pre-tensioning. In order to save labor and anchorage costs, larger wires are preferred for post-tensioning. For the common systems, such as the Freyssinet and the Magnel, the anchorages are manufactured for the 5- and 7-mm wires. Such wires still possess high strength and there are fewer units to handle. Hence they have become popular and almost monopolize the post-tensioning field.

In England, wires are based on the British Imperial Gauge, No. 2 of which has a diameter of 0.276 in., exactly 7 mm, while No. 6 has a diameter of 0.192 in., which is very close to 5 mm. Hence gage Nos. 2 and 6 are sometimes called for in post-tensioning, while the exact equivalents of 7 and 5 mm (0.276 and 0.196 in., respectively) are also frequently employed. In Germany, corrugated wires with flattened cross section are widely used for post-tensioning. These wires have areas equal to 5- or 7-mm round ones.

In this country, wires are manufactured according to the U.S. Steel Wire Gage, No. 2 of which has a diameter of 0.2625 in. and No. 6 has a diameter of 0.1920 in. Neither of these is the exact equivalent of the millimeter counterparts. Hence, when the European types of anchorages are adopted, 0.276-in. and 0.196-in. wires are often specified. For post-tensioning systems developed in the United States, ¼-in. wires have been most commonly incorporated. Smaller wires, with diameters of 3 mm (0.118 in.), are common for pre-tensioning without mechanical end anchorages. Where mechanical end anchorages

¼" WIRES WOULD REQUIRE A LARGE NO. OF WIRES TO GET 630k FINAL FORCE

are provided, ⅜-in. wires have been successfully employed for pre-tensioning.

Seven-wire strands for pre-tensioning have nominal diameters of ¼, 5/16, ⅜, 7/16, and ½ in.; while post-tensioning strands with more wires per strand range from ½ in. to 1 11/16 in. in diameter, with steel area up to 1.73 sq in.

∴ BASED ON ABOVE 2 STATEMENTS, ASSUME THAT STRANDS WITH 19 OR MORE GALVANIZED WIRES WERE USED.

SEE NEXT PG. FOR SELECTION OF STRAND DIA.

2-5 Steel, Physical Properties (FROM REF. 9)

The ultimate strength of steel wires, strands, or bars varies with their manufacture, so that it is frequently necessary to obtain sample tests for each lot of products. However, the general range of values is listed in the table.

	Ultimate Strength, psi
Wires of varying diameters and make	200,000–330,000
Strands of 7 uncoated small wires	230,000–270,000
Strands of 19 or more galvanized wires	200,000–220,000
Strands of 19 or more uncoated wires	220,000–240,000
Bars	140,000–170,000

ONLY THESE 2 TYPES OF P/S STEEL HAVE 200 ksi AS f'_s (MIN.)

Close, Jensen and Miller, P.C.

BY BA DATE 12/2/10 SUBJECT BR. 596 SHEET NO. 7B OF
CHKD. BY DATE ROUTE 68 O/ NAUGATUCK JOB NO.
RIVER, RTE 8, MNRR, SR 710 NAUGATUCK

GIRDER B

PRESTRESSING STEEL (CONTD.):

∴ TOTAL P/S FORCE (AFTER LOSSES) = 630^k, A STRAND DIA WAS SELECTED FROM THE FOLL TABLE THAT GIVES AN EXACT MULTIPLE FOR NO. OF STRANDS.

∴ 1⅛" ϕ STRANDS WERE ASSUMED SINCE

$$\frac{630^k}{90^k \text{ (FROM TABLE BELOW)}} = 7 \text{ STRANDS}$$

Galvanized Strands for Post-Tensioning (PGS. 9)

Diameter, in.	Weight per Foot, lb	Area, sq in.	Minimum Guaranteed Ultimate Strength, lb	Design Load, lb
0.600	0.737	0.215	46,000	26,000
0.835	1.412	0.409	86,000	49,000
1	2.00	0.577	122,000	69,000
1⅛	2.61	0.751	156,000	90,000
1¼	3.22	0.931	192,000	112,000
1⅜	3.89	1.12	232,000	134,000
1½	4.70	1.36	276,000	163,000
1 9/16	5.11	1.48	300,000	177,000
1⅝	5.52	1.60	324,000	192,000
1 11/16	5.98	1.73	352,000	208,000

The average modulus of elasticity of the strands in the above table is 25,000,000 psi.

$f_s = \frac{90^k}{0.751 \text{ in}^2}$

= 120 ksi

= 0.6 f'_s ALLOWABLE FROM PLANS

∴ OK

∴ ASSUME 7 STRANDS WITH A DIA. OF 1⅛" & E = 25,000 ksi

Close, Jensen and Miller, P.C.

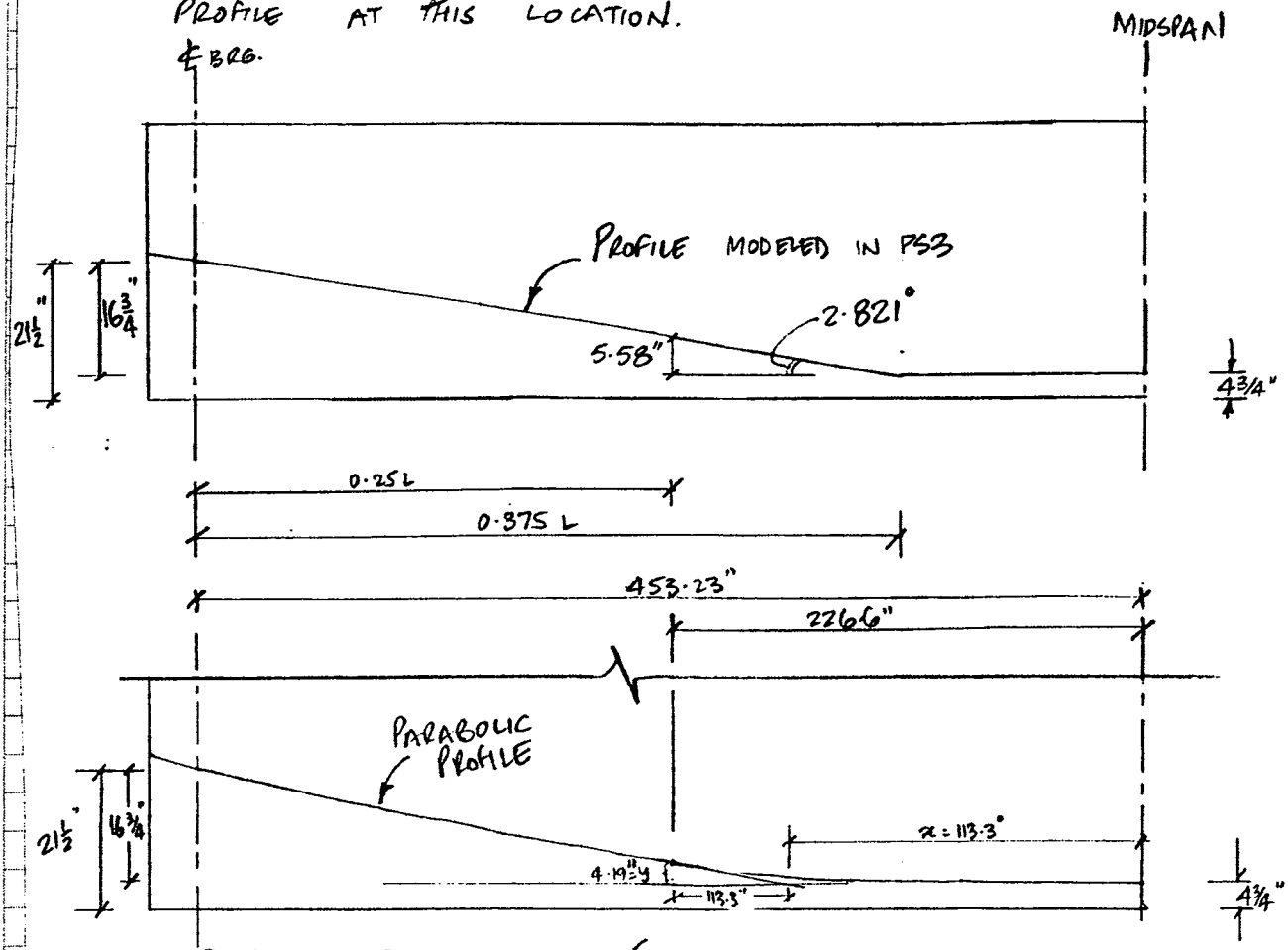
BY EA DATE 12/2/10 SUBJECT B1.596 SHEET NO. 8B OF
CHKD. BY DATE ROUTE 68 O/ NAVGATUK JOB NO.
RIVER, RTE 8, MNRR, SR 710 NAVGATUK

GIRDER B

CRITICAL LOCATION FOR RATING:

FROM OUTPUT FILE "GIRDER-B.OUT", CRITICAL RATING LOCATION IS AT, 0.25 L & SHEAR GOVERNS.

∴ RERUN PS3 WITH ECCENTRICITY & ANGLE AS PER PARABOLIC PROFILE AT THIS LOCATION.



WITH VERTEX @ ORIGIN

$x^2 = 2py$

$453.23^2 = 2p(16\tfrac{3}{4})$

∴ $p = 6131.86''$

∴ FOR $x = 226.6''$

$y = \dfrac{226.6^2}{2(6131.86)}$

$= \underline{\underline{4.19''}}$

FIND ANGLE

$x_0 = y_0 = 0$

$x_1 = 226.6''$

$y_1 = 4.19''$

$y = 0$

x: $y = \dfrac{2(y_1 - y_0)(x - x_1)}{x_1 - x_0} + y_1$

∴ $0 = \dfrac{2(4.19 - 0)(x - 226.6)}{(226.6 - 0)} + 4.19$ ∴ $x = 113.3''$

(SEE NEXT PG. FOR PARABOLA PROPERTIES)

∴ $\measuredangle = \tan^{-1} \dfrac{4.19}{113.3} = \underline{\underline{2.118°}}$

Close, Jensen and Miller, P.C.

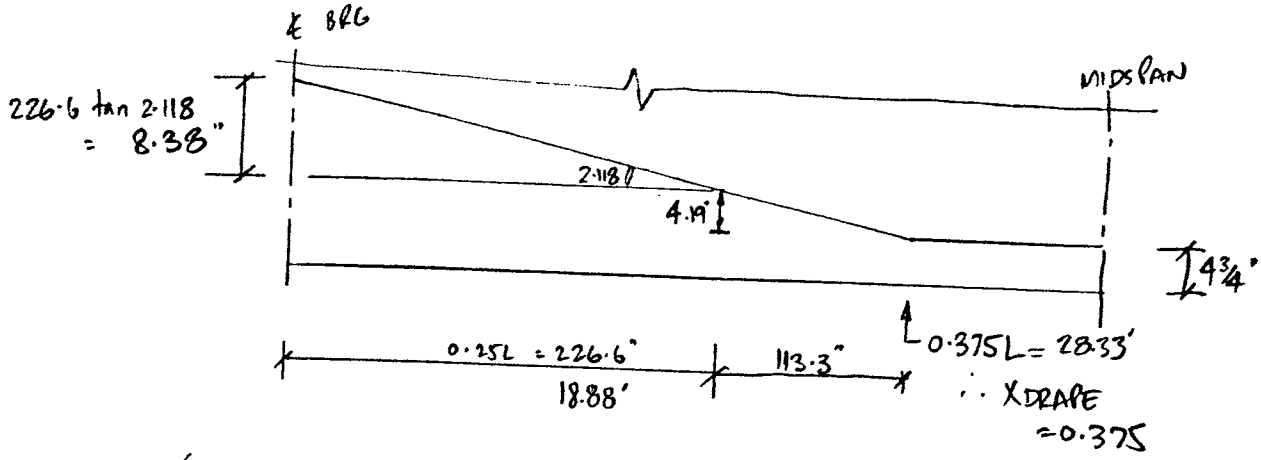
BY BA DATE 12/2/10 SUBJECT BR. 596 SHEET NO. 9B OF

CHKD. BY DATE ROUTE 68 O/ NAUGATUCK JOB NO.

RIVER, RTE 8, MNRR, SR710 NAUGATUCK

Location	0.30 ℓ	0.35 ℓ	0.40 ℓ	0.45 ℓ	0.50 ℓ	
e_{draped} @0.375L	22.11	24.34	25.46	25.46	25.46	B<1 ⇒ Conservative
$e_{parabolic}$	22.77	23.95	24.79	25.29	25.46	B>1 ⇒ Liberal
e_{draped} / $e_{parabolic}$ = B	0.97	1.01	1.03	1.00	1.00	

@ 0.25L { REQD e = 30.21" − 4.19" − 4.75" = 21.27" ; REQD ∡ = 2.118° } critical location for rating



∴ { e_{end} = 30.21" − 8.38" − 4.19" − 4.75" = 12.89" } ← MAKE THIS CHG. TO FILE ONLY FOR CORRECT RATING AT 0.25L.

$e_{m/s}$ = 30.21 − 4.75 = 25.46" } SAME AS BEFORE

XDRAPE = 0.375

THIS DATA WILL PROVIDE CORRECT e & ∡ OF P/S STEEL (AS PER PARABOLIC PROFILE) AT 0.25L.

Parabola (FROM REF. 10)

Parabola equation (by converting to this equation the vertex and parameter p may be ascertained)

	vertex at the origin	vertex elsewhere	parabola open at
f 19	$x^2 = 2py$	$(x-x_0)^2 = 2p(y-y_0)$	top
f 20	$x^2 = -2py$	$(x-x_0)^2 = -2p(y-y_0)$	bottom

F: focus
L: directrix
S: tangent at the vertex

Basic equation

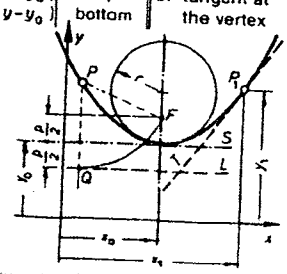
f 21 $y = ax^2 + bx + c$

f 22 **Vertex radius** $r = p$

f 23 **Basic property** $\overline{PF} = \overline{PQ}$

Tangent T at point P_1 (x_1, y_1)

f 24 $y = \dfrac{2(y_1 - y_0)(x - x_1)}{x_1 - x_0} + y_1$



Close, Jensen and Miller, P.C.

BY EA DATE 12/2/10 SUBJECT BR. 596 SHEET NO. 10 B OF
CHKD. BY DATE ROUTE 68 O/ NAUGATUCK JOB NO.
RIVER, RTE. 8, MAIN., SR 710 NAUGATUCK

GIRDER B

STRAND DETAILS

STRAND DIAMETER = 1.125"

STRAND AREA = .751 in² 1 1/8"Ø

G1	2"
G2	4.75"
R1	7

GIRDER B

STIRRUP DETAILS

SPEC A

STIRRUP AREA .2 in²

f_{sy} 40 ksi REF. 2 SECTION 6.6.3.2

STIRRUP LOCATION 0

SPACING 12"

LOCATION 3.66

SPACING 18"

Close, Jensen and Miller, P.C.

BY BA DATE 3/11/11 SUBJECT BR. 596 SHEET NO. 11B OF

CHKD. BY DATE ROUTE 68 O/ NAUGATUCK JOB NO.

LRFR RATING RIVER, RTE 8, MNRR, SR 710 NAUGATUCK

RATING THE INTERIOR GIRDER B10 (SPAN 1) PRESTRESSED CONCRETE GIRDER

AT MIDSPAN FOR MOMENT
AT CRITICAL SECTION FOR SHEAR
AT CHANGE IN STIRRUP SPACING FOR SHEAR

BASED ON "AS-BUILT" CONDITION

SPAN: 75.54'

YEAR BUILT: 1963 (REHAB. 1987 & 1993)

MATERIALS:

CONCRETE: $f'_c = 5$ ksi (P/S BEAM)

$f'_{ci} = 4$ ksi (P/S BEAM AT TRANSFER)

PRESTRESSING STEEL: 3/8" STRESS RELIEVED STRANDS

$A_{ps} = .751$ in^2 TOTAL (STRAND $\phi = 1.125$")

630^k POST TENSIONING P/S FORCE AFTER LOSS

EQUIVALENT: 7 - 1 1/8" ϕ STRANDS $7 \times 90^k = 630^k$

1 1/8" ϕ A = .751 in^2
DESIGN LOAD = 90^k

STIRRUPS: #4 @ 12" A = .2 in^2 0'-3.66'
#4 @ 18" A = .13 in^2

COMPRESSION STEEL: 5 - #4 @ 12" GRADE 40 ksi

CONDITION: NBI ITEM 59 CODE = 6 MINOR DETERIORATIONS

RIDING SURFACE: SOME SURFACE DEVIATIONS

ADTT (ONE DIRECTION): 2000 USE 5000 ADTT

SKEW: 0°

Close, Jensen and Miller, P.C.

BY BA DATE 3/11/11 SUBJECT BR. 596 SHEET NO. 12 B OF

CHKD. BY DATE PART 68 O/ NAUGATUCK JOB NO.

RIVER, RTE 8, MINN, SR 710 NAUGATUCK

LRFD 4.6.2.6.1

EFFECTIVE FLANGE WIDTH: b_e

MINIMUM OF:

1) $\frac{1}{4}L = \frac{1}{4}(75.54) = 18.89 \times 12 = 226.6$ in

2) $12t_s + \frac{1}{2} b_{f_{top}} = 12 \times 8'' + \frac{1}{2} \times 42'' = 117$ in

3) $S = 5.958' \times 12 = 71.5$ in ← GOVERNS

EFFECTIVE FLANGE WIDTH $b_e = 71.5$ in

$E_{c_D} = 33000\, w_c^{1.5} \sqrt{f'_c} = 33000 \times (.15)^{1.5} \sqrt{4} = 3834$ ksi

$E_{c_P} = 33000\, w_c^{1.5} \sqrt{f'_c} = 33000 \times (.15)^{1.5} \sqrt{5} = 4287$ ksi P/S BEAM

MODULAR RATIO: $n = \frac{E_{Deck}}{E_{Beam}} = \frac{3834}{4287} = .89$

TRANSFORMED WIDTH, $b_{Trans} = 71.5'' \times .89 = 63.63$ in

SUMMARY OF SECTION PROPERTIES:

$h = 56''$

$A = 9322$ in^2

$I = 375443.9$ in^4

$S_b = 12429.4$ in^3 $S_T = 14555.3$ in^3

$Y_b = 30.21$ in $Y_T = 25.79$ in

BR.00596 (13) B

INPUT ECC = 25.460 IN.
COMPUTED ECC = 25.456 IN.

THE PROGRAM WILL CONTINUE WITH ECC = 25.460 IN.
(BASED ON INPUT ECCENTRICITY)

****
* RATING OF AN INTERIOR BEAM *
****

BASIC BEAM SECTION PROPERTIES

DEPTH IN	AREA IN.2	WEIGHT LBS/FT	M OF I IN.4	N.A. TO TOP YT IN.	N.A. TO BOT YB IN	Z TOP IN.3	Z BOT IN.3
56.00	932.2	971.09	375443.9	25.79	30.21	14555.3	12429.6

UNIFORM DEAD LOADS ACTING ON GIRDER (KIPS/FT)

GIRDER WEIGHT	FORMWORK WEIGHT	INPUT DL1	FUTURE WEARING SURFACE	INPUT DL2	TOTAL DL1	TOTAL DL2
0.9711	0.0000	0.2460	0.0000	0.3970	1.2171	0.3970

DEAD LOAD AND LIVE LOAD REACTIONS

DL1 REACTION	DL2 REACTION	IMPACT FACTOR	LL+I HS20 REACTION
47.6	15.0	1.249	47.6 T

PRESTRESSING FORCE (STRAND PATTERN UNKNOWN)

INITIAL	LOSS %	EFFECTIVE	NO. OF STRANDS
787.500	20.00	630.000	7

	ECCENTRICITY	C.G.S (GM)
AT MID SPAN:	25.460	4.746

	ECCENTRICITY	C.G.S (GE)
AT CL BRG.:	8.710	21.496

****
* RATING SUMMARY *
****

BR.00596 14B

INPUT ECC = 25.460 IN.
COMPUTED ECC = 25.456 IN.

THE PROGRAM WILL CONTINUE WITH ECC = 25.460 IN.
(BASED ON INPUT ECCENTRICITY)

****
* RATING OF AN INTERIOR BEAM *
****

BASIC BEAM SECTION PROPERTIES

DEPTH IN	AREA IN.2	WEIGHT LBS/FT	M OF I IN.4	N.A. TO TOP YT IN.	N.A. TO BOT YB IN	Z TOP IN.3	Z BOT IN.3
56.00	932.2	971.09	375443.9	25.79	30.21	14555.3	12429.6

UNIFORM DEAD LOADS ACTING ON GIRDER (KIPS/FT)

GIRDER WEIGHT	FORMWORK WEIGHT	INPUT DL1	FUTURE WEARING SURFACE	INPUT DL2	TOTAL DL1	TOTAL DL2
0.9711	0.0000	0.2460	0.0000	0.3970	1.2171	0.3970

DEAD LOAD AND LIVE LOAD REACTIONS

DL1 REACTION	DL2 REACTION	IMPACT FACTOR	LL+I HS20 REACTION
47.6	15.0	1.249	47.6 T

PRESTRESSING FORCE (STRAND PATTERN UNKNOWN)

INITIAL	LOSS %	EFFECTIVE	NO. OF STRANDS
787.500	20.00	630.000	7

	ECCENTRICITY	C.G.S (GM)
AT MID SPAN:	25.460	4.746

	ECCENTRICITY	C.G.S (GE)
AT CL BRG.:	12.890	17.316

Close, Jensen and Miller, P.C.

BY BA DATE 3/11/11 SUBJECT BR. 596 SHEET NO. 15 B OF

CHKD. BY DATE ROUTE 68 O/ NAUGATUCK JOB NO.

RIVER, RTE 8, MNBR, SR 710 NAUGATUCK

DEAD LOAD ANALYSIS (INTERIOR GIRDER)

DL1 : .246 + .971 = 1.22 k/'

DL2 : = .4 k/'

$V_{DL1} = 1.22^{k/'} \times 75.54'/2 = 46.1^{k}$ AT SUPPORT

$M_{DL1} = 1.22^{k/'} \times 75.54^2/8 = 870.2^{k\text{-}FT}$ AT MID-SPAN

$V_{DL2} = .4^{k/'} \times 75.54'/2 = 15.1^{k}$ AT MIDSPAN

$M_{DL2} = .4 \times 75.54^2/8 = 285.3^{k\text{-}FT}$ AT SUPPORT

$V_{DLW} = .14 \times 75.54/2 = 5.3^{k}$ AT SUPPORT

$M_{DLW} = .14 \times 75.54^2/8 = 99.9^{k\text{-}FT}$ AT MIDSPAN

Close, Jensen and Miller, P.C.

BY BA DATE 3/11/11 SUBJECT BR. 596 SHEET NO. 16 B OF

CHKD. BY DATE ROUTE 68 O/ NAUGATUCK JOB NO.

RIVER, RTE 8, MNRR, SR710 NAUGATUCK

LIVE LOAD ANALYSIS:

LRFD TABLE 4.4.6.2.2.1-1

COMPUTE LL DISTRIBUTION FACTORS, g

AASHTO LRFD TYPE (j) CROSS SECTION

LONGITUDINAL STIFFNES PARAMETER, K_g:

$K_g = n(I + Ae_g^2)$

$n = \frac{4287}{3834} = 1.12$

$A = 932.2 \text{ in}^2$

$I = 375443.9 \text{ in}^4$

$L = 75.54'$

$t_s = 8 \text{ in}$

e_g = GIRDER DEPTH − Y_b = 56 − 30.21 = 25.79 in

$K_g = 1.12(375443.9 + 932.2 \times 25.79^2) = 1{,}114{,}929$

$K_g / 12Lt_s^3 = 1{,}114{,}929 / 12 \times 75.54 \times 8^3 = 2.4$

DISTRIBUTION FACTOR FOR MOMENT, g_m (LRFD DESIGN TABLE 4.6.2.2.2b-1)

ONE LANE LOADED:

$g_{m1} = .06 + \left(\frac{S}{14}\right)^{.4}\left(\frac{S}{L}\right)^{.3}\left(\frac{K_g}{12Lt_s^3}\right)^{.1} = .06 + \left(\frac{5.958}{14}\right)^{.4}\left(\frac{5.958}{75.54}\right)^{.3}(2.4)^{.1} = .445$

TWO OR MORE LANES LOADED:

$g_{m2} = .075 + \left(\frac{S}{9.5}\right)^{.6}\left(\frac{S}{L}\right)^{.2}\left(\frac{K_g}{12Lt_s^3}\right)^{.1} = .075 + \left(\frac{5.958}{9.5}\right)^{.6}\left(\frac{5.958}{75.54}\right)^{.2}(2.4)^{.1} = .565$

LRFD g_m = .565

DISTRIBUTION FACTOR FOR SHEAR, g_V (LRFD DESIGN TABLE 4.6.2.2.3a-1)

ONE LANE LOADED:

$$g_{V_1} = .36 + \frac{S}{25} = .36 + \frac{5.958}{25} = .598$$

TWO OR MORE LANE LOADED:

$$g_{V_2} = .2 + \left(\frac{S}{12}\right) - \left(\frac{S}{35}\right)^2 = .2 + \left(\frac{5.958}{12}\right) - \left(\frac{5.958}{35}\right)^2 = .671$$

USE $g_V = .671$

HL93 DESIGN LIVE LOAD:

MAXIMUM LL MOMENT HL-93 @ MIDSPAN

APPENDIX EGA-TABLE EGA-1 (LIVE LOAD MOMENTS IN KIPS-FT PER LANE WITH 33% IM

M_{LL+IM} = 70 1711 K-FT
80 2073 K-FT → 75.54' $M_{LL+IM} = 1911.6$ K-FT

DISTRIBUTION OF LL MOMENT AT MIDSPAN:

$$M_{LL+IM} = 1911.6 \times g_m = 1911.6 \times .565 = 1080.1 \text{ K-FT}$$

COMPUTE NOMINAL FLEXURAL RESISTANCE AT MIDSPAN:

$$f_{ps} = f_{pu}\left(1 - k\frac{c}{d_p}\right)$$ LRFD EQ. 5.7.3.1.1-1

$k = .38$ STRESS RELIEVED STRANDS

$f_{pu} = 200$ ksi

d_p = DISTANCE FROM EXTREME COMPRESSION FIBER TO THE CENTROID OF THE PRESTRESSING TENDONS

$\bar{y} = 4.75''$ DISTANCE FROM BOTTOM OF GIRDER TO CENTROID OF PRESTRESSING STRANDS

$d_p = 56'' - 4.75'' = 51.25''$ LRFD EQ. 5.7.3.1.1-4

c = DISTANCE FROM THE NEUTRAL AXIS TO THE COMPRESSIVE FACE

$$c = \frac{A_{ps} f_{pu}}{.85 f'_c \beta_1 b + k A_{ps} f_{pu}/d_p} = \frac{(.75 \times 7) \times 200^{ksi}}{(.85 \times 4 \times .85 \times 71.5) + .38 \times 5.25 \times \frac{200}{51.25}} = 4.9$$

$a = \beta_1 c = .85 \times 4.9 = 4.17'' < 8''$ LRFD 5.7.2.2

THEREFORE, THE RECTANGULAR SECTION BEHAVIOR ASSUMPTION IS VALID:

$$f_{ps} = 200\left(1 - .38 \times \frac{4.9}{51.25}\right) = 192.7 \text{ ksi}$$

Close, Jensen and Miller, P.C.

BY BA DATE 3/11/11 SUBJECT BR. 596 SHEET NO. 19 B OF

CHKD. BY DATE ROUTE 68 O/ NAUGATUCK RIVER, RTE 8, MNRR, SR710 JOB NO. NAUGATUCK

NOMINAL FLEXURAL RESISTANCE (MIDSPAN): LRFD EQ. 5.7.3.2.2-1

$$M_n = A_{ps} f_{ps}\left(d_p - \frac{a}{2}\right) = 5.257 \times 192.7\left(51.25 - \frac{4.17}{2}\right)\left(\frac{1}{12}\right) = 4150.4 \text{ k-ft}$$

MAXIMUM REINFORCEMENT: 6A.5.5, 5.5.4.2.1
C6A.5.5, C5.7.2.1

$\varepsilon_c = .003$, $c = 4.9$
$d_p = 51.25$

$$\frac{\varepsilon_c}{c} = \frac{\varepsilon_t}{d-c} \Rightarrow \frac{.003}{4.9} = \frac{\varepsilon_t}{51.25 - 4.9} \Rightarrow \varepsilon_t = .028$$

$\varepsilon_t = .028 > .005$ $\phi = 1$ LRFD 5.7.2.1, 5.7.4.2

$P_{pe} = A_{ps} f_{pe}$ EFFECTIVE f_{pe} = INITIAL PRESTRESS − TOTAL PRESTRESS LOSS

$\Delta f_{pT} = \Delta f_{pES} + \Delta f_{pLT}$

MINIMUM REINFORCEMENT:

$M_R = \phi M_n = (1.0)(4104.6) = 4104.6$ k-ft

$1.33 M_n = 1.33\left[1.75(1080.1) + 1.25(870.2 + 285.3) + 1.5(99.9)\right] = 4634.3$ k-ft

$4634.3^{\text{k-ft}} > 4104.6^{\text{k-ft}}$ N.G.

$$M_{cr} = S_c\left(f_r + f_{cpe}\right) - M_{dnc}\left(\frac{S_c}{S_{nc}} - 1\right) \geq S_c f_r$$ LRFD EQ 5.7.3.3.2-1

$M_{dnc} = M_{DC1} = 870.2$ k-ft

$S_c = 14555.3$ in^3 S_{top}
$S_{nc} = 12429.6$ in^3

$f_r = .37\sqrt{f'_c} = .37\sqrt{5} = .827$ ksi LRFD 5.4.2.6

$$f_{cpe} = \frac{P_{pe}}{A} + \frac{P_{pe}\, e}{S_b}$$

$P_{pe} = A_{ps} f_{pe}$

Close, Jensen and Miller, P.C.

BY RA DATE 3/14/11 SUBJECT BK. 596 SHEET NO. 20.B OF

CHKD. BY DATE ROUTE 68 O/NAVIGATOR JOB NO.

RIVER, RTE 8, MILFORD, SECTION NAVIGATOR

$$\Delta f_{pT} = \Delta f_{pES} + \Delta f_{pLT}$$

$$\Delta f_{pES} = \frac{E_p}{E_{ct}} f_{cgp}$$

$$f_{cgp} = \frac{P_i}{A} + \frac{P_i e^2}{I} - \frac{M_D e}{I} = \frac{662.4}{932.2} + \frac{662.4 \times 25.46^2}{3754439} - \frac{693.2 \times 25.46}{3754439} = 1.81 \text{ ksi}$$

$$P_i = .9(.7 \times 200^{ksi}) \times 7 \times .751 = 662.4 \text{ k}$$

$$M_D = \frac{.971 \times 75.54^2}{8} = 693.2 \text{ k-FT}$$

$$Y_p = 30.21$$

$$\bar{y} = 4.75 \text{ in} \qquad e = 30.21 - 4.75 = \underline{25.46 \text{ in}}$$

$$P_i = 662.4 \text{ k}$$

$$E_p = 25000 \text{ ksi}$$

$$E_{ct} = 33000(.15)^{1.5}\sqrt{f'_c} = 33000(.15)^{1.5}\sqrt{4} = 3834 \text{ ksi}$$

$$\Delta f_{pES} = \frac{25000}{3834} \times 1.81 = 11.8 \text{ ksi}$$

LRFD C5.9.5.2.3a-1

$$\Delta f_{pLT} = (\Delta f_{pSR} + \Delta f_{pCR} + \Delta f_{pR1})_{id} + (\Delta f_{pSD} + \Delta f_{pCD} + \Delta f_{pR} - \Delta f_{pSS})_{df}$$

$$\Delta f_{pLT} = 10.0 \frac{f_{pi} A_{ps}}{A_g} \gamma_h \gamma_{st} + 12 \gamma_h \gamma_{st} + \Delta f_{pR}$$

$\Delta f_{pR} \rightarrow 10^{ksi}$

$$\gamma_h = 1.7 - .01H = 1.7 - .01(70) = 1$$

$$\gamma_{st} = \frac{5}{1 + f'_{ci}} = \frac{5}{1+4} = 1.0$$

$$\Delta f_{pi} = .75 \times 200 = 150 \text{ ksi}$$

$$\Delta f_{pLT} = 10 \times \frac{150 \times (7 \times .751)}{932.2} \times 1 \times 1 + 12 \times 1 \times 1 + 10 = 30.46 \text{ ksi}$$

$$\Delta f_{pT} = \Delta f_{pES} + \Delta f_{pLT} = 11.8 + 30.46 = 42.26 \text{ ksi}$$

$$f_{pe} = .75 \times 200 - 42.26 = 107.74 \text{ ksi}$$

$$P_{pe} = 107.74 \times 7 \times .751 = 565.1 \text{ k}$$

Close, Jensen and Miller, P.C.

BY BA DATE 3/14/11 SUBJECT BR. 596 SHEET NO. 21 B OF

CHKD. BY DATE ROUTE 6B O/ NAUGATUCK JOB NO.

RIVER, RTE 8, MNRR, SR 710 NAUGATUCK

$$f_{pb} = \frac{P_{pe}}{A} + \frac{P_{pe}\,e}{S_b} = \frac{525.7}{932.2} + \frac{525.7 \times 25.46}{12429.6} = 1.64 \text{ ksi}$$

$$M_{cr} = S_c\left(f_r + f_{cpe}\right) - M_{dnc}\left(\frac{S_c}{S_{nc}} - 1\right) \geq S_c f_r$$

$$\frac{14555.3}{12}\left(.827 + 1.64\right) = 2992.3 \geq \frac{14555.3}{12} \times .827 = 1003.1 \text{ k-FT}$$

$M_{cr} = 2992.3$ k-FT

$1.2\,M_{cr} = 1.2\,(2992.3)^{kFT} = 3590.8$ k-FT ←

$1.33\,M_n = 4634.3^{kFT}$

$1.2\,M_{cr} < 1.33\,M_n \Longrightarrow 1.2\,M_{cr}$ GOVERNS

$M_r = 4104.6$ k-FT $> 1.2\,M_{cr} = 3590.8$ k-FT OK

Close, Jensen and Miller, P.C.

BY BA DATE 3/14/11 SUBJECT BR. 59.6 SHEET NO. 22 B OF

CHKD. BY DATE ROUTE 68 O/ NAVGATUK JOB NO.

RUSSL, RTE 8, MNRK, SR 710 NAVGATUK

COMPUTE NOMINAL SHEAR RESISTANCE AT FIRST CRITICAL SECTION

SHEAR LOCATION: $.25L = .25 \times 75.5' = 18.885'$

$$C = \frac{A_{ps} f_{pu}}{.85 f'_c \beta_1 b + k A_{ps} \frac{f_{pu}}{d_p}} = \frac{7 \times .751 \times 200}{.85 \times 4 \times .85 \times 71.5 + .38 \times 5.257 \times \frac{200}{(56-12.89)}} = 4.87 \text{ in}$$

$a = \beta_1 c = .85 \times 4.87 = 4.14$ in

$d_v = 43.11 - \frac{4.14}{2} = 41.04$ in

$.5 d_v \cot\theta = .5(41.04)\cot 30^\circ = 35.54$ in

LRFD 5.11.4

CRITICAL SHEAR SECTION: $41.04^{in} + 6^{in} = 47^{in} = 3.92$ ft

Close, Jensen and Miller, P.C.

BY BA DATE 3/14/11 SUBJECT BR. 596 SHEET NO. 23B OF
CHKD. BY DATE ROUTE 68 O/ NAVGATUCK JOB NO.
PWOL., RTE 8, MNUCK, SR 710 NAVGATUCK

MAXIMUM SHEAR @ CRITICAL SECTION NEAR SUPPORT

CRITICAL SECTION AT 3.9' FROM THE SUPPORT

$$V_{TANDEM} = 25^k \times \left(\frac{71.62' + 67.62'}{75.54'}\right) = 46.08^k$$

$$V_{TRUCK} = \frac{32^k(71.62 + 57.62) + 8^k(43.62')}{75.54'} = 59.37^k \leftarrow$$

$$V_{LANE} = \frac{.64^{k/'}(71.62)^2}{2 \times 75.54'} = 21.73^k$$

IM = 33%

TOTAL SHEAR = $V_{LANE} + V_{TRUCK} \times 1.33 = 21.73^k + 1.33 \times 59.37 = 100.7^k$

DISTRIBUTION $V_{LL+IM} = 100.7^k \times .671 = 67.56^k$

$$V_{DC} = 1.22(.5 \times 75.54 - 3.92) + .4(.5 \times 75.54 - 3.92) = 41.3 + 13.54 = 54.84^k$$

$$V_{DW} = .14(.5 \times 75.54 - 3.92) = 4.84^k$$

NOMINAL SHEAR RESISTANCE

$$V_n = V_s + V_c + V_p$$

$$V_n = .25 f'_c b_v d_v + V_p = .25 \times 5 \times 7 \times 41.04 + 25.9 = 385^k$$

$$V_p = .751 \times 7 \times 100^{ksi} \times \sin 2.821^\circ = 25.9^k$$

Close, Jensen and Miller, P.C.

BY BA DATE 3/14/11 SUBJECT B1.596 SHEET NO. 24B OF
CHKD. BY DATE Route 68 O/ Navigatuck JOB NO.
Fiber, Rte 8, Naugatuck, Ohio Navigatuck

CRITICAL SECTION FOR SHEAR NEAR SUPPORT @ 3.92' = 47"
FROM ℄ BRG.

CRITICAL SECTION #4 VERTICAL STIRRUPS @ 18" SPAC.

EFFECTIVE WEB WIDTH, $b_v = 7"$

STIRRUP SPACING $S = 18"$

GRADE 40 REBAR, $f_y = 40$ ksi

$$A_v = .0316\sqrt{f'_c}\,\frac{b_v s}{f_y} = .0316\sqrt{5} \times \frac{7 \times 18}{40} = .22 \text{ in}^2$$

AREA PROVIDED 2 LEGS $\times .13 \text{ in}^2 = .26 \text{ in}^2 > .22 \text{ in}^2$ ok

$$V_c = .0316\beta\sqrt{f'_c}\,b_v d_v = .0316 \times 2 \times \sqrt{5} \times 7 \times 41.04 = 40.6 \text{ k}$$

$$V_s = \frac{A_v f_y d_v \cot\theta}{s} = \frac{.22 \times 40 \times 41.04 \times \cot 45}{18} = 20.1 \text{ k}$$

$$V_n = V_c + V_s + V_p = 40.6 + 20.1 + 25.9 = 86.6^k$$

$$86.6^k < 385^k \quad \therefore V_n = 86.6^k$$

$$\phi V_n = .9 \times 86.6^k = 77.94^k$$

$$V_u = 1.75(67.56^k) + 1.25(41.3 + 13.54) + 1.5(4.84) = 194.04^k > 77.94^k$$

SIMPLIFIED APPROACH

Close, Jensen and Miller, P.C.

BY BA DATE 3/14/11 SUBJECT BR. 594 SHEET NO. 25 B OF

CHKD. BY DATE ROUTE 68 O/ NAVGATUCK JOB NO.

FINE, RTE 8, MONKK, SR710 NAUGATUCK

MCFT Approach

$$v = \frac{V_u - \phi V_p}{\phi b_v d_v} = \frac{194.04 - .9 \times 25.9}{.9 \times 7 \times 41.04} = .66 \text{ ksi}$$

$$\frac{v}{f'_c} = \frac{.66}{5} = .132 < .25 \quad \text{ok}$$

$$M_{TRUCK} = \frac{32^k \times 3.92\,(71.62 + 57.62) + 8^k \times 3.92\,(43.62)}{75.54} = 232.72^k$$

$$M_{LANE} = \frac{.64 \times 71.62^2 \times 3.92}{2 \times 75.54} = 85.18^k$$

$$M_{L+I} = 85.18 + 1.33 \times 232.72 = 394.7 \text{ k-FT}$$

DISTRIBUTED MOMENT $= g_m \times M_{L+IM} = .565 \times 394.7 = 223$ k-FT

$$M_{DC} = .5 \times 1.22 \times 3.92 \times \underset{171.26}{(75.54 - 3.92)} + .5 \times .4 \times 3.92 \times \underset{56.15}{(75.54 - 3.92)} = 227.4 \text{ k-FT}$$

$$M_{DW} = .5 \times .14 \times 3.92 \times (75.54 - 3.92) = 19.7 \text{ k-FT}$$

$$M_u = (1.75 \times 223) + (1.35 \times 227.4) + (1.5 \times 19.7) = 704.1 \text{ k-FT}$$

$$V_c = .0316\,\beta\sqrt{f'_c}\,b_v d_v = .0316\,(2.72)\sqrt{5} \times 7 \times 41.04 = 55.2$$

$$V_s = \frac{A_v f_y d_v \cot\theta}{s} = \frac{.22 \times 40 \times 41.04 \times \cot 25}{18} = 43^k$$

$$V_n = V_c + V_s + V_p = 55.2 + 43 + 25.9 = 124.13^k \quad \text{VERSUS } 86.6^k \text{ SIMPLIFIED APPROACH}$$

$$.25 f'_c b_v d_v + V_p = .25 \times 5 \times 7 \times 41.04 + 25.9 = 385^k$$

$$V_n = 124.13^k$$

$$\phi V_n = .9 \times 124.13^k = 111.7^k$$

Close, Jensen and Miller, P.C.

BY BK DATE 3/14/11 SUBJECT BR. 594 SHEET NO. 26 B OF

CHKD. BY DATE ROUTE 68 O/ NAVGATUK JOB NO.

RIVER, ROUTE 8, MINN, SECTION NAVGATUK

CHECK LONGITUDINAL REINFORCEMENT

$$A_{ps} f_{ps} + A_s f_y \geq \frac{|M_u|}{d_v \phi_f} + .5 \frac{N_u}{\phi_c} + \left[\left| \frac{V_u}{\phi_v} - V_p \right| - .5 V_s \right] \cot \theta$$

$$V_s = 43^k < \frac{V_u}{\phi} = \frac{194.04}{.9} = 215.6^k$$

$$\frac{|704.1 \times 12|}{41.09 \times 1.0} + \left[\left| \frac{194.04}{.9} - 25.9 \right| - .5(215.6) \right] \cot 25 = 381.5^k$$ RIGHT SIDE

Close, Jensen and Miller, P.C.

BY BA DATE 3/14/11 SUBJECT BR. 596 SHEET NO. 27 B OF

CHKD. BY DATE Page 68 of NAVGATOR JOB NO.

BY RMOL, RTE 8, MNKK, SR710 NAVGATOR

SUMMARY TABLE: (MOMENTS & SHEAR)

LOCATION	SUPPORT	CRITICAL SHEAR	MIDSPAN
X/L	0	.05	.5
X	0	3.92	37.77
V_{DC1}	46.1	41.3	—
V_{DC2}	15.1	13.54	—
V_{DW}	5.3	4.84	—
$g_m V_{LL+I}$	—	67.56	—
V_n SIMPLIFIED	—	86.6	—
V_n MCFT	—	124.13	—
M_{DC1}	—	171.3	870.2
M_{DC2}	—	56.2	285.3
M_{DW}	—	19.7	99.9
$g_m M_{LL+I}$	—	223	1080.1
M_n	—	—	4104.6

Close, Jensen and Miller, P.C.

BY BA DATE 3/14/11 SUBJECT BR.596 SHEET NO. 28 B OF
CHKD. BY DATE Route 68 O/ NAVGATUK JOB NO.
RIVER, RTE 8, MNYR, SK710 NAVGATUK

HL-93 (STRENGTH I)

$$RF = \frac{(\varphi_i)\varphi_s\varphi R_n - \gamma_{DC} DC - \gamma_{DW} DW}{\gamma_L (LL + IM)} = \frac{(1)(1)(1)(4104.6) - (1.25)(1155.5) - 99.9(1.5)}{1.75(1080.1)}$$

RF = 1.3 FLEXURE @ MIDSPAN (INV.)

$RF = 1.3 \times \frac{1.75}{1.35} = 1.6$ " (OPER.)

SHEAR

$$RF = \frac{(1)(1)(.9)(124.1) - (1.25)(54.84) - (1.5)(4.84)}{1.75(67.56)} = .3$$

35.91

Close, Jensen and Miller, P.C.

BY BA DATE 3/4/11 SUBJECT BR. 596 SHEET NO. 29 B OF
CHKD. BY DATE ROUTE 68 O/ NAUGATUCK JOB NO.
RIVER, RTE 8, MNRR, SR110 NAUGATUCK, CT

SERVICE III LIMIT STATE

$$RF_{INV.} = \frac{f_R - (\gamma_D)(f_D)}{\gamma_L (f_{LL+I})}$$

$f_R = f_{P_b}$ + Allowable tensile stress $= 1.64 + (.19\sqrt{f'_c}) = 1.64 + .425 = 2.06$ ksi

$$f_D = \frac{(870.2 + 285.3 + 99.9)(12)}{14555.3} = 1.035$$

$$f_{LL+I} = \frac{1080.1 \times 12}{14555.3} = .89$$

$$RF = \frac{2.06 - (1)(1.035)}{.8(.89)} = 1.4$$

LIVE LOAD TYPE: SP-1 (CT-L73.0) GROSS WEIGHT: 36.50 TONS

UNFACTORED MOMENTS AND SHEARS

X	LOCATION FROM CL BRG	DL1 MOMENT	DL2 MOMENT	LL+I MOMENT	DL1 SHEAR	DL2 SHEAR	LL+I SHEAR
H/2	2.333	107.8	34.0	106.1	44.8	14.1	45.5
0.05	3.777	171.1	53.9	168.0	43.0	13.5	44.5
0.10	7.554	324.9	102.2	316.2	38.4	12.0	41.9
0.15	11.331	461.3	144.8	444.4	33.8	10.5	39.2
0.20	15.108	580.4	181.7	552.8	29.2	9.0	36.6
0.25	18.885	682.1	212.9	642.1	24.6	7.5	34.0
0.30	22.662	766.4	238.5	721.2	20.0	6.0	31.3
0.35	26.439	819.0	258.3	780.5	13.8	4.5	28.7
0.40	30.216	866.6	272.5	819.9	9.2	3.0	26.1
0.45	33.993	896.8	281.0	839.5	4.6	1.5	23.4
0.50	37.770	909.6	283.9	840.6	0.0	0.0	20.8

STRENGTHS AND RATINGS

	MOMENT STRENGTHS				MOMENT RATINGS			SHEAR RATINGS	
X	phi*Mn	CRACKING Mcr	IR Mfy	OR Mfy	IR	OR	SHEAR STRENGTH	IR	OR
H/2	1087.1	2124.3	834.4	997.9	3.920U	6.543U	195.3	1.203	2.009
0.05	1641.5	2181.7	1225.1	1465.1	3.700U	6.176U	211.0	1.424	2.377
0.10	2632.0	2331.9	1831.6	2190.4	3.027U	5.053U	214.7	1.642	2.741
0.15	3332.9	2482.1	2172.4	2597.9	2.639U	4.405U	214.7	1.845	3.081
0.20	4100.4	2632.2	2513.1	3005.3	2.592U	4.058F	184.1	1.693	2.826
0.25	4387.2	2782.4	2513.1	3034.2	2.314U	3.332F	136.9	1.290	2.153
0.30	4634.9	2932.6	2513.1	3034.2	2.091F	2.814F	122.2	1.299	2.168
0.35	4882.8	3082.8	2513.1	3034.2	1.839F	2.507F	109.4	1.375	2.295
0.40	5006.8	3157.9	2537.2	3034.2	1.705F	2.311F	97.8	1.449	2.418
0.45	5006.8	3157.9	2537.2	3034.2	1.619F	2.211F	85.6	1.527	2.548
0.50	5006.8	3157.9	2537.2	3034.2	1.599F	2.190F	79.8	1.768	2.951

CODES: MOMENT STRENGTH CODE:
= MOMENT STRENGTH REDUCED BY phi*Mn/MIN(1.2Mcr or 4/3Mu)

INVENTORY RATING CODES:
IF SERVICEABILITY GOVERNS INVENTORY RATING:
B = BOTTOM STRESS GOVERNS
T = TOP STRESS GOVERNS
S = SLAB STRESS GOVERNS

U = phi*Mn GOVERNS
F = Mfy GOVERNS

OPERATING RATING CODES:
U = phi*Mn GOVERNS
F = Mfy GOVERNS

Close, Jensen and Miller, P.C.

BY BA DATE 3/14/11 SUBJECT BR. 596 SHEET NO. 31 B OF

CHKD. BY DATE ROUTE 6B O/ NAUGATUCK JOB NO.

RIVER, RTE 8, MNRR, SR 710 NAUGATUCK

STRENGTH I LEGAL LOAD RATING

GT-L73.0 (73K ON 4 AXLE)

$M_{LL} = 840.6$ K-FT

$V_{LL} = 45.5$ K

$$RF_{MOM} = \frac{(1)(1)(1)(4104.6) - [(1.25)(870.2+285.3)+(1.5)(99.9)]}{1.8\,(840.6)(.565)} = \frac{2510.4}{854.9} = 2.9$$

$$RF_{SHEAR} = \frac{(1)(1)(.9)(124.13) - [(1.25)(41.3+13.54)+(1.5)(4.84)]}{1.8\,(45.5)(.671)} = \frac{35.91}{54.95} = .65$$

LIVE LOAD TYPE: SP-2 (CT-L352) GROSS WEIGHT: 40.00 TONS

UNFACTORED MOMENTS AND SHEARS

X	LOCATION FROM CL BRG	DL1 MOMENT	DL2 MOMENT	LL+I MOMENT	DL1 SHEAR	DL2 SHEAR	LL+I SHEAR
H/2	2.333	107.8	34.0	85.1	44.8	14.1	36.5
0.05	3.777	171.1	53.9	133.5	43.0	13.5	35.4
0.10	7.554	324.9	102.2	245.3	38.4	12.0	32.5
0.15	11.331	461.3	144.8	335.3	33.8	10.5	29.6
0.20	15.108	580.4	181.7	435.2	29.2	9.0	26.7
0.25	18.885	682.1	212.9	513.3	24.6	7.5	23.8
0.30	22.662	766.4	238.5	569.7	20.0	6.0	21.8
0.35	26.439	819.0	258.3	604.2	13.8	4.5	20.1
0.40	30.216	866.6	272.5	622.8	9.2	3.0	18.4
0.45	33.993	896.8	281.0	625.3	4.6	1.5	16.3
0.50	37.770	909.6	283.9	606.1	0.0	0.0	13.7

STRENGTHS AND RATINGS

	MOMENT STRENGTHS				MOMENT RATINGS			SHEAR RATINGS	
X	phi*Mn	CRACKING Mcr	IR Mfy	OR Mfy	IR	OR	SHEAR STRENGTH	IR	OR
H/2	1087.1	2124.3	834.4	997.9	4.891U	8.164U	195.3	1.502	2.506
0.05	1641.5	2181.7	1225.1	1465.1	4.655U	7.770U	211.0	1.792	2.991
0.10	2632.0	2331.9	1831.6	2190.4	3.901U	6.512U	214.7	2.117	3.533
0.15	3332.9	2482.1	2172.4	2597.9	3.498U	5.839U	214.7	2.446	4.083
0.20	4100.4	2632.2	2513.1	3005.3	3.293U	5.155F	175.7	2.175	3.630
0.25	4387.2	2782.4	2513.1	3034.2	2.894U	4.167F	148.8	2.070	3.456
0.30	4634.9	2932.6	2513.1	3034.2	2.647F	3.562F	131.7	2.067	3.450
0.35	4882.8	3082.8	2513.1	3034.2	2.376F	3.239F	117.0	2.139	3.571
0.40	5006.8	3157.9	2537.2	3034.2	2.245F	3.043F	80.0	1.611	2.689
0.45	5006.8	3157.9	2537.2	3034.2	2.174F	2.969F	79.8	2.030	3.388
0.50	5006.8	3157.9	2537.2	3034.2	2.217F	3.037F	86.9	2.912	4.861

CODES: MOMENT STRENGTH CODE:

= MOMENT STRENGTH REDUCED BY phi*Mn/MIN(1.2Mcr or 4/3Mu)

INVENTORY RATING CODES:

IF SERVICEABILITY GOVERNS INVENTORY RATING:

B = BOTTOM STRESS GOVERNS
T = TOP STRESS GOVERNS
S = SLAB STRESS GOVERNS

U = phi*Mn GOVERNS
F = Mfy GOVERNS

OPERATING RATING CODES:

U = phi*Mn GOVERNS
F = Mfy GOVERNS

Close, Jensen and Miller, P.C.

BY BA DATE 3/14/11 SUBJECT BR. 596 SHEET NO. 33 B OF
CHKD. BY DATE ROUTE 68 O/ NAVIGATION JOB NO.
RIVER, RTE 8, MNRR, SR210 NAVIGATION

STRENGTH LEGAL LOAD RATING

CT-L352 (80k ON 5 AXLES)

$M_{LL} = 606.1$ k-ft

$V_{LL} = 36.5$ k

$$RF_{MOM} = \frac{2510.4}{1.8(606.1)(.565)} = 4$$

$$RF_{STEEL} = \frac{35.91}{1.8(36.5)(.671)} = .81$$

LIVE LOAD TYPE: SP-3 (CT-P76.5) GROSS WEIGHT: 38.25 TONS

UNFACTORED MOMENTS AND SHEARS

X	LOCATION FROM CL BRG	DL1 MOMENT	DL2 MOMENT	LL+I MOMENT	DL1 SHEAR	DL2 SHEAR	LL+I SHEAR
H/2	2.333	107.8	34.0	113.5	44.8	14.1	48.7
0.05	3.777	171.1	53.9	179.8	43.0	13.5	47.6
0.10	7.554	324.9	102.2	338.7	38.4	12.0	44.8
0.15	11.331	461.3	144.8	476.9	33.8	10.5	42.1
0.20	15.108	580.4	181.7	594.2	29.2	9.0	39.3
0.25	18.885	682.1	212.9	690.6	24.6	7.5	36.6
0.30	22.662	766.4	238.5	767.8	20.0	6.0	33.8
0.35	26.439	819.0	258.3	835.0	13.8	4.5	31.1
0.40	30.216	866.6	272.5	881.4	9.2	3.0	28.3
0.45	33.993	896.8	281.0	906.9	4.6	1.5	25.5
0.50	37.770	909.6	283.9	911.7	0.0	0.0	22.8

STRENGTHS AND RATINGS

	MOMENT STRENGTHS				MOMENT RATINGS			SHEAR RATINGS	
X	phi*Mn	CRACKING Mcr	IR Mfy	OR Mfy	IR	OR	SHEAR STRENGTH	IR	OR
H/2	1087.1	2124.3	834.4	997.9	3.665U	6.117U	195.3	1.125	1.878
0.05	1641.5	2181.7	1225.1	1465.1	3.458U	5.771U	211.0	1.331	2.222
0.10	2632.0	2331.9	1831.6	2190.4	2.825U	4.716U	214.7	1.533	2.558
0.15	3332.9	2482.1	2172.4	2597.9	2.459U	4.105U	214.7	1.720	2.871
0.20	4100.4	2632.2	2513.1	3005.3	2.412U	3.775F	184.5	1.580	2.637
0.25	4387.2	2782.4	2513.1	3034.2	2.151U	3.097F	160.1	1.491	2.490
0.30	4634.9	2932.6	2513.1	3034.2	1.964F	2.643F	119.0	1.161	1.937
0.35	4882.8	3082.8	2513.1	3034.2	1.719F	2.344F	106.4	1.226	2.047
0.40	5006.8	3157.9	2537.2	3034.2	1.586F	2.150F	94.9	1.288	2.150
0.45	5006.8	3157.9	2537.2	3034.2	1.499F	2.047F	82.9	1.352	2.257
0.50	5006.8	3157.9	2537.2	3034.2	1.474F	2.019F	79.8	1.614	2.695

CODES: MOMENT STRENGTH CODE:
= MOMENT STRENGTH REDUCED BY phi*Mn/MIN(1.2Mcr or 4/3Mu)

INVENTORY RATING CODES:
IF SERVICEABILITY GOVERNS INVENTORY RATING:
B = BOTTOM STRESS GOVERNS
T = TOP STRESS GOVERNS
S = SLAB STRESS GOVERNS

U = phi*Mn GOVERNS
F = Mfy GOVERNS

OPERATING RATING CODES:
U = phi*Mn GOVERNS
F = Mfy GOVERNS

Close, Jensen and Miller, P.C.

BY BA DATE 3/4/11 SUBJECT BR. 596 SHEET NO. 35 B OF
CHKD. BY DATE ROUTE 68 OVER NAVGATUCK JOB NO.
FLOOR, RTE 8, MNRR, SR 710 NAVGATUCK

STRENGTH II PERMIT LOADING

PERMIT TYPE: CT P76.5 (76.5^k ON 4 AXLE)

$M_u = 911.7$ K-FT

$V_u = 48.7$ K

$$RF_{MOM} = \frac{2510.4}{1.8(911.7)(.565)} = 2.7$$

$$RF_{SHEAR} = \frac{35.91}{1.8(48.7)(.671)} = .61$$

BR.00596 (36) B

LIVE LOAD TYPE: SP-4 (P204) GROSS WEIGHT: 102.00 TONS

UNFACTORED MOMENTS AND SHEARS

X	LOCATION FROM CL BRG	DL1 MOMENT	DL2 MOMENT	LL+I MOMENT	DL1 SHEAR	DL2 SHEAR	LL+I SHEAR
H/2	2.333	107.8	34.0	227.6	44.8	14.1	97.5
0.05	3.777	171.1	53.9	357.8	43.0	13.5	94.7
0.10	7.554	324.9	102.2	660.0	38.4	12.0	87.4
0.15	11.331	461.3	144.8	917.1	33.8	10.5	80.0
0.20	15.108	580.4	181.7	1137.7	29.2	9.0	72.7
0.25	18.885	682.1	212.9	1302.7	24.6	7.5	65.3
0.30	22.662	766.4	238.5	1432.9	20.0	6.0	58.3
0.35	26.439	819.0	258.3	1516.3	13.8	4.5	51.5
0.40	30.216	866.6	272.5	1551.4	9.2	3.0	44.6
0.45	33.993	896.8	281.0	1554.6	4.6	1.5	38.5
0.50	37.770	909.6	283.9	1521.9	0.0	0.0	33.2

STRENGTHS AND RATINGS

	MOMENT STRENGTHS				MOMENT RATINGS			SHEAR RATINGS	
X	phi*Mn	CRACKING Mcr	IR Mfy	OR Mfy	IR	OR	SHEAR STRENGTH	IR	OR
H/2	1087.1	2124.3	834.4	997.9	1.828U	3.051U	195.3	0.561	0.937
0.05	1641.5	2181.7	1225.1	1465.1	1.737U	2.900U	211.0	0.669	1.116
0.10	2614.0#	2331.9	1831.6	2190.4	1.437U	2.399U	214.7	0.787	1.313
0.15	3332.9	2482.1	2172.4	2597.9	1.279U	2.135U	206.2	0.855	1.428
0.20	4100.4	2632.2	2513.1	3005.3	1.260U	1.972F	167.2	0.745	1.244
0.25	4387.2	2782.4	2513.1	3034.2	1.140U	1.642F	143.8	0.720	1.201
0.30	4634.9	2932.6	2513.1	3034.2	1.053F	1.416F	113.9	0.633	1.056
0.35	4882.8	3082.8	2513.1	3034.2	0.947F	1.291F	100.8	0.690	1.151
0.40	5006.8	3157.9	2537.2	3034.2	0.901F	1.222F	88.3	0.747	1.247
0.45	5006.8	3157.9	2537.2	3034.2	0.874F	1.194F	79.8	0.861	1.438
0.50	5006.8	3157.9	2537.2	3034.2	0.883F	1.209F	79.8	1.108	1.849

CODES: MOMENT STRENGTH CODE:
= MOMENT STRENGTH REDUCED BY phi*Mn/MIN(1.2Mcr or 4/3Mu)

INVENTORY RATING CODES:
IF SERVICEABILITY GOVERNS INVENTORY RATING:
B = BOTTOM STRESS GOVERNS
T = TOP STRESS GOVERNS
S = SLAB STRESS GOVERNS

U = phi*Mn GOVERNS
F = Mfy GOVERNS

OPERATING RATING CODES:
U = phi*Mn GOVERNS
F = Mfy GOVERNS

Close, Jensen and Miller, P.C.

BY BA DATE 3/14/11 SUBJECT BR. 596 SHEET NO. 37B OF
CHKD. BY DATE ROUTE 68 O/ NAVGATUCK JOB NO.
FNBR, RTE 8, MNRL, SR710 NAVGATUCK

STRENGTH II POSITIVE

CT-P204 (204k ON 8 AXLE)

$M_u = 1521.9$ k-FT

$V_u = 97.5$ k

$$RF_{MOM} = \frac{2510.4}{1.35(1521.9)(.565)} = 2.1$$

$$RF_{SHEAR} = \frac{35.91}{1.35(97.5)(.67)} = .4$$

BR.00596 (38) B

LIVE LOAD TYPE: SP-5 (P380) GROSS WEIGHT: 190.00 TONS

UNFACTORED MOMENTS AND SHEARS

X	LOCATION FROM CL BRG	DL1 MOMENT	DL2 MOMENT	LL+I MOMENT	DL1 SHEAR	DL2 SHEAR	LL+I SHEAR
H/2	2.333	107.8	34.0	182.2	44.8	14.1	78.1
0.05	3.777	171.1	53.9	284.8	43.0	13.5	75.4
0.10	7.554	324.9	102.2	519.4	38.4	12.0	68.8
0.15	11.331	461.3	144.8	730.3	33.8	10.5	62.1
0.20	15.108	580.4	181.7	897.5	29.2	9.0	55.4
0.25	18.885	682.1	212.9	1034.6	24.6	7.5	49.0
0.30	22.662	766.4	238.5	1134.4	20.0	6.0	43.1
0.35	26.439	819.0	258.3	1225.7	13.8	4.5	37.9
0.40	30.216	866.6	272.5	1314.6	9.2	3.0	33.2
0.45	33.993	896.8	281.0	1361.3	4.6	1.5	28.8
0.50	37.770	909.6	283.9	1386.5	0.0	0.0	24.3

STRENGTHS AND RATINGS

	MOMENT STRENGTHS				MOMENT RATINGS			SHEAR RATINGS	
X	phi*Mn	CRACKING Mcr	IR Mfy	OR Mfy	IR	OR	SHEAR STRENGTH	IR	OR
H/2	1087.1	2124.3	834.4	997.9	2.283U	3.811U	195.3	0.701	1.170
0.05	1641.5	2181.7	1225.1	1465.1	2.182U	3.643U	211.0	0.840	1.402
0.10	2632.0	2331.9	1831.6	2190.4	1.843U	3.076U	214.7	1.000	1.669
0.15	3332.9	2482.1	2172.4	2597.9	1.606U	2.681U	209.9	1.130	1.887
0.20	4100.4	2632.2	2513.1	3005.3	1.597U	2.499F	169.6	0.997	1.664
0.25	4387.2	2782.4	2513.1	3034.2	1.436U	2.068F	135.1	0.877	1.464
0.30	4634.9	2932.6	2513.1	3034.2	1.330F	1.789F	118.5	0.905	1.510
0.35	4882.8	3082.8	2513.1	3034.2	1.171F	1.597F	117.6	1.140	1.902
0.40	5006.8	3157.9	2537.2	3034.2	1.064F	1.442F	101.7	1.190	1.986
0.45	5006.8	3157.9	2537.2	3034.2	0.999F	1.364F	79.8	1.151	1.921
0.50	5006.8	3157.9	2537.2	3034.2	0.969F	1.328F	79.8	1.513	2.525

CODES: MOMENT STRENGTH CODE:
= MOMENT STRENGTH REDUCED BY phi*Mn/MIN(1.2Mcr or 4/3Mu)

INVENTORY RATING CODES:
IF SERVICEABILITY GOVERNS INVENTORY RATING:
B = BOTTOM STRESS GOVERNS
T = TOP STRESS GOVERNS
S = SLAB STRESS GOVERNS

U = phi*Mn GOVERNS
F = Mfy GOVERNS

OPERATING RATING CODES:
U = phi*Mn GOVERNS
F = Mfy GOVERNS

Close, Jensen and Miller, P.C.

BY BA DATE 3/14/11 SUBJECT BR. 596 SHEET NO. 39 B OF
CHKD. BY DATE ROUTE 68 O/ NAUGATUCK JOB NO.
RIVER, RTE 8, MNRR SECTION NAUGATUCK

PERMIT LOAD RATING (STRENGTH II)

CT-P380 (380k ON 19 AXLE)

$M_{LL} = 1386.5$ k-ft

$V_{LL} = 78.1$ k

$$RF_{mom} = \frac{2510.4}{1.15(1386.5)(.565)} = 2.7$$

$$RF_{shear} = \frac{35.91}{1.15(78.1)\left(\frac{.671}{1.2}\right)} = .71$$

BR.00596 (40) B

LIVE LOAD TYPE: SP-6 (CT-TLC) GROSS WEIGHT: 138.80 TONS

UNFACTORED MOMENTS AND SHEARS

X	LOCATION FROM CL BRG	DL1 MOMENT	DL2 MOMENT	LL+I MOMENT	DL1 SHEAR	DL2 SHEAR	LL+I SHEAR
H/2	2.333	107.8	34.0	247.8	44.8	14.1	106.2
0.05	3.777	171.1	53.9	390.5	43.0	13.5	103.4
0.10	7.554	324.9	102.2	725.2	38.4	12.0	96.0
0.15	11.331	461.3	144.8	1004.0	33.8	10.5	88.6
0.20	15.108	580.4	181.7	1227.0	29.2	9.0	81.2
0.25	18.885	682.1	212.9	1394.2	24.6	7.5	73.8 ← .25L
0.30	22.662	766.4	238.5	1505.5	20.0	6.0	66.4
0.35	26.439	819.0	258.3	1632.0	13.8	4.5	58.9
0.40	30.216	866.6	272.5	1737.3	9.2	3.0	51.0
0.45	33.993	896.8	281.0	1786.8	4.6	1.5	42.8
0.50	37.770	909.6	283.9	1780.5	0.0	0.0	33.9

STRENGTHS AND RATINGS

	MOMENT STRENGTHS				MOMENT RATINGS			SHEAR RATINGS	
X	phi*Mn	CRACKING Mcr	IR Mfy	OR Mfy	IR	OR	SHEAR STRENGTH	IR	OR
H/2	1087.1	2124.3	834.4	997.9	1.679U	2.802U	195.3	0.515	0.860
0.05	1641.5	2181.7	1225.1	1465.1	1.592U	2.657U	211.0	0.613	1.023
0.10	2475.6#	2331.9	1831.6	2190.4	1.220U	2.037U	214.7	0.716	1.195
0.15	3332.9	2482.1	2172.4	2597.9	1.168U	1.950U	214.7	0.817	1.364
0.20	4100.4	2632.2	2513.1	3005.3	1.168U	1.828F	187.6	0.783	1.306
0.25	4387.2	2782.4	2513.1	3034.2	1.066U	1.534F	163.5	0.760	1.268
0.30	4634.9	2932.6	2513.1	3034.2	1.002F	1.348F	148.3	0.794	1.325
0.35	4882.8	3082.8	2513.1	3034.2	0.880F	1.199F	112.9	0.697	1.163
0.40	5006.8	3157.9	2537.2	3034.2	0.805F	1.091F	99.3	0.754	1.259
0.45	5006.8	3157.9	2537.2	3034.2	0.761F	1.039F	85.5	0.836	1.395
0.50	5006.8	3157.9	2537.2	3034.2	0.755F	1.034F	79.8	1.085	1.812

CODES: MOMENT STRENGTH CODE:
= MOMENT STRENGTH REDUCED BY phi*Mn/MIN(1.2Mcr or 4/3Mu)

INVENTORY RATING CODES:
IF SERVICEABILITY GOVERNS INVENTORY RATING:
B = BOTTOM STRESS GOVERNS
T = TOP STRESS GOVERNS
S = SLAB STRESS GOVERNS

U = phi*Mn GOVERNS
F = Mfy GOVERNS

OPERATING RATING CODES:
U = phi*Mn GOVERNS
F = Mfy GOVERNS

Close, Jensen and Miller, P.C.

BY BA DATE 3/14/11 SUBJECT BR. 596 SHEET NO. 41B OF
CHKD. BY DATE PONTE 68 O/ NAUGATUCK JOB NO.
RIVER, RTE 8, MNNR, SR 710 NAUGATUCK

PERMIT LOAD RATING (STRENGTH II)

GT - TLC

$M_{LL} = 1780.5$ k-FT

$V_{LL} = 106.2$ k

$$RF_{mom} = \frac{2510.4}{1.5(1780.5)(.565)} = 1.6$$

$$RF_{shear} = \frac{35.91}{1.5(106.2)\left(\frac{.671}{1.2}\right)} = .4$$

.25L = .58

Close, Jensen and Miller, P.C.

BY BA DATE 3/14/11 SUBJECT BR. 596 SHEET NO. 42B OF

CHKD. BY DATE ROUTE 68 O/ NAVIGATION JOB NO.

RIVER, RTE 8, MNRR, SK710 NAVIGATION

SERVICE I LIMIT STATE

$\gamma_L = \gamma_{DL} = \gamma_{DW} = 1$

$g_{fm} = .565$

$M_{DL} + M_{DW} + M_{LLI} = 870.2 + 285.3 + 99.9 + (1080.1 \times .565) = 1865.7$

MOMENT RATIO $= \dfrac{.75\, M_n}{M_{TOTAL}} = \dfrac{.75 \times 4104.6}{1865.7} = 1.6 > 1$ OK

Close, Jensen and Miller, P.C.

BY BA DATE 3/14/11 SUBJECT BR. 596 SHEET NO. 43 B OF
CHKD. BY DATE ROUTE 68 O/ NAUGATUCK JOB NO.
RIVER, RTE 8, MNRR, SR710 NAUGATUCK

SUMMARY OF RATING FACTORS

INTERIOR GIRDERS SPANS 1 & 6

LIMIT STATES	HL-93 DESIGN LOAD RATING INV.	HL-93 DESIGN LOAD RATING OPER.	LEGAL LOADS		PERMIT LOADS			
STRENGTH I								
FLEXURE (MIDSPAN)	1.3	1.6	2.9	4				
SHEAR (CRITICAL)	.3		.65	.81				
STRENGTH II								
FLEXURE (MIDSPAN)					2.7	2.1	2.7	1.6
SHEAR					.61	.4	.71	.4
					(.67)	(.56)	(.82)	(.46)
SERVICE III								
FLEXURE (MIDSPAN)	1.4							
SERVICE I	STRESS RATIO ≥ 1.6							

Close, Jensen and Miller, P.C.

BY. BA DATE 3/15/11 SUBJECT Br. 596 SHEET NO. 44 B OF

CHKD. BY DATE Route 68 O/ NAVGATUCK JOB NO.

RIVER, RTE B, MNRK, SR 710 NAVGATUCK

PERMIT LOAD RATING (I = 1.2)

PERMIT: CT-P76.5

$V_u = 42.9^k$

$RF_{shear} = \frac{35.91}{1.8(42.9)(.671)} =$

$RF_{shear} = .69$

CT-P204

$V_u = 85.5$

$RF_{shear} = \frac{35.91}{1.35(85.5)\left(\frac{.671}{1.2}\right)} =$

$RF_{shear} = .56$

CT-P380

$V_u = 68^k$

$RF_{shear} = \frac{35.91}{1.15(68)\left(\frac{.671}{1.2}\right)} =$

$RF_{shear} = .82$

CT-TLC

$V_u = 93.3^k$

$RF_{shear} = \frac{35.91}{1.5(93.3)\left(\frac{.671}{1.2}\right)} =$

$RF_{shear} = .46$

BR.00596 (45) B

LIVE LOAD TYPE: SP-1 (GT-L73.0) GROSS WEIGHT: 36.50 TONS

LEGAL LOAD

UNFACTORED MOMENTS AND SHEARS

X	LOCATION FROM CL BRG	DL1 MOMENT	DL2 MOMENT	LL+I MOMENT	DL1 SHEAR	DL2 SHEAR	LL+I SHEAR
H/2	2.333	107.8	34.0	95.8	44.8	14.1	41.0
0.05	3.777	171.1	53.9	151.6	43.0	13.5	40.1
0.10	7.554	324.9	102.2	285.3	38.4	12.0	37.8
0.15	11.331	461.3	144.8	401.0	33.8	10.5	35.4
0.20	15.108	580.4	181.7	498.8	29.2	9.0	33.0
0.25	18.885	682.1	212.9	579.3	24.6	7.5	30.6
0.30	22.662	766.4	238.5	650.7	20.0	6.0	28.3
0.35	26.439	819.0	258.3	704.2	13.8	4.5	25.9
0.40	30.216	866.6	272.5	739.8	9.2	3.0	23.5
0.45	33.993	896.8	281.0	757.4	4.6	1.5	21.1
0.50	37.770	909.6	283.9	758.4	0.0	0.0	18.8

STRENGTHS AND RATINGS

	MOMENT STRENGTHS				MOMENT RATINGS			SHEAR RATINGS	
X	phi*Mn	CRACKING Mcr	IR Mfy	OR Mfy	IR	OR	SHEAR STRENGTH	IR	OR
H/2	1087.1	2124.3	834.4	997.9	4.344U	7.251U	195.3	1.334	2.226
0.05	1641.5	2181.7	1225.1	1465.1	4.100U	6.845U	211.0	1.578	2.635
0.10	2632.0	2331.9	1831.6	2190.4	3.355U	5.600U	214.7	1.820	3.038
0.15	3332.9	2482.1	2172.4	2597.9	2.925U	4.882U	214.7	2.045	3.414
0.20	4100.4	2632.2	2513.1	3005.3	2.873U	4.497F	183.6	1.868	3.119
0.25	4387.2	2782.4	2513.1	3034.2	2.564U	3.693F	136.8	1.430	2.387
0.30	4634.9	2932.6	2513.1	3034.2	2.318F	3.119F	122.1	1.438	2.401
0.35	4882.8	3082.8	2513.1	3034.2	2.039F	2.779F	109.1	1.519	2.535
0.40	5006.8	3157.9	2537.2	3034.2	1.890F	2.562F	97.4	1.598	2.668
0.45	5006.8	3157.9	2537.2	3034.2	1.795F	2.451F	85.1	1.682	2.807
0.50	5006.8	3157.9	2537.2	3034.2	1.772F	2.427F	79.8	1.959	3.271

CODES: MOMENT STRENGTH CODE:

= MOMENT STRENGTH REDUCED BY phi*Mn/MIN(1.2Mcr or 4/3Mu)

INVENTORY RATING CODES:

IF SERVICEABILITY GOVERNS INVENTORY RATING:

B = BOTTOM STRESS GOVERNS
T = TOP STRESS GOVERNS
S = SLAB STRESS GOVERNS

U = phi*Mn GOVERNS
F = Mfy GOVERNS

OPERATING RATING CODES:

U = phi*Mn GOVERNS
F = Mfy GOVERNS

BR.00596 (46) B

LIVE LOAD TYPE: SP-2 (CT-L352) GROSS WEIGHT: 40.00 TONS

LEGAL LOAD

UNFACTORED MOMENTS AND SHEARS

X	LOCATION FROM CL BRG	DL1 MOMENT	DL2 MOMENT	LL+I MOMENT	DL1 SHEAR	DL2 SHEAR	LL+I SHEAR
H/2	2.333	107.8	34.0	76.8	44.8	14.1	32.9
0.05	3.777	171.1	53.9	120.5	43.0	13.5	31.9
0.10	7.554	324.9	102.2	221.3	38.4	12.0	29.3
0.15	11.331	461.3	144.8	302.5	33.8	10.5	26.7
0.20	15.108	580.4	181.7	392.7	29.2	9.0	24.1
0.25	18.885	682.1	212.9	463.1	24.6	7.5	21.5
0.30	22.662	766.4	238.5	514.0	20.0	6.0	19.7
0.35	26.439	819.0	258.3	545.2	13.8	4.5	18.1
0.40	30.216	866.6	272.5	561.9	9.2	3.0	16.6
0.45	33.993	896.8	281.0	564.2	4.6	1.5	14.7
0.50	37.770	909.6	283.9	546.9	0.0	0.0	12.4

STRENGTHS AND RATINGS

	MOMENT STRENGTHS				MOMENT RATINGS			SHEAR RATINGS	
X	phi*Mn	CRACKING Mcr	IR Mfy	OR Mfy	IR	OR	SHEAR STRENGTH	IR	OR
H/2	1087.1	2124.3	834.4	997.9	5.420U	9.048U	195.3	1.664	2.778
0.05	1641.5	2181.7	1225.1	1465.1	5.159U	8.612U	211.0	1.986	3.315
0.10	2632.0	2331.9	1831.6	2190.4	4.324U	7.218U	214.7	2.346	3.916
0.15	3332.9	2482.1	2172.4	2597.9	3.877U	6.471U	214.7	2.711	4.526
0.20	4100.4	2632.2	2513.1	3005.3	3.650U	5.713F	175.3	2.402	4.010
0.25	4387.2	2782.4	2513.1	3034.2	3.208U	4.619F	148.4	2.286	3.816
0.30	4634.9	2932.6	2513.1	3034.2	2.934F	3.948F	131.3	2.281	3.808
0.35	4882.8	3082.8	2513.1	3034.2	2.633F	3.589F	116.4	2.355	3.931
0.40	5006.8	3157.9	2537.2	3034.2	2.488F	3.373F	80.1	1.788	2.985
0.45	5006.8	3157.9	2537.2	3034.2	2.409F	3.290F	79.8	2.250	3.755
0.50	5006.8	3157.9	2537.2	3034.2	2.457F	3.366F	85.7	3.186	5.319

CODES: MOMENT STRENGTH CODE:

= MOMENT STRENGTH REDUCED BY phi*Mn/MIN(1.2Mcr or 4/3Mu)

INVENTORY RATING CODES:

IF SERVICEABILITY GOVERNS INVENTORY RATING:

B = BOTTOM STRESS GOVERNS

T = TOP STRESS GOVERNS

S = SLAB STRESS GOVERNS

U = phi*Mn GOVERNS

F = Mfy GOVERNS

OPERATING RATING CODES:

U = phi*Mn GOVERNS

F = Mfy GOVERNS

BR.00596 (47) B

LIVE LOAD TYPE: SP-3 (CT-P76.5) GROSS WEIGHT: 38.25 TONS PERMIT LOADING

UNFACTORED MOMENTS AND SHEARS

X	LOCATION FROM CL BRG	DL1 MOMENT	DL2 MOMENT	LL+I MOMENT	DL1 SHEAR	DL2 SHEAR	LL+I SHEAR
H/2	2.333	107.8	34.0	102.4	44.8	14.1	43.9
0.05	3.777	171.1	53.9	162.2	43.0	13.5	42.9 ←
0.10	7.554	324.9	102.2	305.6	38.4	12.0	40.5
0.15	11.331	461.3	144.8	430.3	33.8	10.5	38.0
0.20	15.108	580.4	181.7	536.1	29.2	9.0	35.5
0.25	18.885	682.1	212.9	623.1	24.6	7.5	33.0
0.30	22.662	766.4	238.5	692.7	20.0	6.0	30.5
0.35	26.439	819.0	258.3	753.4	13.8	4.5	28.0
0.40	30.216	866.6	272.5	795.2	9.2	3.0	25.5
0.45	33.993	896.8	281.0	818.3	4.6	1.5	23.0
0.50	37.770	909.6	283.9	822.6	0.0	0.0	20.6

STRENGTHS AND RATINGS

	MOMENT STRENGTHS				MOMENT RATINGS			SHEAR RATINGS	
X	phi*Mn	CRACKING Mcr	IR Mfy	OR Mfy	IR	OR	SHEAR STRENGTH	IR	OR
H/2	1087.1	2124.3	834.4	997.9	4.062U	6.780U	195.3	1.247	2.082
0.05	1641.5	2181.7	1225.1	1465.1	3.832U	6.397U	211.0	1.475	2.462
0.10	2632.0	2331.9	1831.6	2190.4	3.131U	5.227U	214.7	1.699	2.836
0.15	3332.9	2482.1	2172.4	2597.9	2.726U	4.550U	214.7	1.906	3.182
0.20	4100.4	2632.2	2513.1	3005.3	2.673U	4.184F	184.0	1.744	2.910
0.25	4387.2	2782.4	2513.1	3034.2	2.384U	3.433F	159.5	1.644	2.745
0.30	4634.9	2932.6	2513.1	3034.2	2.177F	2.930F	119.0	1.286	2.147
0.35	4882.8	3082.8	2513.1	3034.2	1.906F	2.598F	106.2	1.355	2.262
0.40	5006.8	3157.9	2537.2	3034.2	1.758F	2.383F	94.6	1.422	2.374
0.45	5006.8	3157.9	2537.2	3034.2	1.661F	2.269F	82.5	1.491	2.490
0.50	5006.8	3157.9	2537.2	3034.2	1.634F	2.238F	79.8	1.789	2.987

CODES: MOMENT STRENGTH CODE:
= MOMENT STRENGTH REDUCED BY phi*Mn/MIN(1.2Mcr or 4/3Mu)

INVENTORY RATING CODES:
IF SERVICEABILITY GOVERNS INVENTORY RATING:
B = BOTTOM STRESS GOVERNS
T = TOP STRESS GOVERNS
S = SLAB STRESS GOVERNS

U = phi*Mn GOVERNS
F = Mfy GOVERNS

OPERATING RATING CODES:
U = phi*Mn GOVERNS
F = Mfy GOVERNS

BR.00596 (#8) B

LIVE LOAD TYPE: SP-4 (P204) GROSS WEIGHT: 102.00 TONS

PERMIT LOADING

UNFACTORED MOMENTS AND SHEARS

X	LOCATION FROM CL BRG	DL1 MOMENT	DL2 MOMENT	LL+I MOMENT	DL1 SHEAR	DL2 SHEAR	LL+I SHEAR
H/2	2.333	107.8	34.0	205.3	44.8	14.1	88.0
0.05	3.777	171.1	53.9	322.8	43.0	13.5	85.5 ← @ .05L
0.10	7.554	324.9	102.2	595.5	38.4	12.0	78.8
0.15	11.331	461.3	144.8	827.5	33.8	10.5	72.2
0.20	15.108	580.4	181.7	1026.5	29.2	9.0	65.6
0.25	18.885	682.1	212.9	1175.4	24.6	7.5	58.9
0.30	22.662	766.4	238.5	1292.9	20.0	6.0	52.6
0.35	26.439	819.0	258.3	1368.1	13.8	4.5	46.4
0.40	30.216	866.6	272.5	1399.7	9.2	3.0	40.3
0.45	33.993	896.8	281.0	1402.6	4.6	1.5	34.7
0.50	37.770	909.6	283.9	1373.2	0.0	0.0	30.0

STRENGTHS AND RATINGS

	MOMENT STRENGTHS				MOMENT RATINGS			SHEAR RATINGS	
X	phi*Mn	CRACKING Mcr	IR Mfy	OR Mfy	IR	OR	SHEAR STRENGTH	IR	OR
H/2	1087.1	2124.3	834.4	997.9	2.026U	3.382U	195.3	0.622	1.038
0.05	1641.5	2181.7	1225.1	1465.1	1.926U	3.214U	211.0	0.741	1.237
0.10	2632.0	2331.9	1831.6	2190.4	1.607U	2.683U	214.7	0.872	1.455
0.15	3332.9	2482.1	2172.4	2597.9	1.417U	2.366U	206.1	0.948	1.582
0.20	4100.4	2632.2	2513.1	3005.3	1.396U	2.185F	167.1	0.825	1.378
0.25	4387.2	2782.4	2513.1	3034.2	1.264U	1.820F	143.7	0.797	1.330
0.30	4634.9	2932.6	2513.1	3034.2	1.167F	1.570F	113.9	0.702	1.172
0.35	4882.8	3082.8	2513.1	3034.2	1.049F	1.430F	100.7	0.764	1.275
0.40	5006.8	3157.9	2537.2	3034.2	0.999F	1.354F	88.2	0.827	1.381
0.45	5006.8	3157.9	2537.2	3034.2	0.969F	1.324F	79.8	0.955	1.593
0.50	5006.8	3157.9	2537.2	3034.2	0.979F	1.341F	79.8	1.228	2.050

CODES: MOMENT STRENGTH CODE:

= MOMENT STRENGTH REDUCED BY phi*Mn/MIN(1.2Mcr or 4/3Mu)

INVENTORY RATING CODES:

IF SERVICEABILITY GOVERNS INVENTORY RATING:

B = BOTTOM STRESS GOVERNS
T = TOP STRESS GOVERNS
S = SLAB STRESS GOVERNS

U = phi*Mn GOVERNS
F = Mfy GOVERNS

OPERATING RATING CODES:

U = phi*Mn GOVERNS
F = Mfy GOVERNS

BR.00596 (49) B

PERMIT LOADING

LIVE LOAD TYPE: SP-5 (P380) GROSS WEIGHT: 190.00 TONS

UNFACTORED MOMENTS AND SHEARS

X	LOCATION FROM CL BRG	DL1 MOMENT	DL2 MOMENT	LL+I MOMENT	DL1 SHEAR	DL2 SHEAR	LL+I SHEAR
H/2	2.333	107.8	34.0	164.4	44.8	14.1	70.5
0.05	3.777	171.1	53.9	257.0	43.0	13.5	68.0
0.10	7.554	324.9	102.2	468.6	38.4	12.0	62.0
0.15	11.331	461.3	144.8	658.9	33.8	10.5	56.0
0.20	15.108	580.4	181.7	809.8	29.2	9.0	50.0
0.25	18.885	682.1	212.9	933.4	24.6	7.5	44.2
0.30	22.662	766.4	238.5	1023.5	20.0	6.0	38.9
0.35	26.439	819.0	258.3	1105.9	13.8	4.5	34.2
0.40	30.216	866.6	272.5	1186.1	9.2	3.0	30.0
0.45	33.993	896.8	281.0	1228.2	4.6	1.5	26.0
0.50	37.770	909.6	283.9	1250.9	0.0	0.0	21.9

STRENGTHS AND RATINGS

	MOMENT STRENGTHS				MOMENT RATINGS			SHEAR RATINGS	
X	phi*Mn	CRACKING Mcr	IR Mfy	OR Mfy	IR	OR	SHEAR STRENGTH	IR	OR
H/2	1087.1	2124.3	834.4	997.9	2.530U	4.223U	195.3	0.777	1.297
0.05	1641.5	2181.7	1225.1	1465.1	2.419U	4.038U	211.0	0.931	1.554
0.10	2632.0	2331.9	1831.6	2190.4	2.042U	3.409U	214.7	1.108	1.849
0.15	3332.9	2482.1	2172.4	2597.9	1.780U	2.971U	209.8	1.252	2.090
0.20	4100.4	2632.2	2513.1	3005.3	1.770U	2.770F	169.5	1.104	1.843
0.25	4387.2	2782.4	2513.1	3034.2	1.592U	2.292F	135.1	0.972	1.623
0.30	4634.9	2932.6	2513.1	3034.2	1.474F	1.983F	118.5	1.003	1.674
0.35	4882.8	3082.8	2513.1	3034.2	1.298F	1.770F	117.2	1.258	2.100
0.40	5006.8	3157.9	2537.2	3034.2	1.179F	1.598F	101.4	1.314	2.193
0.45	5006.8	3157.9	2537.2	3034.2	1.107F	1.511F	79.8	1.276	2.129
0.50	5006.8	3157.9	2537.2	3034.2	1.074F	1.471F	79.8	1.677	2.799

CODES: MOMENT STRENGTH CODE:

= MOMENT STRENGTH REDUCED BY phi*Mn/MIN(1.2Mcr or 4/3Mu)

INVENTORY RATING CODES:

IF SERVICEABILITY GOVERNS INVENTORY RATING:

B = BOTTOM STRESS GOVERNS
T = TOP STRESS GOVERNS
S = SLAB STRESS GOVERNS

U = phi*Mn GOVERNS
F = Mfy GOVERNS

OPERATING RATING CODES:

U = phi*Mn GOVERNS
F = Mfy GOVERNS

BR.00596 (50) B

LIVE LOAD TYPE: SP-6 (TLC) GROSS WEIGHT: 138.80 TONS PERMIT LOADING

UNFACTORED MOMENTS AND SHEARS

X	LOCATION FROM CL BRG	DL1 MOMENT	DL2 MOMENT	LL+I MOMENT	DL1 SHEAR	DL2 SHEAR	LL+I SHEAR
H/2	2.333	107.8	34.0	223.6	44.8	14.1	95.8
0.05	3.777	171.1	53.9	352.4	43.0	13.5	93.3
0.10	7.554	324.9	102.2	654.3	38.4	12.0	86.6
0.15	11.331	461.3	144.8	905.9	33.8	10.5	79.9
0.20	15.108	580.4	181.7	1107.1	29.2	9.0	73.3
0.25	18.885	682.1	212.9	1257.9	24.6	7.5	66.6
0.30	22.662	766.4	238.5	1358.4	20.0	6.0	59.9
0.35	26.439	819.0	258.3	1472.4	13.8	4.5	53.2
0.40	30.216	866.6	272.5	1567.5	9.2	3.0	46.0
0.45	33.993	896.8	281.0	1612.1	4.6	1.5	38.6
0.50	37.770	909.6	283.9	1606.4	0.0	0.0	30.6

STRENGTHS AND RATINGS

	MOMENT STRENGTHS				MOMENT RATINGS			SHEAR RATINGS	
X	phi*Mn	CRACKING Mcr	IR Mfy	OR Mfy	IR	OR	SHEAR STRENGTH	IR	OR
H/2	1087.1	2124.3	834.4	997.9	1.860U	3.106U	195.3	0.571	0.953
0.05	1641.5	2181.7	1225.1	1465.1	1.764U	2.945U	211.0	0.679	1.134
0.10	2630.4#	2331.9	1831.6	2190.4	1.462U	2.440U	214.7	0.793	1.325
0.15	3332.9	2482.1	2172.4	2597.9	1.295U	2.161U	214.7	0.905	1.511
0.20	4100.4	2632.2	2513.1	3005.3	1.294U	2.026F	187.3	0.865	1.444
0.25	4387.2	2782.4	2513.1	3034.2	1.181U	1.701F	163.1	0.839	1.401
0.30	4634.9	2932.6	2513.1	3034.2	1.110F	1.494F	147.9	0.876	1.463
0.35	4882.8	3082.8	2513.1	3034.2	0.975F	1.329F	112.7	0.770	1.286
0.40	5006.8	3157.9	2537.2	3034.2	0.892F	1.209F	99.0	0.833	1.391
0.45	5006.8	3157.9	2537.2	3034.2	0.843F	1.152F	85.2	0.923	1.541
0.50	5006.8	3157.9	2537.2	3034.2	0.836F	1.146F	79.8	1.203	2.008

CODES: MOMENT STRENGTH CODE:

= MOMENT STRENGTH REDUCED BY phi*Mn/MIN(1.2Mcr or 4/3Mu)

INVENTORY RATING CODES:

IF SERVICEABILITY GOVERNS INVENTORY RATING:

B = BOTTOM STRESS GOVERNS
T = TOP STRESS GOVERNS
S = SLAB STRESS GOVERNS

U = phi*Mn GOVERNS
F = Mfy GOVERNS

OPERATING RATING CODES:

U = phi*Mn GOVERNS
F = Mfy GOVERNS

BRIDGE NO.00596

ROUTE 68 OVER NAUGATTUCK RIVER, ROUTES 8, 710 AND METRO NORTH TRACKS

NAUGATUCK, CT

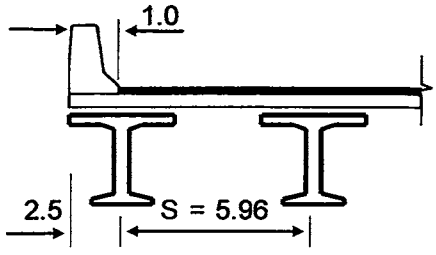
INTERIOR GIRDER "B" - CHECK

BY: m.g.
CHKD.BY: BA DATE 3/17/11

BRIDGE NO.00596

Br. 596, Span 1 Interior Girder B

I - GIRDER BRIDGE (INTERIOR GIRDER)



BRIDGE DATA

SPAN : L = 75.54 ft
L_{total} = 77.04 ft
BRIDGE WIDTH = 50.00 ft (CURB-TO-CURB)
SLAB THICKNESS, t_s = 8 in
BITUMINOUS = 2.5 in
HAUNCH = 0.0 in
NUMBER OF BEAMS = 11 ea.
YEAR BUILT : 1985

BEAM, TYPE: DBT
BRIDGE WIDTH = 64.50 ft (OUT-TO-OUT)

MATERIALS :
CONCRETE : f'_c = 4.0 ksi (DECK)
f'_c = 5.0 ksi (P/S BEAM)
f'_{ci} = 4.0 ksi (P/S BEAM AT TRANSFER)

PRESTRESSING STEEL :
DIAMETER, d_b = 1.125 in STRESS-RELIEVED STRANDS
f'_s = 4.0 ksi
A_{ps} = 0.751 in² (AREA OF ONE STRAND)
ULTIMATE STRENGHT : f_{pu} = 200 ksi
STRANDS : 7 ea. PRESTRESSING STRANDS
0 ea. DEBONDED ON EACH END, OVER THE LAST : 0 ft
STIRRUPS : # 4 @ 12 in OVER END : 2 ft
4 @ 18 in OVER CENTER : 48.75 ft

COMPRESSION STEEL : 5 - # 4
YIELD STRENGTH : f_y = 40 ksi

ADTT = 5000 ACTUAL ADTT = 2000
SKEW = 0 °

MODULUS OF ELASTICITY OF CONCRETE, E_c : $E_c = (33000)(w_c)^{1.5}\sqrt{f'_c}$
CONCRETE UNIT WEIGHT : w_c = 0.145 kcf
DECK CONCRETE : E_c = 3644 ksi
P/S BEAM : E_c = 4074 ksi

MODULAR RATIO, $n = \frac{E_{deck}}{E_{beam}} = \frac{3644}{4074} = 0.894$

EFFECTIVE FLANGE WIDTH, b_e : LRFD Design 4.6.2.6.1

MINIMUM OF :
¼L = 226.6 in
12ts + GREATER OF EITHER tw OR 1/2 $b_{f\,top}$ = 12 * 8 + 0.5 * 42 = 117 in
$b_{f\,top}$ = 42 in
tw = 7 in
S = 71.52 in ← GOVERNS

EFFECTIVE FLANGE WIDTH b_e = 71.52 in

TRANSFORMED FLANGE WIDTH, b_{trans} : $b_{trans.}$ = 71.52 * 0.89 = 63.97 in

BY: m.g.
CHKD.BY: BA DATE 3/17/11

BRIDGE NO.00596

I - GIRDER BRIDGE (INTERIOR GIRDER)

CROSS-SECTION PROPERTIES:

BEAM, TYPE: DBT

$h = 56$ in PCI DESIGN MANUAL

$A = 932.2$ in²

$I_o = 375444$ in⁴

$y_{bot.} = 30.21$ in

$y_{top} = 25.79$ in

$$S_b = \frac{375444}{30.21}$$

$S_b = 12428$ in³ SECTION MODULUS FOR THE EXTREME BOTTOM FIBER OF THE NON-COMPOSITE PRECAST BEAM

$S_t = 14558$ in³ SECTION MODULUS FOR THE EXTREME TOP FIBER OF THE NON-COMPOSITE PRECAST BEAM

COMPOSITE SECTION :

	AREA, (in²)	y, (in)	A·y	d, (in)	Ad² (in⁴)	Io (in⁴)
P/S BEAM	932.2	30.21	28161.8	0.00	0	375444
SLAB, As	0	60	0	29.79	0	2729
TOTALS	932		28161.8		0	378173

AREA SLAB: (btrans.)

$A_s = 0 * 63.97 = 0$ in²

$y_{slab} = 56 + 0.0 + (0.5 * 8) = 60$ in

$$\bar{y} = \frac{28162}{932} = 30.21 \text{ in}$$

$y_{bot.c} = 30.21$ in

$y_{top\,c} = 56 - 30.21 = 25.79$ in²

$$I_{o,slab} = \frac{63.97 * (8)^3}{12} = 2729 \text{ in}^4$$

$I_{comp.} = 378173$ in⁴

$$S_b = \frac{378173}{30.21}$$

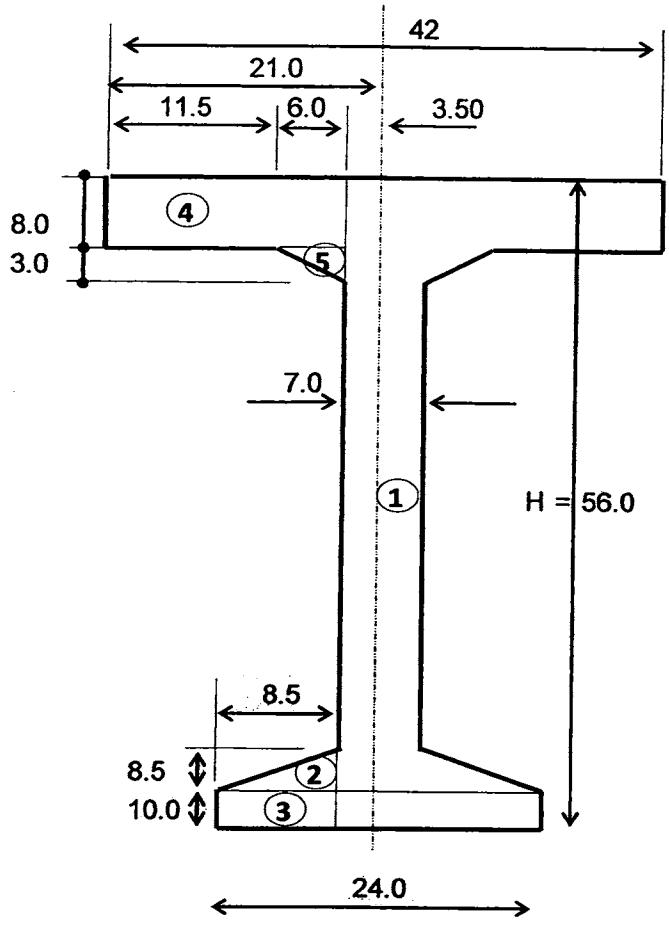
COMPOSITE SECTION MODULUS FOR THE EXTREME BOTTOM FIBER OF THE NON-COMPOSITE PRECAST BEAM

$S_b = 12518$ in³

COMPOSITE SECTION MODULUS FOR THE EXTREME TOP FIBER OF THE NON-COMPOSITE PRECAST BEAM

$S_t = 14664$ in³

BY:
CHKD.BY: DATE



DECKED BULB TEE GIRDER

MOMENT OF INERTIA OF GIRDER CROSS SECTION ABOUT X-X AXIS

Io:

							(in²)
1 =	1/12 *	7.0	*	56.0^3	=		102443
2 =	1/36 *	8.5	*	8.5^3	=		145.0
3 =	1/12 *	8.5	*	10.0^3	=		708.3
4 =	1/12 *	17.5	*	8.0^3	=		746.7
5 =	1/36 *	6.0	*	3.0^3	=		4.5

NON-COMPOSITE SECTION PROPERTIES :

	A (in²)	Y (in)	AY (in²)	AY^2 (in³)	Io (in⁴)
1	392.0	28.0	10976	307328	102443
2	72.3	12.8	927.21	11899.2	290
3	170.0	5.0	850	4250	1417
4	280.0	52.0	14560	757120	1493
5	18.0	47.0	846	39762	9
Σ =	932.3		28159	1120359	105652

$$Y = \frac{28159}{932.3} = 30.21 \text{ in}$$

$$I_{xx} = 1120359 + 105652 - 932.3 * 30.21^2 = \mathbf{375{,}444} \text{ in}^4$$

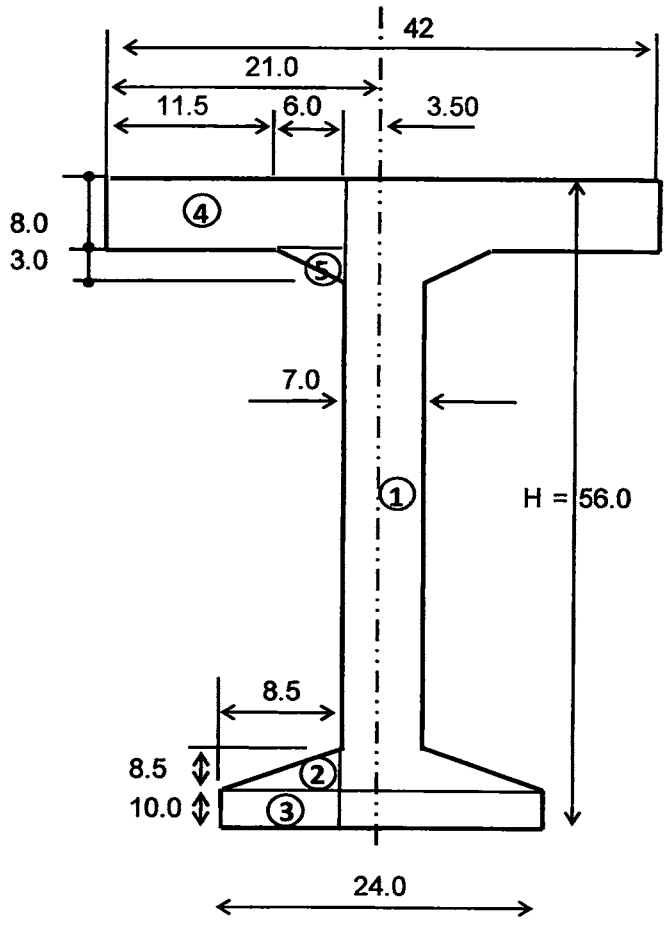
$$S_t = \frac{375444}{25.79} \qquad S_b = \frac{375444}{30.21}$$

$$S_t = 14555 \text{ in}^3 \qquad S_b = 12430 \text{ in}^3$$

Close, Jensen and Miller, P.C

4-BC 3/25/201

BY:
CHKD.BY: DATE



DECKED BULB TEE GIRDER

MOMENT OF INERTIA OF GIRDER CROSS SECTION ABOUT Y-Y AXIS

Io: (in²)

1 = 1/12 * 56.0 * 3.5^3 = 200.083
2 = 1/36 * 8.5 * 8.5^3 = 145.0
3 = 1/12 * 10.0 * 8.5^3 = 511.8
4 = 1/12 * 8.0 * 17.5^3 = 3572.9
5 = 1/36 * 3.0 * 6.0^3 = 18.0

NON-COMPOSITE SECTION PROPERTIES :

	A (in²)	Y (in)	AY (in²)	AY² (in³)	Io (in⁴)
1	196.0	1.8	343	600.25	200
2	36.1	6.3	228.79	1449.01	145
3	85.0	7.8	658.75	5105.31	512
4	140.0	12.3	1715	21008.8	3573
5	9.0	5.5	49.5	272.3	18
Σ =	466		2995	28436	4448

I_{yy} = 28436 + 4448 =

I_{yy} = 32883 * 2 (ea.) = **65,767** in⁴

BY: m.g.
CHKD.BY: BA DATE 3/17/11

BRIDGE NO.00596

I - GIRDER BRIDGE (INTERIOR GIRDER)

NONCOMPOSITE DEAD LOAD, DC1 :

BEAM SELF WEIGHT : = 0.375 kip/ft PCI DESIGN MANUAL

DIAPHRAGMS : = 0.246 kip/ft

SLAB + HAUNCH : $\left[0.667 * 5.96 + \left(0.0 * 42\right)\right] * 0.150 = 0.596$ kip/ft (ts. ft) (S,ft) (HAUNCH,in) (in) (k/ft³)

$\sum DC_1 = 1.22$ kip/ft

$V_{DC1} = 1.22 * \frac{75.5}{2} = 46.0$ kip AT SUPPORT

$M_{DC1} = \frac{1.22 * 75.5^2}{8} = 868.1$ kip-ft AT MIDSPAN

COMPOSITE DEAD LOAD, DC2 :

$W_{parapet}$= 2.20 kip/ft LRFD Design 4.6.2.2.1

$DC_2 = \left(2 * 2.200\right) / 11 = 0.4$ kip/ft (ea.) (BEAMS,ea.)

$V_{DC2} = 0.40 * \frac{75.5}{2} = 15.1$ kip AT SUPPORT

$M_{DC2} = \frac{0.40 * \left(75.5\right)^2}{8} = 285.3$ kip-ft AT MIDSPAN

WEARING SURFACE, DW :

ROADWAY WIDTH : $50.00 - \left(1.0 * 0\right) = 50.0$ ft (ea.PARAPET)

$DW = \left(0.208 * 50.0 * 0.150\right) / 11 = 0.142$ kip/ft (thick., ft) (k/ft³) (BEAMS,ea.)

$V_{DW} = 0.142 * \frac{75.5}{2} = 5.4$ kip AT SUPPORT

$M_{DW} = \frac{0.142 * \left(75.5\right)^2}{8} = 101.3$ kip-ft AT MIDSPAN

BY: m.g.
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BRIDGE NO.00596

I - GIRDER BRIDGE (INTERIOR GIRDER)

LIVE LOAD ANALYSIS :

LRFD Design, Table 4.6.2.2.1-1

LIVE LOAD DISTRIBUTION FACTORS, g :

LONGITUDINAL STIFFNESS PARAMETER, Kg :

AASHTO LRFD TYPE (J) CROSS-SECTION

$$K_g = (I + Ae_g^2)n$$

$$n = \frac{E_{beam}}{E_{deck}} = \frac{4074}{3644} = 1.12$$

$A = 932.2$ in²

$I_0 = 375444$ in⁴

$L = 75.54$ ft

$t_s = 0$ in

e_g = GIRDER DEPTH - y_b + HAUNCH + $t_s/2$

$e_g = [56 - 30.21] + 0.0 + [0 / 2]$

$e_g = 25.79$ in

$$K_g = [375444 + 932.2 * 25.79^2] * 1.12$$

$K_g = 1112972$ in

DISTRIBUTION FACTOR FOR MOMENT, g_m :

LRFD Design, Table 4.6.2.2.2b-1

ONE LANE LOADED :

$$\frac{K_g}{12Lt_s^3} = \frac{1112972}{12 * 75.54 * 8^3} = 2.40$$

$$g_{m1} = 0.06 + \left(\frac{S}{14}\right)^{0.4} * \left(\frac{S}{L}\right)^{0.3} * \left(\frac{K_g}{12Lt_s^3}\right)^{0.1}$$

$$g_{m1} = 0.06 + \left(\frac{5.96}{14}\right)^{0.4} * \left(\frac{5.96}{75.54}\right)^{0.3} * (2.40)^{0.1}$$

$g_{m1} = 0.422$

TWO OR MORE LANES LOADED :

$$g_{m2} = 0.075 + \left(\frac{S}{9.5}\right)^{0.6} * \left(\frac{S}{L}\right)^{0.2} * \left(\frac{K_g}{12Lt_s^3}\right)^{0.1}$$

$$g_{m2} = 0.075 + \left(\frac{5.96}{9.5}\right)^{0.6} * \left(\frac{5.96}{75.54}\right)^{0.2} * (2.40)^{0.1}$$

$g_{m2} = 0.571$

$g_{m2} > g_{m1}$ USE, $g_m = 0.593$

DISTRIBUTION FACTOR FOR SHEAR, g_v :

LRFD Design, Table 4.6.2.2.3a-1

ONE LANE LOADED :

$$g_{v1} = 0.36 + \frac{S}{25} = 0.36 + \frac{5.96}{25} = 0.60$$

TWO OR MORE LANES LOADED :

$$g_{v2} = 0.2 + \left(\frac{S}{12}\right) - \left(\frac{S}{35}\right)^2 = 0.2 + \left(\frac{5.96}{12}\right) - \left(\frac{5.96}{35}\right)^2 = 0.668$$

$g_{v2} > g_{v1}$

USE, $g_v = 0.668$

BY: m.g.
CHKD.BY: BA DATE 3/17/11

BRIDGE NO.00596

I - GIRDER BRIDGE (INTERIOR GIRDER)

LIVE LOAD ANALYSIS : LRFD Design, Table 4.6.2.2.1-1

LIVE LOAD DISTRIBUTION FACTORFOR MOMENT, g_m : LRFD Design, Table 4.6.2.2.2b-1

BRIDGE TYPE (j), IF CONNECTED ONLY ENOUGH TO PREVENT RELATIVE DISPLACEMENT AT INTERFACE

ST.VENANT'S TORSIONAL INERTIA, J :

$$J = \frac{A^4}{40\, I_p} = \frac{932.2^4}{40 * 441210} \longrightarrow J = 42789 \text{ in}^4$$

LRFD Design, Table 4.6.2.2.2b-1

POLAR MOMENT OF INERTIA, I_p :

$I_p = I + I_{yy} = 441210 \text{ in}^4$

GROSS MOMENT OF INERTIA OF GIRDER CROSS SECTION ABOUT CENTROIDAL X-X AXIS: $I = 375444 \text{ in}^4$

GROSS MOMENT OF INERTIA OF GIRDER CROSS SECTION ABOUT CENTROIDAL Y-Y AXIS: $I_{yy} = 65766 \text{ in}^4$

$A = 932.2 \text{ in}^2$

$\mu = 0.20$ (POISSON'S RATIO) LRFD Design, 5.4.2.5

$$K = \left(\frac{(1 + \mu) * I}{J} \right)^{1/2} \qquad K = \sqrt{10.5} = 3.245$$

$$C = K * \left(\frac{W_{overall}}{L} \right) \qquad C = 2.771$$

OVERALL WIDTH OF BRIDGE, $W_{overall} = 64.50$ ft

$L = 75.5$ ft

WHEN $C \leq 5$

WIDTH OF DISTRIBUTION PER LINE, D:

$$D = 11.5 - N_L + 1.4 * N_L * (1 - 0.2 * C)^2$$

NUMBER OF DESIGN LANES, N_L :

$N_L = 1$

$$D = 11.5 - 1 + 1.4 * 1 * (1 - 0.2 * 2.771)^2$$

$D = 10.78$

$$g_{m1} = \frac{S}{D} = \frac{5.96}{10.78} = 0.553$$

$S = 5.96$ ft

$N_L = 2$

$$D = 11.5 - 2 + 1.4 * 2 * (1 - 0.2 * 2.771)^2$$

$D = 10.06$

$g_{m2} = 0.593$

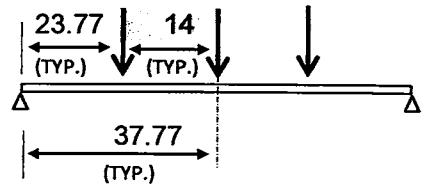
I - GIRDER BRIDGE (INTERIOR GIRDER)

COMPUTE MAXIMUM LIVE LOAD EFFECTS

MAXIMUM DESIGN LIVE LOAD (HL-93) MOMENT AT MIDSPAN

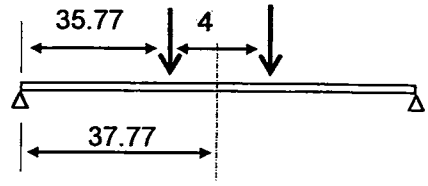
$$\text{DESIGN LANE LOAD MOMENT} = \overset{(klf)}{0.64} * \frac{75.54^2}{8} = 456.5 \text{ kip-ft}$$

DESIGN TRUCK MOMENT WITH THE MIDDLE AXLE LOCATED AT MIDSPAN:



$$\text{DESIGN TRUCK MOMENT} = \frac{\left[\overset{(kip)}{8} + \overset{(kip)}{32}\right] * \overset{(ft)}{37.77} * \overset{(ft)}{23.77}}{75.54} + \frac{\overset{(kip)}{32} * 75.54}{4} = 1080 \text{ kip-ft} \leftarrow \text{GOVERNS}$$

TANDEM AXLES MOMENT WITH TANDEM AXLES LOCATED EQUIDISTANT FROM MIDSPAN:



$$\text{TANDEM AXLES MOMENT} = \overset{(kip)}{25} * \overset{(ft)}{38} = 950 \text{ kip-ft}$$

IM = 33 %

LRFD Design, Table 3.6.2.1-1

M_{LL+I} = 456.5 + [1080 * 1.33]

M_{LL+I} = 1893 kip-ft

DISTRIBUTED LIVE LOAD MOMENT AT MID SPAN:

$g_m M_{LL+I}$ = 1893 * g_m = 1893 * 0.593 = 1122 kip-ft

I - GIRDER BRIDGE (INTERIOR GIRDER)

NOMINAL FLEXURAL RESISTANCE AT MIDSPAN :

AVERAGE STRESS IN PRESTRESSING STEEL, f_{ps} :

$f_{ps} = f_{pu}\,(1 - k\,(c / d_p))$ LRFD Design, Eq. 5.7.3.1.1-1

$k = 0.38$ STRESS-RELIEVED STRANDS LRFD Design, Table C5.7.3.1.1-1

$f_{pu} = 200$ ksi SPECIFIED TENSILE STRENGTH OF PRESTRESSING STEEL

d_p = DISTANCE FROM EXTREME COMPRESSION FIBER TO THE CENTROID OF THE PRESTRESSING TENDONS

	STRANDS	y	STRANDS · y
LAYER 1	7	4.75	33.25
LAYER 2	0	0	0
LAYER 3	0	0	0
TOTAL	7		33.25

$\bar{y} = \dfrac{33.25}{7} = 4.75$ DISTANCE FROM BOTTOM OF GIRDER TO CENTROID OF PRESTRESSING STRANDS

$d_p = \left(56 + 0.0 + 0\right) - 4.75 = 51.25$ in

DISTANCE FROM THE NEUTRAL AXIS TO THE COMPRESSIVE FACE, c :

RECTANGULAR SECTION : LRFD Design, Eq. 5.7.3.1.1-4

$$c = \frac{A_{ps}\,f_{pu}}{0.85 f'_c \beta_1 b + k A_{ps}(f_{pu}/d_p)}$$

AREA OF PRESTRESSING STEEL : (PER STRAND) $A_{ps} = 0.751$ in² LOW-RELAXATION STRANDS

$\sum A_{ps} = 7 * 0.751 = 5.257$ in²

$b = b_e = 71.52$ in (EFFECTIVE FLANGE WIDTH OF DECK)

$f'_c = 4.0$ ksi (DECK)

$\beta_1 = 0.85$ LRFD Design, 5.7.2.2

$A_{ps} f_{pu} = 5.257 * 200 = 1051$ kip

$0.85 f'_c \beta_1 b = 0.85 * 4.0 * 0.85 * 71.52 = 206.7$ k/in

$k A_{ps} (f_{pu}/d_p) = 0.38 * 5.3 * \left(200 / 51.25\right) = 7.80$ k/in

$c = 1051 / \left(206.7 + 7.80\right) = 4.90$ in

DEPTH OF THE EQUIVALENT STRESS BLOCK, a :

$a = \beta_1 c = 0.85 * 4.90 = 4.17$ in LRFD Design, 5.7.2.2

$a < t_s = 8$ in ASSUMPTION OF THE SECTION BEHAVING AS A RECTANGULAR SECTION IS CORRECT

AVERAGE STRESS IN PRESTRESSING STEEL, f_{ps} : LRFD Design, Eq. 5.7.3.1.1-1

$f_{ps} = 200 * \left(1 - 0.38 * \left(4.90 / 51.25\right)\right) = 192.7$ ksi

NOMINAL FLEXURAL RESISTANCE, M_n (AT MIDSPAN) : LRFD Design, Eq. 5.7.3.2.2-1

$M_n = A_{ps} f_{ps} (d_p - a/2) = 5.257 * 192.7 * \left(51.25 - \left(4.17 / 2\right)\right) = 4151$ kip-ft

I - GIRDER BRIDGE (INTERIOR GIRDER)

MAXIMUM REINFORCEMENT

CONCRETE STRAIN, ε_c : LRFD Design, C5.7.2.1

$\varepsilon_c = 0.003$

NET TENSILE STRAIN, ε_t :

$$\frac{\varepsilon_c}{c} = \frac{\varepsilon_t}{d_p - c}$$

$\varepsilon_t = [0.003 * (51.25 - 4.90)] / 4.90 = 0.0284 > 0.005$ LRFD Design, 5.7.2.1

SECTION IS TENSION CONTROLLED

RESISTANCE FACTOR : $\varphi = 1.0$ LRFD Design, 5.5.4.2

MINIMUM REINFORCEMENT LRFD Design, 5.7.3.3.2

AMOUNT OF REINFORCEMENT MUST BE SUFFICIENT TO DEVELOP M_r EQUAL TO THE LESSER OF :

$1.2\ M_{cr}$ OR $1.33\ M_u$

LOAD	LOAD FACTOR, γ
DC	1.25
DW	1.50
LL	1.75

LRFD Design, Table 3.4.1-1

LRFD Design, Table 3.4.1-2

FACTORED FLUXURAL RESISTANCE, M_r : $M_r = \varphi M_n = 1.0 * 4151 = 4151$ kip-ft

FACTORED MOMENT, $1.33\ M_u$:

$1.33\ M_u = 1.33 * [1.25 * (868.1 + 285.3) + 1.50 * 101.3 + 1.75 * 1122]$

$= 4730$ kip-ft $>$ 4151 kip-ft

NO GOOD

CRACKING MOMENT, $1.2\ M_{cr}$: THE MANUAL FOR BRIDGE EVALUATION 6A.5.6

$1.2\ M_{cr} = S_c (f_r + f_{cpe}) - M_{dnc} ((S_c/S_{nc}) - 1) \geq S_c f_r$ LRFD Design, Eq. 5.7.3.3.2-1

UNFACTORED DEAD LOAD MOMENT (NONCOMPOSITE SECTION), M_{dnc}

$M_{dnc} = 868.1$ kip-ft

$S_c = 14664$ in³

$S_{nc} = 12428$ in³

MODULUS OF RUPTURE, f_r : $f_r = 0.37\sqrt{f'_c}$ LRFD Design, 5.4.2.6

$= 0.37 * \sqrt{5.0} = 0.827$ ksi

LRFD Design, 5.7.3.3.2

COMPRESSIVE STRESS IN CONCRETE DUE TO EFFECTIVE PRESTRESS FORCE (AFTER ALLOWANCE FOR ALL PRESTRESS LOSSES) AT EXTREME FIBER OF SECTION WHERE TENSILE STRESS IS CAUSED BY EXTERNALLY APPLIED LOADS, f_{cpe} :

$$f_{cpe} = \frac{P_{pe}}{A} + \frac{P_{pe}\, e}{S_b}$$

I - GIRDER BRIDGE (INTERIOR GIRDER)

DETERMINE EFFECTIVE PRESTRESS FORCE, P_{pe} :

$P_{pe} = A_{ps} * f_{pe}$

EFFECTIVE PRESTRESS f_{pe} = INITIAL PRESTRESS - TOTAL PRESTRESS LOSSES

TOTAL PRESTRESS LOSSES IMMEDIATELY BEFORE TRANSFER, Δf_{pT} :

$\Delta f_{pT} = \Delta f_{pES} + \Delta f_{pLT}$ LRFD Design, Eq. 5.9.5.1-1

LOSS DUE TO ELASTIC SHORTENING AND/OR EXTERNAL LOADS, Δf_{pES} : LRFD Design, 5.9.5.2.3a

$$\Delta f_{pES} = \frac{E_p}{E_{ct}} f_{cgp}$$

THE CONCRETE STRESS AT THE CENTER OF GRAVITY OF PRESTRESSING TENDONS DUE TO THE PRESTRESSING FORCE IMMEDIATELY AFTER TRANSFER AND SELF-WEIGHT OF THE MEMBER AT THE SECTION OF MAXIMUM MOMENT, f_{cgp} :

$$f_{cgp} = \frac{P_i}{A} + \frac{P_i e^2}{I} - \frac{M_D e}{I}$$

INITIAL PRESTRESS IMMEDIATELY PRIOR TO TRANSFER, $f_{pbt} = 0.7 f_{pu}$: LRFD Design, Table 5.9.3-1

$f_{pbt} = 0.7 * f_{pu}$

IMMEDIATELY AFTER TRANSFER : LRFD Design, 5.9.5.2.3a

$P_i = 0.90 (0.7 f_{pu})(\#\ \text{STRANDS})\ A_{PS}$

$P_i = 0.90 * [0.7 * 200] * 7 * 0.751 = 662.4$ kips

MOMENT DUE TO SELF-WEIGHT OF MEMBER AT SECTION OF MAXIMUM MOMENT (MIDSPAN), M_D :

$$M_D = \frac{0.971 * 75.5^2}{8} = 692.7 \text{ kip-ft}$$

$y_b = 30.21$ in BASIC BEAM SECTION

$\bar{y} = 4.75$ in DISTANCE FROM BOTTOM OF GIRDER TO CENTROID OF PRESTRESSING STRANDS

ECCENTRICITY OF STRANDS :

$e = 30.21 - 4.75 = 25.46$ in

$$f_{cgp} = \frac{662.4}{932.2} + \frac{662.4 * 25.46^2}{375443.9} - \frac{692.7 * 12 * 25.46}{375443.9}$$

$f_{cgp} = 0.711 + 1.144 - 0.564 = 1.291$ ksi

MODULUS OF ELASTICITY OF PRESTRESSING REINFORCEMENT, E_p : LRFD Design, 5.9.5.2.3a

$E_p = 25000$ ksi

MODULUS OF ELASTICITY OF CONCRETE AT TRANSFER, E_{ct} :

$E_{ct} = (33000)(w_c)^{1.5} \sqrt{f'_c}$ $w_c = 0.145$ kcf LRFD Design, Eq. 5.4.2.4-1

$E_{ct} = 3644$ ksi

$\Delta f_{pES} = [25000 / 3644] * 1.291 = 8.85$ ksi

I - GIRDER BRIDGE (INTERIOR GIRDER)

APPROXIMATE LUMP SUM ESTIMATE OF TIME-DEPENDENT LOSESS, Δf_{pLT} :

$$\Delta f_{pLT} = \left[\Delta f_{pSR} + \Delta f_{pCR} + \Delta f_{pR1} \right]_{id} + \left[\Delta f_{pSD} + \Delta f_{pCD} + \Delta f_{pR} - \Delta f_{pSS} \right]_{df}$$ LRFD Design, Eq. 5.9.5.4.1-1

FOR I-BEAM : LRFD Design, 5.9.5.3

$$\Delta f_{pLT} = 10.0\ ((f_{pi}\ A_{ps})/A_g)\ \gamma_h \gamma_{st} + 12.0\ \gamma_h \gamma_{st} + \Delta f_{pR}$$

CORRECTION FACTOR FOR RELATIVE HUMUDITY :

$$\gamma_h = 1.7 - 0.01H$$ LRFD Design, Eq. 5.9.5.3-2

ASSUME RELATIVE HUMUDITY RANGING BETWEEN 40% - 100% : H = 70 %

$$\gamma_h = 1.7 - 0.01 * 70$$

$$\gamma_h = 1.0$$

CORRECTION FACTOR FOR SPECIFIED CONCRETE STRENGTH AT TIME OF PRESTRESS TRANSFER TO THE CONCRETE MEMBER :

$$\gamma_{st} = 5 / (1 + f'_{ci})$$

$$\gamma_{st} = 5 / [1 + 4.0] = 1.0$$

ESTIMATE OF RELAXATION LOSS :

Δf_{pR} = 10.0 ksi STRESS RELIEVED STRANDS LRFD Design, 5.9.5.3

f_{pbt} = 0.75 * 200 = 150 ksi

A_{ps} = 7 * 0.751 = 5.257 in²

$$\Delta f_{pLT} = 10.0 * \frac{150 * 5.257}{932.2} * 1.0 * 1.0 + 12.0 * 1.0 * 1.0 + 10$$

Δf_{pLT} = 30.46 ksi

TOTAL PRESTRESS LOSSES, Δf_{pT} :

$$\Delta f_{pT} = \Delta f_{pES} + \Delta f_{pLT}$$

$$\Delta f_{pT} = 8.853 + 30.46 = 39.31 \text{ ksi}$$

EFFECTIVE PRESTRESS f_{pe} = INITIAL PRESTRESS - TOTAL PRESTRESS LOSSES

f_{pe} = 0.75 * 200 - 39.31 = 110.7 ksi

$P_{pe} = A_{ps} * f_{pe}$

P_{pe} = 5.257 * 110.7 = 581.9 kips

$$f_{cpe} = \frac{P_{pe}}{A} + \frac{P_{pe}\ e}{S_b}$$

$$f_{cpe} = \frac{581.9}{932.2} + \frac{581.9 * 25.46}{12428}$$

f_{cpe} = 1.816 ksi

I - GIRDER BRIDGE (INTERIOR GIRDER)

CRACKING MOMENT, 1.2 M_{cr}:

THE MANUAL FOR BRIDGE EVALUATION 6A.5.6

LRFD Design, Eq. 5.7.3.3.2-1

$$M_{cr} = S_c (f_r + f_{cpe}) - M_{dnc} ((S_c/S_{nc}) - 1) \geq S_c f_r$$

$$S_c (f_r + f_{cpe}) - M_{dnc} ((S_c/S_{nc}) - 1) = \frac{14664}{12} * \left(0.827 + 1.816 \right) - 868.1 * \left(\frac{14664}{12428} - 1 \right)$$

M_{cr} = 3074 kip-ft

$S_c f_r$ = (14664 / 12) * 0.827 = 1011 kip-ft OK

1.2 M_{cr} = 1.2 * 3074 = 3689 kip-ft ← CONTROLS 1.2 M_{cr} < 1.33 M_u

1.33 M_u = 4730 kip-ft

M_r = 4151 kip-ft > 3689 kip-ft

OK

I - GIRDER BRIDGE (INTERIOR GIRDER)

NOMINAL SHEAR RESISTANCE AT FIRST CRITICAL SECTION

CRITICAL SECTION NEAR THE SUPPORTS IS THE GREATER OF: LRFD Design, 5.8.3.2

d_v OR $0.5d_v \cot\theta$

EFFECTIVE SHEAR DEPTH, d_v: LRFD Design, 5.8.2.9

d_v = DISTANCE BETWEEN RESULTANTS OF THE TENSILE AND COMPRESSIVE FORCES, (d_e-a/2)
BUT NOT LESS THAN (0.9 d_e) OR (0.72h)

d_e = DISTANCE FROM THE EXTREME COMPRESSION FIBER TO THE CENTER OF THE PRESTRESSING STEEL AT THE SECTIO

h = DEPTH OF PRECAST BEAM + STRUCTURAL SLAB THICKNESS

STRANDS: 7 ea. PRESTRESSING STRANDS

0 ea. DEBONDED ON EACH END, OVER THE LAST: 0 ft

ASSUME THAT CRITICAL SECTION WILL BE WITHIN : 0 ft

DISTANCE FROM THE NEUTRAL AXIS TO THE COMPRESSIVE FACE, c: LRFD Design, Eq. 5.7.3.1.1-4

$$c = \frac{A_{ps} f_{pu}}{0.85 f'_c \beta_1 b + k A_{ps}(f_{pu}/d_p)}$$

A_{ps} = (7 - 0) * 0.751 = 5.257 in²

b = b_e = 71.52 in (EFFECTIVE FLANGE WIDTH OF DECK)

f'_c = 4.0 ksi (DECK)

β_1 = 0.85 LRFD Design, 5.7.2.2

k = 0.38 STRESS RELIEVED STRANDS

f_{pu} = 200 ksi SPECIFIED TENSILE STRENGTH OF PRESTRESSING STEEL

	STRANDS	y	STRANDS · y
LAYER 1	7	12.89	90.23
LAYER 2	0	0	0
LAYER 3	0	0	0
TOTAL	7		90.23

$\bar{y} = \frac{90.23}{7} = 12.89$ (DISTANCE FROM BOTTOM OF GIRDER TO CENTROID OF PRESTRESSING STRANDS)

d_p = (56 + 0.0 + 0) - 12.89 = 43.11 in

$$c = \frac{5.257 * 200}{0.85 * 4.0 * 0.85 * 71.52 + 0.38 * 5.257 * (200 / 43.11)} = 4.87 \text{ in}$$

a = $\beta_1 c$ = 0.85 * 4.87 = 4.14 in LRFD Design, 5.7.2.2

$d_v = d_e - \frac{a}{2} = 43.11 - \frac{4.14}{2} = 41.0$ in ← GOVERNS

h = 56 + 0.0 + 0 = 56.0 in 0.72h = 40.32 in 3.36 ft

d_e = 43.11 in 0.9d_e = 38.8 in 3.233 ft

ASSUME: θ = 30 °

$0.5d_v \cot\theta$ = 0.5 * d_v * cot 30 = 0.87 d_v < d_v

BY: m.g.
CHKD.BY: BA DATE 3/17/11

BRIDGE NO.00596

I - GIRDER BRIDGE (INTERIOR GIRDER)

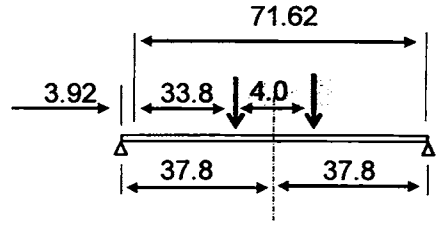
DISTANCE FROM FACE OF SUPPORT TO CENTERLINE OF BEARING: 6 in LRFD Design, 5.11.4

DISTANCE FROM CENTERLINE OF BEARING TO CRITICAL SHEAR SECTION : 41.0 + 6 = 47.0 in
= 3.92 ft

MAXIMUM SHEAR AT CRITICAL SECTION NEAR SUPPORT L = 75.54 - 3.92 = 71.62 ft

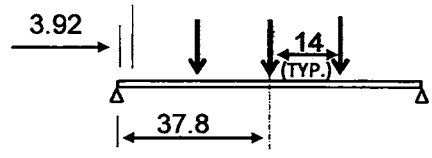
$$V_{LANE} = \frac{\overset{(klf)}{0.64} * 71.62^2}{2 * 75.54} = 21.7 \text{ kip-ft}$$

$$V_{TANDEM} = \overset{(kip)}{25} * \frac{\overset{(ft)}{71.62} + \overset{(ft)}{67.62}}{75.54} = 46.08 \text{ kips}$$



$$V_{TRUCK} = \frac{\overset{(kip)}{32} * (71.62 + 57.62) + \overset{(kip)}{8} * 43.62}{75.54}$$

V_{TRUCK} = 59.4 kips ← GOVERNS



IM = 33 % LRFD Design, Table 3.6.2.1-1

TOTAL SHEAR :

V_{LL+I} = 21.73 + 59.4 * 1.33 = 100.7 kips DISTRIBUTION FACTOR FOR SHEAR, g_V = 0.668

DISTRIBUTED TOTAL SHEAR :

V_{LL+I} = 100.7 * 0.668 = 67.2 kips

DEAD LOAD SHEARS : $\sum DC_1$ = 1.22 kip/ft
DC_2 = 0.4 kip/ft
DW = 0.142 kip/ft

V_{DC} = (1.22 + 0.4) * (0.5 * 75.54 - 3.92)
V_{DC} = 41.2 + 13.5 = 54.7 kips

V_{DW} = 0.142 * (0.5 * 75.54 - 3.92) = 4.81 kips

I - GIRDER BRIDGE (INTERIOR GIRDER)

NOMINAL SHEAR RESISTANCE, V_n : LRFD Design, Eq. 5.8.3.3-1

SHALL BE LESSER OF: LRFD Design, Eq. 5.8.3.3-2

$V_n = V_s + V_c + V_p$

$V_n = 0.25 f'_c b_v d_v + V_p$

MINIMUM TRANSVERSE REINFORCEMENT, A_v : LRFD Design, Eq. 5.8.2.5-1

$$A_v = 0.0316 \sqrt{f'_c} \frac{b_v s}{f_y}$$

b_v = 7.0 in WEB WIDTH

s = 18.0 in

$$A_v = 0.0316 * \sqrt{5.0} * \frac{7 * 18}{40} = 0.223 \text{ in}^2$$

STIRRUPS AREA PROVIDED : # 4 A = 0.13 in²
(2 LEGS)

A_v = 2 * 0.13 = 0.26 in² > 0.223 in² OK

CONCRETE : $V_c = 0.0316 \beta \sqrt{f'_c} b_v d_v$ LRFD Design, Eq. 5.8.3.3-3

STEEL : $V_s = \frac{A_v f_y d_v \cot\theta}{s}$ LRFD Design, Eq. C5.8.3.3-1

$V_n = 0.25 f'_c b_v d_v + V_p$ LRFD Design, Eq. 5.8.3.3-2

$V_p = A_{PS} * N_s * f_{pe} * SIN(\theta)$ V_p = 17.46 kips

V_n = 0.25 * 5.0 * 7.0 * 41.0 + 17.46 = 377 kips

NOMINAL SHEAR RESISTANCE, V_n (SIMPLIFIED APPROACH) : LRFD Design, Eq. 5.8.3.4.1

ASSUME : θ = 45 °

β = 2.0

CONCRETE : $V_c = 0.0316 \beta \sqrt{f'_c} b_v d_v$ LRFD Design, Eq. 5.8.3.3-3

b_v = 7 in

d_v = 41.0 in

V_c = 0.0316 * 2.0 * √ 5.0 * 7 * 41.0 = 40.6 kips

STEEL : $V_s = \frac{A_v f_y d_v \cot\theta}{s}$ α = 90 °

STIRRUPS : # 4 @ 18 in

A_v = 0.26 in²

$$V_s = \frac{0.26 * 40 * 41.0 * \cot 45}{18} = 23.71 \text{ kips}$$

NOMINAL SHEAR RESISTANCE, V_n :

$V_n = V_s + V_c + V_p$ LRFD Design, C5.8.3.3-1

= 23.71 + 40.6 + 17.5 = 81.8 kips

V_n = 81.8 kips < 377 kips

φV_n = 0.90 * 81.8 = 73.59 kips LRFD Design, 5.5.4.2.1

RESISTANCE FACTOR FOR SHEAR, φ = 0.90

I - GIRDER BRIDGE (INTERIOR GIRDER)

MAXIMUM DISTRIBUTED SHEARS AT CRITICAL SECTION (HL-93 INVENTORY LOADING) :

V_{LL+I} = 67.2 kips

V_{DC} = 54.7 kips

V_{DW} = 4.81 kips

LOAD	LOAD FACTOR, γ
DC	1.25
DW	1.50
LL	1.75

LRFD Design, Table 3.4.1-1

LRFD Design, Table 3.4.1-2

FACTORED SHEAR :

V_u = 1.25 * 54.7 + 1.50 * 4.81 + 1.75 * 67.2

V_u = 193.3 kips > 73.59 kips NO GOOD (SIMPLIFIED APPROACH)

NOMINAL SHEAR RESISTANCE, V_n (MCFT APPROACH) : LRFD Design, Eq.5.8.2.9-1

SHEAR STRESS ON THE CONCRETE :

$$v_u = \frac{V_u - \varphi V_p}{\varphi b_v d_v}$$

$$v_u = \frac{193.3 - 15.71}{0.90 * 7.0 * 41.0} = 0.748 \text{ ksi}$$

LRFD Design, C5.8.2.9

LRFD Design, 5.5.4.2.1

RATIO OF THE APPLIED FACTORED SHEAR STRESS TO THE CONCRETE COMPRESSIVE STRENGTH :

$$\frac{v_u}{f'_c} = \frac{0.748}{5.0} = 0.150 < 0.25$$

DISTANCE FROM CENTERLINE OF BEARING TO CRITICAL SHEAR SECTION = 3.92 ft

DEAD LOAD MOMENTS AT FIRST CRITICAL SECTION FOR SHEAR :

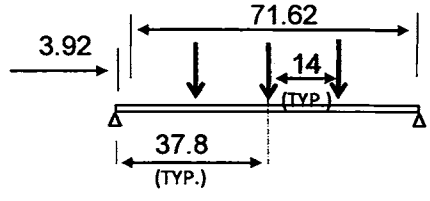
$$M_{DC} = 0.5 * (\overset{(k/ft)}{1.22} + \overset{(k/ft)}{0.4}) * 3.92 * (\overset{(L, ft)}{75.54 - 3.92})$$

M_{DC} = 170.9 + 56.15 = 227.0 kip-ft

M_{DW} = 0.5 * 0.142 * 3.92 * 75.54 - 3.92 = 19.9 kip-ft

LIVE LOAD MOMENTS AT FIRST CRITICAL SECTION FOR SHEAR :

$$M_{TRUCK} = \frac{\overset{(k)}{32} * 3.92 * (71.62 + 57.62) + \overset{(k)}{8} * 3.92 * 43.62}{75.54}$$



M_{TRUCK} = 232.7 kip-ft

$$M_{LANE} = \frac{\overset{(klf)}{0.64} * 71.62^2}{2 * 75.54} * 3.92 = 85.2 \text{ kip-ft}$$

$$M_{LL+I} = \overset{(IM)}{1.33} * 232.7 + 85.2 = 394.7 \text{ kip-ft}$$

DISTRIBUTED MOMENT :

$g_m * M_{LL+I}$ = 0.593 * 394.7 = 233.9 kip-ft

I - GIRDER BRIDGE (INTERIOR GIRDER)

NOMINAL SHEAR RESISTANCE, V_n (MCFT APPROACH) :

LOAD	LOAD FACTOR, γ
DC	1.25
DW	1.50
LL	1.75

LRFD Design, Table 3.4.1-1

LRFD Design, Table 3.4.1-2

FACTORED MOMENT :

M_u = 1.25 * 227.0 + 1.50 * 19.9 + 1.75 * 233.9 = 723 kip-ft

STRAIN IN THE REINFORCEMENT, ε_x :

LRFD Design, 5.8.3.4.2

$$\varepsilon_x = \frac{\frac{M_u}{d_v} + 0.5N_u + 0.5(V_u - V_p)\cot\theta - A_{ps} f_{po}}{2(E_sA_s + E_pA_{ps})} \leq 0.001$$

$N_u = 0$

$V_p = 0$

$E_sA_s = 0$

A_{ps} = 7 * 0.751 = 5.257 in²

$f_{po} = 0.7f_{pu}$ = 0.7 * 200 = 140 ksi

E_p = 25000 ksi

V_u = 193.3 kips

d_v = 41.0 in

ASSUME CRACK INCINATION ANGLE, θ :

V_u / f'_c = 0.150 ⟶ $\varepsilon_x \times 1000 \leq$ -0.10 ε_x = -0.0001

LRFD Design, Table B5.2-1

θ = 21.9 ° cot 21.9 = 2.488

$$\varepsilon_x = \frac{\frac{723 * 12}{41.0} + 0.5 * 193.3 * 2.488 - 5.257 * 140}{2 * (0 + 25000 * 5.257)}$$

ε_x = -0.001081

RECALCULATE ε_x, INCLUDE AREA OF CONCRETE ON THE TENSION SIDE OF THE BEAM WITHIN HALF THE TOTAL DEPTH OF THE BEA

A_c = AREA BELOW * h/2

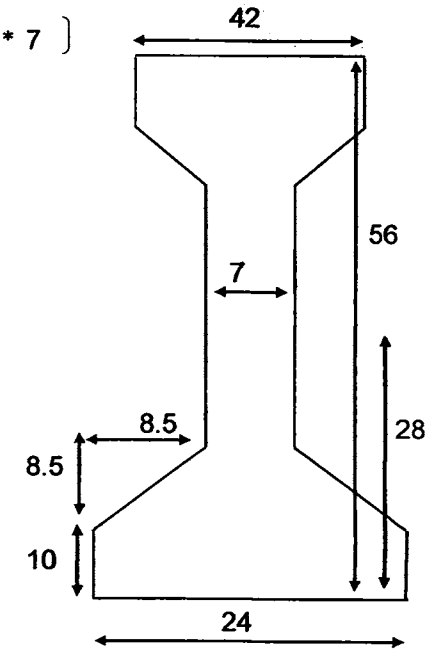
A_c = (10 * 24) + (0.5 * 8.5 * 8.5 * 2) + (8.5 * 7) + 9.5 * 7

A_c = 438.3 in²

E_c = 4074 ksi

$$\varepsilon_x = \frac{\frac{723 * 12}{41.0} + 0.5 * 193.3 * 2.488 - 5.257 * 140}{2 * (4074 * 438.3 + 25000 * 5.257)}$$

ε_x = -0.000074 ≥ -0.00010



BY: m.g.
CHKD.BY: BA DATE 3/17/11

BRIDGE NO.00596

I - GIRDER BRIDGE (INTERIOR GIRDER)

NOMINAL SHEAR RESISTANCE, V_n (MCFT APPROACH) :

ASSUME :

$\varepsilon_x \leq 0$ LRFD Design, Table B5.2-1

$v_u / f'_c = 0.150$

$\theta = 23.7°$ cot 23.7 = 2.278

$\beta = 2.87$

$$\varepsilon_x = \frac{\frac{723 * 12}{41.0} + 0.5 * 193.3 * 2.278 - 5.257 * 140}{2 * \left[4074 * 438.3 + 25000 * 5.257 \right]}$$

$\varepsilon_x = -0.000079 \leq 0$

CONCRETE : $V_c = 0.0316\beta\sqrt{f'_c}\, b_v\, d_v$ LRFD Design, Eq. 5.8.3.3-3

$V_c = 0.0316 * 2.87 * \sqrt{5.0} * 7.0 * 41.0 = 58.3$ kips

SHEAR RESISTANCE PROVIDED BY THE TRANSVERSE REINFORCEMENT (STIRRUPS), V_s :

$$V_s = \frac{A_v f_y d_v \cot\theta}{s}$$ LRFD Design, Eq. C5.8.3.3-1

STIRRUPS : # 4 @ 18 in $A_v = 0.26$ in²

$$V_s = \frac{0.26 * 40 * 41.0 * 2.278}{18} = 54 \text{ kips}$$

NOMINAL SHEAR RESISTANCE, V_n :

$V_n = V_s + V_c + V_p$ LRFD Design, C5.3.3-1

$= 54.02 + 58.3 + 17.5 = 129.7$ kips

$V_n = 0.25 f'_c b_v d_v + V_p$ LRFD Design, Eq. 5.8.3.3-2

$= 0.25 * 5.0 * 7.0 * 41.0 + 17.46 = 377$ kips

$V_n = 130$ kips < 377 kips

$V_n = 130$ kips

$\varphi V_n = 0.90 * 130 = 117$ kips LRFD Design, 5.5.4.2.1

RESISTANCE FACTOR FOR SHEAR, $\varphi = 0.90$

I - GIRDER BRIDGE (INTERIOR GIRDER)

LONGITUDINAL REINFORCEMENT : LRFD Design, 5.8.3.5

$N_u = 0$

$$A_{ps}f_{ps} + A_s f_y \geq \frac{|M_u|}{d_v \varphi_f} + \cancel{0.5 * \frac{N_u}{\varphi_c}} + \left(\left|\frac{V_u}{\varphi_v} - V_p\right| - 0.5V_s\right) * \cot\theta$$ LRFD Design, Eq. 5.8.3.5-1

MINIMUM REQUIRED TENSILE CAPACITY, V_s :

$V_s = 54$ kips

$\frac{V_u}{\varphi} = \frac{193.3}{0.90} = 214.8$ kips

$V_s = 214.8$ kips

$\varphi_c = 0$ LRFD Design, 5.5.4.2

$\varphi_f = 1.0$

$\varphi_v = 0.9$

$$A_{ps}f_{ps} + A_s f_y \geq \frac{|723 * 12|}{41.0 * 1.0} + \left(\left|\frac{193.3}{0.9}\right| - 0.5 * 214.8\right) * \cot 23.7$$

$A_{ps}f_{ps} + A_s f_y \geq 416.3$ kips

TRANSFER LENGTH, ℓ_t : LRFD Design, 5.11.4.1

$\ell_t = 60 \times$ STRAND DIAMETERS

$\ell_t = 60 * 1.125 = 67.5$ in

DEVELOPMENT LENGTH, ℓ_d : LRFD Design, 5.11.4.2-1

$\ell_d \geq k\,(f_{ps} - \frac{2}{3} f_{pe})d_b$ $k = 1.6$

$$\ell_d \geq 1.6 * \left(192.7 - \frac{2}{3} * 110.7\right) * 1.125$$

$\ell_d \geq 214.1$ in

DISTANCE FROMM FREE END OF PRETENSIONED STRAND TO SECTION OF MEMBER UNDER CONSIDERATION, ℓ_{px} :

$\ell_{px} = 47.0$ in LRFD Design, 5.11.4.3

LRFD Design, 5.11.4.1

DESIGN STRESS, f_{px} : LRFD Design, 5.11.4.2-3

$$f_{px} = f_{pe} + \frac{\ell_{px} - 60d_b}{\ell_d - 60d_b} * (f_{ps} - f_{pe})$$

$$f_{px} = 110.7 + \frac{47.0 - 67.5}{214.1 - 67.5} * (192.7 - 110.7) = 99.24 \text{ ksi}$$

$A_{ps}f_{ps} + A_s f_y = f_{px} * A_{ps} = 99.24 * 5.257 = 521.7$ kips

$$A_{ps}f_{ps} + A_s f_y \geq \frac{|M_u|}{d_v \varphi_f} + 0.5 * \frac{N_u}{\varphi_c} + \left(\left|\frac{V_u}{\varphi_v} - V_p\right| - 0.5V_s\right) * \cot\theta$$

521.7 kips $\geq$ 416.3 kips

OK

I - GIRDER BRIDGE (INTERIOR GIRDER)

NOMINAL SHEAR RESISTANCE AT STIRRUP CHANGE / QUARTER POINT : THE MANUAL FOR BRIDGE EVALUATION 6A.5.8

ASSUME : 18.89 ft, FROM CENTERLINE OF BEARING

CHECK TRANSFER LENGTH : LRFD Design, 5.11.4

60 * 1.125 = 67.5 in

DEBONDED LENGTH = 28.33 ft

STRANDS = 7 ea.

ALL STRANDS ARE BONDED AT : 0 + 67.5 = 5.63 ft < 18.89 ft OK

$d_v = d_e - a/2$ LRFD Design, 5.8.2.9

$h = 56 + 0.0 + 0 = 56.0$ in

$d_e = h - \overline{y} = 56.0 - 4.75 = 51.25$ in

$a = 4.17$ in

$d_v = 49.17$ in $> 0.9d_e = 0.9 * 51.25 = 46.13$ in

$> 0.72h = 0.72 * 56.0 = 40.32$ in

$d_v = M_n / (A_s f_y + A_{ps} f_{ps})$ LRFD Design, Eq. C5.8.2.9-1

$A_{ps} = 7 * 0.751 = 5.257$ in²

$d_v = 4151 * 12 / [0 + 5.257 * 192.7] = 49.17$ in

MAXIMUM SHEAR AT STIRRUP CHANGE :

18.89 ft, FROM CENTERLINE OF BEARING

MAXIMUM SHEAR AT CRITICAL SECTION NEAR SUPPORT

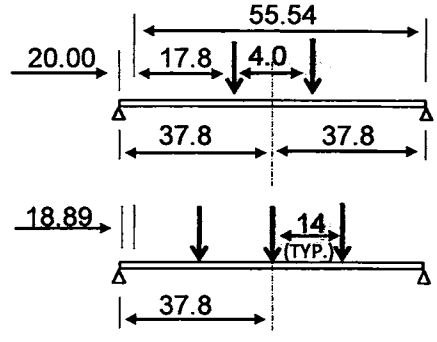
L = 75.54 - 18.89 = 56.66 ft

$$V_{LANE} = \frac{\overset{(klf)}{0.64} * 56.66^2}{2 * 75.54} = 13.6 \text{ kip-ft}$$

$$V_{TANDEM} = \overset{(kip)}{25} * \frac{\overset{(ft)}{56.66} + \overset{(ft)}{52.66}}{75.54} = 36.18 \text{ kips}$$

$$V_{TRUCK} = \frac{\overset{(kip)}{32} * [56.66 + 42.66] + \overset{(kip)}{8} * 28.66}{75.54} =$$

$V_{TRUCK} = 45.1$ kips ← GOVERNS



IM = 33 % LRFD Design, Table 3.6.2.1-1

TOTAL SHEAR :

$V_{LL+I} = 13.6 + 45.1 * 1.33 = 73.59$ kips DISTRIBUTION FACTOR FOR SHEAR, $g_v = 0.668$

DISTRIBUTED TOTAL SHEAR :

$V_{LL+I} = 73.59 * 0.668 = 49.1$ kips

I - GIRDER BRIDGE (INTERIOR GIRDER)

MAXIMUM SHEAR AT CRITICAL SECTION NEAR SUPPORT

DEAD LOAD SHEARS : $\sum DC_1 = 1.22$ kip/ft

$DC_2 = 0.4$ kip/ft

$DW = 0.142$ kip/ft

$V_{DC} = (1.22 + 0.4) * (0.5 * 75.54 - 18.89) =$

$V_{DC} = 22.98 + 7.554 = 30.5$ kips

$V_{DW} = 0.142 * (0.5 * 75.54 - 18.89) = 2.7$ kips

MINIMUM TRANSVERSE REINFORCEMENT : LRFD Design, Eq. 5.8.2.5

$$A_v = 0.0316 \sqrt{f'_c} \frac{b_v s}{f_y}$$ LRFD Design, Eq. 5.8.2.5-1

$b_v = 7.0$ in WEB WIDTH

$s = 18.0$ in

$$A_v = 0.0316 * \sqrt{5.0} * \frac{7.0 * 18}{40} = 0.223 \text{ in}^2$$

STIRRUPS AREA PROVIDED : # 4 $A = 0.13$ in²

(2 LEGS)

$A_v = 2 * 0.13 = 0.26$ in² > 0.223 in² OK

NOMINAL SHEAR RESISTANCE, V_n (SIMPLIFIED APPROACH) : LRFD Design, Eq. 5.8.3.4.1

ASSUME : $\theta = 45°$ $\cot\theta = 1.00$

$\beta = 2.0$

CONCRETE : $V_c = 0.0316\beta\sqrt{f'_c}\, b_v d_v$ LRFD Design, Eq. 5.8.3.3-3

$b_v = 7.0$ in

$d_v = 49.17$ in

$V_c = 0.0316 * 2.0 * \sqrt{5.0} * 7 * 49.17 = 48.6$ kips

STEEL : $$V_s = \frac{A_v f_y d_v \cot\theta}{s}$$

STIRRUPS : # 4 @ 18 in

$A_v = 0.26$ in²

$$V_s = \frac{0.26 * 40 * 49.17 * 1.00}{18} = 28.41 \text{ kips}$$

NOMINAL SHEAR RESISTANCE, V_n :

$V_n = V_s + V_c + V_p$ LRFD Design, C5.8.3.3-1

$= 28.41 + 48.6 + 17.5 = 94.5$ kips

$V_n = 0.25 f'_c b_v d_v + V_p$ LRFD Design, Eq. 5.8.3.3-2

$= 0.25 * 5.0 * 7.0 * 49.2 + 17.46 = 448$ kips

$V_n = 94.5$ kips < 448 kips

$\varphi V_n = 0.90 * 94.5 = 85.05$ kips LRFD Design, 5.5.4.2.1

RESISTANCE FACTOR FOR SHEAR, $\varphi = 0.90$

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NOMINAL SHEAR RESISTANCE, V_n (SIMPLIFIED APPROACH) :

FACTORED SHEAR :

$$V_u = 1.25 * 30.5 + 1.50 * 2.68 + 1.75 * 49.1 = 128.2 \text{ kips}$$

$$\varphi V_n = 85.05 \text{ kips} < 128.2 \text{ kips} \qquad \text{NO GOOD}$$

NOMINAL SHEAR RESISTANCE, V_n (MCFT APPROACH) : LRFD Design, Eq.5.8.2.9-1

SHEAR STRESS ON THE CONCRETE :

$$v_u = \frac{V_u - \varphi V_p}{\varphi\, b_v\, d_v}$$

$$v_u = \frac{128.2 - 0}{0.90 * 7.0 * 49.2} = 0.414 \text{ ksi}$$ LRFD Design, C5.8.2.9

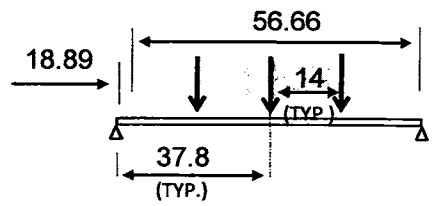
LRFD Design, 5.5.4.2.1

RATIO OF THE APPLIED FACTORED SHEAR STRESS TO THE CONCRETE COMPRESSIVE STRENGTH :

$$\frac{v_u}{f'_c} = \frac{0.414}{5.0} = 0.083 < 0.25$$ LRFD Design, 5.5.4.2.1

LIVE LOAD MOMENTS AT STIRRUP CHANGE :

$$M_{TRUCK} = \frac{\overset{(kip)}{32} * 18.89 * (56.66 + 42.66) + \overset{(kip)}{8} * 18.89 * 28.66}{75.54}$$



$$M_{TRUCK} = 851.8 \text{ kip-ft}$$

$$M_{LANE} = \frac{\overset{(klf)}{0.64} * 56.66^2}{2 * 75.54} * 18.89 = 256.8 \text{ kip-ft}$$

$$M_{LL+I} = \overset{(IM)}{1.33} * 851.8 + 256.8 = 1390 \text{ kip-ft}$$

DISTRIBUTED MOMENT :

$$g_m * M_{LL+I} = 0.593 * 1390 = 823.6 \text{ kip-ft}$$

DEAD LOAD SHEARS : $\sum DC_1 = 1.22$ kip/ft

$DC_2 = 0.4$ kip/ft

$DW = 0.142$ kip/ft

$$M_{DC} = 0.5 * (\overset{(k/ft)}{1.22} + \overset{(k/ft)}{0.4}) * 18.89 * (\overset{(L,\,ft)}{75.54} - 18.89)$$

$$M_{DC} = 651.1 + 214 = 865.1 \text{ kip-ft}$$

$$M_{DW} = 0.5 * 0.142 * 18.89 * 75.54 - 18.89 = 76.0 \text{ kip-ft}$$

FACTORED MOMENT :

$$M_u = 1.25 * 865.1 + 1.50 * 76.0 + 1.75 * 824 = 2637 \text{ kip-ft}$$

UPPER LIMIT OF SHEAR :

$$V_n = 0.25 f'_c b_v d_v + V_p = 448 \text{ kips}$$ LRFD Design, Eq. 5.8.3.3-2

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NOMINAL SHEAR RESISTANCE, V_n (MCFT APPROACH) :

STRAIN IN THE REINFORCEMENT, ε_x : LRFD Design, 5.8.3.4.2

$$\varepsilon_x = \frac{\frac{M_u}{d_v} + 0.5N_u + 0.5(V_u - V_p)\cot\theta - A_{ps} f_{po}}{2(E_s A_s + E_p A_{ps})} \leq 0.001$$

$N_u = 0$
$V_p = 0$
$E_s A_s = 0$

$A_{ps} = 7 * 0.751 = 5.257$ in²
$f_{po} = 0.7 f_{pu} = 0.7 * 200 = 140$ ksi
$E_p = 25000$ ksi
$V_u = 128.2$ kips
$d_v = 49.17$ in

ASSUME CRACK INCINATION ANGLE, θ :

$v_u / f'_c = 0.083 \longrightarrow \varepsilon_x \times 1000 \leq -0.10$ $\quad \varepsilon_x = -0.0001$ LRFD Design, Table B5.2-1

$\theta = 21.9°$ $\quad \cot 21.9 = 2.488$

$$\varepsilon_x = \frac{\frac{2637 * 12}{49.17} + 0.5 * 128.2 * 2.488 - 5.257 * 140}{2 * [0 + 25000 * 5.257]}$$

$\varepsilon_x = 0.000255$

ASSUME :

$\varepsilon_x \leq 0.125 \times 10^{-3}$ $\quad (\varepsilon_x \times 1000 \leq 0.125)$

$\theta = 24.9°$ $\quad \cot 24.9 = 2.154$

$\varepsilon_x = 0.000173$ $\quad \beta = 2.91$

CALCULATE, V_n :

CONCRETE : $V_c = 0.0316\beta\sqrt{f'_c}\, b_v d_v$ LRFD Design, Eq. 5.8.3.3-3

$V_c = 0.0316 * 2.91 * \sqrt{5.0} * 7.0 * 49.2 = 70.8$ kips

SHEAR RESISTANCE PROVIDED BY THE TRANSVERSE REINFORCEMENT (STIRRUPS), V_s :

$$V_s = \frac{A_v f_y d_v \cot\theta}{s}$$ LRFD Design, Eq. C5.8.3.3-1

STIRRUPS : # 4 @ 18 in $\quad A_v = 0.26$ in²

$$V_s = \frac{0.26 * 40 * 49.2 * 2.154}{18} = 61 \text{ kips}$$

NOMINAL SHEAR RESISTANCE, V_n :

$V_n = V_s + V_c + V_p$ LRFD Design, C5.3.3-1

$= 61 + 70.8 + 17.5 = 132$ kips

UPPER LIMIT OF SHEAR :

$V_n = 0.25 f'_c b_v d_v + V_p = 448$ kips LRFD Design, Eq. 5.8.3.3-2

$V_n = 132$ kips < 448 kips

$\varphi V_n = 0.90 * 132 = 119$ kips

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I - GIRDER BRIDGE (INTERIOR GIRDER)

LONGITUDINAL REINFORCEMENT : LRFD Design, 5.8.3.5

$N_u = 0$

$$A_{ps}f_{ps} + A_s f_y \geq \frac{|M_u|}{d_v \varphi_f} + \cancel{0.5 * \frac{N_u}{\varphi_c}} + \left(\left| \frac{V_u}{\varphi_v} - V_p \right| - 0.5V_s \right) * \cot \theta$$ LRFD Design, Eq. 5.8.3.5-1

MINIMUM REQUIRED TENSILE CAPACITY, V_s :

$V_s = 61$ kips

$$\frac{V_u}{\varphi} = \frac{128.2}{0.90} = 142.4 \text{ kips}$$

$V_s = 142.4$ kips

$\varphi_c = 0$ LRFD Design, 5.5.4.2

$\varphi_f = 1.0$

$\varphi_v = 0.9$

$$A_{ps}f_{ps} + A_s f_s \geq \frac{|2637 * 12|}{49.17 * 1.0} + \left(\left| \frac{128.2}{0.9} \right| - 0.5 * 61 \right) * \cot 24.9$$

$A_{ps}f_{ps} + A_s f_s \geq 846.8$ kips

DEVELOPMENT LENGTH, ℓ_d : LRFD Design, 5.11.4.2-1

$\ell_d \geq k\,(f_{ps} - \tfrac{2}{3} f_{pe})d_b$

$k = 2.0$ LRFD Design, 5.11.4.3

$f_{ps} = 192.7$ ksi

$f_{pe} = 110.7$ ksi

$$\ell_d \geq 2.0 * \left(192.7 - \frac{2}{3} * 110.7 \right) * 1.125$$

$\ell_d \geq 268$ in

(ft)

268 + 28.33 = 50.6 ft > 18.89 ft THE STRANDS ARE NOT FULLY DEVELOPED.

FROM END OF DEBONDED ZONES :

(ft) (ft)

$\ell_{px} = 18.9 - 5.625 = 159.1$ in

60 * 1.125 = 67.5

DESIGN STRESS, f_{px} : LRFD Design, 5.11.4.2-3

$$f_{px} = f_{pe} + \frac{\ell_{px} - 60d_b}{\ell_d - 60d_b} * \left(f_{ps} - f_{pe} \right)$$

$$f_{px} = 110.7 + \frac{159.1 - 67.5}{268 - 67.5} * \left(192.7 - 110.7 \right) = 148.3 \text{ ksi}$$

$A_{ps}f_{ps} + A_s f_y = 7 * 0.751 * 192.7 + 0 * 0.751 * 148.3 = 1013$ kips

$A_{ps}f_{ps} + A_s f_y = 1013$ kips > 846.8 kips

OK

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BRIDGE NO.00596

I - GIRDER BRIDGE (INTERIOR GIRDER)

SUMMARY :

L = 75.54 ft

LOCATION	SUPPORT	CRITICAL SHEAR	STIRRUP CHANGE	MIDSPAN
x/L		0.052	0.25	0.5
X, ft		3.92	18.89	37.77
V_{DC1}, kips	46	41	23	
V_{DC2}, kips	15	14	8	
V_{DW}, kips	5	5	3	
$g_m V_{LL+I}$, kips		67	49	
V_n, kips, SIMPLIFIED		82	95	
V_n, kips, MCFT		130	132	
M_{DC1}, kip-ft		171	651	868.1
M_{DC2}, kip-ft		56	214	285.3
M_{DW}, kip-ft		20	76	101.3
$g_m M_{LL+I}$, kip-ft		234	824	1122
M_n, kip-ft				4151

GENERAL LOAD RATING EQUATION : THE MANUAL FOR BRIDGE EVALUATION 6A.4.2

$$RF = \frac{C - (\gamma_{DC})(DC) - (\gamma_{DW})(DW) \pm (\gamma_P)(P)}{(\gamma_L)(LL+IM)}$$

Eq. 6A.4.2.1-1

EVALUATION FACTORS (FOR STRENGTH LIMIT STATE)

RESISTANCE FACTOR, φ : LRFD Design, 5.5.4.2.1

$\varphi = 1.0$ FLEXURE TENSION CONTROLLED SECTION

$\varphi = 0.9$ SHEAR

RESISTANCE FACTOR, φ_c :

$\varphi_c = 1.00$ GOOD CONDITION THE MANUAL FOR BRIDGE EVALUATION 6A.4.2.3

SYSTEM FACTOR, φ_s :

$\varphi_s = 1.0$ THE MANUAL FOR BRIDGE EVALUATION 6A.4.2.4

REDUNDENT STRUCTURE GIRDER SPACING > 4 FT

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DESIGN LOAD RATING — THE MANUAL FOR BRIDGE EVALUATION 6A.4.3

STRENGTH I LIMIT STATE :

$$RF = \frac{(\varphi_c)(\varphi_s)(\varphi)R_n - (\gamma_{DC})(DC) - (\gamma_{DW})(DW)}{(\gamma_L)(LL+IM)}$$

THE MANUAL FOR BRIDGE EVALUATION 6A.5.4.1

INVENTORY LEVEL : — TABLE 6A.4.2.2-1

LOAD	LOAD FACTOR
DC	1.25
DW	1.50
LL	1.75

FLEXURE AT MIDSPAN :

$$RF = \frac{[1.0] * [1.0] * [1.0] * [4151] - [1.25 * [868.1 + 285.3] + 1.50 * 101.3]}{1.75 * 1122}$$

$$RF = 1.30$$

OPERATING LEVEL : — TABLE 6A.4.2.2-1

LOAD	LOAD FACTOR, γ
DC	1.25
DW	1.50
LL	1.35

FLEXURE AT MIDSPAN :

$$RF = 1.30 * \frac{1.75}{1.35} = 1.69$$

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I - GIRDER BRIDGE (INTERIOR GIRDER)

DESIGN LOAD RATING

SHEAR AT FIRST CRITICAL SHEAR SECTION : 47.0 in FROM CENTERLINE OF BEARING

SIMPLIFIED APPROACH :

$$RF = \frac{[1.00] * [1.0] * [0.9] * [82] - [1.25 * [41 + 14] + 1.50 * 5]}{1.75 * 67}$$

RF = -0.02

MCFT

$$RF = \frac{[1.00] * [1.0] * [0.9] * [130] - [1.25 * [41 + 14] + 1.50 * 5]}{1.75 * 67}$$

RF = 0.35

SHEAR AT STIRRUP CHANGE : 18.89 ft FROM CENTERLINE OF BEARING

SIMPLIFIED APPROACH :

$$RF = \frac{[1.00] * [1.0] * [0.9] * [95] - [1.25 * [23 + 8] + 1.50 * 3]}{1.75 * 49}$$

RF = 0.50

MCFT

$$RF = \frac{[1.0] * [1.0] * [0.9] * [132] - [1.25 * [23 + 8] + 1.50 * 3]}{1.75 * 49}$$

RF = 0.89

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DESIGN LOAD RATING

SERVICE III LIMIT STATE (INVENTORY LEVEL) : THE MANUAL FOR BRIDGE EVALUATION 6A.5.4.1

$$RF = \frac{f_R - (\gamma_D)(f_D)}{(\gamma_L)(LL+IM)}$$

FLEXURAL RESISTANCE, f_R :

$f_R = f_{pb}$ + ALLOWABLE TENSILE STRESS

COMPRESSIVE STRESS DUE TO EFFECTIVE PRESTRESS, f_{cpe} :

$f_{cpe} = 1.816$ ksi

ALLOWABLE TENSILE STRESS $= 0.19\sqrt{f'_c}$ LRFD Design, 5.9.4.2.2

$= 0.19 * \sqrt{5.0} = 0.425$ ksi

$f_R = 1.816 + 0.425 = 2.241$ ksi

DETERMINE DEAD LOAD STRESSES AT MIDSPAN :

$M_{DC1} = 868.1$ kip-ft

$M_{DC2} = 285.3$ kip-ft

$M_{DW} = 101.3$ kip-ft

$S_{b(nc)} = 12428$ in³

$S_{b(comp)} = 14664$ in³

$$f_{DC} = \frac{868.1 * 12}{12428} + \frac{285.3 * 12}{14664} = 1.07$$

$$f_{DW} = \frac{101.3 * 12}{14664} = 0.08$$

$\sum f_D = 1.15$ ksi

DETERMINE LIVE LOAD STRESSES AT MIDSPAN :

$M_{LL+I} = 1122$ kip-ft

$S_{b(comp)} = 14664$ in³

$$f_{LL+I} = \frac{1122 * 12}{14664} = 0.92$$

THE MANUAL FOR BRIDGE EVALUATION, TABLE 6A.4.2.2-1

$\gamma_{LL} = 0.8$

LRFD Design, Table 3.4.1-1

$$RF = \frac{2.241 - (1.0 * 1.15)}{0.8 * 0.92}$$

$RF = 1.48$

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I - GIRDER BRIDGE (INTERIOR GIRDER)

PERMIT LOAD RATING — THE MANUAL FOR BRIDGE EVALUATION, 6A.4.5

PERMIT VEHICLE : CT-P204

PERMIT WEIGHT : 204 kips

ADTT (ONE DIRECTION): 5000

FROM LIVE LOAD ANALYSIS (UNDISTRIBUTED MAXIMUM):

M_{LL} = 1522 kip-ft

V_{LL} = 97.5 kips

STRENGTH II LIMIT STATE : — THE MANUAL FOR BRIDGE EVALUATION, 6A.5.4.2.1

LRFD Design, Table 3.4.1-1, 3.4.1-2

THE MANUAL FOR BRIDGE EVALUATION, TABLE 6A.4.5.4.2a-1

LOAD	LOAD FACTOR, γ
DC	1.25
DW	1.50
LL	1.35

THE MANUAL FOR BRIDGE EVALUATION, 6A.4.5.4.2b

$$g_{m1} = 0.553 * \frac{1}{1.2} = 0.461$$

$$g_{v1} = 0.598 * \frac{1}{1.2} = 0.499$$

IM = 23 % — THE MANUAL FOR BRIDGE EVALUATION, 6A.4.5.5

MAXIMUM LIVE LOAD EFFECT :

M_{LL+I} = 1522 * 0.461 * 1.23 = 862.6 kip-ft

V_{LL+I} = 97.5 * 0.499 * 1.23 = 60 kip-ft

FLEXURE :

$$RF = \frac{(1.0) * (1.0) * (1.0) * (4151) - [1.25 * (868.1 + 285.3) + 1.50 * 101.3]}{1.35 * 862.6}$$

RF = 2.20

SHEAR EVALUATION (USING MCFT): — THE MANUAL FOR BRIDGE EVALUATION, 6A.5.8

$$RF = \frac{(1.0) * (1.0) * (0.9) * (130) - [1.25 * 54.7 + 1.50 * 4.81]}{1.35 * 60}$$

RF = 0.51

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I - GIRDER BRIDGE (INTERIOR GIRDER)

PERMIT LOAD RATING

SERVICE I LIMIT STATE (OPTIONAL) THE MANUAL FOR BRIDGE EVALUATION, 6A.5.4.2.2b

$\gamma_L = \gamma_{DC} = \gamma_{DW} = 1.0$ THE MANUAL FOR BRIDGE EVALUATION, TABLE 6A.4.5.4.2a

$g_m = 0.593$

DISTRIBUTED LIVE LOAD EFFECT, MOMENTS AT MIDSPAN :

$M_{DC1} = 868.1$ kip-ft

$M_{DC2} = 285.3$ kip-ft IM = 20 %

$M_{DW} = 101.3$ kip-ft

$M_{LL+I} = 1522 * 0.593 * 1.20 = 1082$ kip-ft

$M_{DC} + M_{DW} + M_{LL+I} = 2337$ kip-ft

SIMPLIFIED CHECK USING $0.75M_n$: THE MANUAL FOR BRIDGE EVALUATION, C6A.4.2.2

$M_n = 4151$ kip-ft

$0.75M_n = 0.75 * 4151 = 3113$ kip-ft > 2337 kip-ft OK

$$\text{MOMENT RATIO} = \frac{0.75M_n}{M_{DC} + M_{DW} + M_{LL+I}} = 1.33$$

REFINED CHECK USING $0.9f_y$:

$f_R = 0.9\ f_{py}$ THE MANUAL FOR BRIDGE EVALUATION, 6A.5.4.2.2b

LOW RELAXATION STRAND $= 0.9f_{pu}$ TABLE 6A.5.4.2.2b-1

STRESS RELIEVED STRAND (TYPE 1) $= 0.85f_{pu}$

STRESS RELIEVED STRAND (TYPE 2) $= 0.8f_{pu}$

$f_R = 0.9 * (0.9f_{pu}) = 0.9 * 0.9 * 200 = 162$ ksi

$M_{cr} = 3074$ kip-ft

EFFECTIVE PRESTRESS $f_{pe} = 110.7$ ksi

$M_{DC} + M_{DW} + M_{LL+I} - M_{cr} = -737$ kip-ft

SECTION PROPERTIES FOR THE CRACKED COMPOSITE SECTION :

TRANSFORMED FLANGE WIDTH : $b_{trans} = 63.97$ in

$h = 56 + 0.0 + 0 = 56.0$ in

$A_{ps} = 7 * 0.751 = 5.257$ in²

$$\text{MODULAR RATIO, } n = \frac{E_{ps}}{E_{beam}} = \frac{25000}{4074} = 6.14$$

$A_{trans} = 5.257 * 6.14 = 32.26$ in²

$y = 4.75$ in

OUTER STRAND, $y = 2.25$ in

I - GIRDER BRIDGE (INTERIOR GIRDER)

PERMIT LOAD RATING

REFINED CHECK USING $0.9f_y$:

ASSUME NEUTRAL AXIS IS IN SLAB :

$$c = \frac{\frac{c}{2}\,(b_{trans} \times c) + (h - y)\,(A_{trans})}{(b_{trans} \times c) + (A_{trans})}$$

$$c = \frac{\left(\frac{c}{2}\right) * (63.97 * c) + (56.0 - 4.75) * 32.26}{(63.97 * c) + 32.26}$$

$$(63.97 * c^2) + (32.26 * c) = (31.98 * c^2) + 1653$$

$$(31.98 * c^2) + (32.26 * c) - 1653 = 0$$

$$c = \frac{-32.26 \pm \sqrt{32.26^2 - 4 * 31.98 * -1653}}{2 * 31.98} = \frac{-32.26 \pm \sqrt{212546.9}}{64.0}$$

$$c = 6.70 \text{ in}$$

$$I_{cr} = \frac{1}{12}(63.97) * (6.70)^3 + 63.97 * 6.70 * \left(\frac{6.70}{2}\right)^2 + 32.26 * (56.0 - 4.75 - 6.70)^2$$

$$I_{cr} = 1605 + 4816 + 64013$$

$$I_{cr} = 70434 \text{ in}^4$$

STRESS BEYOND THE EFFECTIVE PRESTRESS :

$$f_s = n * \frac{My}{I} = 6.14 * \frac{-737 * 12 * (56.0 - 2.25 - 6.70)}{70434} = -36.3 \text{ ksi}$$

STRESS IN THE REINFORCEMENT AT PERMIT CROSSING SERVICE I :

$f_s = 110.7 + -36.3 = 74.43$ ksi $<$ $f_R = 162$ ksi

OK

STRESS RATIO $= \frac{162}{74.43} = 2.18 > 1$ OK

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BRIDGE NO.00596

I - GIRDER BRIDGE (INTERIOR GIRDER)

SUMMARY OF RATING FACTORS

	DESIGN LOAD RATING (HL-93)		PERMIT LOAD RATING				
LIMIT STATE	INVERTORY	OPERATING	CT-P204	CT-L73	CT-P76.5	CT-P380	CT-TLC
STRENGTH I							
FLEXURE (AT MIDSPAN)	1.30	1.69					
SHEAR AT : 64 in	0.35						
SHEAR AT : 20 ft	0.89						
SRENGTH II							
FLEXURE (AT MIDSPAN)			2.20	2.98	2.75	2.83	2.08
SHEAR			0.51	0.82	0.76	0.75	0.52
SERVICE III							
FLEXURE (AT MIDSPAN)	1.48						
SERVICE I			2.18				

I - GIRDER BRIDGE (INTERIOR GIRDER)

PERMIT LOAD RATING — THE MANUAL FOR BRIDGE EVALUATION, 6A.4.5

PERMIT VEHICLE : CT-L73.0

PERMIT WEIGHT : 73 kips

ADTT (ONE DIRECTION): 5000

FROM LIVE LOAD ANALYSIS (UNDISTRIBUTED MAXIMUM):

M_{LL} = 840.6 kip-ft

V_{LL} = 45.5 kips

STRENGTH II LIMIT STATE : — THE MANUAL FOR BRIDGE EVALUATION, 6A.5.4.2.1

LRFD Design, Table 3.4.1-1, 3.4.1-2

THE MANUAL FOR BRIDGE EVALUATION, TABLE 6A.4.5.4.2a-1

LOAD	LOAD FACTOR, γ
DC	1.25
DW	1.50
LL	1.80

THE MANUAL FOR BRIDGE EVALUATION, 6A.4.5.4.2b

$$g_{m1} = 0.553 * \frac{1}{1.2} = 0.461$$

$$g_{v1} = 0.598 * \frac{1}{1.2} = 0.499$$

IM = 23 % — THE MANUAL FOR BRIDGE EVALUATION, 6A.4.5.5

MAXIMUM LIVE LOAD EFFECT :

M_{LL+I} = 840.6 * 0.461 * 1.23 = 476.4 kip-ft

V_{LL+I} = 45.5 * 0.499 * 1.23 = 28 kip-ft

FLEXURE :

$$RF = \frac{(1.0) * (1.0) * (1.0) * (4151) - (1.25 * (868.1 + 285.3) + 1.50 * 101.3)}{1.80 * 476.4}$$

RF = 2.98

SHEAR EVALUATION (USING MCFT): — THE MANUAL FOR BRIDGE EVALUATION, 6A.5.8

$$RF = \frac{(1.0) * (1.0) * (0.9) * (130) - (1.25 * 54.7 + 1.50 * 4.81)}{1.80 * 28}$$

RF = 0.82

BY: m.g.
CHKD.BY: BA DATE 3/17/11

BRIDGE NO.00596

I - GIRDER BRIDGE (INTERIOR GIRDER)

PERMIT LOAD RATING — THE MANUAL FOR BRIDGE EVALUATION, 6A.4.5

PERMIT VEHICLE : CT-P76.5

PERMIT WEIGHT : 76.5 kips

ADTT (ONE DIRECTION): 5000

FROM LIVE LOAD ANALYSIS (UNDISTRIBUTED MAXIMUM):

M_{LL} = 911.7 kip-ft

V_{LL} = 48.7 kips

STRENGTH II LIMIT STATE : — THE MANUAL FOR BRIDGE EVALUATION, 6A.5.4.2.1

LOAD	LOAD FACTOR, γ
DC	1.25
DW	1.50
LL	1.80

LRFD Design, Table 3.4.1-1, 3.4.1-2
THE MANUAL FOR BRIDGE EVALUATION, TABLE 6A.4.5.4.2a-1

THE MANUAL FOR BRIDGE EVALUATION, 6A.4.5.4.2b

$$g_{m1} = 0.553 * \frac{1}{1.2} = 0.461$$

$$g_{v1} = 0.598 * \frac{1}{1.2} = 0.499$$

IM = 23 % — THE MANUAL FOR BRIDGE EVALUATION, 6A.4.5.5

MAXIMUM LIVE LOAD EFFECT :

M_{LL+I} = 911.7 * 0.461 * 1.23 = 516.7 kip-ft

V_{LL+I} = 48.7 * 0.499 * 1.23 = 30 kip-ft

FLEXURE :

$$RF = \frac{(1.0) * (1.0) * (1.0) * (4151) - (1.25 * (868.1 + 285.3) + 1.50 * 101.3)}{1.80 * 516.7}$$

RF = 2.75

SHEAR EVALUATION (USING MCFT): — THE MANUAL FOR BRIDGE EVALUATION, 6A.5.8

$$RF = \frac{(1.0) * (1.0) * (0.9) * (130) - (1.25 * 54.7 + 1.50 * 4.81)}{1.80 * 30}$$

RF = 0.76

BY: m.g.
CHKD.BY: BA DATE 3/17/11

BRIDGE NO.00596

I - GIRDER BRIDGE (INTERIOR GIRDER)

PERMIT LOAD RATING — THE MANUAL FOR BRIDGE EVALUATION, 6A.4.5

PERMIT VEHICLE : CT-P380

PERMIT WEIGHT : 380 kips

ADTT (ONE DIRECTION): 5000

FROM LIVE LOAD ANALYSIS (UNDISTRIBUTED MAXIMUM):

M_{LL} = 1386.5 kip-ft

V_{LL} = 78.1 kips

STRENGTH II LIMIT STATE : — THE MANUAL FOR BRIDGE EVALUATION, 6A.5.4.2.1

LOAD	LOAD FACTOR, γ
DC	1.25
DW	1.50
LL	1.15

LRFD Design, Table 3.4.1-1, 3.4.1-2
THE MANUAL FOR BRIDGE EVALUATION, TABLE 6A.4.5.4.2a-1

THE MANUAL FOR BRIDGE EVALUATION, 6A.4.5.4.2b

$$g_{m1} = 0.553 * \frac{1}{1.2} = 0.461$$

$$g_{v1} = 0.598 * \frac{1}{1.2} = 0.499$$

IM = 23 % — THE MANUAL FOR BRIDGE EVALUATION, 6A.4.5.5

MAXIMUM LIVE LOAD EFFECT :

M_{LL+I} = 1387 * 0.461 * 1.23 = 785.8 kip-ft

V_{LL+I} = 78.1 * 0.499 * 1.23 = 48 kip-ft

FLEXURE :

$$RF = \frac{(1.0) * (1.0) * (1.0) * (4151) - (1.25 * (868.1 + 285.3) + 1.50 * 101.3)}{1.15 * 785.8}$$

RF = 2.83

SHEAR EVALUATION (USING MCFT): — THE MANUAL FOR BRIDGE EVALUATION, 6A.5.8

$$RF = \frac{(1.0) * (1.0) * (0.9) * (130) - (1.25 * 54.7 + 1.50 * 4.81)}{1.15 * 48}$$

RF = 0.75

BY: m.g.
CHKD.BY: BA DATE 3/17/11

BRIDGE NO.00596

I - GIRDER BRIDGE (INTERIOR GIRDER)

PERMIT LOAD RATING — THE MANUAL FOR BRIDGE EVALUATION, 6A.4.5

PERMIT VEHICLE : CT-TLC

ADTT (ONE DIRECTION): 5000

FROM LIVE LOAD ANALYSIS (UNDISTRIBUTED MAXIMUM):

M_{LL} = 1780.5 kip-ft

V_{LL} = 106.2 kips

STRENGTH II LIMIT STATE : — THE MANUAL FOR BRIDGE EVALUATION, 6A.5.4.2.1

LRFD Design, Table 3.4.1-1, 3.4.1-2

THE MANUAL FOR BRIDGE EVALUATION, TABLE 6A.4.5.4.2a-1

LOAD	LOAD FACTOR, γ
DC	1.25
DW	1.50
LL	1.50

THE MANUAL FOR BRIDGE EVALUATION, 6A.4.5.4.2b

$$g_{m1} = 0.553 * \frac{1}{1.2} = 0.461$$

$$g_{v1} = 0.598 * \frac{1}{1.2} = 0.499$$

IM = 0 % — THE MANUAL FOR BRIDGE EVALUATION, 6A.4.5.5

MAXIMUM LIVE LOAD EFFECT :

M_{LL+I} = 1781 * 0.461 * 1.00 = 820.5 kip-ft

V_{LL+I} = 106.2 * 0.499 * 1.00 = 53 kip-ft

FLEXURE :

$$RF = \frac{(1.0) * (1.0) * (1.0) * (4151) - (1.25 * (868.1 + 285.3) + 1.50 * 101.3)}{1.50 * 820.5}$$

RF = 2.08

SHEAR EVALUATION (USING MCFT): — THE MANUAL FOR BRIDGE EVALUATION, 6A.5.8

$$RF = \frac{(1.0) * (1.0) * (0.9) * (130) - (1.25 * 54.7 + 1.50 * 4.8)}{1.50 * 53}$$

RF = 0.52

BRIDGE NO.00596

ROUTE 68 OVER NAUGATTUCK RIVER, ROUTES 8, 710 AND METRO NORTH TRACKS

NAUGATUCK, CT

SHEAR RESISTANCE CALCULATION

NCHRP

REPORT 678

NATIONAL
COOPERATIVE
HIGHWAY
RESEARCH
PROGRAM

Design of FRP Systems for Strengthening Concrete Girders in Shear

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

Close, Jensen and Miller, P.C.

BY BA DATE 3/10/11 SUBJECT BR. 596 SHEET NO. 1F OF

CHKD. BY DATE ROUTE 68 O/ NAVIGATOR JOB NO.

FWOR, RTE 8, MNRR, SR 710 NAVIGATOR

I-BEAM W/ INTERNAL TRANSVERSE STEEL REINFORCEMENT STRENGTHENED W/ FRP IN U-WRAP CONFIGURATION WITHOUT ANCHORAGE SYSTEMS

- EXTERNALLY BONDED FRP SHEAR REINFORCEMENT OF A PRESTRESSED I-BEAM BRIDGE USING A U-WRAP CONFIGURATION WITHOUT ANCHORAGE. THE BRIDGE CONSISTS OF 11 SIMPLY SUPPORTED PRETENSIONED I-BEAMS SPANNING 97.5' AND SPACED AT 6.958' ON CENTER. THE I-BEAMS ARE LIGHTLY REINFORCED WITH TRANSVERSE STEEL REINFORCEMENT.

BEAM LENGTH = 97.5'

.375L = 36.56' START OF DRAPPED

$\frac{97.5'}{2} - 36.56' = 12.19'$ TO ℄ FROM DRAPPED POINT

$21.5'' - 4.75'' = 16.75''$ FROM MIDSPAN C.G. (4.75") TO END C.G. (21.5") (℄ BRG.)

$\theta = 1.641°$

MATERIAL PROPERTIES:

COMPRESSIVE STRENGTH $f'_{cd} = 4$ ksi

$E_{cd} = 33(1.5)^{1.5}\sqrt{f'_{cd} \times 1000}$ ksi $= 3834$ ksi

$\beta_{1d} = .85$

IF $f'_{cd} \leq 4$ $\beta_{1d} = .85$

IF $f'_{cd} \geq 8$ $\beta_{1d} = .65$

$.85 - .05(f'_{cd} - 4)$ OTHERWISE

$f'_{cb} = 5$ ksi

$E_{1b} = 33(1.5)^{1.5}\sqrt{f'_{cd} \times 1000}$ ksi $= 4287$ ksi

$\beta_{1b} = .8$

Close, Jensen and Miller, P.C.

BY BA DATE 3/10/11 SUBJECT BR. 596 SHEET NO. 27 OF
CHKD. BY DATE ROUTE 68 O/ NAVIGATION JOB NO.
RIVER, TYP B, MNRR, SR 710 NAVIGATION

PRESTRESSING STRANDS

$f_{pu} = 200$ ksi

YIELD STRENGTH $f_{py} = .9 \times 200 = 180$ ksi

MODULUS OF ELASTICITY $E_{ps} = 25000$ ksi

DIAMETER OF STRAND $= 1.152''$ (EQUIVALENT)

TOTAL AREA OF THE 9 STRANDS $A_{ps} = 9 \times .788 \text{ in}^2 = 7.09 \text{ in}^2$

$K = .38$ STRESS RELIEVED STEEL

STEEL SHEAR REINFORCEMENT f_{yt} (YIELD STRENGTH) $= 40$ ksi

FRP REINFORCEMENT

CARBON FIBER SHEETS

THICKNESS $t_f = .0045$ in

FAILURE STRENGTH $f_{fu} = 550$ ksi

MODULUS OF ELASTICITY $E_f = 33000$ ksi

FAILURE STRAIN $\varepsilon_{fu} = \frac{f_{fu}}{E_f} = .017$ in/in

GEOMETRICAL PROPERTIES

TOTAL HT $= h_T = 56$ in

FLANGE THICKNESS $= h_f = 8''$ TOP $10''$ BOTTOM

WEB WIDTH $b_v = 7$ in

TOP $8'' \times 42''$
BOTT. $10'' \times 24''$

EFFECTIVE WIDTH OF FLANGE $b_{eff} = 71.5''$

INTERNAL SHEAR REINFORCEMENT = #4 @ $18''$ SPACING

$A_v = .13 \times 2 = .26 \text{ in}^2$

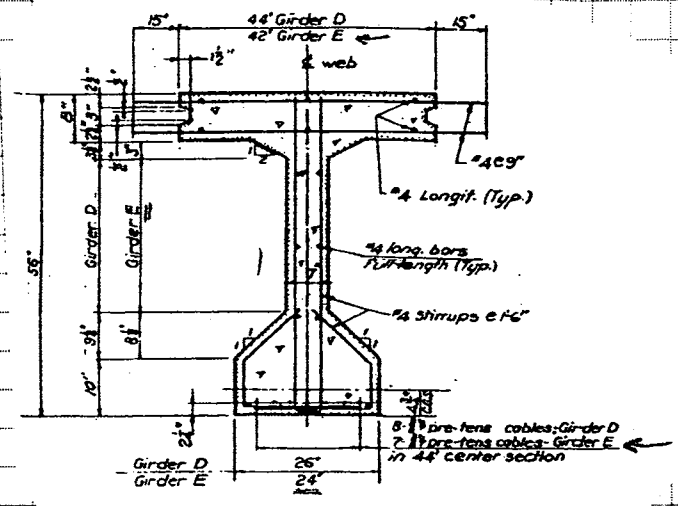
$S_v = 18$ in $\alpha = 90$ DEG.

Close, Jensen and Miller, P.C.

BY BA DATE 3/10/11 SUBJECT BR. 596 SHEET NO. 3F OF

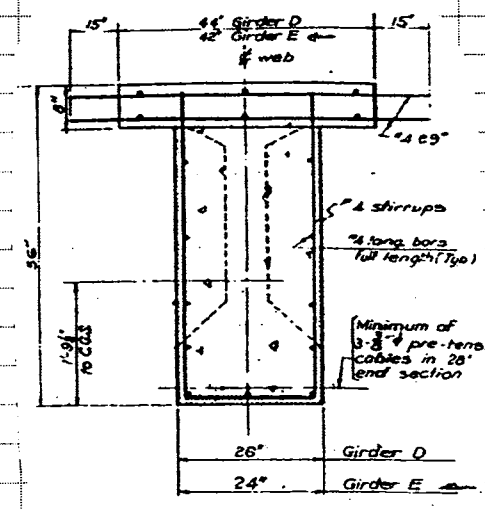
CHKD. BY DATE ROUTE 68 OF NAUGATUCK JOB NO.

RIVER, RTE 8, MNAR, SR 710 NAUGATUCK



SECTION D-D

Scale: ¾" = 1'-0"



SECTION A-A

Scale: ¾" = 1'-0"

MID C.G. = 4.75" e = 25.5"

END C.G. = 21.5" e = 8.7"

e_{END} = 12.89 C.G. = 17.3"

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BY BA DATE 3/10/11 SUBJECT BR. 596 SHEET NO. 4F OF
CHKD. BY DATE ROUTE 68 O/ NANGATUCK JOB NO.
RIVER, RTE 8, MINER, SR710 NANGATUCK

FACTORED SHEAR FORCE AND NOMINAL SHEAR RESISTANCE

. FACTORED SHEAR FORCE AT THE CRITICAL SECTION

$V_{u\text{-END}} = V_{DL1} + V_{DL2} + V_{DLW} = 59.5^k + 19.4^k + 6.93^k = 85.83^k$ @ END

AT CRITICAL SECTION:

$V_{u\text{-CRITICAL}} = V_{DL1} + V_{DL2} + V_{DLW} = 54.74 + 17.95 + 6.37 = 79.06^k$

$V_{LL\text{-CRITICAL}} = 74.5^k$ $\gamma_V V_{LL+IM}$ $\gamma_V = .668$

$V_{TOTAL} = 79.06^k + 74.5^k = 153.57\ k$

NOMINAL SHEAR RESISTANCE

SIMPLIFIED APPROACH

$\theta = 45^\circ$ $\beta = 2$

NOMINAL SHEAR RESISTANCE PROVIDED BY THE CONCRETE V_c LRFD EQ. 5.8.3.3-3

THE DISTANCE FROM THE EXTREME COMPRESSION FIBER TO THE CENTER OF GRAVITY OF THE STRANDS AT THE MIDSPAN:

$d_p = 51.25''$

ASSUMING RECTANGULAR SECTION BEHAVIOR WITH NO COMPRESSION STEEL, THE DISTANCE FROM THE EXTREME COMPRESSION FIBER TO THE NEUTRAL AXIS, c_c:

$$c_c = \frac{A_{ps} f_{pu}}{.85 f'_{cd} b_{eff} \beta_{1d} + k A_{ps} \cdot \frac{f_{pu}}{d_p}} = \frac{7.09 \times 200}{.85 \times 4 \times 71.5 \times .85 + .38 \times 7.09 \times \frac{200}{51.25}} = 6.53 \text{ in}$$

$a_c = \beta_{1d} \cdot c_c = .85 \times 6.53 = 5.55$ in

$a_c = 5.55$ in

if $a_c \geq h_f$ ASSUMPTION IS CORRECT

OTHERWISE NOT BEHAVE AS RECTANGULAR

CHECK a_c = ASSUMPTION IS CORRECT

THE EFFECTIVE SHEAR DEPTH d_v IS TAKEN AS THE DISTANCE, MEASURED PERPENDICULAR TO THE NEUTRAL AXIS, BETWEEN THE RESULTANTS OF THE TENSILE AND COMPRESSIVE FORCES DUE TO FLEXURE; IT NEED NOT BE TAKEN TO BE LESS THAN THE GREATER OF $.9d_e$ OR $.72h$ LRFD 5.8.2.9

SINCE ALL OF THE STRANDS ARE HARPED, THE EFFECTIVE DEPTH MIGHT VARY POINT TO POINT. HOWEVER, THE EFFECTIVE DEPTH MUST BE CALCULATED AT THE CRITICAL SECTION IN SHEAR, WHICH IS NOT YET DETERMINED; THEREFORE, AN ITERATIVE PROCEDURE IS REQUIRED:

ASSUME $d_v = 40.34$ $\qquad \frac{d_v}{b_v} = \frac{40.34}{7} = 5.76 > 4$ ok

CRITICAL SECTION @ 3.9' ←

NOMINAL SHEAR RESISTANCE PROVIDED BY THE CONCRETE:

$V_c = .0316\beta\sqrt{f'_c}\, b_v d_v = .0316 \times 2 \times \sqrt{5} \times 7 \times 40.34 = 39.9^k$ LRFD 5.8.3.3-3 & -4

$V_s = \frac{A_v f_{yt} d_v (\cot\theta + \cot\alpha)\sin\alpha}{S_v} = \frac{.26 \times 40 \times 40.34 (\cot 45 + \cot 90)\sin 90}{18} = 23.3^k$

HARPED TENDON FORCE $= 8 \times .788 \times 100^{ksi} = 630.4^k$ $\qquad f_{pe} = 100^{ksi}$ P.42

$.75 \times 200 - 50 = 100^{ksi}$ ↳ TOTAL LOSS

$V_p = 780.1 \times \gamma = 630.4 \times .038 = 23.96^k$

LRFD 5.8.3.3-1

$V_n = V_c + V_s + V_p = 39.9 + 23.3 + 23.96 = 87.2^k$

V_n = NOMINAL SHEAR RESISTANCE OF THE MEMBER

V_c NOMINAL SHEAR RESISTANCE PROVIDED BY CONCRETE
V_s NOMINAL SHEAR RESISTANCE PROVIDED BY THE INTERNAL STEEL REINFORCEMENT
V_p NOMINAL SHEAR RESISTANCE BY THE HARPED TENDON

DESIGN OF FRP SHEAR REINFORCEMENT

CHECK IF FRP REINFORCEMENT IS NECESSARY OR NOT

STRENGTH REDUCTION FACTOR FOR SHEAR $\phi = .9$

IF $\phi V_n \geq V_{u\text{-critical}}$ NO SHEAR REINFORCEMENT IS NEEDED

OTHERWISE SHEAR REINFORCEMENT IS NEEDED

COMPUTE REQUIRED V_f

$$V_{f_{req}} = \frac{V_{u\text{-critical}}}{\phi} - V_n = \frac{153.57}{.9} - 87.2 = 83.4^k$$

SELECTION OF FRP STRENGTHENING SCHEME

U-WRAP CONFIGURATION IS USED WITH ANCHORAGE SYSTEMS AT THE END OF THE SHEETS. THE FRP SHEETS WILL BE APPLIED AT 90 DEGREES WITH RESPECT TO THE LONGITUDINAL AXIS OF THE GIRDER AS SHOWN IN FIG BELOW. FIRST THE SPACING OF FRP STRIPS IS CHOSEN TO MEET THE MAXIMUM SPACING REQUIRED. THEN THE WIDTH OF THE FRP STRIPS IS SELECTED TO ADJUST THE AMOUNT OF FRP STRIPS.

USE NUMBER OF PLIES OF FRP SHEETS $n_f = 2$

USE THE WIDTH OF FRP SHEETS $W_f = 10$ in

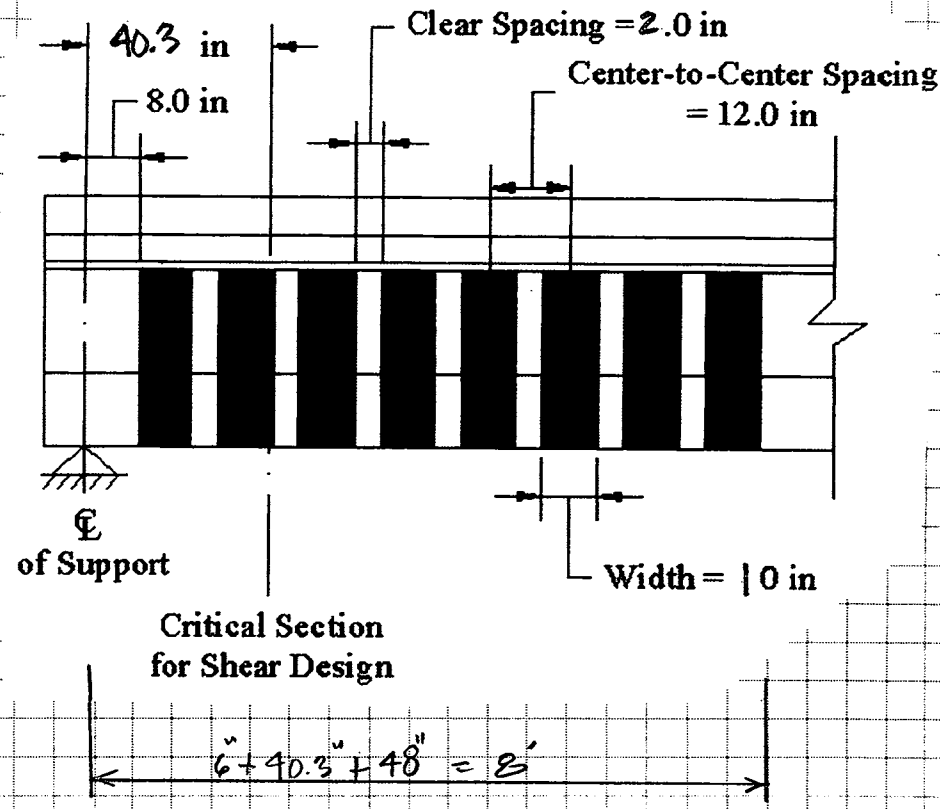
USE CENTER TO CENTER SPACING OF FRP $S_f = 12$ in

ORIENTATION OF FRP STRIPS $\alpha_f = 90°$

EFFECTIVE DEPTH OF FRP $d_f = d_p - h_f = 56 - 4.75 = 51.25$ in

Close, Jensen and Miller, P.C.

BY BA DATE 3/10/11 SUBJECT BR. 596 SHEET NO. 7F OF
CHKD. BY DATE ROUTE 68 O/ NAUGATUCK JOB NO.
RIVER, RTE 8, MNRR, SR 710 NAUGATUCK



CHECK SELECTED SPACING:

SHEAR STRESS ON CONCRETE:

LRFD 5.8.2.9-1

$$V_u = \frac{V_{u\text{-CRITICAL}} - \phi V_p}{\phi\, b_v d_v} = \frac{153.57 - .9 \times 23.96}{.9 \times 7 \times 40.34} = .52 \text{ ksi}$$

THE MAX. SPACING OF THE TRANSVERSE REINFORCEMENT IS:

$$S_{max} = \begin{cases} \text{Min}\,(.8 d_v, 24) & \text{if } V_u < .125 f'_{cb} \quad \text{LRFD EQ. 5.8.2.7-1} \\ \text{Min}\,(.4 d_v, 12) & \text{OTHERWISE} \quad \text{EQ. 5.8.2.7-2} \end{cases}$$

$S_{max} = \text{Min}\,(32.27, 24)$ $\qquad .52 < .125 \times 5 = .625$

$S_{max} = 24$ $\qquad S_s < S_{max}$

$12 < 24$ ACCEPTABLE

Close, Jensen and Miller, P.C.

BY BA DATE 3/10/11 SUBJECT BR. 596 SHEET NO. 8F OF
CHKD. BY DATE ROUTE 68 O/ NAVGATUCK JOB NO.
RIVER, RTE 8, MNRR, SR 710 NAVGATUCK

CALCULATE SHEAR RESISTANCE OF FRP, V_f

FRP REINFORCEMENT RATIO: $\rho_f = \frac{2 h_f W_f t_f}{b_v S_f} = \frac{2 \times 2 \times 10 \times .0065}{7 \times 12} = 3.10 \times 10^{-3}$

FRP STRAIN REDUCTION FACTOR:

$$R_f = \min\left[3\left(\rho_f E_f\right)^{-.67}, 1\right] = \min\left[3 \times \left(3.1 \times 10^{-3} \times 33000^{ksi}\right)^{-.67}\right]$$

EQ. 5.8.3.3-10

EQ. 5.8.3.3-9

$R_f = .135$

THE EFFECTIVE STRAIN OF FRP:

$$\varepsilon_{fe} = \min\left(R_f \varepsilon_{fu}, .012\right) = \min\left(.135 \times .017, .012\right)$$ EQ. 5.8.3.3-7

$= 2.30 \times 10^{-3}$ in/in

THE EFFECTIVE STRESS OF FRP:

EQ. 5.8.3.3-6

$$f_{fe} = \varepsilon_{fe} \cdot E_f = 2.30 \times 10^{-3} \times 33000 = 75.8 \text{ ksi}$$

THE SHEAR CONTRIBUTION OF FRP:

$$V_f = \rho_f E_f \varepsilon_{fe} b_v d_f \left(\sin(\alpha_f) + \cos(\alpha_f)\right)$$ EQ. 5.8.3.3-5

$$V_f = 3.1 \times 10^{-3} \times 33000 \times 2.3 \times 10^{-3} \times 7 \times 51.25 \left(\sin 90 + \cos 90\right) = 84.4 \text{ k}$$

$V_{f_{check}}$ = CHANGE FRP STRENGTHENING SCHEME if $V_f < V_{f\text{-}req}$.

PROVIDED FRP AMOUNT IS ADEQUATE if $\overset{83.4^k}{V_{f req.}} \leq V_f < \overset{91.74^k}{1.1 V_{f req.}}$

$\downarrow$

84.4

CALCULATE DESIGN SHEAR RESISTANCE OF MEMBER:

THE DESIGN STRENGTH OF THE MEMBER:

EQ. 5.8.3.3-1

$$\phi V_{n\text{-TOTAL}} = \phi\left(V_c + V_p + V_s + V_f\right)$$

$$= .9\left(\underbrace{39.9 + 23.96 + 23.3}_{87.16} + 84.4\right) = 154.4$$

$$V_{u\text{-CRITICAL}} = 153.57^k < \phi V_{n\text{TOTAL}} = 154.4 \qquad \text{OK}$$

WEB CRUSHING LIMIT $= \left(.25 f'_{cb} \times b_v \times d_v\right) + V_p$ EQ. 5.8.3.3-2

WEB CRUSHING LIMIT $= \left(.25 \times 5 \times 7 \times 40.34\right) + 23.96 = 376.9\ k$

$$V_c + V_p + V_s + V_f = 171.6\ k < 376.9^k \qquad \text{OK}$$

SUMMARY

EXTERNALLY BONDED SHEETS WERE DESIGNED. THE FRP SHEETS ARE APPLIED AT 90° WITH RESPECT TO THE LONGITUDINAL AXIS OF THE MEMBER WITH THE U-WRAP CONFIGURATION AND WITHOUT ANCHORAGE SYSTEMS. THE FINAL DESIGN SUMMARY:

USE NUMBER OF PLIES OF FRP SHEETS $n_f = 2$ MIN.

USE WIDTH OF FRP SHEETS $W_f = 10$ in

USE C TO C. SPACING OF FRP SHEETS $S_f = 12$ in

WRAP LAST 10' OF BEAM END W/ (MANUFACTURER'S RECOMMENDATION OF 3 LAYERS FRP SHEETS)

Close, Jensen and Miller, P.C.

BY BA DATE 3/10/11 SUBJECT BR 596 SHEET NO. 10F OF
CHKD. BY DATE ROUTE 68 O/ NAVIGATION JOB NO.
RIVER, RTE 8, MNDOT, SR 710 NAVIGATION

WRAP BEAMS

$$\left[\left(\frac{56''}{12}\times 2\right)+\frac{24''}{12}\right]\times(8'\times 2) = 185 \text{ SF}$$

(WEB, SIDES, BOTT., ENDS, 2 ENDS) (SEE PAGE 9E)

$(185^{SF} \times 11 \text{ BEAMS} \times 6 \text{ SPANS}) = 12{,}210^{SF}$ ONLY ENDS

$12{,}210^{SF} \times \$50/SF \times 2^{LAYERS} = 1{,}221{,}000$ COST OF WRAPING ENDS ONLY

MIDDLE ONLY BEAMS @ SPANS 2-5

$$\left[\left(\frac{56''}{12}\times 2\right)+\frac{24''}{12}\right]\times 40' = 455 \text{ SF}$$

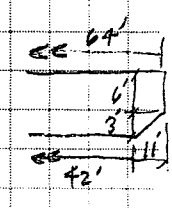
(SIDES, BOTT.)

$455^{SF} \times 5^{BEAMS} = 2{,}275^{SF}$ MIDSPAN

$2{,}275^{SF} \times \$50/SF \times 3^{LAYERS} = 341{,}250$ COST OF WRAPING MIDDLE 5 BEAMS ONLY

TOTAL = 1,221,000 + 341,250 = 1,562,250 BEAMS ONLY
≃ 1,600,000

WRAPPING PIER CAPS : ALL 5 PIERS



$$[(64'\times 6')+(42'\times 3')+(11'\times 3')](2)+(64'\times 5')+(42'\times 5')+(11.5'\times 5'\times 2)+(6'\times 5'\times 2) = 1791 \text{ SF}$$

(TOP, BOTT., BOTT. SIDE, SIDE)

$1791^{SF} \times 5 \text{ PIERS} = 8955 \text{ SF} \simeq 9000 \text{ SF}$

$9000^{SF} \times \$50/SF \times 3^{LAYERS} = \$1{,}350{,}000$ PIER CAPS ONLY
≃ 1,400,000

TOTAL BEAM ENDS (ALL) + 5 BEAMS MIDDLE + ALL 5 PIER CAPS

1,600,000 + 1,400,000 = SAY 3,000,000

BRIDGE NO.00596

ROUTE 68 OVER NAUGATTUCK RIVER, ROUTES 8, 710 AND METRO NORTH TRACKS

NAUGATUCK, CT

APPENDIX "A"

LRFD PRESTRESSED BEAM DESIGN

(1A)

LRFD English Prestressed Beam Program

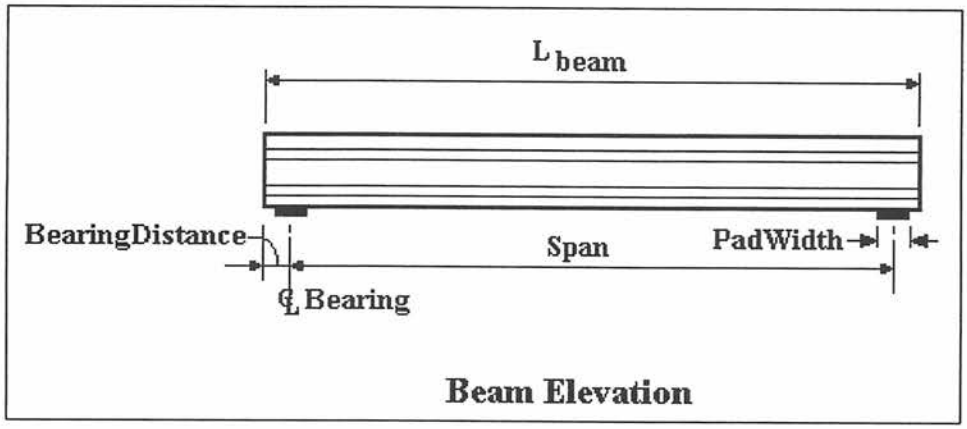
Project = "Br596E4"
DesignedBy = "BA"
Date = "3/15/11"

Legend

TanHighlight = DataEntry | YellowHighlight = CheckValues | GreyHighlight = UserComments + Graphs

BlackText = ProgramEquations | *Maroon Text = Code Reference* | *Blue Text = Commentary*

Bridge Layout and Dimensions



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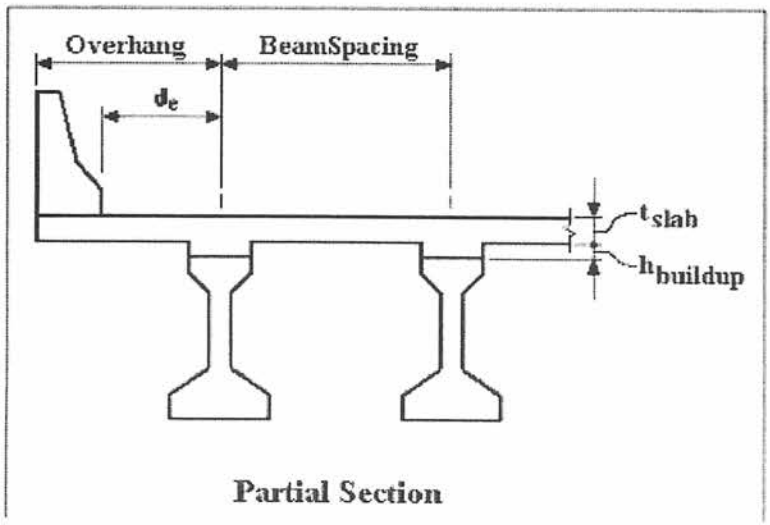
Comment = "56 inch Beam"

DataMessage = "This is a Single Web Beam Design, AASHTO distribution factor criteria not met"

$L_{beam} = 99.33 \cdot ft$ | Span = $97.5 \cdot ft$ | BearingDistance = $11 \cdot in$ | PadWidth = $12 \cdot in$

BeamTypeTog = "Custom"

These are typically the FDOT designations found in our standards. The user can also create a coordinate file for a custom shape. In all cases the top of the beam is at the y=0 ordinate.



(2A)

$Overhang = 2.5 \cdot ft$ $BeamSpacing = 5.96 \cdot ft$ $t_{slab} = 2 \cdot in$ $h_{buildup} = 0 \cdot in$

$Skew = 0 \cdot deg$ $t_{integral.ws} = 0.5 \cdot in$ $NumberOfBeams = 11$ $t_{slab.delta} = 0 \cdot in$

$de = 1.5\,ft$

$BeamPosition = \text{"interior"}$ *For calculating distribution factors must be either interior or exterior*

$SectionType = \text{"transformed"}$ *Can be either gross or transformed. Gross uses the section properties of the concrete only ignoring the steel and does not include elastic gains. Transformed includes the effect of the transformed steel areas on the section properties.*

$b_e = 5.96\,ft$ *effective slab width* *LRFD 4.6.2.6*

$t_{slab} := if(t_{slab} \le 0 \cdot in, 0.00001 \cdot in, t_{slab})$ *Provide a minimum slab thickness to prevent divide by zero errors*

Material Properties

$SectTog := if(SectionType = \text{"transformed"}, 1, 0)$ $SectTog = 1$

Concrete

Corrosion Classification $Environment = \text{"moderately"}$

density of slab concrete $\gamma_{slab} = 0.15 \cdot \frac{kip}{ft^3}$

strength of slab concrete $f_{c.slab} = 4 \cdot ksi$

density of beam concrete $\gamma_{beam} = 0.15 \cdot \frac{kip}{ft^3}$

strength of beam concrete $f_{c.beam} = 5 \cdot ksi$

weight of future wearing surface $Weight_{future.ws} = 0.05 \cdot \frac{kip}{ft^2}$

release beam strength $f_{ci.beam} = 4 \cdot ksi$

type of course aggregate, "Florida" *or* "Standard" $AggregateType = \text{"Standard"}$

relative humidity $H = 70$

$n_d := \sqrt{\frac{f_{c.beam}}{f_{c.slab}}}$ *used in distribution calculation* $n_d = 1.12$

$AggFactor := if[AggregateType = \text{"Florida"}, (0.9 \cdot 1820), 1820]$ $AggFactor = 1820$

$E_{ci} := AggFactor \cdot \sqrt{f_{ci.beam} \cdot ksi}$ *initial beam concrete modulus of elasticity* *(LRFD 5.4.2.4)* $E_{ci} = 3640 \cdot ksi$

$E_c := AggFactor \cdot \sqrt{f_{c.beam} \cdot ksi}$ *beam concrete modulus of elasticity* *(LRFD 5.4.2.4)* $E_c = 4070 \cdot ksi$

Prestressing Tendons

tendon ultimate tensile strength $f_{pu} = 200 \cdot ksi$

tendon modulus of elasticity $E_p = 25000 \cdot ksi$

time in days between jacking and transfer $t_j = 1.5$

ratio of tendon modulus to initial beam concrete modulus $n_{pi} := \frac{E_p}{E_{ci}}$

ratio of tendon modulus to beam concrete modulus $n_p := \frac{E_p}{E_c}$

Mild Steel

mild steel yield strength $f_y = 40 \cdot ksi$

mild steel modulus of elasticity $E_s = 29000 \cdot ksi$

ratio of rebar modulus to initial beam concrete modulus $n_{mi} := \frac{E_s}{E_{ci}}$ $n_{mi} = 7.97$

area per unit width of longitudinal slab reinf. $A_{slab.rebar} = 0.3 \cdot \frac{in^2}{ft}$

ratio of rebar modulus to beam concrete modulus $n_m := \frac{E_s}{E_c}$ $n_m = 7.13$

area of mild reinf lumped at centroid of bar locations $A_{s.long} = 0 \cdot in^2$

d distance from top of slab to centroid of slab reinf. $d_{slab.rebar} = 4 \cdot in$

d distance from top of beam to centroid of mild flexural tension reinf. $d_{long} = 0 \cdot in$

Size of bar used create used to calculate development length $BarSize = 4$

Permit Loads *P204 Permit Loading*

This is the number of wheel loads that comprise the truck, max for DLL is 11 $PermitAxles = 8$

Indexes used to identify values in the P and d vectors $q := 0 .. (PermitAxles - 1)$ $qt := 0 .. PermitAxles$

$PermitAxleLoad^T = (15 \;\; 27 \;\; 27 \;\; 27 \;\; 27 \;\; 27 \;\; 27 \;\; 27) \cdot kip$

$PermitAxleSpacing^T = (0 \;\; 11 \;\; 4 \;\; 4 \;\; 24 \;\; 4 \;\; 4 \;\; 4 \;\; -1) \cdot ft$

Distribution Factors

DataMessage = "This is a Single Web Beam Design, AASHTO distribution factor criteria not met"

calculated values

$tmp\_g_{mom} = 0.78$ $tmp\_g_{shear} = 0.67$

user values

$user\_g_{mom} := 0$ $user\_g_{shear} := 0$

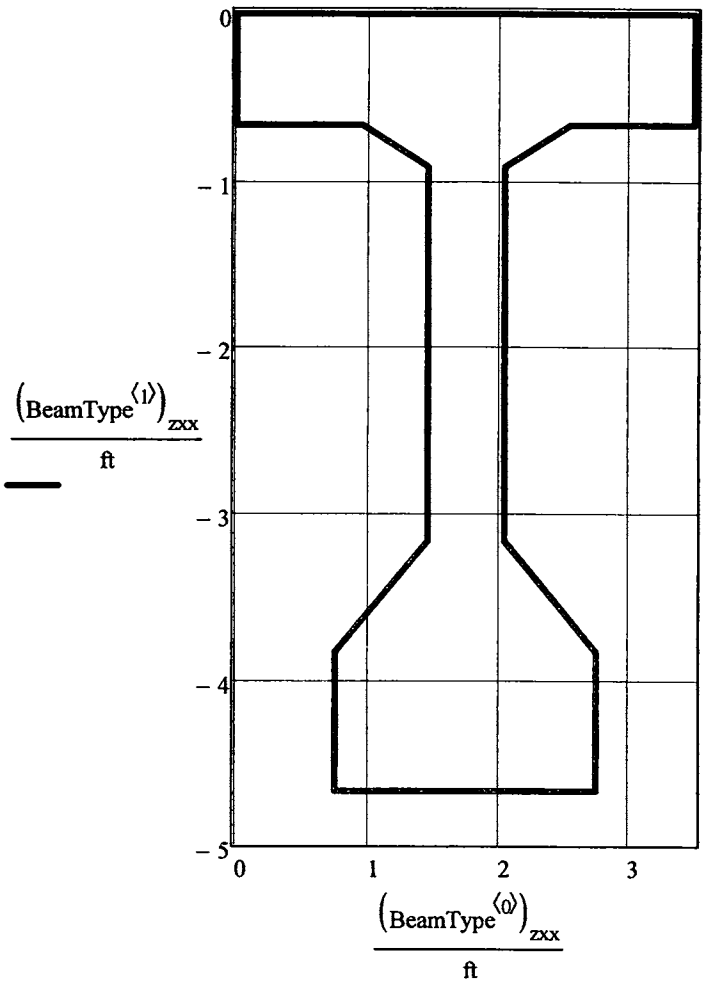
value check

$g_{mom} := \text{if}(user\_g_{mom} \neq 0, user\_g_{mom}, tmp\_g_{mom})$ $\qquad g_{mom} = 0.78$

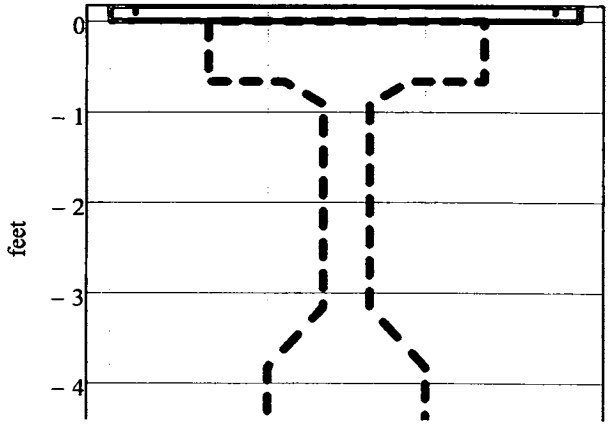
$g_{shear} := \text{if}(user\_g_{shear} \neq 0, user\_g_{shear}, tmp\_g_{shear})$ $\qquad g_{shear} = 0.67$

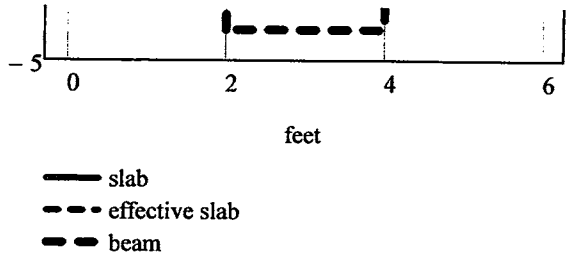
Section Properties

Beam Section



Total Slab, Effective Slab, and Beam





Non-Composite Dead Loads

$$w_{slab} := \text{if}\left[\text{BeamPosition} = \text{"interior"}, \left[\text{BeamSpacing}\cdot\left(t_{slab} \cdots + t_{integral.ws}\right) \cdots + \left(h_{buildup}\cdot \text{Width}_{buildup}\right)\right]\cdot\gamma_{slab}, \left[\left(\text{Overhang}_{plus} \cdots + \text{BeamSpacing}\cdot 0.5\right)\cdot\left(t_{slab} \cdots + t_{integral.ws}\right) \cdots + \left(h_{buildup}\cdot \text{Width}_{buildup}\right)\right]\cdot\gamma_{slab}\right]$$

$$w_{slab} = 0.186\cdot\frac{kip}{ft}$$

$$w_{beam} := \text{Beam}_0\cdot in^2\cdot\gamma_{beam}$$

$$w_{beam} = 0.967\cdot\frac{kip}{ft}$$

SDG 2.5 & 4.2.13

$$w_{forms} = 0.049\cdot\frac{kip}{ft}$$

$$w_{delta.max} := \text{if}\left[\text{BeamPosition} = \text{"interior"}, \left[\text{BeamSpacing}\cdot\left(t_{slab.delta}\right)\right]\cdot\gamma_{slab}, \left[\left(\text{Overhang}_{plus} \cdots + \text{BeamSpacing}\right)\cdot\left(t_{slab.delta}\right)\right]\cdot\gamma_{slab}\right]$$

$$w_{delta.max} = 0\cdot\frac{kip}{ft}$$

$$\text{Add\_w}_{noncomp} := 0.0\cdot\frac{kip}{ft}$$

additional non composite dead load (positive or negative)

$$w_{noncomposite} := w_{slab} + w_{beam} + w_{forms} + \text{Add\_w}_{noncomp}$$

$$w_{noncomposite} = 1.202\cdot\frac{kip}{ft}$$

$$wb_{noncomposite} := w_{slab} + w_{forms} + \text{Add\_w}_{noncomp}$$

$$wb_{noncomposite} = 0.235\cdot\frac{kip}{ft}$$

Composite Dead Loads

$$w_{future.ws} = 0.298\cdot\frac{kip}{ft}$$

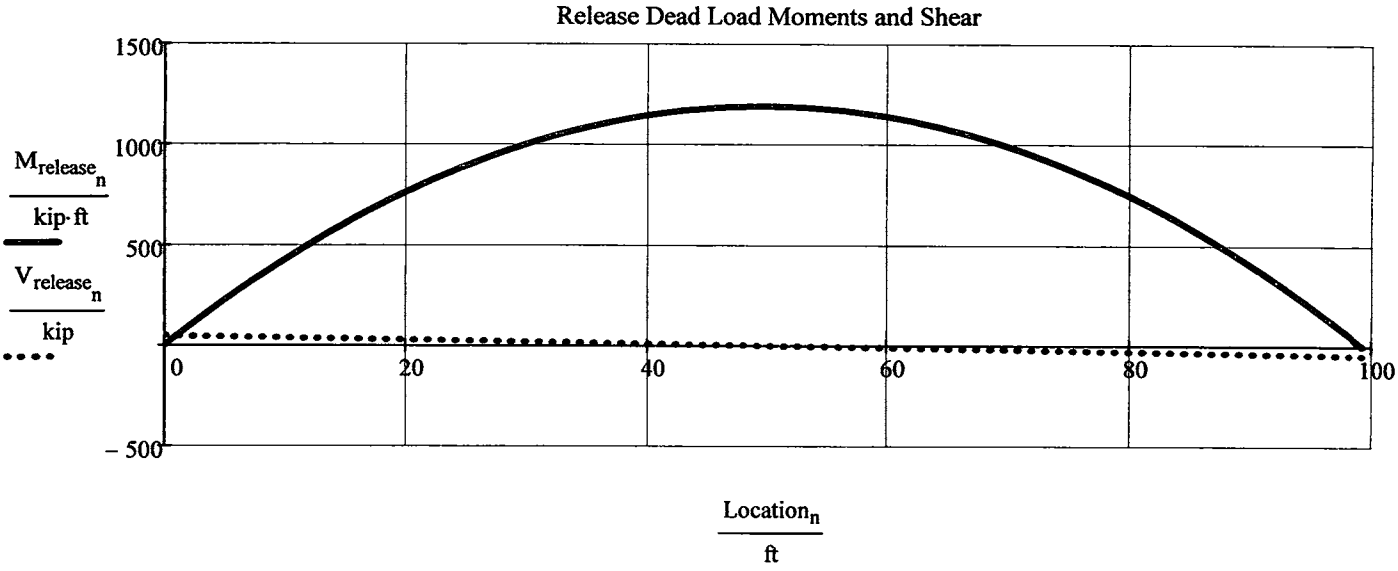
$$w_{barrier} = 0.076\cdot\frac{kip}{ft}$$

$Add\_w_{comp} := 0.0 \cdot \frac{kip}{ft}$ *additional composite dead load (positive or negative)*

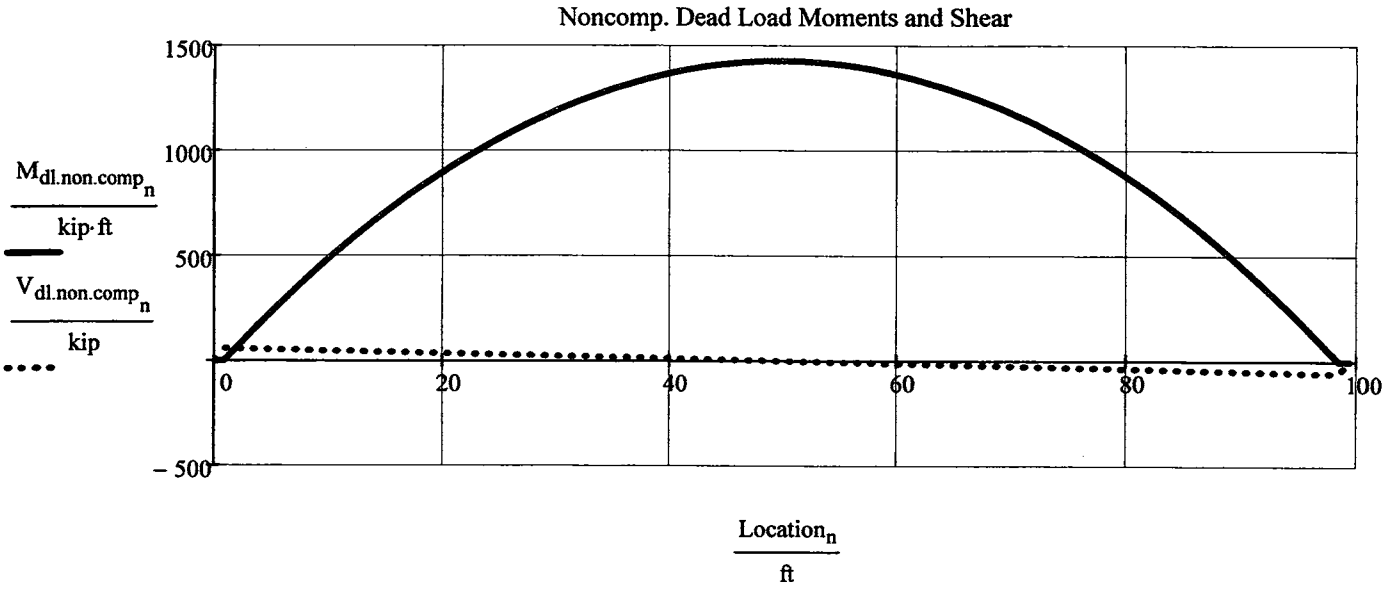
$w_{composite} := w_{future.ws} + w_{barrier} + Add\_w_{comp}$ $w_{composite} = 0.374 \cdot \frac{kip}{ft}$

$w_{comp.str} := w_{barrier} + Add\_w_{comp}$ $w_{comp.str} = 0.076 \cdot \frac{kip}{ft}$

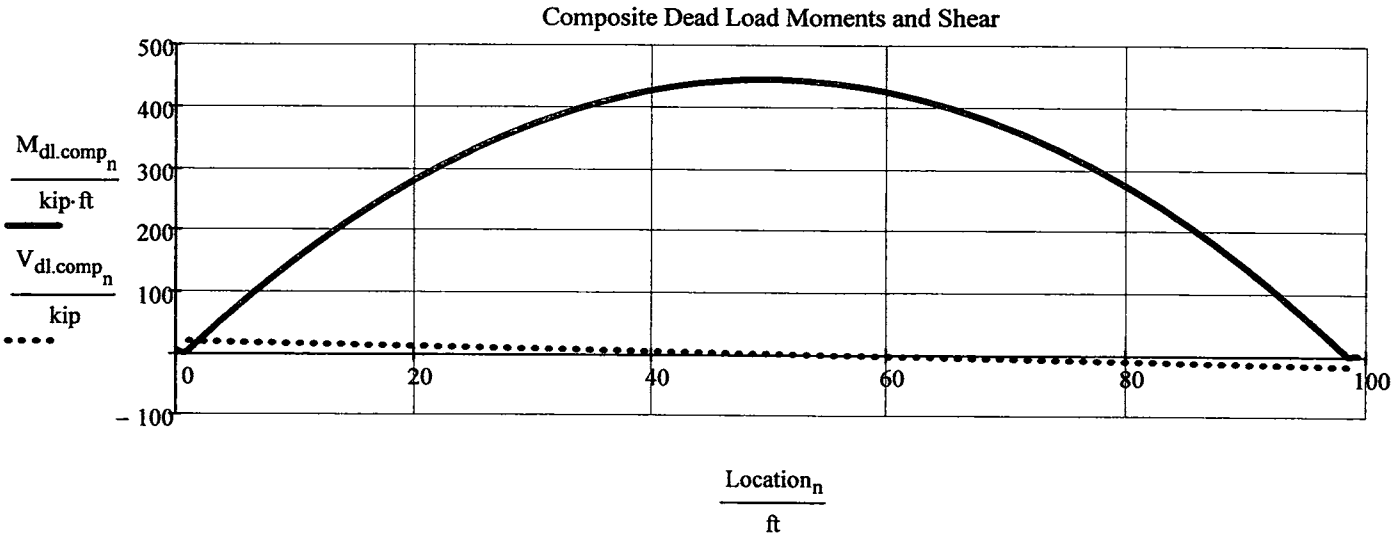
Dead Load Moments and Shear - Release / Non-Composite / Composite & Distributed Live Load Moments and Shear



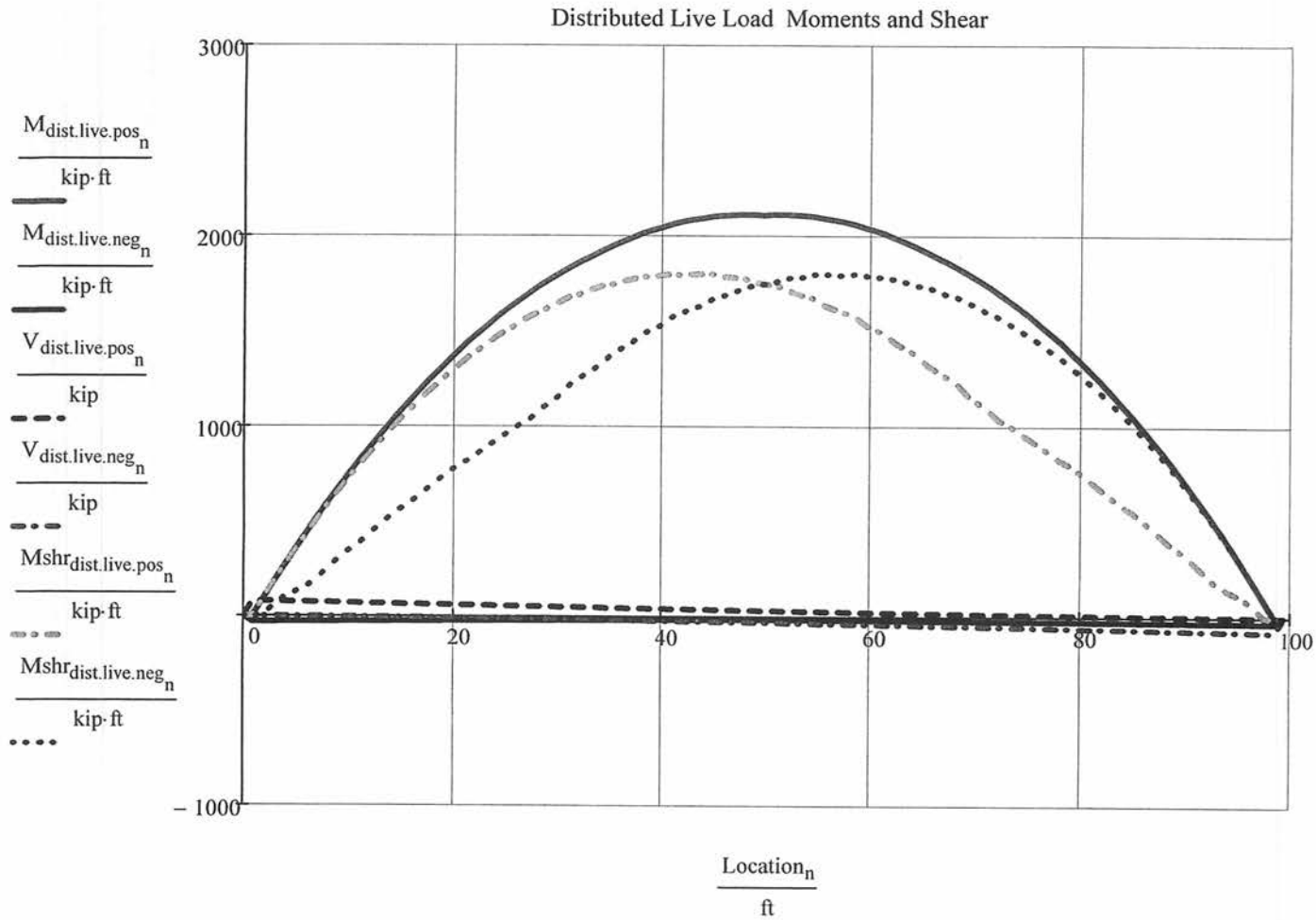
$\max(M_{release}) = 1192.2 \cdot kip \cdot ft$ $\max(V_{release}) = 48 \cdot kip$



$\max(M_{dl.non.comp}) = 1427.8 \cdot kip \cdot ft$ $\max(V_{dl.non.comp}) = 58.6 \cdot kip$



$\max(M_{dl.comp}) = 444.7 \cdot kip \cdot ft$ $\max(V_{dl.comp}) = 18.2 \cdot kip$



$\max(M_{dist.live.pos}) = 2111.8 \cdot kip \cdot ft$ $\min(M_{dist.live.neg}) = -30.4 \cdot kip \cdot ft$ $Reaction_{LL} = 79.64 \cdot kip$

$\max(V_{dist.live.pos}) = 78.6 \cdot kip$ $\max(Mshr_{dist.live.pos}) = 1799.8 \cdot kip \cdot ft$ $Reaction_{DL} = 78.3 \cdot kip$

Design Prestress Strand Layout

Double click on the **Strand Geometry** *icon to specify type, location, size, and debonding of strands. Then click on* Stranddata *and press* **F9** *to read in the data.*

Strand Geometry

```
Stranddata := | a ← READPRN("tendsect.dat")
              | w ← READPRN("strand.dat")
              | x ← READPRN("area.dat")
              | y ← READPRN("shield.dat")
              | z ← READPRN("distance.dat")
              | (w x y z a)
```

StrandTemplate := Standard / Custom — *adjusts 'Strand Pattern Generator' input mode*

$CheckPattern_0$ = "OK" *check 0 - no debonded tendon in outside row*

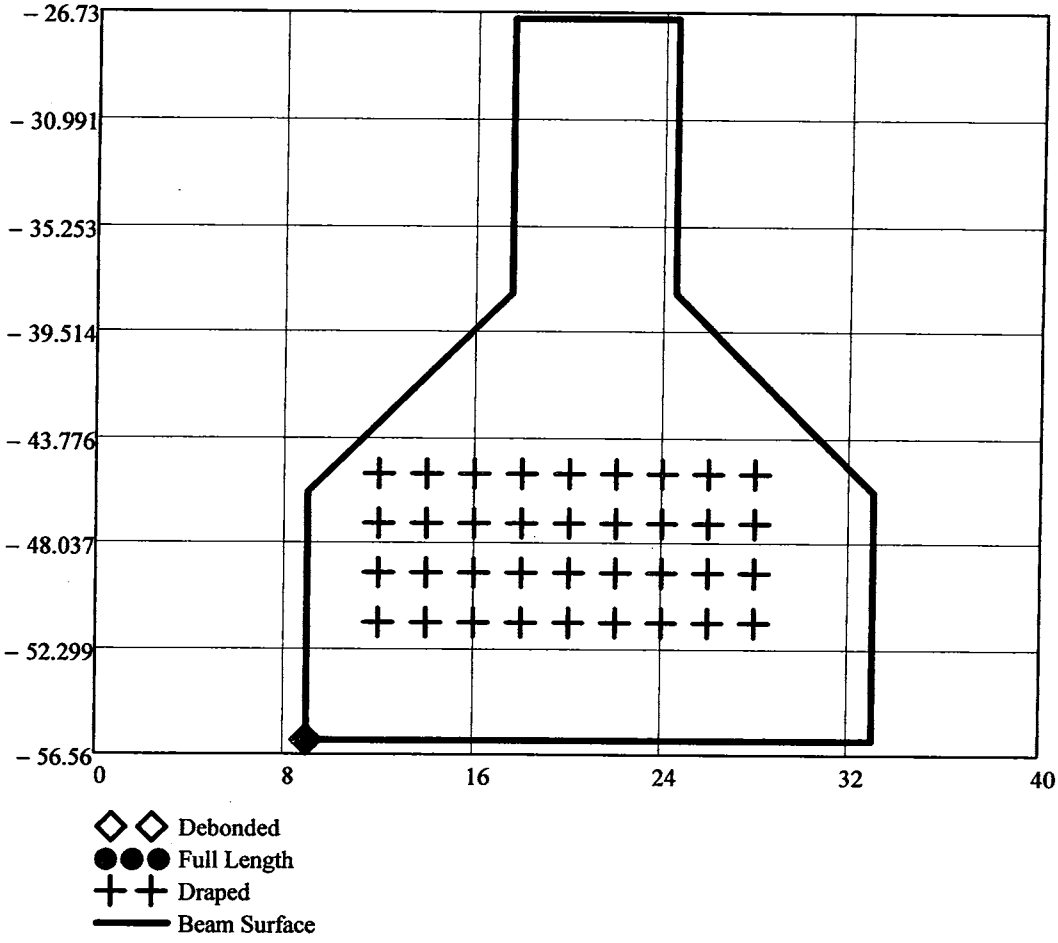
$CheckPattern_1$ = "OK" *check 1 - less than 25% debonded tendons total*

$CheckPattern_2$ = "OK" *check 2 - less than 40% debonded tendons in any row*

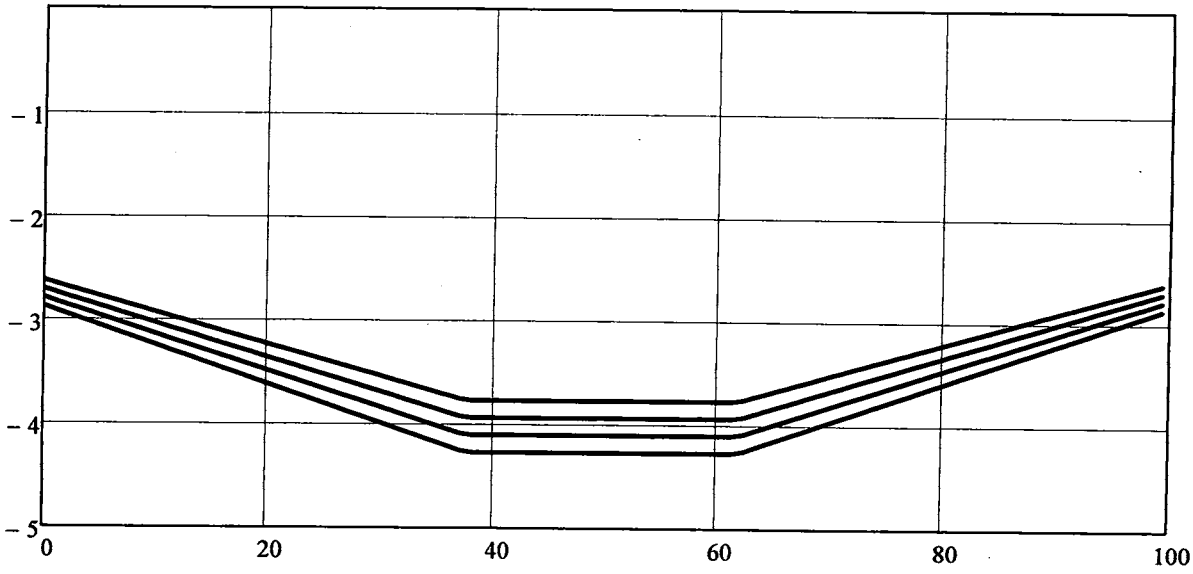
$CheckPattern_3$ = "OK" *check 3 - less than 40% of debonded tendons terminated at same section* (LRFD 5.11.4.3)

$CheckPattern_4$ = "OK" *check 4 - more than half beam depth debond length* (SDG 4.3.1.E)

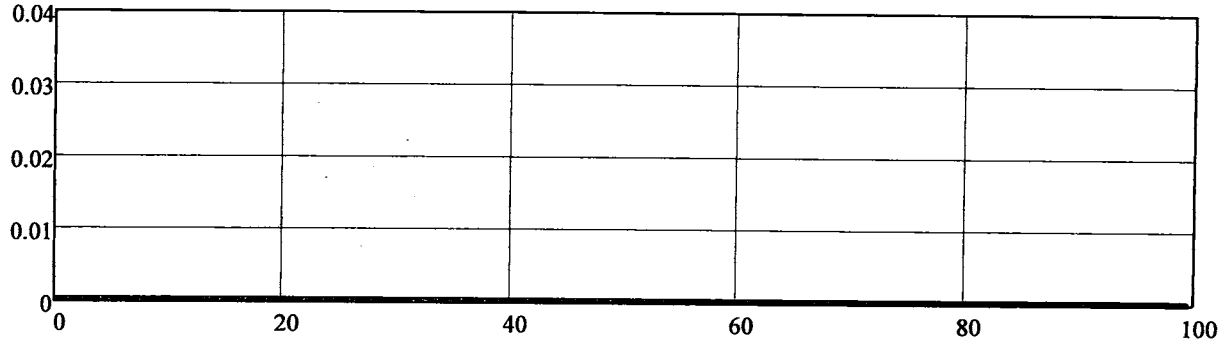
Tendon Layout



Location of Depressed Strands



Bonded Length of Debonded Strands



Section and Tendon Properties Summary

$A_{beam} = 928 \cdot in^2$	*Concrete area of beam*	$I_{beam} = 374504.5096 \cdot in^4$	*Gross Moment of Inertia of Beam*
$y_{comp} = -22.49 \cdot in$	*Dist. from top of beam to CG of composite section*	$I_{comp} = 454865.084 \cdot in^4$	*Gross Moment of Inertia Composite Section*
$A_{deck} = 127.94 \cdot in^2$	*Concrete area of deck slab*	$A_{ps} = 7.8 \cdot in^2$	*total area of strands*
$d_{b.ps} = 0.6 \cdot in$	*diameter of Prestressing strand*	min(PrestressType) = 1	*0 - low lax 1 - stress relieved*
$f_{py} = 170 \cdot ksi$	*tendon yield strength*	$f_{pj} = 140 \cdot ksi$	*prestress jacking stress*

$L_{shielding}^T = (0 \;\; 0 \;\; 0 \;\; 0) \cdot ft$

$A_{ps.row}^{T} = (2\ \ 2\ \ 2\ \ 2)\cdot in^2$

$d_{ps.row} =$

	0	1	2	3	4	5	6	7	8
0	-34.5	-34.91	-35.35	-35.78	-36.22	-36.65	-37.09	-37.52	-37.96
1	-33.5	-33.89	-34.29	-34.7	-35.11	-35.52	-35.93	-36.34	-36.75
2	-32.5	-32.86	-33.24	-33.63	-34.01	-34.4	-34.78	-35.16	-35.55
3	-31.5	-31.84	-32.19	-32.55	-32.91	-33.27	-33.62	-33.98	...

$\cdot in$

TotalNumberOfTendons = 36

NumberOfDebondedTendons = 0

NumberOfDrapedTendons = 36

StrandSize = "0.6 in stress relieved"

StrandArea = $0.22\cdot in^2$

$JackingForce_{per.strand} = 30.38\cdot kip$

Prestress Losses Summary

$f_{pj} = 140\cdot ksi$

$f_{pi} = 140\cdot ksi$

$f_{pe} = 106\cdot ksi$

$\Delta f_{pES} = 0\cdot ksi$

$\Delta f_{pi} = 0\cdot ksi$

$\Delta f_{pTot} = -34\cdot ksi$

Note: Elastic shortening losses are zero in concrete stress calculations when using transformed section properties per LRFD 5.9.5.2.3

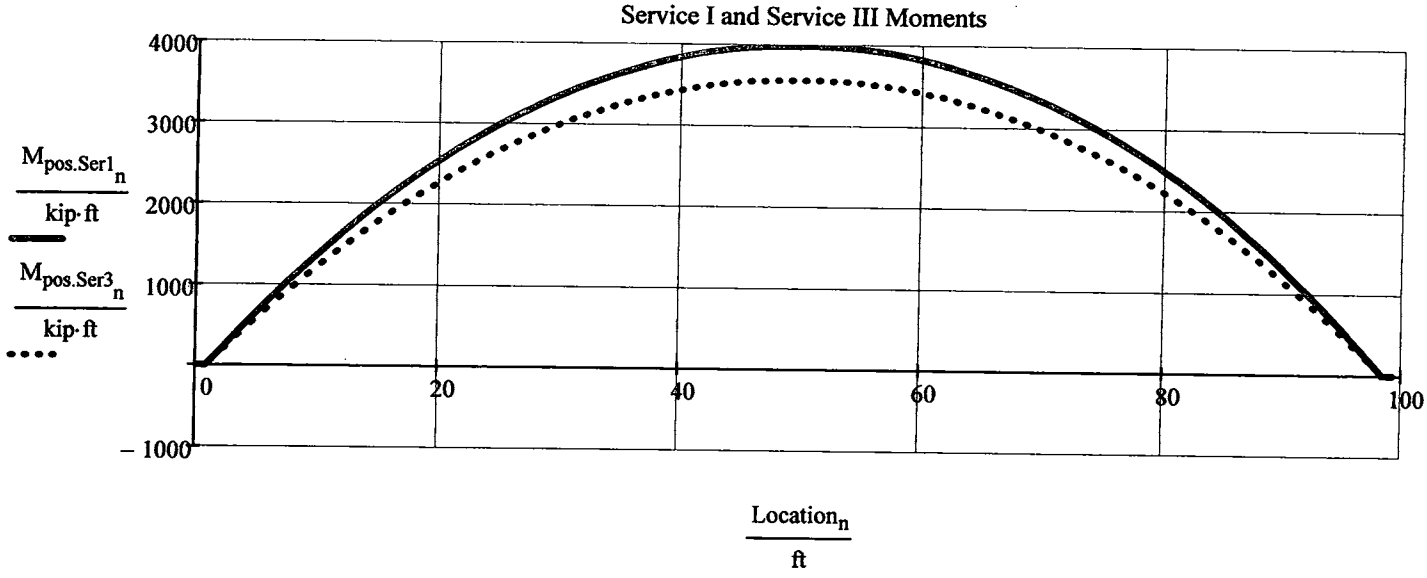
percentages $\frac{\Delta f_{pi}}{f_{pj}} = 0\cdot\%$ $\frac{f_{pi}}{f_{pj}} = 100\cdot\%$ $\frac{\Delta f_{pTot}}{f_{pj}} = -24.13\cdot\%$ $\frac{f_{pe}}{f_{pj}} = 75.87\cdot\%$

Check_f_{pt} = "OK"

$0.8\cdot f_{py} = 136\cdot ksi$

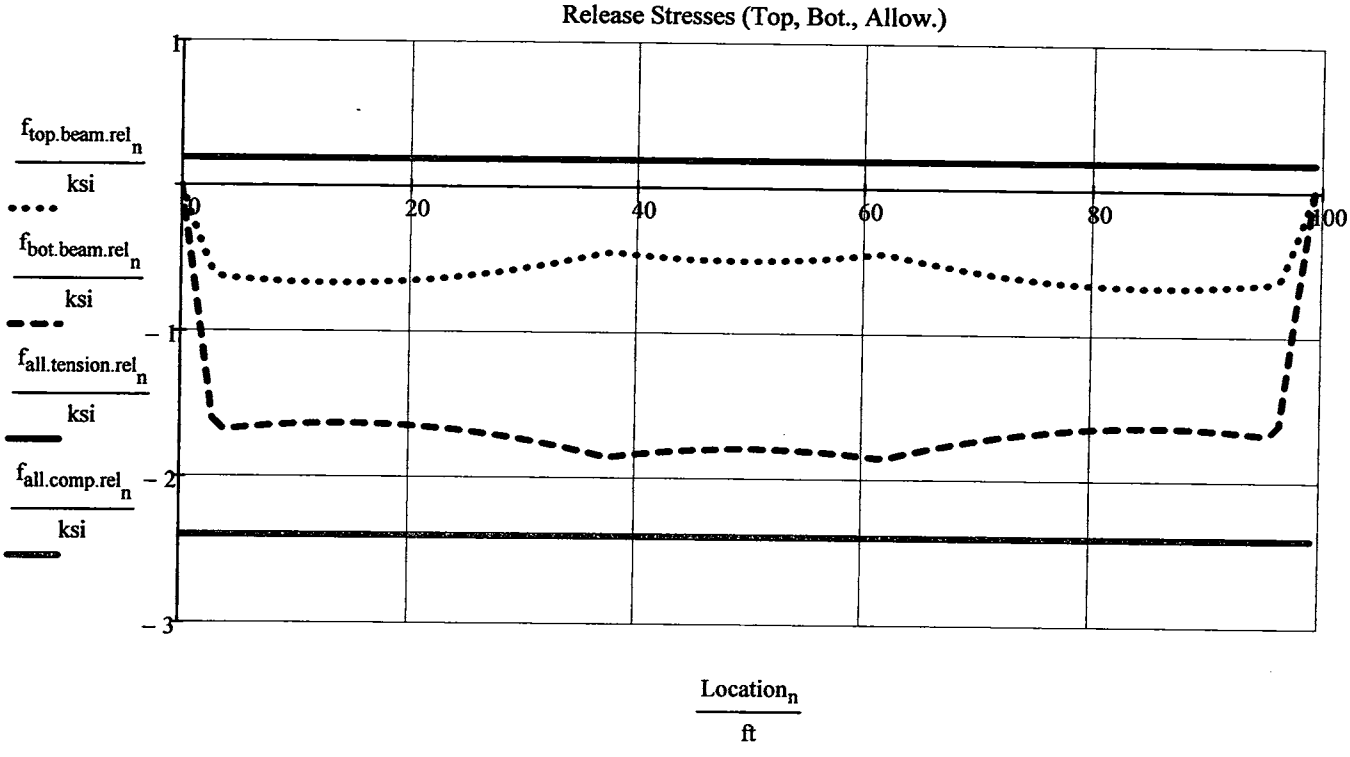
Check_f_{pe} = "OK"

Service Limit State



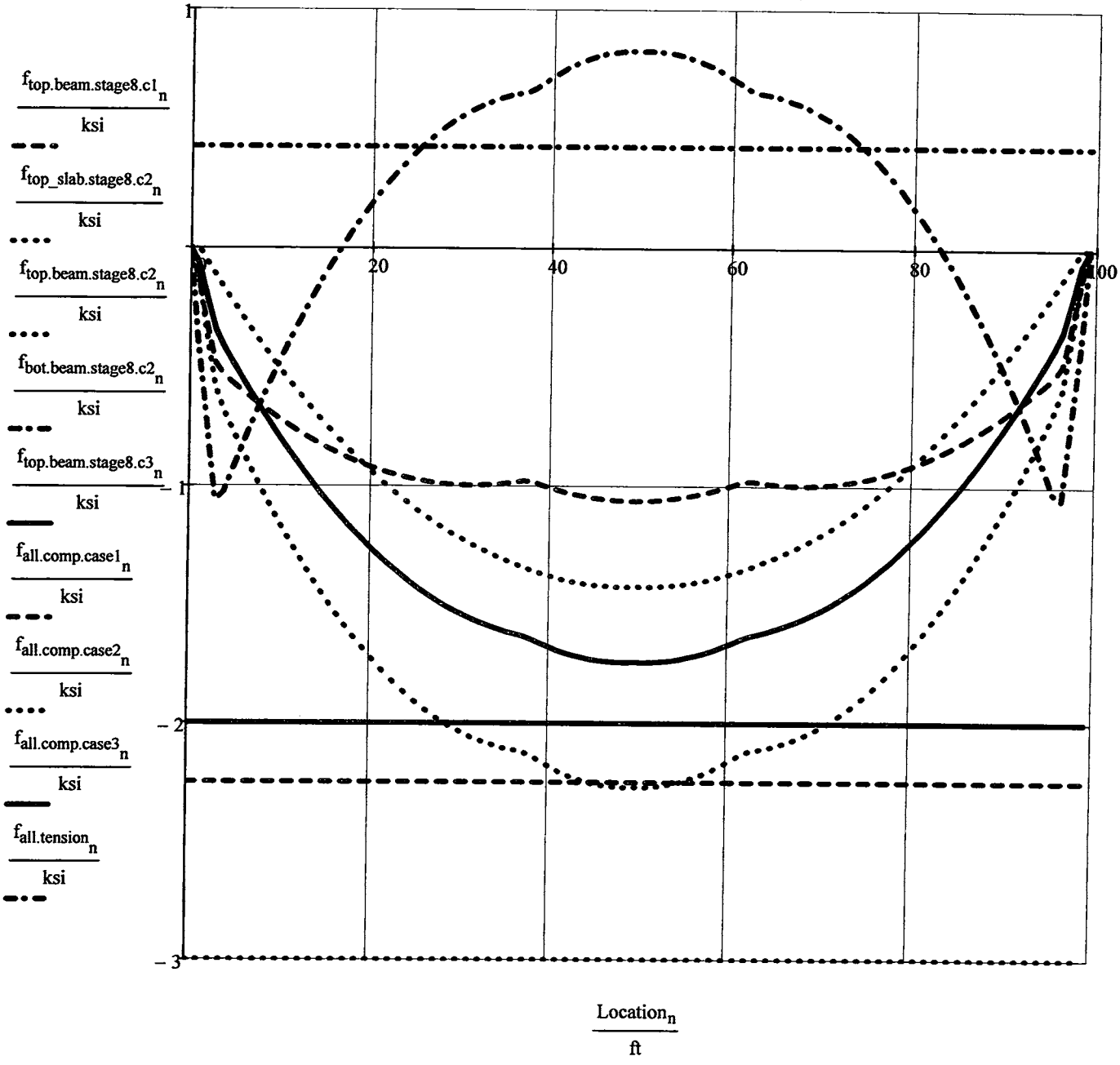
$\max(M_{pos.Ser1}) = 3983.5 \cdot kip \cdot ft$ $\max(M_{pos.Ser3}) = 3561.1 \cdot kip \cdot ft$

Release and Final Stresses



13A

Final Stresses (Top, Bot., Allowable)



$\min(CR\_f_{tension.rel}) = 10$	$Check\_f_{tension.rel}$ = "OK"	*(Release tension)*
$\min(CR\_f_{comp.rel}) = 1.29$	$Check\_f_{comp.rel}$ = "OK"	*(Release compression)*
$\min(CR\_f_{tension.stage8}) = 0.51$	$Check\_f_{tension.stage8}$ = "No Good!"	*(Service III , PS + DL +LL*0.8)*
$\min(CR\_f_{comp.stage8.c1}) = 2.12$	$Check\_f_{comp.stage8.c1}$ = "OK"	*(Service I , PS + DL)*
$\min(CR\_f_{comp.stage8.c2}) = 1.32$	$Check\_f_{comp.stage8.c2}$ = "OK"	*(Service I , PS + DL +LL)*

$\min(CR\_f_{comp.stage8.c3}) = 1.15$ Check_$f_{comp.stage8.c3}$ = "OK" *(Service I , (PS + DL)*0.5 +LL)*

Summary of Values at Midspan

Stresses =

"Stage "	"Top of Beam (ksi) "	"Bott of Beam (ksi)"
1	−0.5	−1.8
2	−0.62	−1.11
4	−0.58	−1.15
6	−0.81	−0.9
8	−2.27	0.83

PrestressForce =

"Condition "	"Axial (kip)"	"Moment (kip*ft)"
"Release"	−1093.7	−2070.5
"Final (about composite centroid)"	−829.7	−1493

Properties =

"Section "	"Area (in^2) "	"Inertia (in^4) "	"distance to centroid from top of bm (in)"
"Net Beam "	920.19	370467.48	−25.54
"Transformed Beam (initial)"	973.84	396901.79	−26.79
"Transformed Beam "	968.18	394247.97	−26.66
"Composite "	1107.07	485741.98	−23.22

ServiceMoments =

"Type "	"Value (kip*ft)"
"Release"	1192.2
"Non-composite (includes bm wt.)"	1427.8
"Composite"	444.7
"Distributed Live Load"	2108.8

Stage 1 ---> At release with span length equal to length of the beam. Prestress losses are elastic shortening and overnight relax

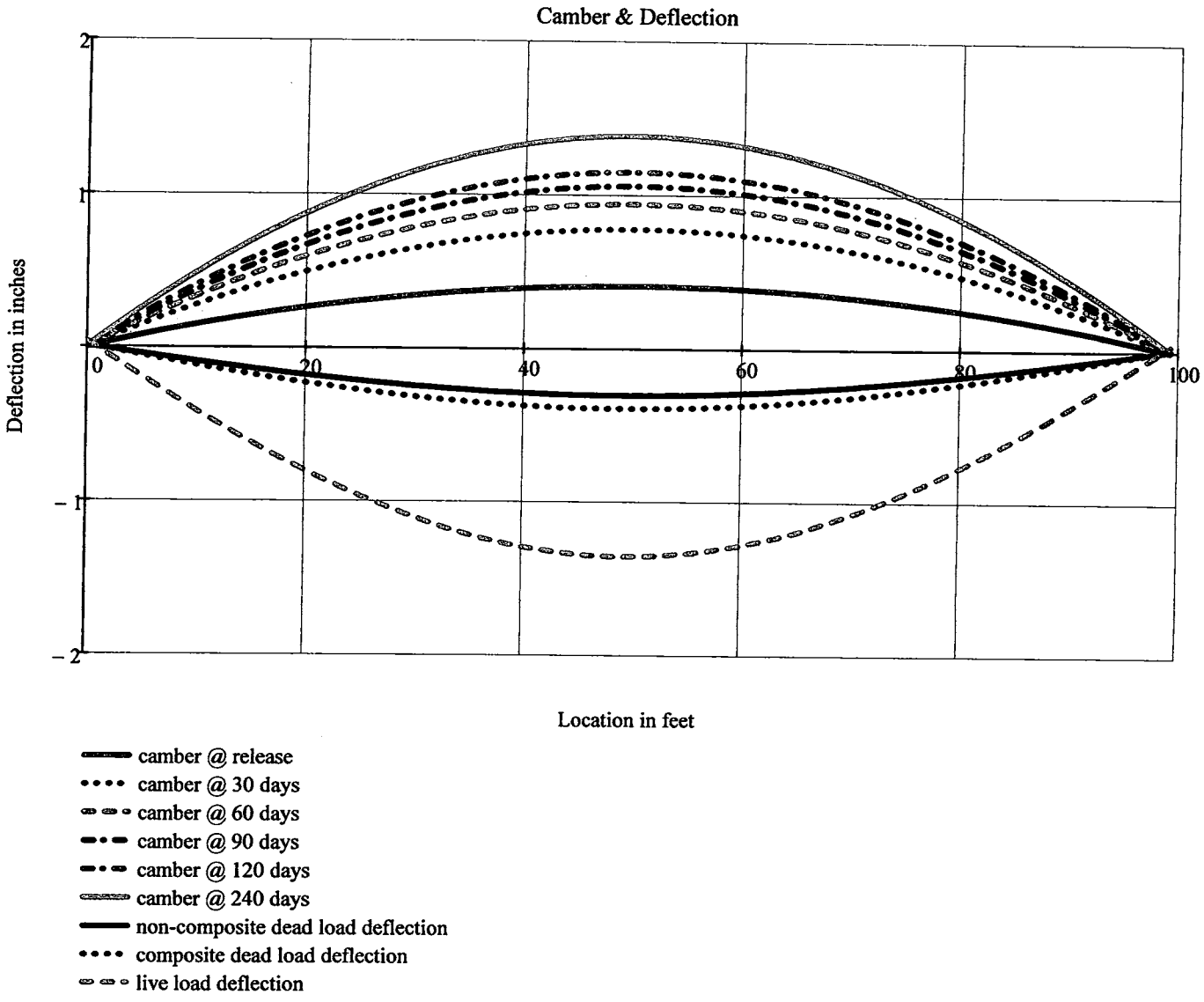
Stage 2 ---> Same as release with the addition of the remaining prestress losses applied to the transformed beam

Stage 4 ---> Same as stage 2 with supports changed from the end of the beam to the bearing locations

Stage 6 ---> Stage 4 with the addition of non-composite dead load excluding beam weight which has been included since Stage 1

Stage 8 ---> Stage 6 with the addition of composite dead load and live loads applied to the composite section

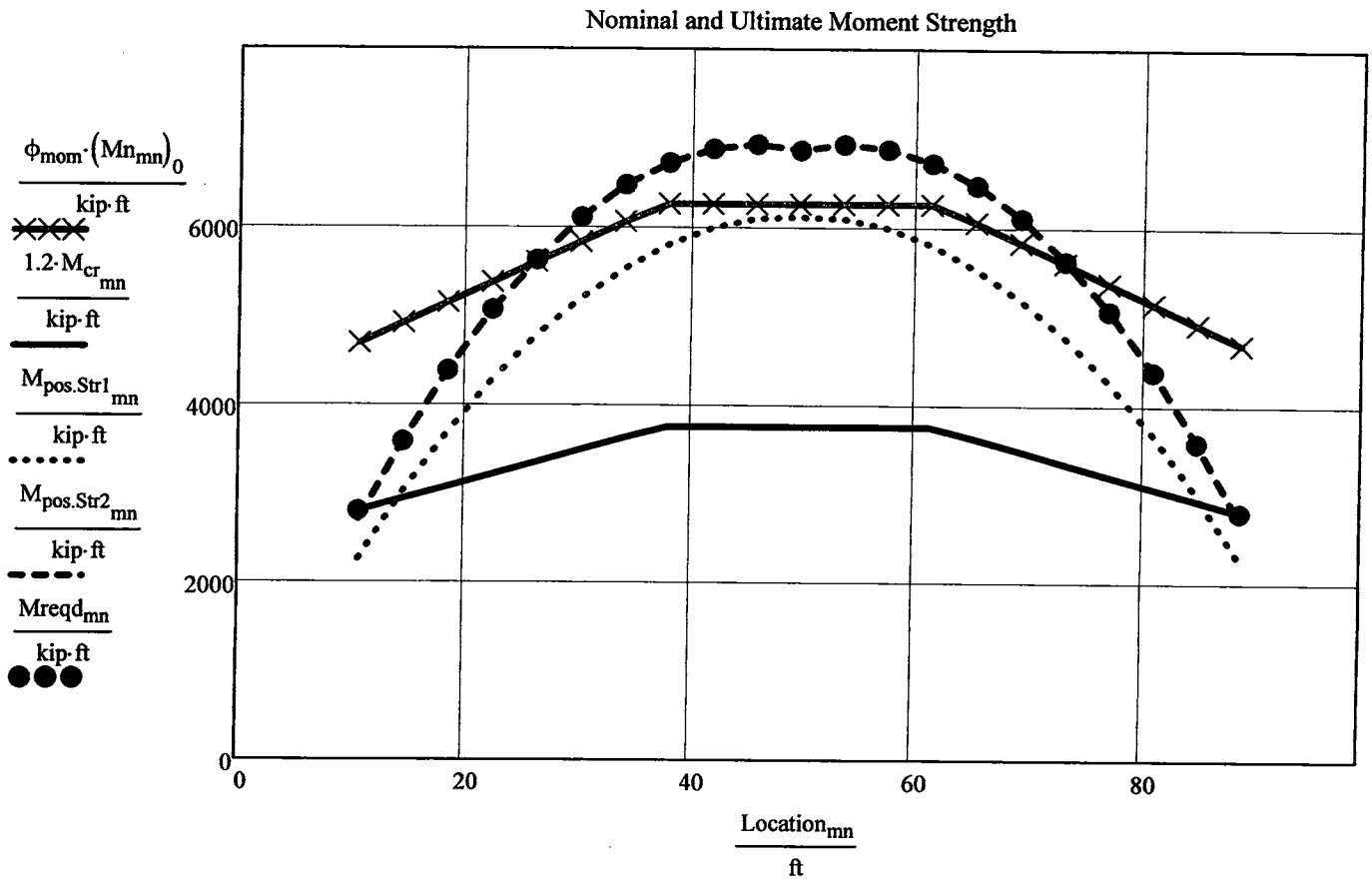
Camber and Shrinkage and Dead Load Deflections



SlopeData =

"Stage"	"Change in L @ Top (in)"	"Change in L @ Bot. (in)"	"Slope at End (deg)"	"midspan defl (in)"
"Release"	−0.1843	−0.5532	0.0777	0.4102
"30 Days"	−0.3943	−0.9284	0.1425	0.7784
"60 Days"	−0.5038	−1.1109	0.1712	0.9413
"90 Days"	−0.5724	−1.2328	0.1921	1.0601
"120 Days"	−0.6351	−1.3371	0.2084	1.1528
"240 Days"	−0.7657	−1.5724	0.2496	1.3865
"non-comp DL"	−0.0438	0.0487	−0.0474	−0.3005
"comp DL"	−0.0492	0.0701	−0.0611	−0.3877
"LL"	−0.1729	0.2464	−0.2146	−1.3525

Strength Limit State

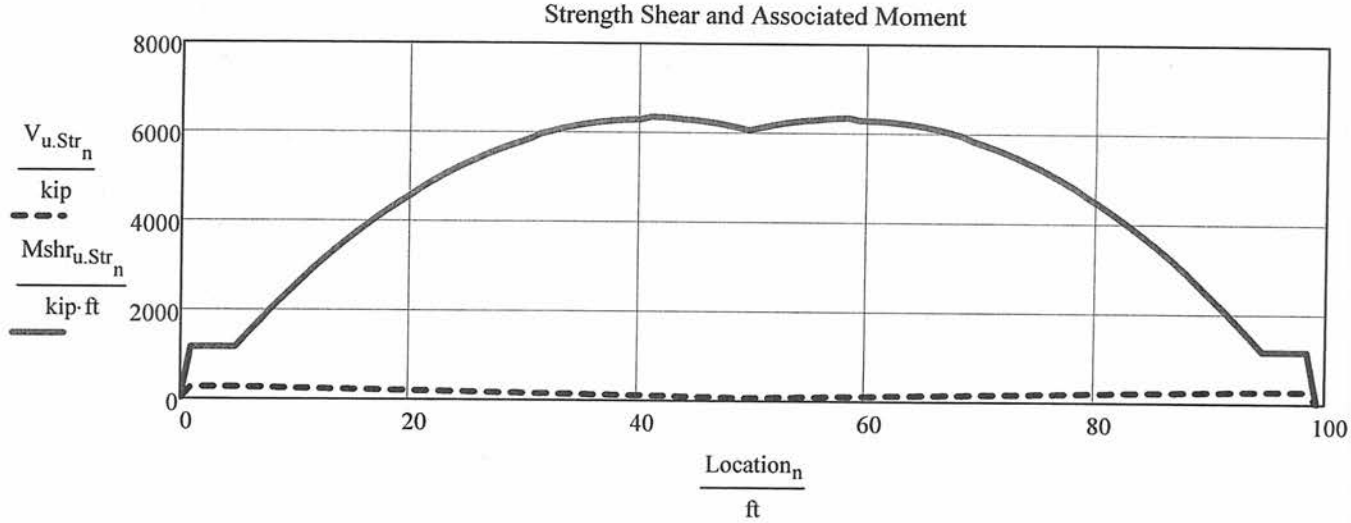


$CR_{Str.mom_n} := 10$ $\qquad CR_{Str.mom_{mn}} := \frac{\phi_{mom}\cdot(Mn_{mn})_0}{Mreqd_{mn}}$ $\qquad$ *(LRFD 5.7.3.3.2)*

$\min(CR_{Str.mom}) = 0.9$

$\max(Mreqd) = 6936.0\cdot kip\cdot ft$

$CheckMomentCapacity := \text{if}(\min(CR_{Str.mom}) > 1, \text{"OK"}, \text{"No Good!"})$ $\qquad CheckMomentCapacity = \text{"No Good!"}$



$\max(V_{u.Str}) = 268.1 \cdot kip$ $\max(Mshr_{u.Str}) = 6355.9 \cdot kip \cdot ft$

Design Shear, Longitudinal, Interface and Anchorage Reinforcement

Stirrup sizes and spacings assigned in input file

Location	*spacing*	*Number of Spaces*	*area per stirrup*
A1 stirrup	6	2	0.4
A2 stirrup	12	2	0.2
A3 stirrup	18	32	0.13
S1 stirrup	18	1	0.13
S2 stirrup	18	1	0.13
S3 stirrup	18	1	0.13
S4 stirrup	18	0	0.13

$tmp\_s = \begin{pmatrix} 6 \\ 12 \\ 18 \\ 18 \\ 18 \\ 18 \\ 18 \end{pmatrix} \cdot in$ $tmp\_NumberSpaces = \begin{pmatrix} 2 \\ 2 \\ 32 \\ 1 \\ 1 \\ 1 \\ 0 \end{pmatrix}$ $tmp\_A_{stirrup} = \begin{pmatrix} 0.4 \\ 0.2 \\ 0.13 \\ 0.13 \\ 0.13 \\ 0.13 \\ 0.13 \end{pmatrix} \cdot in^2$

Locally assigned stirrup sizes and spacings

To change the values from the input file enter the new values into the vectors below. Input only those that you wish to change. Values less than 0 are ignored.

The interface_factor accounts for situations where not all of the shear reinforcing is embedded in the poured in place slab.

	$user\_s_{nspacings} :=$	$user\_NumberSpaces_{nspacings} :=$	$user\_A_{stirrup_{nspacings}} :=$	$interface\_factor_{nspacings} :=$
A1 stirrup	$-1 \cdot in$	-1	$-1 \cdot in^2$	0.25
A2 stirrup	$-1 \cdot in$	-1	$-1 \cdot in^2$	0.5
A3 stirrup	$-1 \cdot in$	-1	$-1 \cdot in^2$	1
S1 stirrup	$-1 \cdot in$	-1	$-1 \cdot in^2$	1
S2 stirrup	$-1 \cdot in$	-1	$-1 \cdot in^2$	1
S3 stirrup	$-1 \cdot in$	-1	$-1 \cdot in^2$	1
S4 stirrup	$-1 \cdot in$	-1	$-1 \cdot in^2$	1

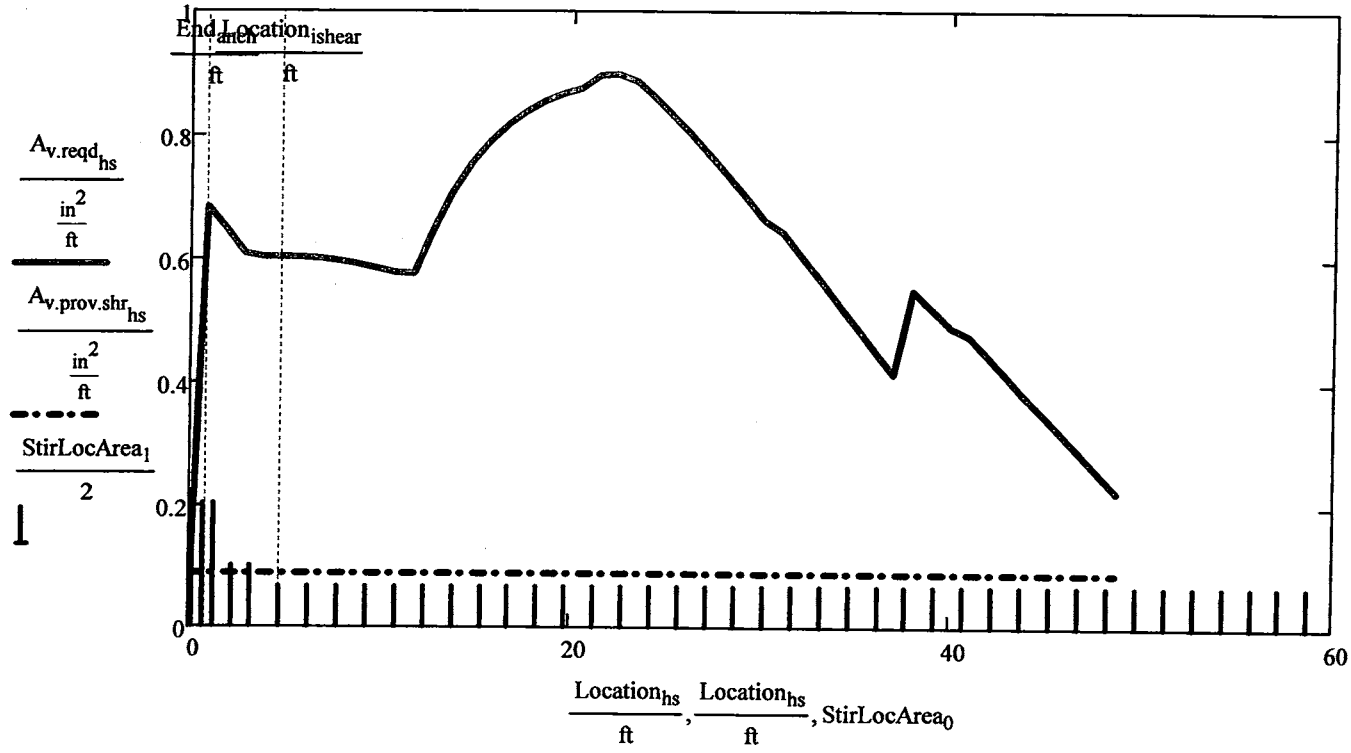
Stirrup sizes and spacings used in analysis

The number of spaces for the S4 stirrup is calculated by the program to complete the half beam length.

A1 stirrup	6	2	0.4
A2 stirrup	12	2	0.2
A3 stirrup	18	32	0.13
S1 stirrup	18	1	0.13
S2 stirrup	18	1	0.13
S3 stirrup	18	1	0.13
S4 stirrup	18	0	0.13
	$s = \begin{pmatrix} 6 \\ 12 \\ 18 \\ 18 \\ 18 \\ 18 \\ 18 \end{pmatrix} \cdot in$	$NumberSpaces = \begin{pmatrix} 2 \\ 2 \\ 32 \\ 1 \\ 1 \\ 1 \\ 0 \end{pmatrix}$	$A_{stirrup} = \begin{pmatrix} 0.4 \\ 0.2 \\ 0.13 \\ 0.13 \\ 0.13 \\ 0.13 \\ 0.13 \end{pmatrix} \cdot in^2$

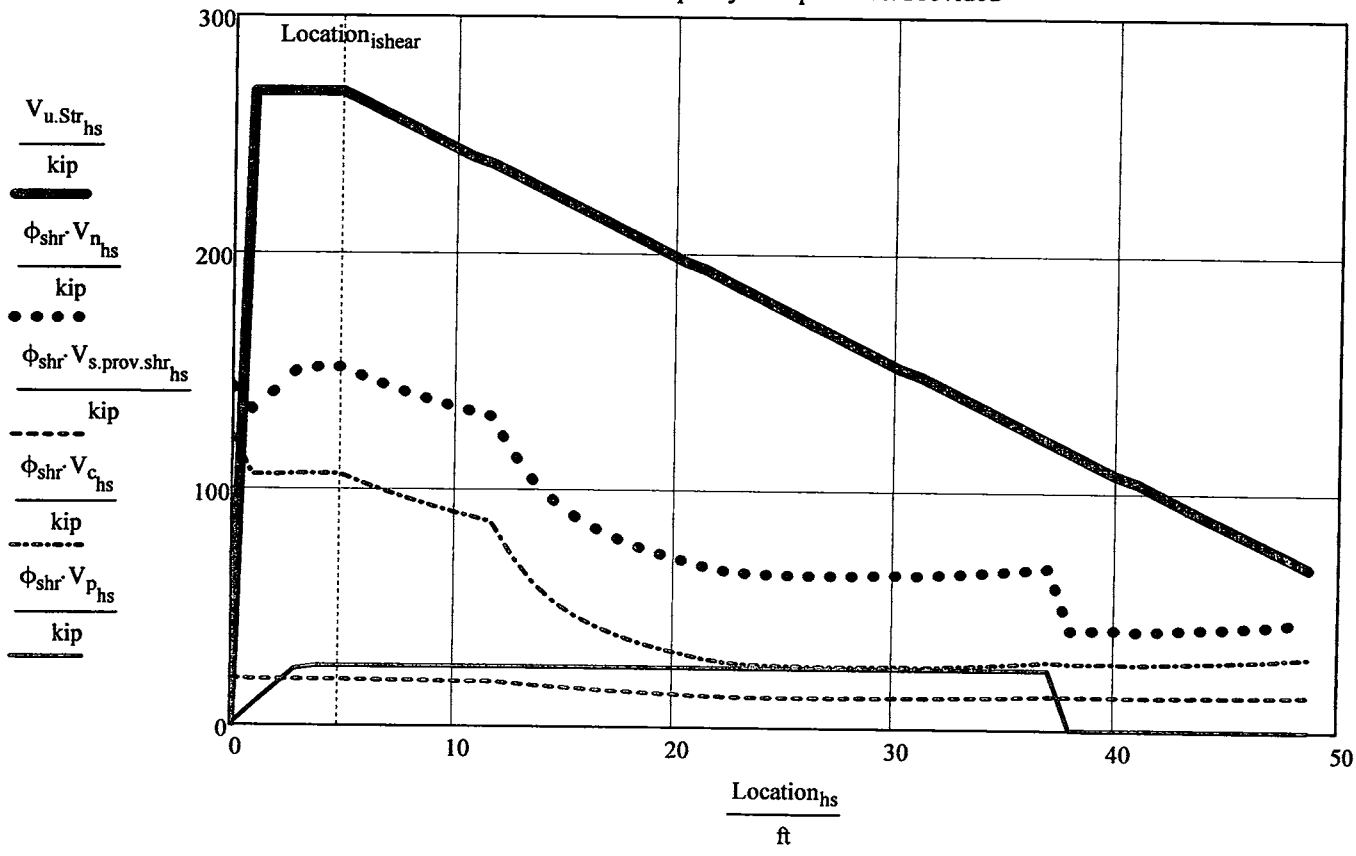
$EndCover = 3 \cdot in$

Shear Steel Required vs. Provided



CheckStirArea := if(min($CR_{StirArea}$) > 1, "OK", "No Good, increase stirrups!")

Shear Capacity - Required vs. Provided

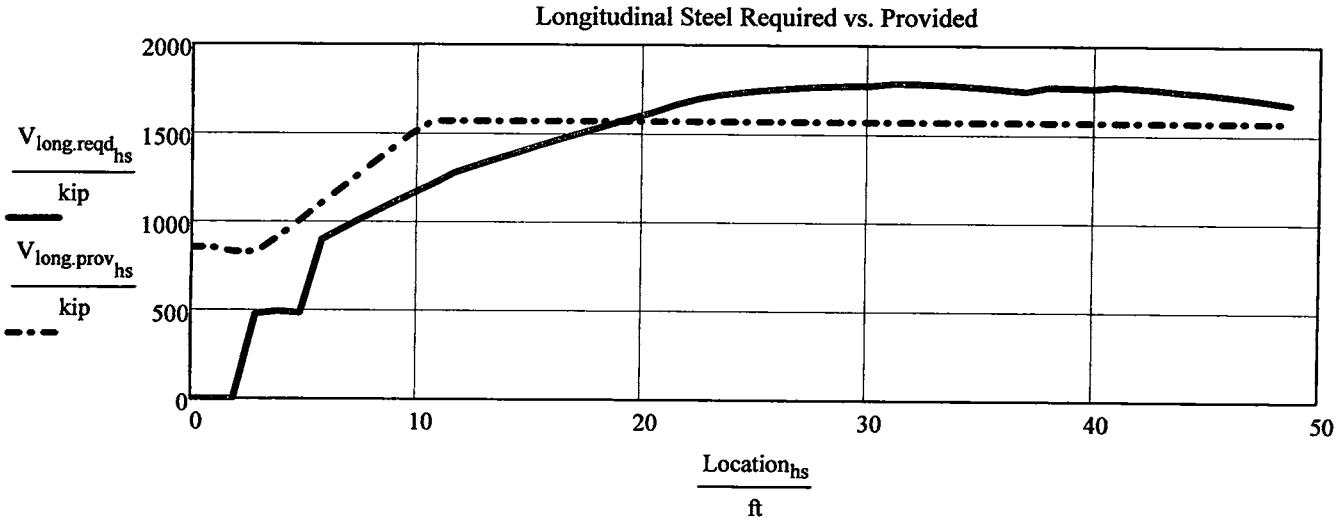


CheckShearCapacity = "No Gooc

$CheckStirArea := if(substr(BeamTypeTog,0,3) = "FLT", "N.A.", CheckStirArea)$ CheckStirArea = "No Good, incr

$CheckMinStirArea := if(substr(BeamTypeTog,0,3) = "FLT", "N.A.", CheckMinStirArea)$ CheckMinStirArea = "No Good,

$CheckMaxStirSpacing := if(substr(BeamTypeTog,0,3) = "FLT", "N.A.", CheckMaxStirSpacing)$ CheckMaxStirSpacing = "No Go

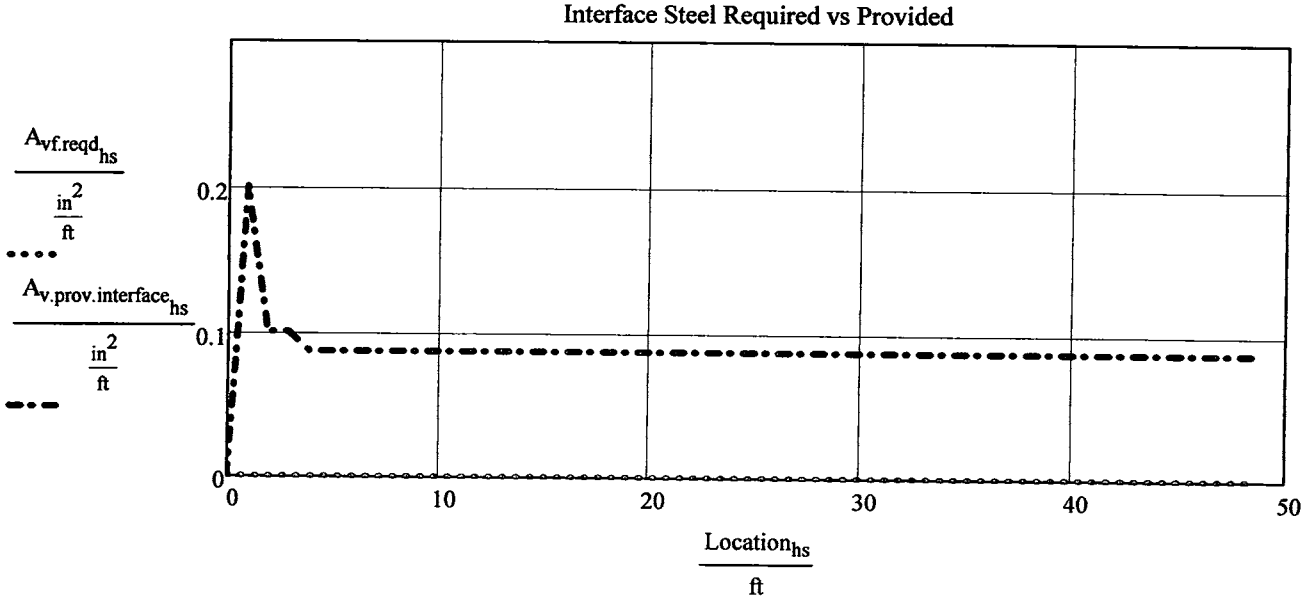


$$CR_{LongSteel_{hs}} := if\left(V_{long.reqd_{hs}} < .01kip, 100, \frac{V_{long.prov_{hs}}}{V_{long.reqd_{hs}}}\right)$$

$min(CR_{LongSteel}) = 0.88$

$CheckLongSteel := if(min(CR_{LongSteel}) > 1, "OK", "No Good, add steel!")$

CheckLongSteel = "No Good, add steel!"



Typically shear steel is extended up into the deck slab.
These calculations are based on shear steel functioning as interface reinforcing.
The interface_factor *can be used to adjust this assumption.*

$\max(A_{vf.min}) = 0 \cdot \frac{in^2}{ft}$ $\max(A_{vf.des}) = 0 \cdot \frac{in^2}{ft}$

If max(Avf.min) or max(Avf.des) is greater than 0 in²/ft, interface steel is required.

CheckInterfaceSpacing = "OK"

$$CheckInterfaceSteel := if\left(\frac{TotalInterfaceSteelProvided}{TotalInterfaceSteelRequired + 0.001 \cdot in^2} \geq 1, "OK", "No Good"\right)$$

CheckInterfaceSteel := if(substr(BeamTypeTog, 0, 3) = "FLT", "N.A.", CheckInterfaceSteel) CheckInterfaceSteel = "OK"

Anchorage Reinforcement and Maximum Prestressing Force

StandardSplittingReinforcing := yes *Was FDOT Design Standard splitting reinforcing used?*

CheckSplittingSteel = "N.A." CheckMaxPrestressingForce = "OK"

Summary of Design Checks

$j := 0..29$

$check_0 := AcceptAASHTO$ $check_1 := AcceptSDG$ $check_2 := AcceptOntario$

$check_3 := Check\_f_{pt}$ $check_4 := Check\_f_{pe}$ $check_5 := Check\_f_{tension.rel}$

$check_6 := Check\_f_{comp.rel}$ $check_7 := Check\_f_{tension.stage8}$ $check_8 := Check\_f_{comp.stage8.c1}$

$check_9 := Check\_f_{comp.stage8.c2}$ $check_{10} := Check\_f_{comp.stage8.c3}$ $check_{11} := CheckMomentCapacity$

$check_{12} := CheckMaxCapacity$ $check_{13} := CheckStirArea$ $check_{14} := CheckShearCapacity$

$check_{15} := CheckMinStirArea$ $check_{16} := CheckMaxStirSpacing$ $check_{17} := CheckLongSteel$

$check_{18} := CheckInterfaceSpacing$ $check_{19} := CheckSplittingSteel$ $check_{20} := CheckMaxPrestressingForce$

$check_{21} := CheckPattern_0$ $check_{22} := CheckPattern_1$ $check_{23} := CheckPattern_2$

$check_{24} := CheckPattern_3$ $check_{25} := CheckPattern_4$ $check_{26} := CheckMaxReinforcement$

$check_{27} := CheckInterfaceSteel$ $check_{28} := CheckStrandFit$ $check_{29} := Check\_SDG_{1.2.Display_2}$

$check^T =$

	0	1	2	3	4
0	"No Good"	"N.A."	"N.A."	"OK"	...

Design Check Note

$TotCheck_j := if\left[\left(check_j = \text{"OK"}\right) + \left(check_j = \text{"N.A."}\right), 0, 1\right]$

TotalCheck := if(max(TotCheck) = 0, "OK", "No Good, one or more checks failed")

TotalCheck = "No Good, one or more checks failed"

LRFR Load Rating Analysis

Structures Manual (SM) Vol-8: FDOT Modifications to LRFR

(SM Vol-8 G.6)

(Load Rating Summary Details for Prestressed Concrete Bridges - Flat Slab and Deck/Girder - Sheet 4)

$LRFR_{loadrating} =$

	Moment (Strength) or Stress (Service)					Shear (Strength)				
	"Limit State"	"DF"	"Rating"	"Tons"	"Dim(ft)"	"DF"	"Rating"	"Tons"	"Dim(ft)"	
	"Strength I(Inv)"	0.78	1.04	"N/A"	48.75	0.67	0.29	"N/A"	21.45	HL-93
	"Strength I(Op)"	0.78	1.35	"N/A"	48.75	0.67	0.38	"N/A"	21.45	HL-93
	"Service III(Inv)"	0.78	0.70	"N/A"	47.77	"N/A"	"N/A"	"N/A"	"N/A"	HL-93
	"Service III(Op)"	0.78	0.78	"N/A"	47.77	"N/A"	"N/A"	"N/A"	"N/A"	HL-93
P204	"Strength II"	0.78	0.85	51.10	44.85	0.67	0.07	4.48	20.47	*Permit
	"Service III"	0.78	0.57	34.07	45.82	"N/A"	"N/A"	"N/A"	"N/A"	*Permit

*note: default permit load is FL-120 per input worksheet

Longitudinal Steel Check:

$CR_{LongSteel.HL93} = 1.02$ $CR_{LongSteel.Permit} = 0.88$ $CheckLongSteel_{loadrating}$ = "no good, add steel"

LRFD English Prestressed Beam Program
Data Input

Project = "Br596E4"
DesignedBy = "BA"
Date = "3/15/11"

DataFile ≡ vec2str(READPRN("PbeamFileName.dat"))

DataFile = "C:\FDOT Structures\Programs\LRFDPBeamV3.21\Beam Data Files\Br596E4S5P204.dat"

Comment = "56 inch Beam"

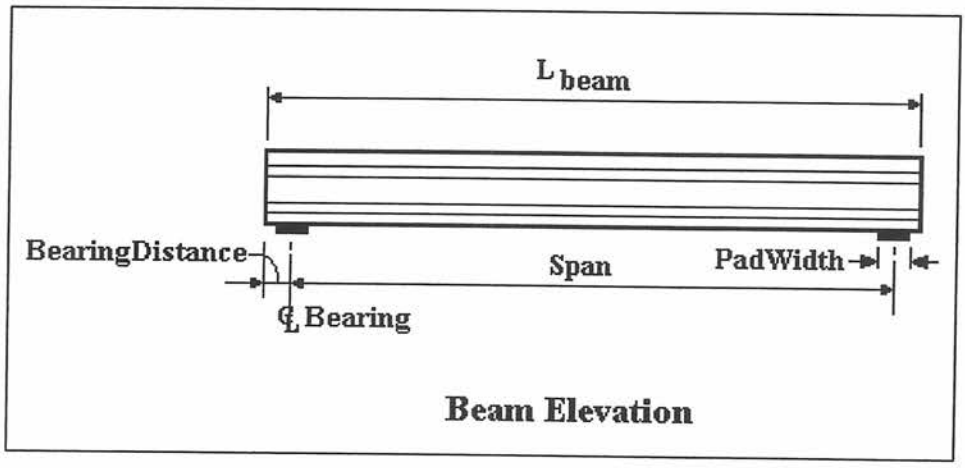
newComment := "56 inch Beam"

Only change the new values. If current data values are OK, leave the double X (XX) *in the* newData *field.*

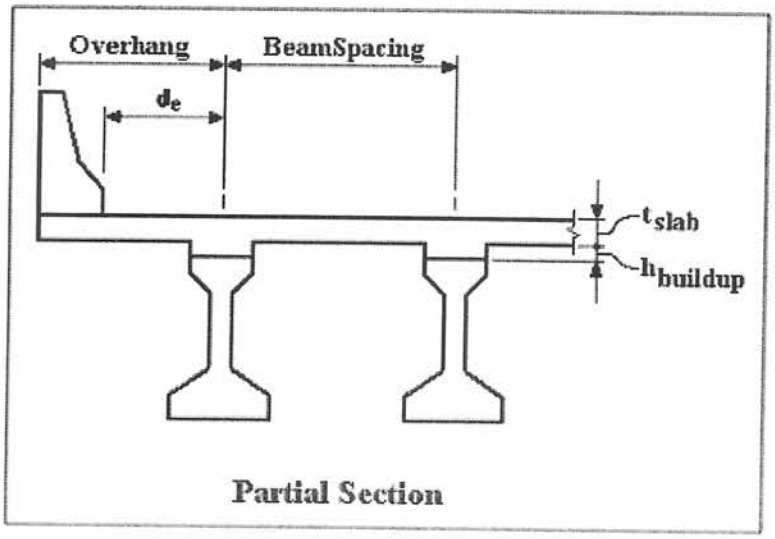
Enter or Change Project Data

newProject := "Br596E4" newDesignedBy := "BA" newDate := "3/15/11"

Plan, Elevation, and Cross Section Data



Note: All dimensions shown in Beam Elevation measured along centerline of beam (requiring adjustment for a skew)



Note: The top of the precast beam is the location of the origin for the coordinate system.

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Echo of Input

		Input New Values
$L_{beam} = 99.33 \cdot ft$	*see Beam Elevation*	$newL_{beam} := 99.33 \cdot ft$
$BearingDistance = 11 \cdot in$	*see Beam Elevation*	$newBearingDistance := 11 \cdot in$
$PadWidth = 12 \cdot in$	*width of the bearing pad - used in the shear calculations - see Beam Elevation*	$newPadWidth := 12 \cdot in$
$BeamSpacing = 5.96 \cdot ft$	*see Partial Section*	$newBeamSpacing := 5.96 \cdot ft$
$Overhang = 2.5 \cdot ft$	*see Partial Section*	$newOverhang := 2.5 \cdot ft$
$t_{slab} = 8 \cdot in$	*see Partial Section, not including integral WS*	$newt_{slab} := XX \cdot in$ 2
$h_{buildup} = 0 \cdot in$	*average buildup, see Partial Section*	$newh_{buildup} := XX \cdot in$
$d_e = 1.5 \cdot ft$	*see Partial Section (3 ft max).* *(LRFD 4.6.2.2.1)*	$newd_e := 1.5 \cdot ft$
BeamPosition = "interior"	*This should be either* "interior" *or* "exterior"	newBeamPosition := XX
BeamType = "Custom"	*These are typically the FDOT designations FIB36, FIB45... FIB84, FIB96*	newBeamType := Custom
	you may also enter "Custom" *and enter the required shape information following Loads. This is for single web sections that are not one of the Florida Standard shapes.*	
$t_{integral.ws} = 2.5 \cdot in$	*wearing surface thickness cast with the deck* *(SDG 4.2.2)*	$newt_{integral.ws} := 2.5 \cdot in$ .5
$Weight_{future.ws} = 0.25 \cdot \frac{kip}{ft^2}$	*future wearing surface* *(SDG Table 2.1)*	$newWeight_{future.ws} := .25 \cdot \frac{kip}{ft^2}$ .05
$Weight_{barrier} = 0.42 \cdot \frac{kip}{ft}$	*weight of single traffic railing barrier (distributed evenly to all beams)* *(SDG 2.8, Table 2.2-1)*	$newWeight_{barrier} := XX \cdot \frac{kip}{ft}$
NumberOfBarriers = 2	*number of traffic railing barriers in cross section (multiplies single barrier weight)*	newNumberOfBarriers := XX
NumberOfBeams = 11	*number of beams in the span cross section* *(LRFD 4.6.2.2.1)*	newNumberOfBeams := 11
SectionType = "transformed"	*transformed* = "transformed" *gross* = "gross" *(w/o elastic gains)*	newSectionType := XX
$Skew = 0 \cdot deg$	*see Plan View*	$newSkew := XX \cdot deg$

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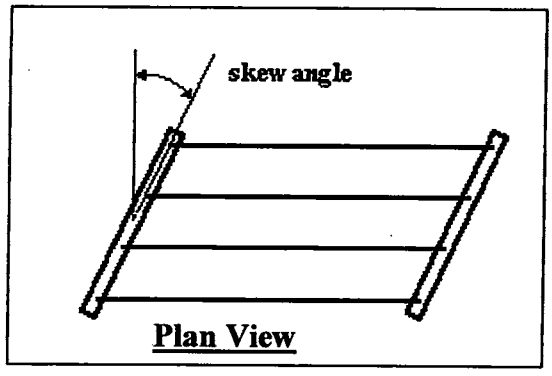
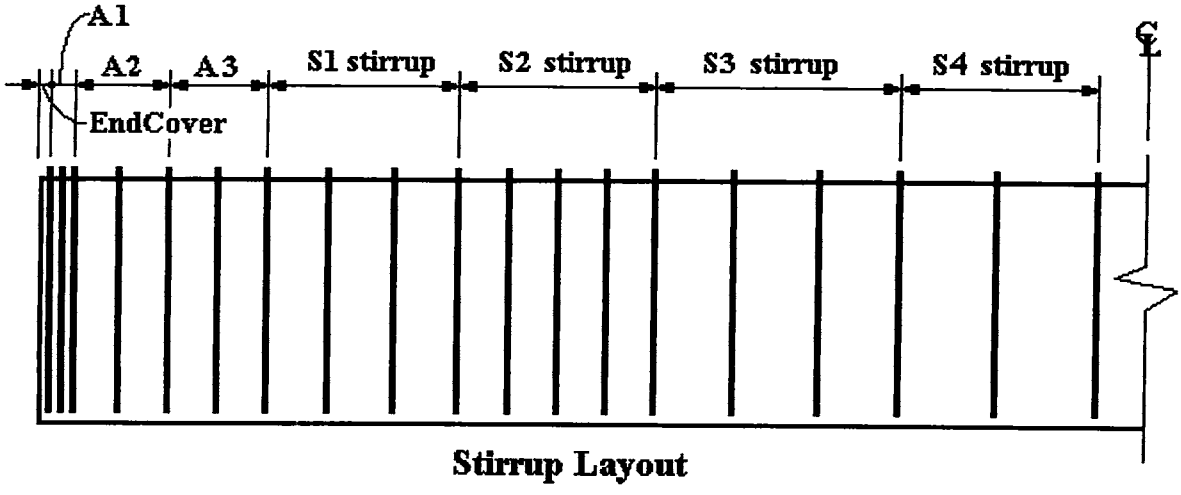


Shear Stirrup Size and Spacing (values are for one half of the beam)



$EndCover = 3 \cdot in$	*see Stirrup Layout*	$newEndCover := 3 \cdot in$
$StirrupSpacing_{A1} = 6 \cdot in$	*see Stirrup Layout*	$newStirrupSpacing_{A1} := 6 \cdot in$
$NumberOfStirrupSpaces_{A1} = 2$	*see Stirrup Layout*	$newNumberOfStirrupSpaces_{A1} := 2$
$StirrupArea_{A1} = 0.4 \cdot in^2$	*see Stirrup Layout*	$newStirrupArea_{A1} := .4 \cdot in^2$
$StirrupSpacing_{A2} = 12 \cdot in$	*see Stirrup Layout*	$newStirrupSpacing_{A2} := 12 \cdot in$
$NumberOfStirrupSpaces_{A2} = 2$	*see Stirrup Layout*	$newNumberOfStirrupSpaces_{A2} := XX$
$StirrupArea_{A2} = 0.2 \cdot in^2$	*see Stirrup Layout*	$newStirrupArea_{A2} := .2 \cdot in^2$
$StirrupSpacing_{A3} = 18 \cdot in$	*see Stirrup Layout*	$newStirrupSpacing_{A3} := 18 \cdot in$
$NumberOfStirrupSpaces_{A3} = 25$	*see Stirrup Layout*	$newNumberOfStirrupSpaces_{A3} := 25$
$StirrupArea_{A3} = 0.13 \cdot in^2$	*see Stirrup Layout*	$newStirrupArea_{A3} := .13 \cdot in^2$

$StirrupSpacing_{S1} = 18 \cdot in$	*see Stirrup Layout*	$newStirrupSpacing_{S1} := 18 \cdot in$
$NumberOfStirrupSpaces_{S1} = 1$	*see Stirrup Layout*	$newNumberOfStirrupSpaces_{S1} := XX$
$StirrupArea_{S1} = 0.13 \cdot in^2$	*see Stirrup Layout*	$newStirrupArea_{S1} := .13 \cdot in^2$
$StirrupSpacing_{S2} = 18 \cdot in$	*see Stirrup Layout*	$newStirrupSpacing_{S2} := 18 \cdot in$
$NumberOfStirrupSpaces_{S2} = 1$	*see Stirrup Layout*	$newNumberOfStirrupSpaces_{S2} := XX$
$StirrupArea_{S2} = 0.13 \cdot in^2$	*see Stirrup Layout*	$newStirrupArea_{S2} := .13 \cdot in^2$
$StirrupSpacing_{S3} = 18 \cdot in$	*see Stirrup Layout*	$newStirrupSpacing_{S3} := 18 \cdot in$
$NumberOfStirrupSpaces_{S3} = 1$	*see Stirrup Layout*	$newNumberOfStirrupSpaces_{S3} := XX$
$StirrupArea_{S3} = 0.13 \cdot in^2$	*see Stirrup Layout*	$newStirrupArea_{S3} := .13 \cdot in^2$
$StirrupSpacing_{S4} = 18 \cdot in$	*see Stirrup Layout*	$newStirrupSpacing_{S4} := 18 \cdot in$
$StirrupArea_{S4} = 0.13 \cdot in^2$	*see Stirrup Layout*	$newStirrupArea_{S4} := .13 \cdot in^2$

(The number of S4 stirrups will be calculated internally to extend the stirrups the full length of the beam)

Permit Truck Axle Loads and Spacings

Default value for the Permit loading is the FL-120 truck

$PermitAxles = 8$	*This is the number of wheel loads that comprise the permit truck(max=11/min=2 for dll). A value must be entered for* newPermitAxles *for changes to* newPermitAxleLoad *or* newPermitAxleSpacing *to register*	$newPermitAxles := 8$ *Warning: Removing default FL-120 axles will change Permit load rating results*
$Permit\_uniform\_LL = 0 \cdot \frac{lbf}{ft}$	*Uniform live load to be considered in conjunction with the Permit Vehicle (per lane)*	$newPermit\_uniform\_LL := XX \cdot \frac{lbf}{ft}$

$$PermitAxleLoad = \begin{pmatrix} 15 \\ 27 \\ 27 \\ 27 \\ 27 \\ 27 \\ 27 \\ 27 \end{pmatrix} \cdot kip$$

The PermitAxleSpacing *vector contains the spacings between the concentrated loads. The first and last values are place holders and should always be zero*

$$PermitAxleSpacing = \begin{pmatrix} 0 \\ 11 \\ 4 \\ 4 \\ 24 \\ 4 \\ 4 \\ 4 \\ -1 \end{pmatrix} \cdot ft$$

Indexes used to identify values in the P and d vectors

$newPermitAxles := if(newPermitAxles = XX, 1, newPermitAxles)$

$q := 0..(newPermitAxles - 1)$ $\quad qt := 0..newPermitAxles$

$newPermitAxleLoad_q :=$

15·kip
27·kip
27·kip
27·kip
27·kip
27·kip
27·kip
27·kip
XX·kip

$newPermitAxleSpacing_{qt} :=$

0·ft
11·ft
4·ft
4·ft
24·ft
4·ft
4·ft
4·ft
XX·ft
0·ft

Material Properties - Concrete

AggregateType = "Standard"	*This should be either* "Florida" *or* "Standard" *depending on the type of course aggregate used.*	newAggregateType := Standard
$f_{c.slab} = 4 \cdot ksi$	*strength of slab concrete*	$newf_{c.slab} := 4 \cdot ksi$
$f_{c.beam} = 5 \cdot ksi$	*strength of beam concrete*	$newf_{c.beam} := 5 \cdot ksi$
$f_{ci.beam} = 4 \cdot ksi$	*release beam strength* *(SDG 4.3.1.D)*	$newf_{ci.beam} := 4 \cdot ksi$
$\gamma_{slab} = 0.15 \cdot \frac{kip}{ft^3}$	*density of slab concrete, used for load calculations*	$new\gamma_{slab} := XX \cdot \frac{kip}{ft^3}$
$\gamma_{beam} = 0.15 \cdot \frac{kip}{ft^3}$	*density of beam concrete, used for load calculations*	$new\gamma_{beam} := XX \cdot \frac{kip}{ft^3}$
Environment = "moderately"	*This should be either* "slightly", "moderately" *or* "extremely"	newEnvironment := XX

Material Properties *- Prestressing Tendons*

$f_{pu} = 200 \cdot ksi$	*tendon ultimate tensile strength, used for stress calcs*	$newf_{pu} := 200 \cdot ksi$
$E_p = 25000 \cdot ksi$	*tendon modulus of elasticity*	$newE_p := 25000 \cdot ksi$

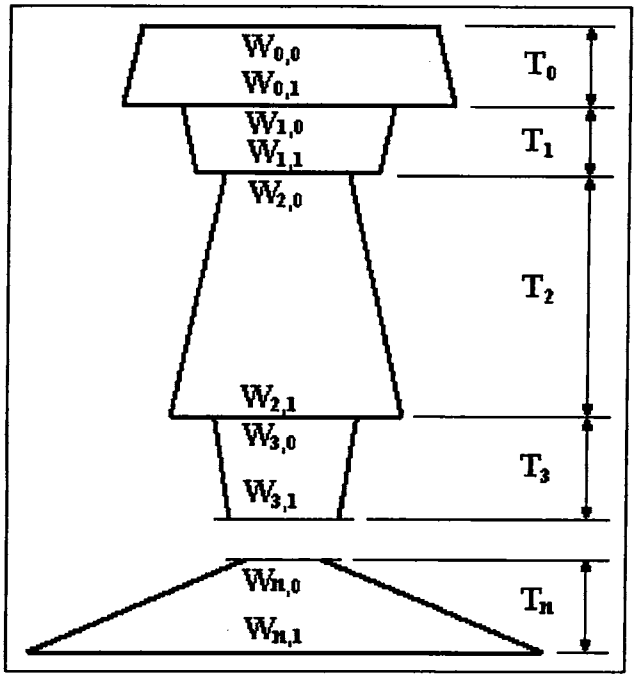
Material Properties - Mild Steel

$f_y = 40 \cdot ksi$	*mild steel yield strength*	$newf_y := 40 \cdot ksi$
$E_s = 29000 \cdot ksi$	*mild steel modulus of elasticity*	$newE_s := XX \cdot ksi$
$H = 70$	*% relative humidity* *(LRFD 5.9.5.4.2)*	$newH := 70$
$t_j = 1.5$	*time in days between jacking and transfer* *(LRFD 5.9.5.4.4b)*	$newt_j := XX$
$A_{slab.rebar} = 0.3 \cdot \frac{in^2}{ft}$	*area of longitudinal slab reinf per unit width of slab, both layers combined*	$newA_{slab.rebar} := .3 \cdot \frac{in^2}{ft}$
$d_{slab.rebar} = 4 \cdot in$	*distance from top of slab to centroid of longitudinal steel*	$newd_{slab.rebar} := XX \cdot in$
$A_{s.long} = 0 \cdot in^2$	*area of longitudinal mild reinforcing in the flexural tension zone of the beam*	$newA_{s.long} := XX \cdot in^2$
$d_{long} = 0 \cdot in$	*absolute distance from top of the beam to the centroid of the longitudinal steel in the flexural tension zone*	$newd_{long} := XX \cdot in$
$BarSize = 4$	*Size of bars used to create* $A_{s.long}$ *needed to calculate development length*	$newBarSize :=$ 4

Loads

Composite and non-composite dead loads are calculated based on the provided data and FDOT standards. In the main program are locations where changes to the non-composite or composite dead loads can be made. These locations are noted as $Add\_w_{noncomp}$ *and* Add_w_{comp} *for non-composite and composite loads respectively. Loads can be added by setting these values equal to positive values and subtracted by setting them equal to a negative value. The program will calculate and apply the HL-93 live load automatically. Additional permit loads must be listed in the permit truck section above.*

Custom Coordinates



$W_{0,0} := 42.0 \cdot in$	$W_{0,1} := 42.0 \cdot in$	$T_0 := 8.0 \cdot in$
$W_{1,0} := 19.0 \cdot in$	$W_{1,1} := 7.0 \cdot in$	$T_1 := 3.0 \cdot in$
$W_{2,0} := 7.0 \cdot in$	$W_{2,1} := 7.0 \cdot in$	$T_2 := 27.0 \cdot in$
$W_{3,0} := 7 \cdot in$	$W_{3,1} := 24 \cdot in$	$T_3 := 8 \cdot in$
$W_{4,0} := 24 \cdot in$	$W_{4,1} := 24 \cdot in$	$T_4 := 10 \cdot in$
$W_{5,0} := 0 \cdot in$	$W_{5,1} := 0 \cdot in$	$T_5 := 0 \cdot in$
$W_{6,0} := 0 \cdot in$	$W_{6,1} := 0 \cdot in$	$T_6 := 0 \cdot in$
$W_{7,0} := 0 \cdot in$	$W_{7,1} := 0 \cdot in$	$T_7 := 0 \cdot in$
$W_{8,0} := 0 \cdot in$	$W_{8,1} := 0 \cdot in$	$T_8 := 0 \cdot in$
$W_{9,0} := 0 \cdot in$	$W_{9,1} := 0 \cdot in$	$T_9 := 0 in$
$W_{10,0} := 0 \cdot in$	$W_{10,1} := 0 \cdot in$	$T_{10} := 0 \cdot in$

Enter the data only for the trapazoids needed to describe your section. The matrix values that follow the ones you require should contain zeros. You can add on additional values if required to describe complex shapes. Values should be entered sequentially from the top of the beam. ***A minimum of 2 sections must be entered***

end of data input

Initialize Values

Project := if(newProject = "XX", **Project**, newProject)

DesignedBy := if(newDesignedBy = "XX", **DesignedBy**, newDesignedBy)

Date := if(newDate = "XX", **Date**, newDate)

Comment := if(newComment = "XX", Comment, newComment)

$L_{beam} := if(newL_{beam} = XX \cdot ft, L_{beam}, newL_{beam})$

BearingDistance := if(newBearingDistance = XX·in, BearingDistance, newBearingDistance)

PadWidth := if(newPadWidth = XX·in, PadWidth, newPadWidth)

$BeamSpacing := if(newBeamSpacing = XX \cdot ft, BeamSpacing, newBeamSpacing)$

$Overhang := if(newOverhang = XX \cdot ft, Overhang, newOverhang)$

$t_{slab} := if(newt_{slab} = XX \cdot in, t_{slab}, newt_{slab})$

$h_{buildup} := if(newh_{buildup} = XX \cdot in, h_{buildup}, newh_{buildup})$

$d_e := if(newd_e = XX \cdot ft, d_e, newd_e)$

$newBeamPosition := if(newBeamPosition = 1, "interior", if(newBeamPosition = 3, XX, "exterior"))$

$BeamPosition := if(newBeamPosition = XX, BeamPosition, newBeamPosition)$

$$newBeamType := \begin{cases} "II" & \text{if } newBeamType = 9 \\ "III" & \text{if } newBeamType = 10 \\ "IV" & \text{if } newBeamType = 11 \\ "V" & \text{if } newBeamType = 12 \\ "VI" & \text{if } newBeamType = 13 \\ "FBT72" & \text{if } newBeamType = 14 \\ "FBT78" & \text{if } newBeamType = 15 \\ "Custom" & \text{if } newBeamType = 16 \\ XX & \text{if } newBeamType = 17 \\ "FIB36" & \text{if } newBeamType = 1 \\ "FIB45" & \text{if } newBeamType = 2 \\ "FIB54" & \text{if } newBeamType = 3 \\ "FIB63" & \text{if } newBeamType = 4 \\ "FIB72" & \text{if } newBeamType = 5 \\ "FIB78" & \text{if } newBeamType = 6 \\ "FIB84" & \text{if } newBeamType = 7 \\ "FIB96" & \text{if } newBeamType = 8 \end{cases}$$

$BeamType := if(newBeamType = XX, BeamType, newBeamType)$

$t_{integral.ws} := if(newt_{integral.ws} = XX \cdot in, t_{integral.ws}, newt_{integral.ws})$

$Weight_{future.ws} := if\left(newWeight_{future.ws} = XX \cdot \frac{kip}{ft^2}, Weight_{future.ws}, newWeight_{future.ws}\right)$

$Weight_{barrier} := if\left(newWeight_{barrier} = XX \cdot \frac{kip}{ft}, Weight_{barrier}, newWeight_{barrier}\right)$

Clc $NumberOfBarriers := if(newNumberOfBarriers = XX, NumberOfBarriers, newNumberOfBarriers)$

$NumberOfBeams := if(newNumberOfBeams = XX, NumberOfBeams, newNumberOfBeams)$

$newSectionType := if(newSectionType = 1, "transformed", if(newSectionType = 3, XX, "gross"))$

$SectionType := if(newSectionType = XX, SectionType, newSectionType)$

$Skew := if(newSkew = XX \cdot deg, Skew, newSkew)$

$EndCover := if(newEndCover = XX \cdot in, EndCover, newEndCover)$

$StirrupSpacing_{A1} := if(newStirrupSpacing_{A1} = XX \cdot in, StirrupSpacing_{A1}, newStirrupSpacing_{A1})$

$NumberOfStirrupSpaces_{A1} := if(newNumberOfStirrupSpaces_{A1} = XX, NumberOfStirrupSpaces_{A1}, newNumberOfStirrupSpaces_{A1})$

$StirrupArea_{A1} := if(newStirrupArea_{A1} = XX \cdot in^2, StirrupArea_{A1}, newStirrupArea_{A1})$

$StirrupSpacing_{A2} := if(newStirrupSpacing_{A2} = XX \cdot in, StirrupSpacing_{A2}, newStirrupSpacing_{A2})$

$NumberOfStirrupSpaces_{A2} := if(newNumberOfStirrupSpaces_{A2} = XX, NumberOfStirrupSpaces_{A2}, newNumberOfStirrupSpaces_{A2})$

$StirrupArea_{A2} := if(newStirrupArea_{A2} = XX \cdot in^2, StirrupArea_{A2}, newStirrupArea_{A2})$

$StirrupSpacing_{A3} := if(newStirrupSpacing_{A3} = XX \cdot in, StirrupSpacing_{A3}, newStirrupSpacing_{A3})$

$NumberOfStirrupSpaces_{A3} := if(newNumberOfStirrupSpaces_{A3} = XX, NumberOfStirrupSpaces_{A3}, newNumberOfStirrupSpaces_{A3})$

$StirrupArea_{A3} := if(newStirrupArea_{A3} = XX \cdot in^2, StirrupArea_{A3}, newStirrupArea_{A3})$

$StirrupSpacing_{S1} := if(newStirrupSpacing_{S1} = XX \cdot in, StirrupSpacing_{S1}, newStirrupSpacing_{S1})$

$NumberOfStirrupSpaces_{S1} := if(newNumberOfStirrupSpaces_{S1} = XX, NumberOfStirrupSpaces_{S1}, newNumberOfStirrupSpaces_{S1})$

$StirrupArea_{S1} := if(newStirrupArea_{S1} = XX \cdot in^2, StirrupArea_{S1}, newStirrupArea_{S1})$

$StirrupSpacing_{S2} := if(newStirrupSpacing_{S2} = XX \cdot in, StirrupSpacing_{S2}, newStirrupSpacing_{S2})$

$NumberOfStirrupSpaces_{S2} := if(newNumberOfStirrupSpaces_{S2} = XX, NumberOfStirrupSpaces_{S2}, newNumberOfStirrupSpaces_{S2})$

$StirrupArea_{S2} := if(newStirrupArea_{S2} = XX \cdot in^2, StirrupArea_{S2}, newStirrupArea_{S2})$

$StirrupSpacing_{S3} := if(newStirrupSpacing_{S3} = XX \cdot in, StirrupSpacing_{S3}, newStirrupSpacing_{S3})$

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Clc $NumberOfStirrupSpaces_{S3} := if(newNumberOfStirrupSpaces_{S3} = XX, NumberOfStirrupSpaces_{S3}, newNumberOfStirrupSpaces_{S3})$ FR

$StirrupArea_{S3} := if(newStirrupArea_{S3} = XX \cdot in^2, StirrupArea_{S3}, newStirrupArea_{S3})$

$StirrupSpacing_{S4} := if(newStirrupSpacing_{S4} = XX \cdot in, StirrupSpacing_{S4}, newStirrupSpacing_{S4})$

$StirrupArea_{S4} := if(newStirrupArea_{S4} = XX \cdot in^2, StirrupArea_{S4}, newStirrupArea_{S4})$

$PermitAxles := if(newPermitAxles = 1, PermitAxles, newPermitAxles)$

$Permit\_uniform\_LL := if\left(newPermit\_uniform\_LL = XX \cdot \frac{lbf}{ft}, Permit\_uniform\_LL, newPermit\_uniform\_LL\right)$

$PermitAxleLoad := if(newPermitAxles = 1, PermitAxleLoad, newPermitAxleLoad)$

$PermitAxleSpacing := if(newPermitAxles = 1, PermitAxleSpacing, newPermitAxleSpacing)$

$newAggregateType := if(newAggregateType = 1, \text{"Florida"}, if(newAggregateType = 3, XX, \text{"Standard"}))$

$AggregateType := if(newAggregateType = XX, AggregateType, newAggregateType)$

$f_{c.slab} := if(newf_{c.slab} = XX \cdot ksi, f_{c.slab}, newf_{c.slab})$

$f_{c.beam} := if(newf_{c.beam} = XX \cdot ksi, f_{c.beam}, newf_{c.beam})$

$f_{ci.beam} := if(newf_{ci.beam} = XX \cdot ksi, f_{ci.beam}, newf_{ci.beam})$

$\gamma_{slab} := if\left(new\gamma_{slab} = XX \cdot \frac{kip}{ft^3}, \gamma_{slab}, new\gamma_{slab}\right)$

$\gamma_{beam} := if\left(new\gamma_{beam} = XX \cdot \frac{kip}{ft^3}, \gamma_{beam}, new\gamma_{beam}\right)$

$$newEnvironment := \begin{cases} \text{"slightly"} & \text{if } newEnvironment = 1 \\ \text{"moderately"} & \text{if } newEnvironment = 2 \\ \text{"extremely"} & \text{if } newEnvironment = 3 \\ XX & \text{if } newEnvironment = 4 \end{cases}$$

$Environment := if(newEnvironment = XX, Environment, newEnvironment)$

$f_{pu} := if(newf_{pu} = XX \cdot ksi, f_{pu}, newf_{pu})$

$E_p := \text{if}(newE_p = XX \cdot ksi, E_p, newE_p)$

$f_y := \text{if}(newf_y = XX \cdot ksi, f_y, newf_y)$

$E_s := \text{if}(newE_s = XX \cdot ksi, E_s, newE_s)$

$H := \text{if}(newH = XX, H, newH)$

$t_j := \text{if}(newt_j = XX, t_j, newt_j)$

$A_{slab.rebar} := \text{if}\left(newA_{slab.rebar} = XX \cdot \frac{in^2}{ft}, A_{slab.rebar}, newA_{slab.rebar}\right)$

$d_{slab.rebar} := \text{if}(newd_{slab.rebar} = XX \cdot in, d_{slab.rebar}, newd_{slab.rebar})$

$A_{s.long} := \text{if}(newA_{s.long} = XX \cdot in^2, A_{s.long}, newA_{s.long})$

$d_{long} := \text{if}(newd_{long} = XX \cdot in, d_{long}, newd_{long})$

$newBarSize := \text{if}(newBarSize = 12, XX, newBarSize)$

$BarSize := \text{if}(newBarSize = XX, BarSize, newBarSize)$

Beam Properties

$Span := L_{beam} - 2 \cdot BearingDistance$ $\qquad Span = 97.4967 \cdot ft$

$C_{BeamCoord}(W,T) :=$

```
k ← 0
widest ← max(W)
last ← rows(W) − 1
for z ∈ 2.. last
  if W_{z,0} ≤ 0
    end ← z − 1
    break
for j ∈ end.. 0
  x_k ← (widest − W_{j,1})·0.5
  x_{k+1} ← (widest − W_{j,0})·0.5
  y_{k+1} ← 0  if (j − 1) < 0
  y_{k+1} ← − Σ_{n=0}^{j−1} T_n  otherwise
  y_k ← − Σ_{n=0}^{j} T_n
  k ← k + 2
for j ∈ 0.. end
  x_k ← (widest − W_{j,0})·0.5 + W_{j,0}
  x_{k+1} ← (widest − W_{j,1})·0.5 + W_{j,1}
  y_k ← 0  if (j − 1) < 0
  y_k ← − Σ_{n=0}^{j−1} T_n  otherwise
  y_{k+1} ← − Σ_{n=0}^{j} T_n
  k ← k + 2
x_k ← x_0
y_k ← y_0
result ← augment(x, y)
result
```

```
C AdjustCoord(coor) := | last ← rows(coor) − 1
                       | bottom ← min(coor)
                       | for k ∈ 0 .. last
                       |   if coor[k,1] = 0
                       |     | itop ← k
                       |     | break
                       | for j ∈ 1 .. last
                       |   | continue  if coor[j,1] = 0
                       |   | continue  if coor[j,1] = bottom
                       |   | continue  if j = 0
                       |   | chk1 ← 1  if coor[j,1] = coor[j−1,1]
                       |   | chk1 ← 0  otherwise
                       |   | chk2 ← 1  if coor[j,0] ≠ coor[j−1,0]
                       |   | chk2 ← 0  otherwise
                       |   | if (chk1 ≥ 1)·(chk2 ≥ 1)
                       |   |   | coor[j,1] ← coor[j,1] + 0.0000001  if j ≤ itop
                       |   |   | coor[(j−1),1] ← coor[(j−1),1] + 0.0000001  otherwise
                       | coor
```

$$\text{FindCoord} := \text{BeamCoord}\left(\frac{W}{in}, \frac{T}{in}\right) \qquad \text{CustomBeamInt} := \text{AdjustCoord}(\text{FindCoord})$$

```
ElimDupl(coord) := | last ← rows(coord) − 1
                   | count ← 1
                   | x[0] ← coord[0,0]
                   | y[0] ← coord[0,1]
                   | for k ∈ 1 .. last
                   |   | x[count] ← coord[k,0]
                   |   | y[count] ← coord[k,1]
                   |   | count ← count + 1  if (|x[count] − x[count−1]|) + (|y[count] − y[count−1]|) ≠ 0
                   | for j ∈ 0 .. count − 1
                   |   | ans[j,0] ← x[j]
                   |   | ans[j,1] ← y[j]
                   | ans
```

$$\text{Custom} := \text{ElimDupl}(\text{CustomBeamInt})\cdot in$$

$$II := \begin{pmatrix} 0 & -36 \\ 0 & -30 \\ 6 & -24 \\ 6 & -9 \\ 3 & -6 \\ 3 & 0 \\ 15 & 0 \\ 15 & -6 \\ 12 & -9 \\ 12 & -24 \\ 18 & -30 \\ 18 & -36 \\ 0 & -36 \end{pmatrix} \cdot in \qquad III := \begin{pmatrix} 0 & -45 \\ 0 & -38 \\ 7.5 & -30.5 \\ 7.5 & -11.5 \\ 3 & -7 \\ 3 & 0 \\ 19 & 0 \\ 19 & -7 \\ 14.5 & -11.5 \\ 14.5 & -30.5 \\ 22 & -38 \\ 22 & -45 \\ 0 & -45 \end{pmatrix} \cdot in \qquad IV := \begin{pmatrix} 0 & -54 \\ 0 & -46 \\ 9 & -37 \\ 9 & -14 \\ 3 & -8 \\ 3 & 0 \\ 23 & 0 \\ 23 & -8 \\ 17 & -14 \\ 17 & -37 \\ 26 & -46 \\ 26 & -54 \\ 0 & -54 \end{pmatrix} \cdot in$$

$$V := \begin{pmatrix} 7 & -63 \\ 7 & -55 \\ 17 & -45 \\ 17 & -12 \\ 13 & -8 \\ 0 & -5 \\ 0 & 0 \\ 42 & 0 \\ 42 & -5 \\ 29 & -8 \\ 25 & -12 \\ 25 & -45 \\ 35 & -55 \\ 35 & -63 \\ 7 & -63 \end{pmatrix} \cdot in \qquad VI := \begin{pmatrix} 7 & -72 \\ 7 & -64 \\ 17 & -54 \\ 17 & -12 \\ 13 & -8 \\ 0 & -5 \\ 0 & 0 \\ 42 & 0 \\ 42 & -5 \\ 29 & -8 \\ 25 & -12 \\ 25 & -54 \\ 35 & -64 \\ 35 & -72 \\ 7 & -72 \end{pmatrix} \cdot in \qquad FBT78 := \begin{pmatrix} 16 & -78 \\ 16 & -70 \\ 26.5 & -60 \\ 26.5 & -10 \\ 23.5 & -7 \\ 0 & -3 \\ 0 & 0 \\ 60 & 0 \\ 60 & -3 \\ 36.5 & -7 \\ 33.5 & -10 \\ 33.5 & -60 \\ 44 & -70 \\ 44 & -78 \\ 16 & -78 \end{pmatrix} \cdot in$$

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$$FBT54 := \begin{pmatrix} 9 & -54 \\ 9 & -46.5 \\ 16.14 & -43.16 \\ 19.50 & -40.20 \\ 20.75 & -35.91 \\ 20.75 & -12.95 \\ 18.98 & -7.93 \\ 14.45 & -5.13 \\ 0 & -2 \\ 0 & 0 \\ 48 & 0 \\ 48 & -2 \\ 33.55 & -5.13 \\ 29.02 & -7.93 \\ 27.25 & -12.95 \\ 27.25 & -35.91 \\ 28.50 & -40.20 \\ 31.86 & -43.16 \\ 39 & -46.5 \\ 39 & -54 \\ 9 & -54 \end{pmatrix} \cdot in$$

$$FBT63 := \begin{pmatrix} 9 & -63 \\ 9 & -55.5 \\ 16.14 & -52.16 \\ 19.50 & -49.20 \\ 20.75 & -44.91 \\ 20.75 & -12.95 \\ 18.98 & -7.93 \\ 14.45 & -5.13 \\ 0 & -2 \\ 0 & 0 \\ 48 & 0 \\ 48 & -2 \\ 33.55 & -5.13 \\ 29.02 & -7.93 \\ 27.25 & -12.95 \\ 27.25 & -44.91 \\ 28.50 & -49.20 \\ 31.86 & -52.16 \\ 39 & -55.5 \\ 39 & -63 \\ 9 & -63 \end{pmatrix} \cdot in$$

$$FBT72 := \begin{pmatrix} 9 & -72 \\ 9 & -64.5 \\ 16.14 & -61.16 \\ 19.87 & -58.44 \\ 20.75 & -53.91 \\ 20.75 & -12.61 \\ 19.44 & -7.08 \\ 14.26 & -4.75 \\ 0 & -2 \\ 0 & 0 \\ 48 & 0 \\ 48 & -2 \\ 33.74 & -4.75 \\ 28.56 & -7.08 \\ 27.25 & -12.61 \\ 27.25 & -53.91 \\ 28.13 & -58.44 \\ 31.86 & -61.16 \\ 39 & -64.5 \\ 39 & -72 \\ 9 & -72 \end{pmatrix} \cdot in$$

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$$FIB36 := \begin{pmatrix} 5.75 & -36 \\ 5 & -35.25 \\ 5 & -29 \\ 12.0334 & -25.5967 \\ 13.8539 & -24.5528 \\ 15.5108 & -23.2650 \\ 16.9718 & -21.7586 \\ 18.2083 & -20.0630 \\ 19.1960 & -18.2115 \\ 19.9157 & -16.2402 \\ 20.3532 & -14.1877 \\ 20.5 & -12.0944 \\ 20.5 & -8.5 \\ 17 & -5 \\ 0 & -3.5 \\ 0 & 0 \\ 48 & 0 \\ 48 & -3.5 \\ 31 & -5 \\ 27.5 & -8.5 \\ 27.5 & -12.0944 \\ 27.6478 & -14.1877 \\ 28.0843 & -16.2402 \\ 28.8040 & -18.2115 \\ 29.7917 & -20.0630 \\ 31.0282 & -21.7586 \\ 32.4892 & -23.2650 \\ 34.1461 & -24.5528 \\ 35.9666 & -25.5967 \\ 43 & -29 \\ 43 & -35.25 \\ 42.25 & -36 \\ 5.75 & -36 \end{pmatrix} \cdot in$$

$$FIB45 := \begin{pmatrix} 5.75 & -45 \\ 5 & -44.25 \\ 5 & -38 \\ 12.0334 & -34.5967 \\ 13.8539 & -33.5528 \\ 15.5108 & -32.2650 \\ 16.9718 & -30.7586 \\ 18.2083 & -29.0630 \\ 19.1960 & -27.2115 \\ 19.9157 & -25.2402 \\ 20.3532 & -23.1877 \\ 20.5 & -21.0944 \\ 20.5 & -8.5 \\ 17 & -5 \\ 0 & -3.5 \\ 0 & 0 \\ 48 & 0 \\ 48 & -3.5 \\ 31 & -5 \\ 27.5 & -8.5 \\ 27.5 & -21.0944 \\ 27.6478 & -23.1877 \\ 28.0843 & -25.2402 \\ 28.8040 & -27.2115 \\ 29.7917 & -29.0630 \\ 31.0282 & -30.7586 \\ 32.4892 & -32.2650 \\ 34.1461 & -33.5528 \\ 35.9666 & -34.5967 \\ 43 & -38 \\ 43 & -44.25 \\ 42.25 & -45 \\ 5.75 & -45 \end{pmatrix} \cdot in$$

$$FIB54 := \begin{pmatrix} 5.75 & -54 \\ 5 & -53.25 \\ 5 & -47 \\ 12.0334 & -43.5967 \\ 13.8539 & -42.5528 \\ 15.5108 & -41.2650 \\ 16.9718 & -39.7586 \\ 18.2083 & -38.0630 \\ 19.1960 & -36.2115 \\ 19.9157 & -34.2402 \\ 20.3532 & -32.1877 \\ 20.5 & -30.0944 \\ 20.5 & -8.5 \\ 17 & -5 \\ 0 & -3.5 \\ 0 & 0 \\ 48 & 0 \\ 48 & -3.5 \\ 31 & -5 \\ 27.5 & -8.5 \\ 27.5 & -30.0944 \\ 27.6478 & -32.1877 \\ 28.0843 & -34.2402 \\ 28.8040 & -36.2115 \\ 29.7917 & -38.0630 \\ 31.0282 & -39.7586 \\ 32.4892 & -41.2650 \\ 34.1461 & -42.5528 \\ 35.9666 & -43.5967 \\ 43 & -47 \\ 43 & -53.25 \\ 42.25 & -54 \\ 5.75 & -54 \end{pmatrix} \cdot in$$

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$$FIB63 := \begin{pmatrix} 5.75 & -63 \\ 5 & -62.25 \\ 5 & -56 \\ 12.0334 & -52.5967 \\ 13.8539 & -51.5528 \\ 15.5108 & -50.2650 \\ 16.9718 & -48.7586 \\ 18.2083 & -47.0630 \\ 19.1960 & -45.2115 \\ 19.9157 & -43.2402 \\ 20.3532 & -41.1877 \\ 20.5 & -39.0944 \\ 20.5 & -8.5 \\ 17 & -5 \\ 0 & -3.5 \\ 0 & 0 \\ 48 & 0 \\ 48 & -3.5 \\ 31 & -5 \\ 27.5 & -8.5 \\ 27.5 & -39.0944 \\ 27.6478 & -41.1877 \\ 28.0843 & -43.2402 \\ 28.8040 & -45.2115 \\ 29.7917 & -47.0630 \\ 31.0282 & -48.7586 \\ 32.4892 & -50.2650 \\ 34.1461 & -51.5528 \\ 35.9666 & -52.5967 \\ 43 & -56 \\ 43 & -62.25 \\ 42.25 & -63 \\ 5.75 & -63 \end{pmatrix} \cdot in$$

$$FIB72 := \begin{pmatrix} 5.75 & -72 \\ 5 & -71.25 \\ 5 & -65 \\ 12.0334 & -61.5967 \\ 13.8539 & -60.5528 \\ 15.5108 & -59.2650 \\ 16.9718 & -57.7586 \\ 18.2083 & -56.0630 \\ 19.1960 & -54.2115 \\ 19.9157 & -52.2402 \\ 20.3532 & -50.1877 \\ 20.5 & -48.0944 \\ 20.5 & -8.5 \\ 17 & -5 \\ 0 & -3.5 \\ 0 & 0 \\ 48 & 0 \\ 48 & -3.5 \\ 31 & -5 \\ 27.5 & -8.5 \\ 27.5 & -48.0944 \\ 27.6478 & -50.1877 \\ 28.0843 & -52.2402 \\ 28.8040 & -54.2115 \\ 29.7917 & -56.0630 \\ 31.0282 & -57.7586 \\ 32.4892 & -59.2650 \\ 34.1461 & -60.5528 \\ 35.9666 & -61.5967 \\ 43 & -65 \\ 43 & -71.25 \\ 42.25 & -72 \\ 5.75 & -72 \end{pmatrix} \cdot in$$

$$FIB78 := \begin{pmatrix} 5.75 & -78 \\ 5 & -77.25 \\ 5 & -71 \\ 12.0334 & -67.5967 \\ 13.8539 & -66.5528 \\ 15.5108 & -65.2650 \\ 16.9718 & -63.7586 \\ 18.2083 & -62.0630 \\ 19.1960 & -60.2115 \\ 19.9157 & -58.2402 \\ 20.3532 & -56.1877 \\ 20.5 & -54.0944 \\ 20.5 & -8.5 \\ 17 & -5 \\ 0 & -3.5 \\ 0 & 0 \\ 48 & 0 \\ 48 & -3.5 \\ 31 & -5 \\ 27.5 & -8.5 \\ 27.5 & -54.0944 \\ 27.6478 & -56.1877 \\ 28.0843 & -58.2402 \\ 28.8040 & -60.2115 \\ 29.7917 & -62.0630 \\ 31.0282 & -63.7586 \\ 32.4892 & -65.2650 \\ 34.1461 & -66.5528 \\ 35.9666 & -67.5967 \\ 43 & -71 \\ 43 & -77.25 \\ 42.25 & -78 \\ 5.75 & -78 \end{pmatrix} \cdot in$$

$$FIB84 := \begin{pmatrix} 5.75 & -84 \\ 5 & -83.25 \\ 5 & -77 \\ 12.0334 & -73.5967 \\ 13.8539 & -72.5528 \\ 15.5108 & -71.2650 \\ 16.9718 & -69.7586 \\ 18.2083 & -68.0630 \\ 19.1960 & -66.2115 \\ 19.9157 & -64.2402 \\ 20.3532 & -62.1877 \\ 20.5 & -60.0944 \\ 20.5 & -8.5 \\ 17 & -5 \\ 0 & -3.5 \\ 0 & 0 \\ 48 & 0 \\ 48 & -3.5 \\ 31 & -5 \\ 27.5 & -8.5 \\ 27.5 & -60.0944 \\ 27.6478 & -62.1877 \\ 28.0843 & -64.2402 \\ 28.8040 & -66.2115 \\ 29.7917 & -68.0630 \\ 31.0282 & -69.7586 \\ 32.4892 & -71.2650 \\ 34.1461 & -72.5528 \\ 35.9666 & -73.5967 \\ 43 & -77 \\ 43 & -83.25 \\ 42.25 & -84 \\ 5.75 & -84 \end{pmatrix} \cdot in$$

$$FIB96 := \begin{pmatrix} 5.75 & -96 \\ 5 & -95.25 \\ 5 & -89 \\ 12.0334 & -85.5967 \\ 13.8539 & -84.5528 \\ 15.5108 & -83.2650 \\ 16.9718 & -81.7586 \\ 18.2083 & -80.0630 \\ 19.1960 & -78.2115 \\ 19.9157 & -76.2402 \\ 20.3532 & -74.1877 \\ 20.5 & -72.0944 \\ 20.5 & -8.5 \\ 17 & -5 \\ 0 & -3.5 \\ 0 & 0 \\ 48 & 0 \\ 48 & -3.5 \\ 31 & -5 \\ 27.5 & -8.5 \\ 27.5 & -72.0944 \\ 27.6478 & -74.1877 \\ 28.0843 & -76.2402 \\ 28.8040 & -78.2115 \\ 29.7917 & -80.0630 \\ 31.0282 & -81.7586 \\ 32.4892 & -83.2650 \\ 34.1461 & -84.5528 \\ 35.9666 & -85.5967 \\ 43 & -89 \\ 43 & -95.25 \\ 42.25 & -96 \\ 5.75 & -96 \end{pmatrix} \cdot in$$

$$FIB120 := \begin{pmatrix} 5.75 & -120 \\ 5 & -119.25 \\ 5 & -113 \\ 12.0334 & -109.5967 \\ 13.8539 & -108.5528 \\ 15.5108 & -107.2650 \\ 16.9718 & -105.7586 \\ 18.2083 & -104.0630 \\ 19.1960 & -102.2115 \\ 19.9157 & -100.2402 \\ 20.3532 & -98.1877 \\ 20.5 & -96.0944 \\ 20.5 & -8.5 \\ 17 & -5 \\ 0 & -3.5 \\ 0 & 0 \\ 48 & 0 \\ 48 & -3.5 \\ 31 & -5 \\ 27.5 & -8.5 \\ 27.5 & -96.0944 \\ 27.6478 & -98.1877 \\ 28.0843 & -100.2402 \\ 28.8040 & -102.2115 \\ 29.7917 & -104.0630 \\ 31.0282 & -105.7586 \\ 32.4892 & -107.2650 \\ 34.1461 & -108.5528 \\ 35.9666 & -109.5967 \\ 43 & -113 \\ 43 & -119.25 \\ 42.25 & -120 \\ 5.75 & -120 \end{pmatrix} \cdot in$$

$C_{BeamTypeTog} := BeamType$

$$BeamType := \begin{cases} FIB36 & \text{if } BeamType = \text{"FIB36"} \\ FIB45 & \text{if } BeamType = \text{"FIB45"} \\ FIB54 & \text{if } BeamType = \text{"FIB54"} \\ FIB63 & \text{if } BeamType = \text{"FIB63"} \\ FIB72 & \text{if } BeamType = \text{"FIB72"} \\ FIB78 & \text{if } BeamType = \text{"FIB78"} \\ FIB84 & \text{if } BeamType = \text{"FIB84"} \\ FIB96 & \text{if } BeamType = \text{"FIB96"} \\ FIB120 & \text{if } BeamType = \text{"FIB120"} \\ II & \text{if } BeamType = \text{"II"} \\ III & \text{if } BeamType = \text{"III"} \\ IV & \text{if } BeamType = \text{"IV"} \\ V & \text{if } BeamType = \text{"V"} \\ VI & \text{if } BeamType = \text{"VI"} \\ FBT72 & \text{if } BeamType = \text{"FBT72"} \\ FBT78 & \text{if } BeamType = \text{"FBT78"} \\ Custom & \text{if } BeamType = \text{"Custom"} \end{cases}$$

```
Shapen(BeamType) := | count ← 0
                    | ylast ← BeamType[0,1]
                    | yset[0] ← BeamType[0,1]
                    | last ← rows(BeamType)
                    | for i ∈ 1..(last − 1)
                    |   | set ← 0
                    |   | for j ∈ 0..(rows(yset) − 1)
                    |   |   set ← 1  if yset[j] = BeamType[i,1]
                    |   | if set = 0
                    |   |   | yset[count] ← BeamType[i,1]
                    |   |   | count ← count + 1
                    | y ← reverse(sort(yset))
                    | for j ∈ 0..(rows(yset) − 1)
                    |   | count ← 0
                    |   | for i ∈ 0..(last − 2)
                    |   |   if BeamType[i,1] = y[j]
                    |   |     | xgrp[j,count] ← BeamType[i,0]
                    |   |     | count ← count + 1
                    | for j ∈ 0..(rows(xgrp) − 1)
                    |   | xtmp ← sort[(xgrp^T)^⟨j⟩]
                    |   | W[j] ← Σ_{q=1}^{rows(xtmp)/2} [xtmp[2·q−1] − xtmp[2·(q−1)]]
                    | T[0] ← 0·in
                    | for j ∈ 0..(rows(y) − 2)
                    |   T[j+1] ← y[j] − y[j+1]
                    | result ← augment(W,T)
                    | result
```

$Shape := Shapen(BeamType)$

$Width_{flange} := Shape_{0,0}$

$Width := Shape^{\langle 0 \rangle}$

$Width_{web} := \min(Width)$

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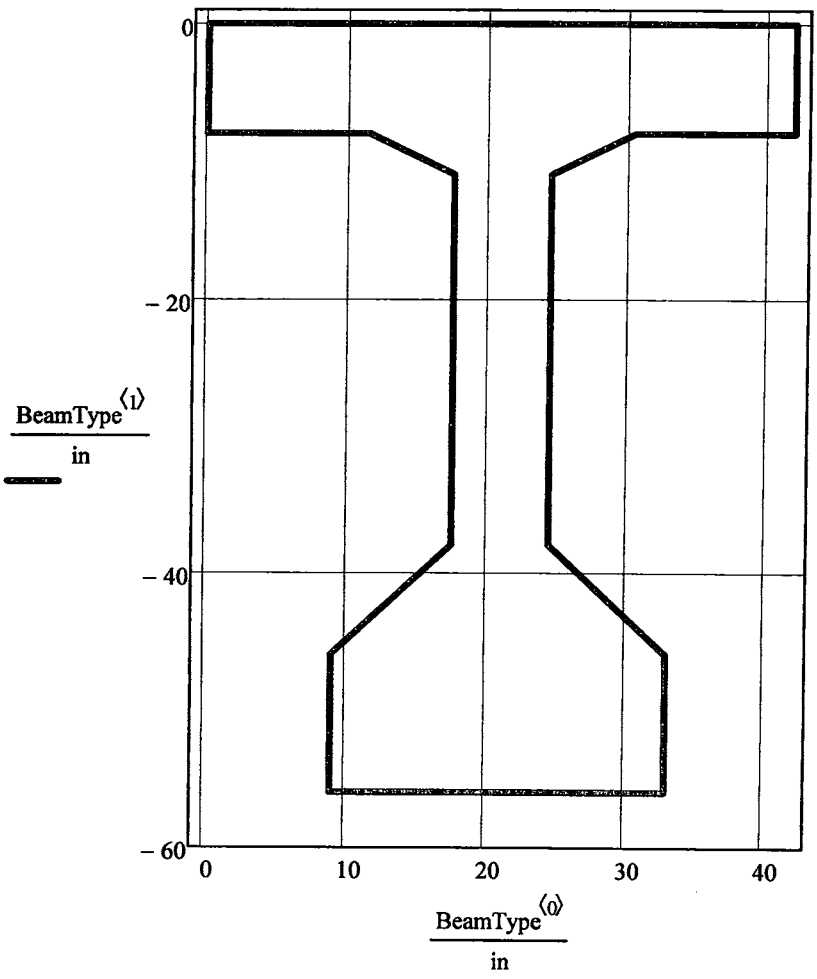
$$b_e := \left| \begin{array}{l} b_{tmp} \leftarrow \text{BeamSpacing} \\ \text{out} \leftarrow \text{Overhang} \\ b_{fin} \leftarrow b_{tmp} \ \text{ if BeamPosition} = \text{"interior"} \\ b_{fin} \leftarrow b_{tmp} \cdot 0.5 + \text{out} \ \text{ if BeamPosition} \neq \text{"interior"} \\ b_{fin} \end{array} \right.$$

$b_e = 5.96 \cdot ft$ *effective slab width* *(LRFD 4.6.2.6)*



$$\text{Prop}(q) := \left| \begin{array}{l} nr \leftarrow \text{rows}(q) \\ s \leftarrow 0 \\ m1 \leftarrow 0 \\ r1 \leftarrow 0 \\ p \leftarrow 0 \\ a \leftarrow 0 \\ yt \leftarrow q_{0,1} \\ yb \leftarrow q_{0,1} \\ \text{for } i \in 0..(nr-2) \\ \quad \left| \begin{array}{l} s \leftarrow \dfrac{q_{i,0}\cdot q_{i+1,1} - q_{i+1,0}\cdot q_{i,1}}{2} \\ m1 \leftarrow m1 + s\cdot\dfrac{q_{i,1} + q_{i+1,1}}{3} \\ r1 \leftarrow r1 + s\cdot\dfrac{(q_{i,1})^2 + (q_{i+1,1})^2 + q_{i,1}\cdot q_{i+1,1}}{6} \\ p \leftarrow \left[(q_{i+1,0} - q_{i,0})^2 + (q_{i+1,1} - q_{i,1})^2\right]^{0.5} + p \\ a \leftarrow a + s \\ yt \leftarrow q_{i+1,1} \text{ if } q_{i+1,1} > yt \\ yb \leftarrow q_{i+1,1} \text{ if } q_{i+1,1} < yb \end{array} \right. \\ \left(\left(-a \quad -m1 \quad |r1| \quad p \quad yt \quad yb \quad \dfrac{m1}{a}\right)\right)^T \end{array} \right.$$

$$\text{Beam} := \text{Prop}\left(\frac{\text{BeamType}}{\text{in}}\right)$$

$$A_{beam} := \text{Beam}_0\cdot\text{in}^2$$

$$A_{beam} = 928\cdot\text{in}^2$$

$$I_{beam} := \left[\text{Beam}_2\cdot\text{in}^4 - \text{Beam}_0\cdot(\text{Beam}_6)^2\cdot\text{in}^4\right]$$

$$I_{beam} = 374505\cdot\text{in}^4$$

$$n_d := \sqrt{\frac{f_{c.beam}}{f_{c.slab}}}$$

Special Dead Loads

$$w_{forms} := \text{if}\left[\text{BeamPosition} = \text{"interior"}, \left[(\text{BeamSpacing} - \text{Width}_{flange})\cdot 0.02\cdot\frac{\text{kip}}{\text{ft}^2}\right], \left[(\text{BeamSpacing}\cdot 0.5) - \frac{\text{Width}_{flange}}{2}\right]\cdot\left(0.02\cdot\frac{\text{kip}}{\text{ft}^2}\right)\right]$$

$$w_{forms} = 0.049\cdot\frac{\text{kip}}{\text{ft}}$$ *(SDG 2.5)*

$$w_{future.ws} := \text{if}\left[\text{BeamPosition} = \text{"interior"}, ((\text{BeamSpacing}\cdot\text{Weight}_{future.ws})), \left[(d_e + \text{BeamSpacing}\cdot 0.5)\cdot\text{Weight}_{future.ws}\right]\right]$$

C

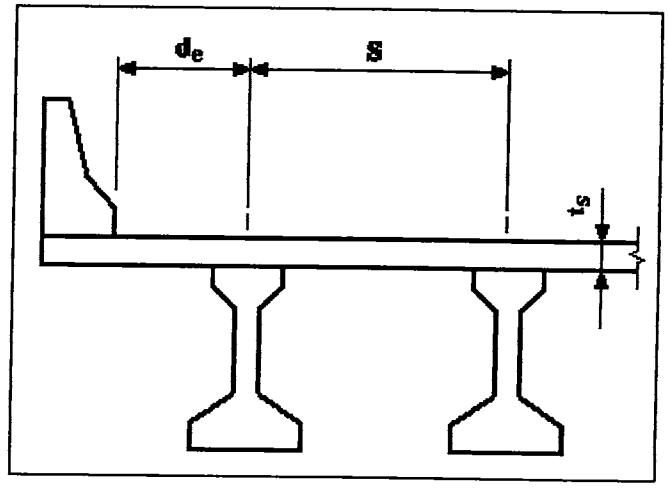
$w_{future.ws} = 1.49 \cdot \frac{kip}{ft}$, P.C.

$Weight_{barrier} = 0.42 \cdot \frac{kip}{ft}$ NumberOfBarriers = 2 NumberOfBeams = 11

$$w_{barrier} := \frac{(Weight_{barrier})(NumberOfBarriers)}{NumberOfBeams}$$

$w_{barrier} = 0.0764 \cdot \frac{kip}{ft}$ *(SDG 2.8)*

Live Load Distribution Factors



$$e_g := \frac{b_e \cdot t_{slab} \cdot \left(\frac{t_{slab}}{2} + h_{buildup}\right) + \frac{h_{buildup}^2}{2} \cdot Width_{flange}}{b_e \cdot t_{slab} + h_{buildup} \cdot Width_{flange}} - Beam_6 \cdot in$$

(LRFD 4.6.2.2.1-1)

$S := BeamSpacing$ $t_s := t_{slab}$ $L_s := Span$

$K_g := n_d \cdot \left(I_{beam} + A_{beam} \cdot e_g^2\right)$ $K_g = 1.3356 \times 10^6 \cdot in^4$

Check acceptability of AASHTO distribution factors for interior beam moments *LRFD Table 4.6.2.2.2b-1*

$$Accept_{InteriorM} := if\left[(S \le 16 \cdot ft) \cdot (S \ge 3.5 \cdot ft) \cdot (t_s \ge 4.4 \cdot in) \cdot (t_s \le 12.1 \cdot in) \cdot (L_s \ge 20 \cdot ft) \cdot (L_s \le 240 \cdot ft), "OK", "No Good"\right]$$

$$Accept_{InteriorM} := if\left[(Accept_{InteriorM} = "OK") \cdot (NumberOfBeams \ge 4) \cdot (K_g \ge 10000 \cdot in^4) \cdot (K_g \le 7000000 \cdot in^4), "OK", "No Good"\right]$$

$Accept_{InteriorM} = "OK"$

distribution factors for interior beam moments

$$g_{interior.onelane.mom} := 0.06 + \left(\frac{S}{14 \cdot ft}\right)^{0.4} \cdot \left(\frac{S}{L_s}\right)^{0.3} \cdot \left(\frac{K_g}{L_s \cdot t_s^3}\right)^{0.1}$$

$g_{interior.onelane.mom} = 0.3929$

$$g_{interior.multilane.mom} := 0.075 + \left(\frac{S}{9.5 \cdot ft}\right)^{0.6} \cdot \left(\frac{S}{L_s}\right)^{0.2} \cdot \left(\frac{K_g}{L_s \cdot t_s^3}\right)^{0.1}$$

$g_{interior.multilane.mom} = 0.5434$

$C\ g_{interior.mom} := \max(g_{interior.onelane.mom}, g_{interior.multilane.mom})$ Br. 596 $g_{interior.mom} = 0.5434$ Span 5, P204 LRFR

Check acceptability of AASHTO distribution factors for exterior beam moments *LRFD Table 4.6.2.2.2d-1*

$Accept_{ExteriorM} := \text{if}\left[\left(Accept_{InteriorM} = \text{"OK"}\right)\cdot\left(d_e \le 5.5\cdot ft\right)\cdot\left(d_e \ge -1\cdot ft\right), \text{"OK"}, \text{"No Good"}\right]$

$Accept_{ExteriorM} = \text{"OK"}$

distribution factors for exterior beam moments

$g_{exterior.onelane.mom} := \left[\text{if}\left[(2\cdot ft + 6\cdot ft) < (d_e + S), \frac{2\cdot(S + d_e) - 10\cdot ft}{2\cdot S}, \frac{S + d_e - 2\cdot ft}{2\cdot S}\right]\right]\cdot 1.2$ *uses lever rule*

$g_{exterior.onelane.mom} = 0.5497$

$g_{exterior.multilane.mom} := g_{interior.multilane.mom}\cdot\left(0.77 + \frac{d_e}{9.1\cdot ft}\right)$ $g_{exterior.multilane.mom} = 0.508$

$g_{exterior.mom} := \max(g_{exterior.onelane.mom}, g_{exterior.multilane.mom})$ $g_{exterior.mom} = 0.5497$

Check acceptability of AASHTO distribution factors for interior beam shears *LRFD Table 4.6.2.2.3a-1*

$Accept_{InteriorV} := \text{if}\left(Accept_{InteriorM} = \text{"OK"}, \text{"OK"}, \text{"No Good"}\right)$

$Accept_{InteriorV} = \text{"OK"}$

distribution factors for interior beam shears

$g_{interior.onelane.shear} := 0.36 + \frac{S}{25\cdot ft}$ $g_{interior.onelane.shear} = 0.5984$

$g_{interior.multilane.shear} := 0.2 + \frac{S}{12\cdot ft} - \left(\frac{S}{35\cdot ft}\right)^2$ $g_{interior.multilane.shear} = 0.6677$

$g_{interior.shear} := \max(g_{interior.onelane.shear}, g_{interior.multilane.shear})$ $g_{interior.shear} = 0.6677$

Check acceptability of AASHTO distribution factors for exterior beam shears *LRFD Table 4.6.2.2.3b-1*

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$Accept_{ExteriorV} := if\left[\left(d_e \le 5.5\cdot ft\right)\cdot\left(d_e \ge -1\cdot ft\right), "OK", "No\ Good"\right]$

$Accept_{ExteriorV} = "OK"$

distribution factor for exterior beam shears

$g_{exterior.onelane.shear} := g_{exterior.onelane.mom}$ $\quad g_{exterior.onelane.shear} = 0.5497$

$g_{exterior.multilane.shear} := \left(0.6 + \frac{d_e}{10\cdot ft}\right)\cdot g_{interior.multilane.shear}$ $\quad g_{exterior.multilane.shear} = 0.5008$

$g_{exterior.shear} := \max\left(g_{exterior.onelane.shear}, g_{exterior.multilane.shear}\right)$ $\quad g_{exterior.shear} = 0.5497$

BeamPosition = "interior"

$g_{interior.mom} = 0.5434$ $\quad g_{exterior.mom} = 0.5497$

$g_{interior.shear} = 0.6677$ $\quad g_{exterior.shear} = 0.5497$

$g_{mom} := if\left(BeamPosition = "interior", g_{interior.mom}, g_{exterior.mom}\right)$ $\quad g_{mom} = 0.5434$

$g_{shear} := if\left(BeamPosition = "interior", g_{interior.shear}, g_{exterior.shear}\right)$ $\quad g_{shear} = 0.6677$

$Accept_{mom} := if\left(BeamPosition = "interior", Accept_{InteriorM}, Accept_{ExteriorM}\right)$ $\quad Accept_{mom} = "OK"$

$Accept_{shear} := if\left(BeamPosition = "interior", Accept_{InteriorV}, Accept_{ExteriorV}\right)$ $\quad Accept_{shear} = "OK"$

$AcceptAASHTO := if\left[\left(Accept_{mom} = "OK"\right)\cdot\left(Accept_{shear} = "OK"\right), "OK", "No\ Good"\right]$ $\quad AcceptAASHTO = "OK"$

skew modification to distribution factor for beam moments

LRFD Table 4.6.2.2.2e-1

$Skew := if(Skew > 60\cdot deg, 60\cdot deg, Skew)$

$$c_1 := if\left[Skew < 30\cdot deg, 0, \left[0.25\cdot\left[\left(\frac{K_g}{L_s\cdot t_s^3}\right)^{0.25}\right]\cdot\left(\frac{S}{L_s}\right)^{0.5}\right]\right]$$ $\quad c_1 = 0$

$ReductionFactor := 1 - c_1\cdot\tan(Skew)^{1.5}$ $\quad ReductionFactor = 1$

skew modified moment distribution factor

$g_{mom} := g_{mom}\cdot ReductionFactor$ $\quad g_{mom} = 0.5434$

skew modification to distribution factor for beam shears *LRFD Table 4.6.2.2.3c-1*

$$CorrectionFactor := 1 + 0.2 \cdot \left(\frac{L_s \cdot t_s^3}{K_g} \right)^{0.3} \cdot \tan(Skew)$$

$CorrectionFactor = 1$

skew modified shear distribution factor

$g_{shear} := g_{shear} \cdot CorrectionFactor$

$g_{shear} = 0.6677$

DataMessage := "This is a Single Web Beam Design, "

AddedMessage := if(AcceptAASHTO = "OK" , " AASHTO distribution factors used" , " AASHTO distribution factor criteria not met"

DataMessage := concat(DataMessage, AddedMessage)

DataMessage = "This is a Single Web Beam Design, AASHTO distribution factors used"

Write Out Data Values to New File

$dataOut_0 := 0$

$dataOut_1 := str2vec(\mathbf{Project})$ $dataOut_2 := str2vec(\mathbf{DesignedBy})$ $dataOut_3 := str2vec(\mathbf{Date})$

$dataOut_4 := str2vec(Comment)$

$dataOut_5 := \frac{L_{beam}}{ft}$ $dataOut_6 := \frac{BearingDistance}{in}$

$Depth_{flg} := 0$ $dataOut_7 := Depth_{flg}$

$dataOut_8 := \frac{PadWidth}{in}$

$dataOut_9 := \frac{BeamSpacing}{ft}$

$dataOut_{10} := \frac{Overhang}{ft}$

$dataOut_{11} := \frac{t_{slab}}{in}$

$dataOut_{12} := \frac{h_{buildup}}{in}$

$dataOut_{13} := \frac{d_e}{ft}$

$dataOut_{14} := BeamPosition$

$t_{slab.delta} := 0$

$dataOut_{15} := t_{slab.delta}$

$dataOut_{16} := BeamTypeTog$

$dataOut_{17} := \frac{t_{integral.ws}}{in}$

$dataOut_{18} := \frac{Weight_{future.ws} \cdot ft^2}{kip}$

$dataOut_{19} := NumberOfBeams$

$dataOut_{20} := SectionType$

$dataOut_{21} := \frac{Skew}{deg}$

$dataOut_{22} := \frac{EndCover}{in}$

$dataOut_{23} := \frac{StirrupSpacing_{A1}}{in}$ $dataOut_{24} := NumberOfStirrupSpaces_{A1}$ $dataOut_{25} := \frac{StirrupArea_{A1}}{in^2}$

$dataOut_{26} := \frac{StirrupSpacing_{A2}}{in}$ $dataOut_{27} := NumberOfStirrupSpaces_{A2}$ $dataOut_{28} := \frac{StirrupArea_{A2}}{in^2}$

$dataOut_{29} := \frac{StirrupSpacing_{A3}}{in}$ $dataOut_{30} := NumberOfStirrupSpaces_{A3}$ $dataOut_{31} := \frac{StirrupArea_{A3}}{in^2}$

$dataOut_{32} := \frac{StirrupSpacing_{S1}}{in}$ $dataOut_{33} := NumberOfStirrupSpaces_{S1}$ $dataOut_{34} := \frac{StirrupArea_{S1}}{in^2}$

$dataOut_{35} := \frac{StirrupSpacing_{S2}}{in}$ $dataOut_{36} := NumberOfStirrupSpaces_{S2}$ $dataOut_{37} := \frac{StirrupArea_{S2}}{in^2}$

$dataOut_{38} := \frac{StirrupSpacing_{S3}}{in}$ $dataOut_{39} := NumberOfStirrupSpaces_{S3}$ $dataOut_{40} := \frac{StirrupArea_{S3}}{in^2}$

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$dataOut_{41} := \frac{StirrupSpacing_{S4}}{in}$

$dataOut_{42} := \frac{StirrupArea_{S4}}{in^2}$

$dataOut_{46} := PermitAxles$

$dataOut_{48} := \frac{Permit\_uniform\_LL}{\frac{lbf}{ft}}$

$dataOut_{49} := \frac{PermitAxleLoad}{kip}$

$dataOut_{50} := \frac{PermitAxleSpacing}{ft}$

$dataOut_{51} := AggregateType$

$dataOut_{52} := \frac{f_{c.slab}}{ksi}$

$dataOut_{53} := \frac{f_{c.beam}}{ksi}$

$dataOut_{54} := \frac{f_{ci.beam}}{ksi}$

$dataOut_{55} := \frac{\gamma_{slab} \cdot ft^3}{kip}$

$dataOut_{56} := \frac{\gamma_{beam} \cdot ft^3}{kip}$

$dataOut_{57} := Environment$

$dataOut_{58} := 0$

$dataOut_{59} := 0$

$dataOut_{60} := 0$

$dataOut_{61} := \frac{f_{pu}}{ksi}$

$dataOut_{62} := \frac{E_p}{ksi}$

$dataOut_{63} := \frac{f_y}{ksi}$

$dataOut_{64} := \frac{E_s}{ksi}$

$dataOut_{65} := H$

$dataOut_{66} := t_j$

$dataOut_{67} := \frac{A_{slab.rebar} \cdot ft}{in^2}$

$dataOut_{68} := \frac{d_{slab.rebar}}{in}$

$dataOut_{69} := \frac{A_{s.long}}{in^2}$

$dataOut_{70} := \frac{d_{long}}{in}$

$dataOut_{71} := BarSize$

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$dataOut_{72} := Weight_{barrier} \cdot \frac{ft}{kip}$ $dataOut_{73} := NumberOfBarriers$ $dataOut_{74} := 0$

$dataOut_{75} := \frac{Span}{ft}$ $dataOut_{76} := \frac{b_e}{ft}$

$dataOut_{77} := w_{forms} \cdot \frac{ft}{kip}$ $dataOut_{78} := w_{future.ws} \cdot \frac{ft}{kip}$ $dataOut_{79} := w_{barrier} \cdot \frac{ft}{kip}$

$dataOut_{80} := 0$

$dataOut_{81} := g_{mom}$ $dataOut_{82} := g_{shear}$

$dataOut_{83} := str2vec(AcceptAASHTO)$ $dataOut_{84} := str2vec("N.A.")$

$dataOut_{85} := str2vec("N.A.")$ $dataOut_{86} := str2vec(DataMessage)$

$dataOut_{91} := str2vec(DataFile)$

$PRNPRECISION := 6$

Write and read project data files from the PSBeam Program root directory or full path

DataFile = "C:\FDOT Structures\Programs\LRFDPBeamV3.21\Beam Data Files\Br596E4S5P204.dat"

$WRITEPRN(DataFile) := dataOut$

$WRITEPRN("psbeam.inp") := dataOut$

$WRITEPRN("BeamCoord.dat") := \frac{BeamType}{in}$

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Read In Data Values from Existing File

$dataIn \equiv READPRN(DataFile)$

Project $\equiv vec2str(dataIn_1)$ **DesignedBy** $\equiv vec2str(dataIn_2)$ **Date** $\equiv vec2str(dataIn_3)$

$Comment \equiv vec2str(dataIn_4)$

$L_{beam} \equiv dataIn_5 \cdot ft$

$BearingDistance \equiv dataIn_6 \cdot in$

$PadWidth \equiv dataIn_8 \cdot in$

$BeamSpacing \equiv dataIn_9 \cdot ft$

$Overhang \equiv dataIn_{10} \cdot ft$

$t_{slab} \equiv dataIn_{11} \cdot in$

$h_{buildup} \equiv dataIn_{12} \cdot in$

$d_e \equiv dataIn_{13} \cdot ft$

$BeamPosition \equiv dataIn_{14}$

$BeamType \equiv dataIn_{16}$

$t_{integral.ws} \equiv dataIn_{17} \cdot in$

$Weight_{future.ws} \equiv dataIn_{18} \cdot \frac{kip}{ft^2}$

$NumberOfBeams \equiv dataIn_{19}$

$SectionType \equiv dataIn_{20}$

$Skew \equiv dataIn_{21} \cdot deg$

$EndCover \equiv dataIn_{22} \cdot in$

$StirrupSpacing_{A1} \equiv dataIn_{23} \cdot in$ $NumberOfStirrupSpaces_{A1} \equiv dataIn_{24}$ $StirrupArea_{A1} \equiv dataIn_{25} \cdot in^2$

$StirrupSpacing_{A2} \equiv dataIn_{26} \cdot in$ $NumberOfStirrupSpaces_{A2} \equiv dataIn_{27}$ $StirrupArea_{A2} \equiv dataIn_{28} \cdot in^2$

$StirrupSpacing_{A3} \equiv dataIn_{29} \cdot in$ $NumberOfStirrupSpaces_{A3} \equiv dataIn_{30}$ $StirrupArea_{A3} \equiv dataIn_{31} \cdot in^2$

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$StirrupSpacing_{S1} \equiv dataIn_{32} \cdot in$ $NumberOfStirrupSpaces_{S1} \equiv dataIn_{33}$ $StirrupArea_{S1} \equiv dataIn_{34} \cdot in^2$

$StirrupSpacing_{S2} \equiv dataIn_{35} \cdot in$ $NumberOfStirrupSpaces_{S2} \equiv dataIn_{36}$ $StirrupArea_{S2} \equiv dataIn_{37} \cdot in^2$

$StirrupSpacing_{S3} \equiv dataIn_{38} \cdot in$ $NumberOfStirrupSpaces_{S3} \equiv dataIn_{39}$ $StirrupArea_{S3} \equiv dataIn_{40} \cdot in^2$

$StirrupSpacing_{S4} \equiv dataIn_{41} \cdot in$ $StirrupArea_{S4} \equiv dataIn_{42} \cdot in^2$

$PermitAxles \equiv dataIn_{46}$

$Permit\_uniform\_LL \equiv dataIn_{48} \cdot \frac{lbf}{ft}$

$PermitAxleLoad \equiv dataIn_{49} \cdot kip$

$PermitAxleSpacing \equiv dataIn_{50} \cdot ft$

$AggregateType \equiv dataIn_{51}$

$f_{c.slab} \equiv dataIn_{52} \cdot ksi$ $f_{c.beam} \equiv dataIn_{53} \cdot ksi$ $f_{ci.beam} \equiv dataIn_{54} \cdot ksi$

$\gamma_{slab} \equiv dataIn_{55} \cdot \frac{kip}{ft^3}$ $\gamma_{beam} \equiv dataIn_{56} \cdot \frac{kip}{ft^3}$

$Environment \equiv dataIn_{57}$

$f_{pu} \equiv dataIn_{61} \cdot ksi$ $E_p \equiv dataIn_{62} \cdot ksi$

$f_y \equiv dataIn_{63} \cdot ksi$ $E_s \equiv dataIn_{64} \cdot ksi$

$H \equiv dataIn_{65}$ $t_j \equiv dataIn_{66}$

$A_{slab.rebar} \equiv dataIn_{67} \cdot \frac{in^2}{ft}$ $d_{slab.rebar} \equiv dataIn_{68} \cdot in$

$A_{s.long} \equiv dataIn_{69} \cdot in^2$ $d_{long} \equiv dataIn_{70} \cdot in$

$BarSize \equiv dataIn_{71}$ $Weight_{barrier} \equiv dataIn_{72} \cdot \frac{kip}{ft}$

$NumberOfBarriers \equiv dataIn_{73}$

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Constants - Do Not Alter

exterior ≡ "exterior" Florida ≡ "Florida" florida ≡ "Florida" slightly ≡ "slightly" XX ≡ −1

interior ≡ "interior" Standard ≡ "Standard" extremely ≡ "extremely" moderately ≡ "moderately" xx ≡ −1

transformed ≡ "transformed" gross ≡ "gross"

II ≡ "II" III ≡ "III" IV ≡ "IV" V ≡ "V" VI ≡ "VI" Custom ≡ "Custom"

FBT54 ≡ "FBT54" FBT63 ≡ "FBT63" FBT72 ≡ "FBT72" FBT78 ≡ "FBT78"

FIB36 ≡ "FIB36" FIB45 ≡ "FIB45" FIB54 ≡ "FIB54" FIB63 ≡ "FIB63" FIB72 ≡ "FIB72"

FIB78 ≡ "FIB78" FIB84 ≡ "FIB84" FIB96 ≡ "FIB96" FIB120 ≡ "FIB120"