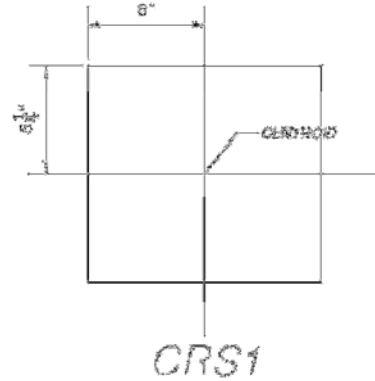


NCHRP Project 12-94
LRFD Minimum Flexural Reinforcement Requirements
Final Report

Appendix C
Parametric Study Results

1 Section Properties

$h =$	10.50 in
$b =$	12.00 in
$A =$	126.00 in ²
$I =$	1157.63 in ⁴
$y_b =$	5.25 in
$f'_c =$	3.60 ksi
$f_y =$	60.00 ksi
Clearance (clr) =	2.00 in



$$S = I/y_b = 221 \text{ in}^3$$

$$f_r = 0.24 f'_c{}^{0.5} h^{-0.15} = 0.465 \text{ ksi}$$

$$m_{cr} = S_b f_r = 8.54 \text{ kft (unfactored)}$$

2 AASHTO LRFD 5.6.3.3

$$M_r \geq M_{cr}$$

$$M_{cr} = \gamma_3 \gamma_1 f_r S = 8.97 \text{ kft} \quad \text{AASHTO 5.4.2.6}$$

$$\gamma_3 = 0.67 \quad \text{A615 Grade 60}$$

$$\gamma_1 = 1.6$$

$$f_r = 0.24 f'_c{}^{0.5} = 0.455 \text{ psi}$$

$$M_r = \phi M_n = 8.97 \text{ kft} \quad \text{(AASHTO 5.7.3.2.2)}$$

$$\phi = 0.9 \quad \text{(AASHTO 5.5.4.2)}$$

$$M_n = A_s f_y (d - a/2) = 9.97 \text{ kft}$$

$$A_s = 0.2753 \text{ in}^2$$

$$d = h - \text{clr} - 1.5 db = 7.47 \text{ in}$$

$$db = 0.6875 \text{ No. 5}$$

$$a = A_s f_y / (0.85 f'_c b) = 0.45 \text{ in}$$

$$M_o = M_n / \gamma_3 = 14.88 \text{ kft} \quad \text{Flexural strength including effects of strain hardening}$$

$$\gamma_3 = 0.67 \quad \text{A615 Grade 60}$$

$$FS = M_o / m_{cr} = 1.74$$

3 Proposed

$$M_r \geq M_{cr}$$

$$M_{cr} = \gamma_3 \gamma_1 f_r S = 9.15 \text{ kft} \quad \text{AASHTO 5.4.2.6}$$

$$\gamma_3 = 0.67 \quad \text{A615 Grade 60}$$

$$\gamma_1 = 1.6$$

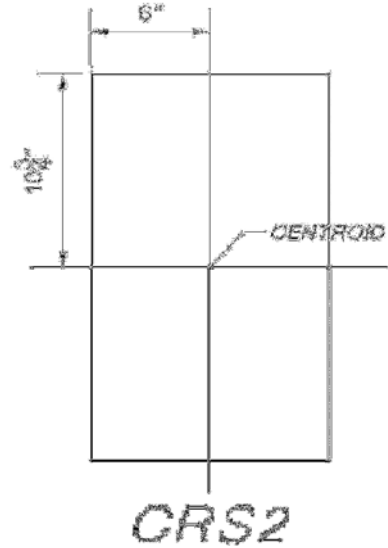
$$f_r = 0.24 f'_c{}^{0.5} h^{-0.15} = 0.465 \text{ psi}$$

$M_r = \phi M_n =$	9.15 kft	(AASHTO 5.7.3.2.2)
$\phi =$	0.9	(AASHTO 5.5.4.2)
$M_n = A_s f_y (d - a/2) =$	10.17 kft	
$A_s =$	0.281 in ²	
$d = h - clr - 1.5 db =$	7.47 in	
$db =$	0.6875 No. 5	
$a = A_s f_y / (0.85 f'_c b) =$	0.46 in	
$M_o = M_n / \gamma_3 =$	15.18 kft	Flexural strength including the strain hardening
$\gamma_3 =$	0.67	A615 Grade 60
$FS = M_o / m_{cr} =$	1.78	

1 Section Properties

$$\begin{aligned}
 h &= 21.50 \text{ in} \\
 b &= 12.00 \text{ in} \\
 A &= 258.00 \text{ in}^2 \\
 I &= 9,938.38 \text{ in}^4 \\
 y_b &= 10.75 \text{ in} \\
 f'_c &= 3.60 \text{ ksi} \\
 f_y &= 60.00 \text{ ksi} \\
 \text{Clearance (clr)} &= 2.00 \text{ in} \\
 \\
 S = I/y_b &= 925 \text{ in}^3 \\
 f_r = 0.24 f'_c{}^{0.5} h^{-0.15} &= 0.417 \text{ ksi} \\
 m_{cr} = S_b f_r &= 32.14 \text{ kft}
 \end{aligned}$$

(unfactored)



2 AASHTO LRFD 5.6.3.3

$$\begin{aligned}
 M_r &\geq M_{cr} \\
 M_{cr} = \gamma_3 \gamma_1 f_r S &= 37.61 \text{ kft} && \text{(AASHTO 5.4.2.6)} \\
 \gamma_3 &= 0.67 && \text{A615 Grade 60} \\
 \gamma_1 &= 1.6 \\
 f_r = 0.24 f'_c{}^{0.5} &= 0.455 \text{ psi} \\
 \\
 M_r = \phi M_n &= 37.61 \text{ kft} && \text{(AASHTO 5.7.3.2.2)} \\
 \phi &= 0.9 && \text{(AASHTO 5.5.4.2)} \\
 M_n = A_s f_y (d - a/2) &= 41.79 \text{ kft} \\
 A_s &= 0.462 \text{ in}^2 \\
 d = h - \text{clr} - 1.5 d_b &= 18.47 \text{ in} \\
 d_b &= 0.6875 \text{ in} && \text{No. 5 bar} \\
 a = A_s f_y / (0.85 f'_c b) &= 0.75 \text{ in} \\
 \\
 M_o = M_n / \gamma_3 &= 62.37 \text{ kft} && \text{Flexural strength including effects of strain hardening} \\
 \gamma_3 &= 0.67 && \text{A615 Grade 60} \\
 FS = M_o / m_{cr} &= 1.94
 \end{aligned}$$

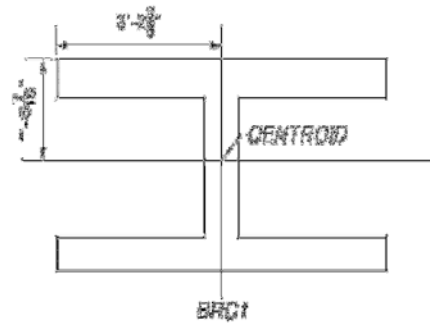
3 Proposed

$$\begin{aligned}
 M_r &\geq M_{cr} \\
 M_{cr} = \gamma_3 \gamma_1 f_r S &= 34.46 \text{ kft} && \text{(AASHTO 5.4.2.6)} \\
 \gamma_3 &= 0.67 && \text{A615 Grade 60} \\
 \gamma_1 &= 1.6 \\
 f_r = 0.24 f'_c{}^{0.5} h^{-0.15} &= 0.417 \text{ ksi} && \text{Proposed modified equation} \\
 \\
 M_r = \phi M_n &= 34.42 \text{ kft} && \text{(AASHTO 5.7.3.2.2)}
 \end{aligned}$$

$\phi =$	0.9	(AASHTO 5.5.4.2)
$M_n = A_s f_y (d - a/2) =$	38.24 kft	
$A_s =$	0.422 in ²	1.001189
$d = h - \text{clr} - 1.5 d_b =$	18.47 in	
$d_b =$	0.6875 in	No. 5 bar
$a = A_s f_y / (0.85 f'_c b) =$	0.69 in	
$M_o = M_n / \gamma_3 =$	57.08 kft	Flexural strength including effects of strain hardening
$\gamma_3 =$	0.67	A615 Grade 60
$FS = M_o / m_{cr} =$	1.78	

1 Section Properties

h =	38.40 in
b _f =	76.80 in
b _w =	8.00 in
t _d =	7.10 in
t _s =	6.00 in
A =	1208.48 in ²
I =	268,255.86 in ⁴
y _b =	19.96 in
f' _c =	3.60 ksi
f _y =	60.00 ksi
Clearance (clr) =	2.00 in



S = I/y _b =	13,438 in ³	
f _r = 0.24 f' _c ^{0.5} h ^{-0.15} =	0.382 ksi	
m _{cr} = S _b f _r =	428.30 kft	(unfactored)

2 AASHTO LRFD 5.6.3.3

M _r ≥ M _{cr}		
M _{cr} = γ ₃ γ ₁ f _r S =	546.65 kft	(AASHTO 5.4.2.6)
γ ₃ =	0.67	A615 Grade 60
γ ₁ =	1.6	
f _r = 0.24 f' _c ^{0.5} =	0.455 psi	
M _r = φ M _n =	546.46 kft	(AASHTO 5.7.3.2.2)
φ =	0.9	(AASHTO 5.5.4.2)
M _n = A _s f _y (d - a/2) =	607.18 kft	
A _s =	3.525 in ²	
d = h - clr - 1.5 d _b =	34.90 in	
d _b =	1 in	No. 8
a = A _s f _y / (0.85 f' _c b) =	0.90 in ²	
M _o = M _n / γ ₃ =	906.24 kft	Flexural strength including effects of strain hardening
γ ₃ =	0.67	A615 Grade 60
FS = M _o / m _{cr} =	2.12	

3 Proposed

M _r ≥ M _{cr}		
M _{cr} = γ ₃ γ ₁ f _r S =	459.13 kft	(AASHTO 5.4.2.6)
γ ₃ =	0.67	A615 Grade 60
γ ₁ =	1.6	

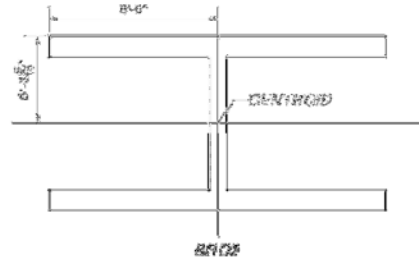
BRC1

JH

$f_r = 0.24 f'_c{}^{0.5} h^{-0.15} =$	0.382 ksi	Proposed modified equation
$M_r = \phi M_n =$	459.07 kft	(AASHTO 5.7.3.2.2)
$\phi =$	0.9	(AASHTO 5.5.4.2)
$M_n = A_s f_y (d - a/2) =$	510.07 kft	
$A_s =$	2.955 in ²	
$d = h - c_{lr} - 1.5 d_b =$	34.90 in	
$d_b =$	1 in	No. 8
$a = A_s f_y / (0.85 f'_c b) =$	0.75 in	
$M_o = M_n / \gamma_3 =$	761.30 kft	Flexural strength including effects of strain hardening
$\gamma_3 =$	0.67	A615 Grade 60
$FS = M_o / m_{cr} =$	1.78	

1 Section Properties

h =	79.20 in
b _f =	156.00 in
b _w =	8.00 in
t _d =	9.50 in
t _s =	9.30 in
A =	3,416 in ²
I =	3,740,351 in ⁴
y _b =	39.89 in
f' _c =	3.60 ksi
f _y =	60.00 ksi
Clearance (clr) =	2.00 in



$$S = I/y_b = 93,773 \text{ in}^3$$

$$f_r = 0.24 f'_c{}^{0.5} h^{-0.15} = 0.343 \text{ ksi}$$

$$m_{cr} = S_b f_r = 2,681 \text{ kft}$$

(unfactored)

2 AASHTO LRFD 5.6.3.3

$$M_r \geq M_{cr}$$

$$M_{cr} = \gamma_3 \gamma_1 f_r S = 3,815 \text{ kft}$$

$$\gamma_3 = 0.67$$

$$\gamma_1 = 1.6$$

$$f_r = 0.24 f'_c{}^{0.5} = 0.455 \text{ psi}$$

$$M_r = \phi M_n = 3,815 \text{ kft}$$

$$\phi = 0.9$$

$$M_n = A_s f_y (d - a/2) = 4,239 \text{ kft}$$

$$A_s = 11.305 \text{ in}^2$$

$$d = h - \text{clr} - 1.5 d_b = 75.70 \text{ in}$$

$$d_b = 1 \text{ in}$$

$$a = A_s f_y / (0.85 f'_c b) = 1.42 \text{ in}^2$$

(AASHTO 5.4.2.6)

A615 Grade 60

(AASHTO 5.7.3.2.2)

(AASHTO 5.5.4.2)

No. 8

$$M_o = M_n / \gamma_3 = 6,327 \text{ kft}$$

$$\gamma_3 = 0.67$$

$$FS = M_o / m_{cr} = 2.36$$

Flexural strength, strain hardening

A615 Grade 60

3 Proposed

$$M_r \geq M_{cr}$$

$$M_{cr} = \gamma_3 \gamma_1 f_r S = 2,874 \text{ kft}$$

$$\gamma_3 = 0.67$$

$$\gamma_1 = 1.6$$

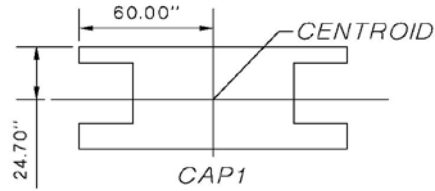
(AASHTO 5.4.2.6)

A615 Grade 60

$f_r = 0.24 f'_c{}^{0.5} h^{-0.15} =$	0.343 ksi	Proposed modified equation
$M_r = \phi M_n =$	2,893 kft	(AASHTO 5.7.3.2.2)
$\phi =$	0.9	(AASHTO 5.5.4.2)
$M_n = A_s f_y (d - a/2) =$	3,214 kft	
$A_s =$	8.5 in ²	
$d = h - clr - 1.5 d_b =$	76.17 in	
$d_b =$	0.6875 in	No. 5 bar
$a = A_s f_y / (0.85 f'_c b) =$	1.07 in	
$M_o = M_n / \gamma_3 =$	4,798 kft	Flexural strength, strain hardening
$\gamma_3 =$	0.67	A615 Grade 60
$FS = M_o / m_{cr} =$	1.79	

1 Section Properties

h =	48.00 in
b _f =	120.00 in
b _w =	72.00 in
t _d =	7.50 in
t _s =	12.00 in
A =	4,392 in ²
I =	1,004,241 in ⁴
y _b =	23.30 in
f' _c =	4.00 ksi
f _y =	60.00 ksi
Clearance (clr) =	2.00 in



S = I/y _b =	43,100 in ³	
f _r = 0.24 f' _c ^{0.5} h ^{-0.15} =	0.390 ksi	
m _{cr} = S _b f _r =	1,400 kft	(unfactored)

2 AASHTO LRFD 5.6.3.3

M _r ≥ M _{cr}		
M _{cr} = γ ₃ γ ₁ f _r S =	1,848 kft	(AASHTO 5.4.2.6)
γ ₃ =	0.67	A615 Grade 60
γ ₁ =	1.6	
f _r = 0.24 f' _c ^{0.5} =	0.480 psi	
M _r = φ M _n =	1,848 kft	(AASHTO 5.7.3.2.2)
φ =	0.9	(AASHTO 5.5.4.2)
M _n = A _s f _y (d - a/2) =	2,053 kft	
A _s =	9.51 in ²	
d = h - clr - 1.5 d _b =	43.89 in	
d _b =	1.41 in	No. 11
a = A _s f _y / (0.85 f' _c b) =	1.40 in	
M _o = M _n / γ ₃ =	3,065 kft	Flexural strength, strain hardening
γ ₃ =	0.67	A615 Grade 60
FS = M _o / m _{cr} =	2.19	

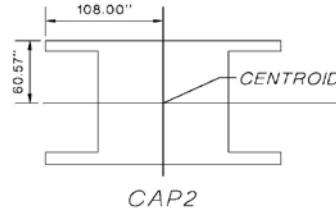
3 Proposed

M _r ≥ M _{cr}		
M _{cr} = γ ₃ γ ₁ f _r S =	1,501 kft	(AASHTO 5.4.2.6)
γ ₃ =	0.67	A615 Grade 60
γ ₁ =	1.6	

$f_r = 0.24 f'_c{}^{0.5} h^{-0.15} =$	0.390 ksi	Proposed modified equation
$M_r = \phi M_n =$	1,501 kft	(AASHTO 5.7.3.2.2)
$\phi =$	0.9	(AASHTO 5.5.4.2)
$M_n = A_s f_y (d - a/2) =$	1,668 kft	
$A_s =$	7.7 in ²	
$d = h - clr - 1.5 d_b =$	43.89 in	
$d_b =$	1.41 in	No. 11
$a = A_s f_y / (0.85 f'_c b) =$	1.13 in	
$M_o = M_n / \gamma_3 =$	2,489 kft	Flexural strength, strain hardening
$\gamma_3 =$	0.67	A615 Grade 60
$FS = M_o / m_{cr} =$	1.78	

1 Section Properties

h =	120.00 in
b _f =	216.00 in
b _w =	120.00 in
t _d =	10.00 in
t _s =	12.00 in
A =	16,512 in ²
I =	23,559,696 in ⁴
y _b =	59.43 in
f' _c =	4.00 ksi
f _y =	60.00 ksi
Clearance (clr) =	2.00 in



S = I/y _b =	396,428 in ³	
f _r = 0.24 f' _c ^{0.5} h ^{-0.15} =	0.340 ksi	
m _{cr} = S _b f _r =	11,226 kft	(unfactored)

2 AASHTO LRFD 5.6.3.3

M _r ≥ M _{cr}		
M _{cr} = γ ₃ γ ₁ f _r S =	16,999 kft	(AASHTO 5.4.2.6)
γ ₃ =	0.67	A615 Grade 60
γ ₁ =	1.6	
f _r = 0.24 f' _c ^{0.5} =	0.480 psi	
M _r = φ M _n =	16,999 kft	(AASHTO 5.7.3.2.2)
φ =	0.9	(AASHTO 5.5.4.2)
M _n = A _s f _y (d - a/2) =	18,887 kft	
A _s =	32.98 in ²	
d = h - clr - 1.5 d _b =	115.89 in	
d _b =	1.41 in	No. 11
a = A _s f _y / (0.85 f' _c b) =	2.69 in ²	
M _o = M _n / γ ₃ =	28,190 kft	Flexural strength, strain hardening
γ ₃ =	0.67	A615 Grade 60
FS = M _o / m _{cr} =	2.51	

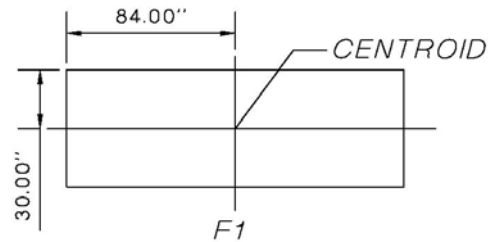
3 Proposed

M _r ≥ M _{cr}		
M _{cr} = γ ₃ γ ₁ f _r S =	12,034 kft	(AASHTO 5.4.2.6)
γ ₃ =	0.67	A615 Grade 60
γ ₁ =	1.6	

$f_r = 0.24 f'_c{}^{0.5} h^{-0.15} =$	0.340 ksi	Proposed modified equation
$M_r = \phi M_n =$	12,051 kft	(AASHTO 5.7.3.2.2)
$\phi =$	0.9	(AASHTO 5.5.4.2)
$M_n = A_s f_y (d - a/2) =$	13,390 kft	
$A_s =$	23.3 in ²	
$d = h - clr - 1.5 d_b =$	115.89 in	
$d_b =$	1.41 in	No. 11
$a = A_s f_y / (0.85 f'_c b) =$	1.90 in	
$M_o = M_n / \gamma_3 =$	19,985 kft	Flexural strength, strain hardening
$\gamma_3 =$	0.67	A615 Grade 60
$FS = M_o / m_{cr} =$	1.78	

1 Section Properties

$h =$	60.00 in
$b =$	168.00 in
$A =$	10,080 in ²
$I =$	3,024,000 in ⁴
$y_b =$	30.00 in
$f'_c =$	4.00 ksi
$f_y =$	60.00 ksi
Clearance (clr) =	3.00 in



$$S = I/y_b = 100,800 \text{ in}^3$$

$$f_r = 0.24 f'_c{}^{0.5} h^{-0.15} = 0.377 \text{ ksi}$$

$$m_{cr} = S_b f_r = 3,167 \text{ kft}$$

(unfactored)

2 AASHTO LRFD 5.6.3.3

$$M_r \geq M_{cr}$$

$$M_{cr} = \gamma_3 \gamma_1 f_r S = 4,322 \text{ kft} \quad (\text{AASHTO 5.4.2.6})$$

$$\gamma_3 = 0.67 \quad \text{A615 Grade 60}$$

$$\gamma_1 = 1.6$$

$$f_r = 0.24 f'_c{}^{0.5} = 0.480 \text{ psi}$$

$$M_r = \phi M_n = 4,321 \text{ kft} \quad (\text{AASHTO 5.7.3.2.2})$$

$$\phi = 0.9 \quad (\text{AASHTO 5.5.4.2})$$

$$M_n = A_s f_y (d - a/2) = 4,802 \text{ kft}$$

$$A_s = 17.73 \text{ in}^2$$

$$d = h - \text{clr} - 1.5 d_b = 55.10 \text{ in}$$

$$d_b = 1.27 \text{ in} \quad \text{No. 10}$$

$$a = A_s f_y / (0.85 f'_c b) = 1.86 \text{ in}$$

$$M_o = M_n / \gamma_3 = 7,167 \text{ kft} \quad \text{Flexural strength, strain hardening}$$

$$\gamma_3 = 0.67 \quad \text{A615 Grade 60}$$

$$FS = M_o / m_{cr} = 2.26$$

3 Proposed

$$M_r \geq M_{cr}$$

$$M_{cr} = \gamma_3 \gamma_1 f_r S = 3,395 \text{ kft} \quad (\text{AASHTO 5.4.2.6})$$

$$\gamma_3 = 0.67 \quad \text{A615 Grade 60}$$

$$\gamma_1 = 1.6$$

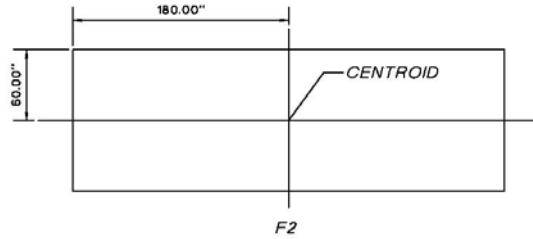
$$f_r = 0.24 f'_c{}^{0.5} h^{-0.15} = 0.377 \text{ ksi} \quad \text{Proposed modified equation}$$

$$M_r = \phi M_n = 3,392 \text{ kft} \quad (\text{AASHTO 5.7.3.2.2})$$

$\phi =$	0.9	(AASHTO 5.5.4.2)
$M_n = A_s f_y (d - a/2) =$	3,769 kft	
$A_s =$	13.865 in ²	
$d = h - \text{clr} - 1.5 d_b =$	55.10 in	
$d_b =$	1.27 in	No. 10
$a = A_s f_y / (0.85 f'_c b) =$	1.46 in	
$M_o = M_n / \Upsilon_3 =$	5625.34 kft	Flexural strength, strain hardening
$\Upsilon_3 =$	0.67	A615 Grade 60
$FS = M_o / m_{cr} =$	1.78	

1 Section Properties

h =	120.00 in
b =	360.00 in
A =	43,200 in ²
I =	51,840,000 in ⁴
y _b =	60.00 in
f' _c =	4.00 ksi
f _y =	60.00 ksi
Clearance (clr) =	6.00 in



S = I/y _b =	864,000 in ³	
f _r = 0.24 f' _c ^{0.5} h ^{-0.15} =	0.340 ksi	
m _{cr} = S _b f _r =	24,467 kft	(unfactored)

2 AASHTO LRFD 5.6.3.3

M _r ≥ M _{cr}		
M _{cr} = γ ₃ γ ₁ f _r S =	37,048 kft	(AASHTO 5.4.2.6)
γ ₃ =	0.67	A615 Grade 60
γ ₁ =	1.6	
f _r = 0.24 f' _c ^{0.5} =	0.480 psi	
M _r = φ M _n =	37,065 kft	(AASHTO 5.7.3.2.2)
φ =	0.9	(AASHTO 5.5.4.2)
M _n = A _s f _y (d - a/2) =	41,184 kft	
A _s =	74.7 in ²	
d = h - clr - 1.5 d _b =	112.10 in	
d _b =	1.27 in	No. 10
a = A _s f _y / (0.85 f' _c b) =	3.66 in	
M _o = M _n / γ ₃ =	61,468 kft	Flexural strength, strain hardening
γ ₃ =	0.67	A615 Grade 60
FS = M _o / m _{cr} =	2.51	

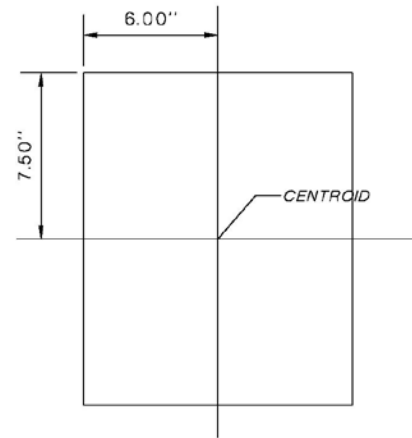
3 Proposed

M _r ≥ M _{cr}		
M _{cr} = γ ₃ γ ₁ f _r S =	26,228 kft	(AASHTO 5.4.2.6)
γ ₃ =	0.67	A615 Grade 60
γ ₁ =	1.6	
f _r = 0.24 f' _c ^{0.5} h ^{-0.15} =	0.340 ksi	Proposed modified equation
M _r = φ M _n =	26,228 kft	(AASHTO 5.7.3.2.2)

$\phi =$	0.9	(AASHTO 5.5.4.2)
$M_n = A_s f_y (d - a/2) =$	29,142 kft	
$A_s =$	52.6 in ²	
$d = h - \text{clr} - 1.5 d_b =$	112.10 in	
$d_b =$	1.27 in	No. 10
$a = A_s f_y / (0.85 f'_c b) =$	2.58 in	
$M_o = M_n / \Upsilon_3 =$	43495.40 kft	Flexural strength, strain hardening
$\Upsilon_3 =$	0.67	A615 Grade 60
$FS = M_o / m_{cr} =$	1.78	

1 Section Properties

$h =$	15.00 in
$b =$	12.00 in
$A =$	180.00 in ²
$I =$	3375.00 in ⁴
$y_b =$	7.50 in
$f'_c =$	4.00 ksi
$f_y =$	60.00 ksi
$f_{pu} =$	270.00 ksi
$f_{pse} =$	172.50 ksi
Clearance centroid (x) =	4.00 in



CPS1

$$S = I/y_b = 450 \text{ in}^3$$

$$f_r = 0.24 f'_c{}^{0.5} h^{-0.15} = 0.464 \text{ ksi} \quad \text{Theoretical}$$

2 AASHTO LRFD 5.6.3.3

$$M_r \geq M_{cr}$$

$$m_{cr} = S_b (f_r + f_{cpe}) = 42.59 \text{ kft} \quad \text{Theoretical}$$

$$M_{cr} = (\gamma_1 f_r + \gamma_2 f_{cpe}) S = 56.50 \text{ kft} \quad \text{Factored (AASHTO 5.6.3.3)}$$

$$f_{pce} = P_f (1/A + e/S) = 0.67 \text{ ksi}$$

$$P_f = A_{ps} f_{pse} = 50.37 \text{ k}$$

$$e = h/2 - x = 3.50 \text{ in}$$

$$f_{ps} = f_{pu} (1 - 0.28 c/d_p) = 254.38 \text{ ksi} \quad \text{(AASHTO 5.6.3.3)}$$

$$c = a/0.85 = 2.27 \text{ in}$$

$$d = h - x = 11.00 \text{ in}$$

$$a = A_{ps} f_{ps} / (0.85 f'_c b) = 1.93 \text{ in}^2$$

$$A_{ps} = 0.292 \text{ in}^2$$

$$\gamma_1 = 1.6 \quad \text{A615 Grade 60}$$

$$\gamma_2 = 1.1$$

$$f_r = 0.24 f'_c{}^{0.5} = 0.480 \text{ psi} \quad \text{(AASHTO 5.4.2.6)}$$

$$M_r = \phi M_n = 59.00 \text{ kft} \quad \text{(AASHTO 5.7.3.2.2)}$$

$$\phi = 0.95 \quad \text{(AASHTO 5.5.4.2)}$$

$$M_n = A_{ps} f_{ps} (d - a/2) = 62.11 \text{ kft}$$

$$FS = M_n / m_{cr} = 1.46$$

3 Proposed

$$M_r \geq M_{cr}$$

$$m_{cr} = S_b (f_r + f_{cpe}) = 41.47 \text{ kft} \quad \text{Theoretical}$$

$$M_{cr} = (\gamma_1 f_r + \gamma_2 f_{cpe}) S = 54.32 \text{ kft} \quad \text{Factored (AASHTO 5.6.3.3)}$$

$$f_{pce} = P_f (1/A + e/S) = 0.64 \text{ ksi}$$

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CPS1

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$$\begin{aligned} P_f &= A_{ps} f_{pse} = && 48.13 \text{ k} \\ e &= h/2 - x = && 3.50 \text{ in} \\ f_{ps} &= f_{pu} (1 - 0.28 c/d_p) = && 255.07 \text{ ksi} && (\text{AASHTO 5.6.3.3}) \\ c &= a/0.85 = && 2.17 \text{ in} \\ d &= h - x = && 11.00 \text{ in} \\ a &= A_{ps} f_{ps} / (0.85 f'_c b) = && 1.85 \text{ in}^2 \\ A_{ps} &= && 0.279 \text{ in}^2 \\ \gamma_1 &= && 1.6 && \text{A615 Grade 60} \\ \gamma_2 &= && 1.1 \\ f_r &= 0.24 f'_c{}^{0.5} h^{-0.15} = && 0.464 \text{ psi} && (\text{AASHTO 5.4.2.6}) \\ M_r &= \phi M_n = && 56.77 \text{ kft} && (\text{AASHTO 5.7.3.2.2}) \\ \phi &= && 0.95 && (\text{AASHTO 5.5.4.2}) \\ M_n &= A_{ps} f_{ps} (d - a/2) = && 59.76 \text{ kft} \\ FS &= M_n / m_{cr} = && 1.44 \end{aligned}$$

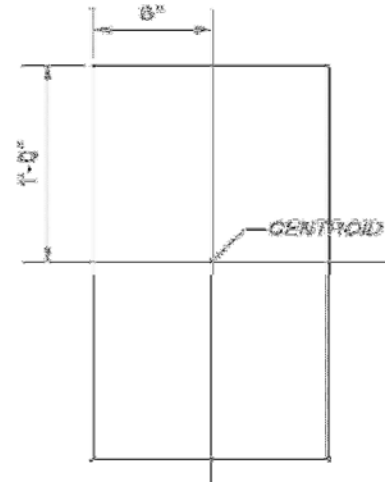
1 Section Properties

h =	24.00 in
b =	12.00 in
A =	288 in ²
I =	13,824 in ⁴
y _b =	12.00 in
f' _c =	4.00 ksi
f _y =	60.00 ksi
f _{pu} =	270.00 ksi
f _{pse} =	172.50 ksi
Clearance centroid (x) =	4.00 in

$$S = I/y_b = 1,152 \text{ in}^3$$

$$f_r = 0.24 f'_c{}^{0.5} h^{-0.15} = 0.433 \text{ ksi}$$

Theoretical



CPS2

2 AASHTO LRFD 5.6.3.3

$M_r \geq M_{cr}$		
$m_{cr} = s_b (f_r + f_{cpe}) =$	115.70 kft	Theoretical
$M_{cr} = (\gamma_1 f_r + \gamma_2 f_{cpe}) S =$	155.32 kft	Factored (AASHTO 5.6.3.3)
$f_{pce} = P_f (1/A + e/S) =$	0.77 ksi	
$P_f = A_{ps} f_{pse} =$	74.18 k	
$e = h/2 - x =$	8.00 in	
$f_{ps} = f_{pu} (1 - 0.28 c/d_p) =$	257.35 ksi	(AASHTO 5.6.3.3)
$c = a/0.85 =$	3.35 in	
$d = h - x =$	20.00 in	
$a = A_{ps} f_{ps} / (0.85 f'_c b) =$	2.85 in ²	
$A_{ps} =$	0.430 in ²	
$\gamma_1 =$	1.6	A615 Grade 60
$\gamma_2 =$	1.1	
$f_r = 0.24 f'_c{}^{0.5} =$	0.480 psi	(AASHTO 5.4.2.6)
$M_r = \phi M_n =$	162.75 kft	(AASHTO 5.7.3.2.2)
$\phi =$	0.95	(AASHTO 5.5.4.2)
$M_n = A_{ps} f_{ps} (d - a/2) =$	171.31 kft	
$FS = M_n / m_{cr} =$	1.48	

3 Proposed

$M_r \geq M_{cr}$		
$m_{cr} = s_b (f_r + f_{cpe}) =$	106.22 kft	Theoretical
$M_{cr} = (\gamma_1 f_r + \gamma_2 f_{cpe}) S =$	137.60 kft	Factored (AASHTO 5.6.3.3)
$f_{pce} = P_f (1/A + e/S) =$	0.67 ksi	

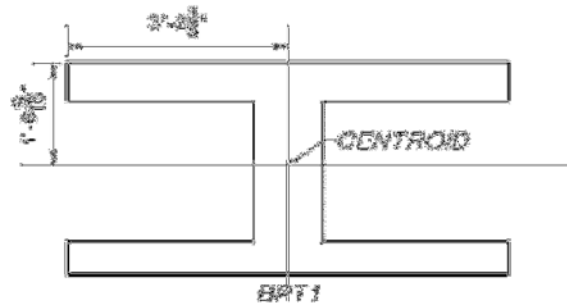
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$$\begin{aligned} P_f &= A_{ps} f_{pse} = && 64.69 \text{ k} \\ e &= h/2 - x = && 8.00 \text{ in} \\ f_{ps} &= f_{pu} (1 - 0.28 c/d_p) = && 258.96 \text{ ksi} && (\text{AASHTO 5.6.3.3}) \\ c &= a/0.85 = && 2.92 \text{ in} \\ d &= h - x = && 20.00 \text{ in} \\ a &= A_{ps} f_{ps} / (0.85 f'_c b) = && 2.48 \text{ in}^2 \\ A_{ps} &= && 0.375 \text{ in}^2 \\ \gamma_1 &= && 1.6 && \text{A615 Grade 60} \\ \gamma_2 &= && 1.1 \\ f_r &= 0.24 f'_c{}^{0.5} h^{-0.15} = && 0.433 \text{ psi} && (\text{AASHTO 5.4.2.6}) \\ M_r &= \phi M_n = && 144.22 \text{ kft} && (\text{AASHTO 5.7.3.2.2}) \\ \phi &= && 0.95 && (\text{AASHTO 5.5.4.2}) \\ M_n &= A_{ps} f_{ps} (d - a/2) = && 151.81 \text{ kft} \\ FS &= M_n / m_{cr} = && 1.43 \end{aligned}$$

1 Section Properties

$h =$	38.40 in
$b_f =$	76.80 in
$b_w =$	12.00
$t_d =$	7.00
$t_s =$	6.00
$A =$	1,303 in ²
$I =$	272,967 in ⁴
$y_b =$	19.84 in
$f'_c =$	4.00 ksi
$f_y =$	60.00 ksi
$f_{pu} =$	270.00 ksi
$f_{pse} =$	172.50 ksi
Clearance centroid (x) =	4.00 in



$$S = I/y_b = 13,760 \text{ in}^3$$

$$f_r = 0.24 f'_c{}^{0.5} h^{-0.15} = 0.403 \text{ ksi} \quad \text{Theoretical}$$

2 AASHTO LRFD 5.6.3.3

$$M_r \geq M_{cr}$$

$$m_{cr} = S_b (f_r + f_{cpe}) = 1950.82 \text{ kft} \quad \text{Theoretical}$$

$$M_{cr} = (\gamma_1 f_r + \gamma_2 f_{cpe}) S = 2518.03 \text{ kft} \quad \text{Factored (AASHTO 5.6.3.3)}$$

$$f_{cpe} = P_f (1/A + e/S) = 1.30 \text{ ksi}$$

$$P_f = A_{ps} f_{pse} = 693.45 \text{ k}$$

$$e = h/2 - x = 15.20 \text{ in}$$

$$f_{ps} = f_{pu} (1 - 0.28 c/d_p) = 259.25 \text{ ksi} \quad \text{(AASHTO 5.6.3.3)}$$

$$c = a/0.85 = 4.89 \text{ in}$$

$$d = h - x = 34.40 \text{ in}$$

$$a = A_{ps} f_{ps} / (0.85 f'_c b) = 4.16 \text{ in}^2$$

$$A_{ps} = 4.020 \text{ in}^2$$

$$\gamma_1 = 1.6 \quad \text{A615 Grade 60}$$

$$\gamma_2 = 1.1$$

$$f_r = 0.24 f'_c{}^{0.5} = 0.480 \text{ psi} \quad \text{(AASHTO 5.4.2.6)}$$

$$M_r = \phi M_n = 2666.77 \text{ kft} \quad \text{(AASHTO 5.7.3.2.2)}$$

$$\phi = 0.95 \quad \text{(AASHTO 5.5.4.2)}$$

$$M_n = A_{ps} f_{ps} (d - a/2) = 2807.13 \text{ kft}$$

$$FS = M_n / m_{cr} = 1.44$$

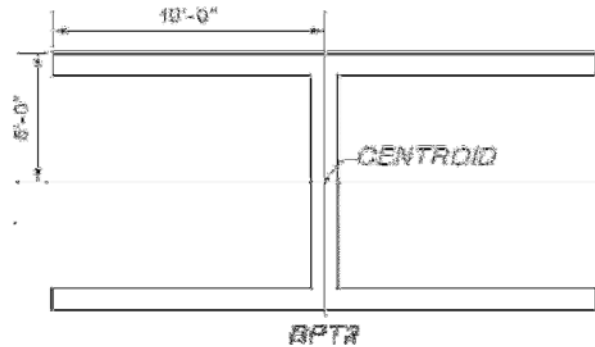
3 Proposed

$$M_r \geq M_{cr}$$

$m_{cr} = S_b (f_r + f_{cpe}) =$	1632.38 kft	Theoretical
$M_{cr} = (\gamma_1 f_r + \gamma_2 f_{cpe}) S =$	2026.76 kft	Factored (AASHTO 5.6.3.3)
$f_{pce} = P_f (1/A + e/S) =$	1.02 ksi	
$P_f = A_{ps} f_{pse} =$	545.10 k	
$e = h/2 - x =$	15.20 in	
$f_{ps} = f_{pu} (1 - 0.28 c/d_p) =$	261.55 ksi	(AASHTO 5.6.3.3)
$c = a/0.85 =$	3.84 in	
$d = h - x =$	34.40 in	
$a = A_{ps} f_{ps} / (0.85 f'_c b) =$	3.27 in ²	
$A_{ps} =$	3.160 in ²	
$\gamma_1 =$	1.6	A615 Grade 60
$\gamma_2 =$	1.1	
$f_r = 0.24 f'_c{}^{0.5} h^{-0.15} =$	0.403 psi	(AASHTO 5.4.2.6)
$M_r = \phi M_n =$	2143.95 kft	(AASHTO 5.7.3.2.2)
$\phi =$	0.95	(AASHTO 5.5.4.2)
$M_n = A_{ps} f_{ps} (d - a/2) =$	2256.79 kft	
$FS = M_n / m_{cr} =$	1.38	

1 Section Properties

h =	120.00 in
b _f =	240.00 in
b _w =	12.00
t _d =	10.10
t _s =	10.10
A =	6,046 in ²
I =	15,673,772 in ⁴
y _b =	60.00 in
f' _c =	4.00 ksi
f _y =	60.00 ksi
f _{pu} =	270.00 ksi
f _{pse} =	172.50 ksi
Clearance centroid (x) =	4.00 in



$$S = I/y_b = 261,230 \text{ in}^3$$

$$f_r = 0.24 f'_c{}^{0.5} h^{-0.15} = 0.340 \text{ ksi}$$

Theoretical

2 AASHTO LRFD 5.6.3.3

$M_r \geq M_{cr}$		
$m_{cr} = S_b (f_r + f_{cpe}) =$	46,517 kft	Theoretical
$M_{cr} = (\gamma_1 f_r + \gamma_2 f_{cpe}) S =$	59,750 kft	Factored (AASHTO 5.6.3.3)
$f_{pce} = P_f (1/A + e/S) =$	1.80 ksi	
$P_f = A_{ps} f_{pse} =$	4731.68 k	
$e = h/2 - x =$	56.00 in	
$f_{ps} = f_{pu} (1 - 0.28 c/d_p) =$	263.04 ksi	(AASHTO 5.6.3.3)
$c = a/0.85 =$	10.68 in	
$d = h - x =$	116.00 in	
$a = A_{ps} f_{ps} / (0.85 f'_c b) =$	9.08 in ²	
$A_{ps} =$	27.430 in ²	
$\gamma_1 =$	1.6	A615 Grade 60
$\gamma_2 =$	1.1	
$f_r = 0.24 f'_c{}^{0.5} =$	0.480 psi	(AASHTO 5.4.2.6)
$M_r = \phi M_n =$	63,668 kft	(AASHTO 5.7.3.2.2)
$\phi =$	0.95	(AASHTO 5.5.4.2)
$M_n = A_{ps} f_{ps} (d - a/2) =$	67,019 kft	
$FS = M_n / m_{cr} =$	1.44	

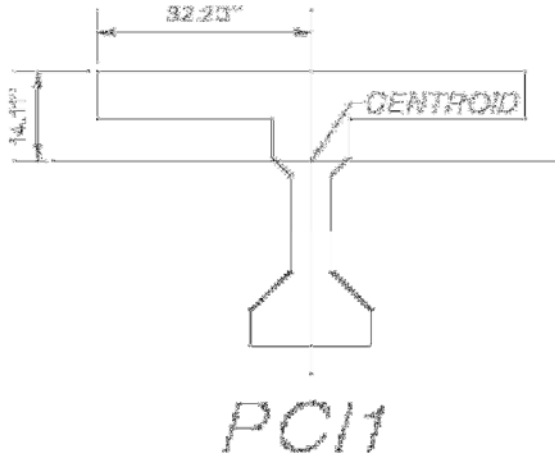
3 Proposed

$$M_r \geq M_{cr}$$

$m_{cr} = S_b (f_r + f_{cpe}) =$	32,783 kft	Theoretical
$M_{cr} = (\gamma_1 f_r + \gamma_2 f_{cpe}) S =$	39,760 kft	Factored (AASHTO 5.6.3.3)
$f_{pce} = P_f (1/A + e/S) =$	1.17 ksi	
$P_f = A_{ps} f_{pse} =$	3070.50 k	
$e = h/2 - x =$	56.00 in	
$f_{ps} = f_{pu} (1 - 0.28 c/d_p) =$	265.48 ksi	(AASHTO 5.6.3.3)
$c = a/0.85 =$	6.93 in	
$d = h - x =$	116.00 in	
$a = A_{ps} f_{ps} / (0.85 f'_c b) =$	5.89 in ²	
$A_{ps} =$	17.800 in ²	
$\gamma_1 =$	1.6	A615 Grade 60
$\gamma_2 =$	1.1	
$f_r = 0.24 f'_c{}^{0.5} h^{-0.15} =$	0.340 psi	(AASHTO 5.4.2.6)
$M_r = \phi M_n =$	42,295 kft	(AASHTO 5.7.3.2.2)
$\phi =$	0.95	(AASHTO 5.5.4.2)
$M_n = A_{ps} f_{ps} (d - a/2) =$	44,521 kft	
$FS = M_n / m_{cr} =$	1.36	

1 Section Properties

$h =$	43.50 in
$b_f =$	64.40 in
$t_d =$	7.50 in
$A =$	852 in ²
$I =$	172,940 in ⁴
$y_b =$	29.39 in
$f'_c{}^g =$	5.00 ksi
$f'_c{}^d =$	4.00 ksi
$f_y =$	60.00 ksi
$f_{pu} =$	270.00 ksi
$f_{pse} =$	172.50 ksi
Clearance centroid (x) =	4.00 in



$$S = I/y_b = 5,884 \text{ in}^3$$

$$f_r = 0.24 f'_c{}^{0.5} h^{-0.15} = 0.442 \text{ ksi}$$

Theoretical

2 AASHTO LRFD 5.6.3.3

$M_r \geq M_{cr}$		
$m_{cr} = S_b (f_r + f_{cpe}) =$	554 kft	Theoretical
$M_{cr} = (\gamma_1 f_r + \gamma_2 f_{cpe}) S =$	826 kft	Factored (AASHTO 5.6.3.3)
$f_{pce} = P_f (1/A + e/S) =$	0.69 ksi	
$P_f = A_{ps} f_{pse} =$	164.22 k	
$e = h/2 - x =$	17.75 in	
$f_{ps} = f_{pu} (1 - 0.28 c/d_p) =$	267.36 ksi	(AASHTO 5.6.3.3)
$c = a/0.85 =$	1.38 in	
$d = h - x =$	39.50 in	
$a = A_{ps} f_{ps} / (0.85 f'_c{}^d b) =$	1.17 in ²	
$A_{ps} =$	0.952 in ²	1.000725
$\gamma_1 =$	1.6	A615 Grade 60
$\gamma_2 =$	1.2	
$f_r = 0.24 f'_c{}^{0.5} =$	0.537 psi	(AASHTO 5.4.2.6)
$M_r = \phi M_n =$	825 kft	(AASHTO 5.7.3.2.2)
$\phi =$	1	(AASHTO 5.5.4.2)
$M_n = A_{ps} f_{ps} (d - a/2) =$	825 kft	
$FS = M_n / m_{cr} =$	1.49	

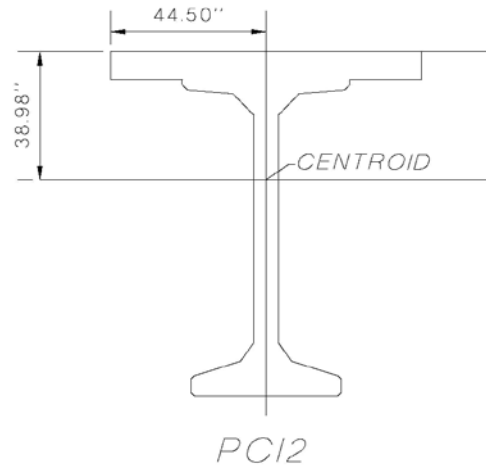
3 Proposed

$M_r \geq M_{cr}$		
$m_{cr} = S_b (f_r + f_{cpe}) =$	493.03 kft	Theoretical

$M_{cr} = (\gamma_1 f_r + \gamma_2 f_{cpe}) S =$	678.41 kft	Factored (AASHTO 5.6.3.3)
$f_{pce} = P_f (1/A + e/S) =$	0.56 ksi	
$P_f = A_{ps} f_{pse} =$	134.38 k	
$e = h/2-x =$	17.75 in	
$f_{ps} = f_{pu} (1 - 0.28 c/d_p) =$	267.84 ksi	(AASHTO 5.6.3.3)
$c = a/0.85 =$	1.13 in	
$d = h - x =$	39.50 in	
$a = A_{ps} f_{ps}/(0.85 f'c b) =$	0.96 in ²	
$A_{ps} =$	0.779 in ²	0.999959
$\gamma_1 =$	1.6	A615 Grade 60
$\gamma_2 =$	1.2	
$f_r = 0.24 f'c^{0.5} h^{-0.15} =$	0.442 psi	(AASHTO 5.4.2.6)
$M_r = \phi M_n =$	678.44 kft	(AASHTO 5.7.3.2.2)
$\phi =$	1	(AASHTO 5.5.4.2)
$M_n = A_{ps} f_{ps} (d - a/2) =$	678.44 kft	
$FS = M_n/m_{cr} =$	1.38	

1 Section Properties

$h =$	104.50 in
$b_f =$	88.99 in
$t_d =$	8.50 in
$A =$	1,954 in ²
$I =$	3,000,091 in ⁴
$y_b =$	65.52 in
$f'_c{}^g =$	10.00 ksi
$f'_c{}^d =$	5.50 ksi
$f_y =$	60.00 ksi
$f_{pu} =$	270.00 ksi
$f_{pse} =$	172.50 ksi
Clearance centroid (x) =	4.00 in



$$S = I/y_b = 45,789 \text{ in}^3$$

$$f_r = 0.24 f'_c{}^{0.5} h^{-0.15} = 0.549 \text{ ksi} \quad \text{Theoretical}$$

2 AASHTO LRFD 5.6.3.3

$$M_r \geq M_{cr}$$

$$m_{cr} = S_b (f_r + f_{cpe}) = 7,029 \text{ kft} \quad \text{Theoretical}$$

$$M_{cr} = (\gamma_1 f_r + \gamma_2 f_{cpe}) S = 10,557 \text{ kft} \quad \text{Factored (AASHTO 5.6.3.3)}$$

$$f_{pce} = P_f (1/A + e/S) = 1.29 \text{ ksi}$$

$$P_f = A_{ps} f_{pse} = 826.28 \text{ k}$$

$$e = h/2 - x = 48.25 \text{ in}$$

$$f_{ps} = f_{pu} (1 - 0.28 c/d_p) = 267.25 \text{ ksi} \quad \text{(AASHTO 5.6.3.3)}$$

$$c = a/0.85 = 3.66 \text{ in}$$

$$d = h - x = 100.50 \text{ in}$$

$$a = A_{ps} f_{ps} / (0.85 f'_c{}^d b) = 3.11 \text{ in}^2$$

$$A_{ps} = 4.790 \text{ in}^2 \quad 1.000153$$

$$\gamma_1 = 1.6 \quad \text{A615 Grade 60}$$

$$\gamma_2 = 1.2$$

$$f_r = 0.24 f'_c{}^{0.5} = 0.759 \text{ psi} \quad \text{(AASHTO 5.4.2.6)}$$

$$M_r = \phi M_n = 10,555 \text{ kft} \quad \text{(AASHTO 5.7.3.2.2)}$$

$$\phi = 1 \quad \text{(AASHTO 5.5.4.2)}$$

$$M_n = A_{ps} f_{ps} (d - a/2) = 10,555 \text{ kft}$$

$$FS = M_n / m_{cr} = 1.50$$

3 Proposed

$$M_r \geq M_{cr}$$

$$m_{cr} = S_b (f_r + f_{cpe}) = 5596.85 \text{ kft} \quad \text{Theoretical}$$

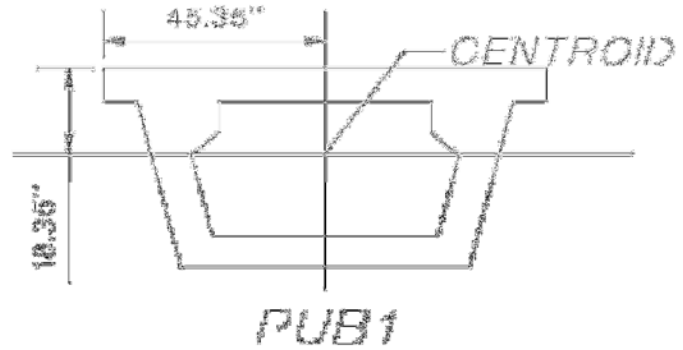
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$M_{cr} = (\gamma_1 f_r + \gamma_2 f_{cpe}) S =$	7553.48 kft	Factored (AASHTO 5.6.3.3)
$f_{pce} = P_f (1/A + e/S) =$	0.92 ksi	
$P_f = A_{ps} f_{pse} =$	586.50 k	
$e = h/2 - x =$	48.25 in	
$f_{ps} = f_{pu} (1 - 0.28 c/d_p) =$	268.05 ksi	(AASHTO 5.6.3.3)
$c = a/0.85 =$	2.60 in	
$d = h - x =$	100.50 in	
$a = A_{ps} f_{ps} / (0.85 f'_c b) =$	2.21 in ²	
$A_{ps} =$	3.400 in ²	1.000613
$\gamma_1 =$	1.6	A615 Grade 60
$\gamma_2 =$	1.2	
$f_r = 0.24 f'_c{}^{0.5} h^{-0.15} =$	0.549 psi	(AASHTO 5.4.2.6)
$M_r = \phi M_n =$	7548.86 kft	(AASHTO 5.7.3.2.2)
$\phi =$	1	(AASHTO 5.5.4.2)
$M_n = A_{ps} f_{ps} (d - a/2) =$	7548.86 kft	
$FS = M_n / m_{cr} =$	1.35	

1 Section Properties

$h =$	43.00 in
$b_f =$	90.71 in
$t_d =$	7.00 in
$A =$	1,667 in ²
$I =$	377,841 in ⁴
$y_b =$	24.65 in
$f'_c{}^g =$	7.00 ksi
$f'_c{}^d =$	4.00 ksi
$f_y =$	60.00 ksi
$f_{pu} =$	270.00 ksi
$f_{pse} =$	172.50 ksi
Clearance centroid (x) =	4.00 in



$S = I/y_b =$	15,328 in ³	
$f_r = 0.24 f'_c{}^{0.5} h^{-0.15} =$	0.524 ksi	Theoretical

2 AASHTO LRFD 5.6.3.3

$M_r \geq M_{cr}$		
$m_{cr} = S_b (f_r + f_{cpe}) =$	2,057 kft	Theoretical
$M_{cr} = (\gamma_1 f_r + \gamma_2 f_{cpe}) S =$	2,962 kft	Factored (AASHTO 5.6.3.3)
$f_{pce} = P_f (1/A + e/S) =$	1.09 ksi	
$P_f = A_{ps} f_{pse} =$	623.59 k	
$e = h/2 - x =$	17.50 in	
$f_{ps} = f_{pu} (1 - 0.28 c/d_p) =$	262.78 ksi	(AASHTO 5.6.3.3)
$c = a/0.85 =$	3.72 in	
$d = h - x =$	39.00 in	
$a = A_{ps} f_{ps} / (0.85 f'_c{}^d b) =$	3.16 in ²	
$A_{ps} =$	3.615 in ²	1.000105
$\gamma_1 =$	1.6	A615 Grade 60
$\gamma_2 =$	1.2	
$f_r = 0.24 f'_c{}^{0.5} =$	0.635 psi	(AASHTO 5.4.2.6)
$M_r = \phi M_n =$	2,962 kft	(AASHTO 5.7.3.2.2)
$\phi =$	1	(AASHTO 5.5.4.2)
$M_n = A_{ps} f_{ps} (d - a/2) =$	2,962 kft	
$FS = M_n / m_{cr} =$	1.44	

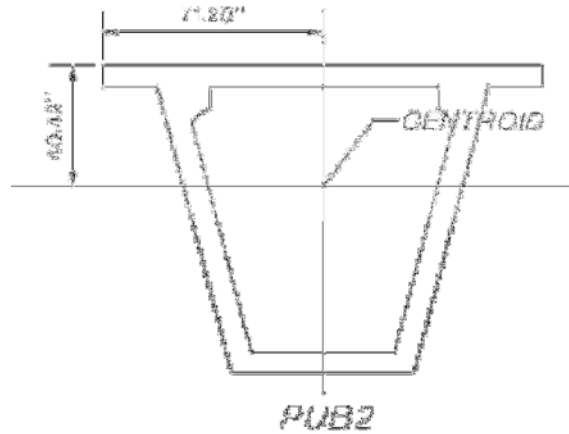
3 Proposed

$M_r \geq M_{cr}$		
$m_{cr} = S_b (f_r + f_{cpe}) =$	1780.32 kft	Theoretical

$M_{cr} = (\gamma_1 f_r + \gamma_2 f_{cpe}) S =$	2404.29 kft	Factored (AASHTO 5.6.3.3)
$f_{pce} = P_f (1/A + e/S) =$	0.87 ksi	
$P_f = A_{ps} f_{pse} =$	499.22 k	
$e = h/2-x =$	17.50 in	
$f_{ps} = f_{pu} (1 - 0.28 c/d_p) =$	264.22 ksi	(AASHTO 5.6.3.3)
$c = a/0.85 =$	2.98 in	
$d = h - x =$	39.00 in	
$a = A_{ps} f_{ps}/(0.85 f'c b) =$	2.53 in ²	
$A_{ps} =$	2.894 in ²	0.999945
$\gamma_1 =$	1.6	A615 Grade 60
$\gamma_2 =$	1.2	
$f_r = 0.24 f'c^{0.5} h^{-0.15} =$	0.524 psi	(AASHTO 5.4.2.6)
$M_r = \phi M_n =$	2404.42 kft	(AASHTO 5.7.3.2.2)
$\phi =$	1	(AASHTO 5.5.4.2)
$M_n = A_{ps} f_{ps} (d - a/2) =$	2404.42 kft	
$FS = M_n/m_{cr} =$	1.35	

1 Section Properties

$h =$	103.00 in
$b_f =$	142.39 in
$t_d =$	7.00 in
$A =$	3,003 in ²
$I =$	4,081,912 in ⁴
$y_b =$	62.58 in
$f'_c{}^g =$	10.00 ksi
$f'_c{}^d =$	5.50 ksi
$f_y =$	60.00 ksi
$f_{pu} =$	270.00 ksi
$f_{pse} =$	172.50 ksi
Clearance centroid (x) =	4.00 in



$S = I/y_b =$	65,227 in ³	
$f_r = 0.24 f'_c{}^{0.5} h^{-0.15} =$	0.550 ksi	Theoretical

2 AASHTO LRFD 5.6.3.3

$M_r \geq M_{cr}$		
$m_{cr} = S_b (f_r + f_{cpe}) =$	9,665 kft	Theoretical
$M_{cr} = (\gamma_1 f_r + \gamma_2 f_{cpe}) S =$	14,613 kft	Factored (AASHTO 5.6.3.3)
$f_{pce} = P_f (1/A + e/S) =$	1.23 ksi	
$P_f = A_{ps} f_{pse} =$	1157.48 k	
$e = h/2 - x =$	47.50 in	
$f_{ps} = f_{pu} (1 - 0.28 c/d_p) =$	267.55 ksi	(AASHTO 5.6.3.3)
$c = a/0.85 =$	3.20 in	
$d = h - x =$	99.00 in	
$a = A_{ps} f_{ps} / (0.85 f'_c{}^d b) =$	2.72 in ²	
$A_{ps} =$	6.710 in ²	1.00036
$\gamma_1 =$	1.6	A615 Grade 60
$\gamma_2 =$	1.2	
$f_r = 0.24 f'_c{}^{0.5} =$	0.759 psi	(AASHTO 5.4.2.6)
$M_r = \phi M_n =$	14,608 kft	(AASHTO 5.7.3.2.2)
$\phi =$	1	(AASHTO 5.5.4.2)
$M_n = A_{ps} f_{ps} (d - a/2) =$	14,608 kft	
$FS = M_n / m_{cr} =$	1.51	

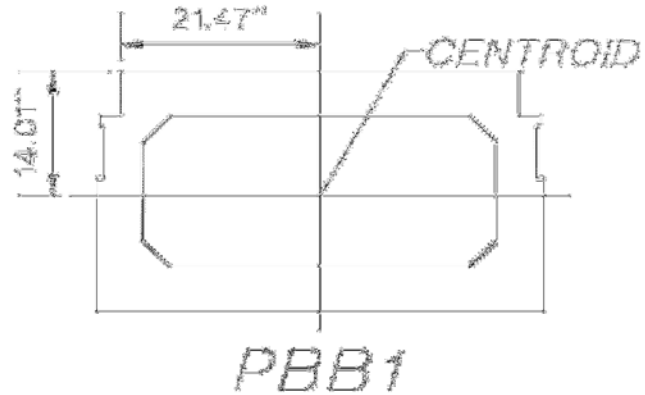
3 Proposed

$M_r \geq M_{cr}$		
$m_{cr} = S_b (f_r + f_{cpe}) =$	7759.57 kft	Theoretical

$M_{cr} = (\gamma_1 f_r + \gamma_2 f_{cpe}) S =$	10506.77 kft	Factored (AASHTO 5.6.3.3)
$f_{pce} = P_f (1/A + e/S) =$	0.88 ksi	
$P_f = A_{ps} f_{pse} =$	827.14 k	
$e = h/2-x =$	47.50 in	
$f_{ps} = f_{pu} (1 - 0.28 c/d_p) =$	268.25 ksi	(AASHTO 5.6.3.3)
$c = a/0.85 =$	2.29 in	
$d = h - x =$	99.00 in	
$a = A_{ps} f_{ps}/(0.85 f'c b) =$	1.94 in ²	
$A_{ps} =$	4.795 in ²	0.99993
$\gamma_1 =$	1.6	A615 Grade 60
$\gamma_2 =$	1.2	
$f_r = 0.24 f'c^{0.5} h^{-0.15} =$	0.550 psi	(AASHTO 5.4.2.6)
$M_r = \phi M_n =$	10507.51 kft	(AASHTO 5.7.3.2.2)
$\phi =$	1	(AASHTO 5.5.4.2)
$M_n = A_{ps} f_{ps} (d - a/2) =$	10507.51 kft	
$FS = M_n/m_{cr} =$	1.35	

1 Section Properties

$h =$	27.00 in
$b_f =$	42.93 in
$t_d =$	5.00 in
$A =$	633 in ²
$I =$	60,660 in ⁴
$y_b =$	12.99 in
$f'_c{}^g =$	5.00 ksi
$f'_c{}^d =$	4.00 ksi
$f_y =$	60.00 ksi
$f_{pu} =$	270.00 ksi
$f_{pse} =$	172.50 ksi
Clearance centroid (x) =	4.00 in



$$S = I/y_b = 4,670 \text{ in}^3$$

$$f_r = 0.24 f'_c{}^{0.5} h^{-0.15} = 0.475 \text{ ksi} \quad \text{Theoretical}$$

2 AASHTO LRFD 5.6.3.3

$$M_r \geq M_{cr}$$

$$m_{cr} = S_b (f_r + f_{cpe}) = 709 \text{ kft} \quad \text{Theoretical}$$

$$M_{cr} = (\gamma_1 f_r + \gamma_2 f_{cpe}) S = 963 \text{ kft} \quad \text{Factored (AASHTO 5.6.3.3)}$$

$$f_{cpe} = P_f (1/A + e/S) = 1.35 \text{ ksi}$$

$$P_f = A_{ps} f_{pse} = 372.60 \text{ k}$$

$$e = h/2 - x = 9.50 \text{ in}$$

$$f_{ps} = f_{pu} (1 - 0.28 c/d_p) = 254.55 \text{ ksi} \quad \text{(AASHTO 5.6.3.3)}$$

$$c = a/0.85 = 4.70 \text{ in}$$

$$d = h - x = 23.00 \text{ in}$$

$$a = A_{ps} f_{ps} / (0.85 f'_c{}^d b) = 4.00 \text{ in}^2$$

$$A_{ps} = 2.160 \text{ in}^2$$

$$\gamma_1 = 1.6 \quad \text{A615 Grade 60}$$

$$\gamma_2 = 1.2$$

$$f_r = 0.24 f'_c{}^{0.5} = 0.537 \text{ psi} \quad \text{(AASHTO 5.4.2.6)}$$

$$M_r = \phi M_n = 962 \text{ kft} \quad \text{(AASHTO 5.7.3.2.2)}$$

$$\phi = 1 \quad \text{(AASHTO 5.5.4.2)}$$

$$M_n = A_{ps} f_{ps} (d - a/2) = 962 \text{ kft}$$

$$FS = M_n / m_{cr} = 1.36$$

3 Proposed

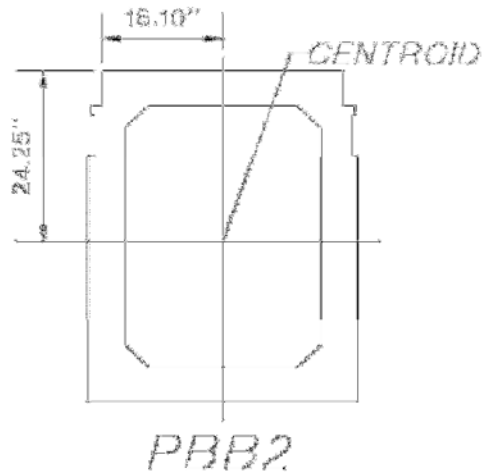
$$M_r \geq M_{cr}$$

$$m_{cr} = S_b (f_r + f_{cpe}) = 615.29 \text{ kft} \quad \text{Theoretical}$$

$M_{cr} = (\gamma_1 f_r + \gamma_2 f_{cpe}) S =$	812.32 kft	Factored (AASHTO 5.6.3.3)
$f_{pce} = P_f (1/A + e/S) =$	1.11 ksi	
$P_f = A_{ps} f_{pse} =$	306.02 k	
$e = h/2-x =$	9.50 in	
$f_{ps} = f_{pu} (1 - 0.28 c/d_p) =$	257.31 ksi	(AASHTO 5.6.3.3)
$c = a/0.85 =$	3.86 in	
$d = h - x =$	23.00 in	
$a = A_{ps} f_{ps}/(0.85 f'c b) =$	3.28 in ²	
$A_{ps} =$	1.774 in ²	0.99979
$\gamma_1 =$	1.6	A615 Grade 60
$\gamma_2 =$	1.2	
$f_r = 0.24 f'c^{0.5} h^{-0.15} =$	0.475 psi	(AASHTO 5.4.2.6)
$M_r = \phi M_n =$	812.49 kft	(AASHTO 5.7.3.2.2)
$\phi =$	1	(AASHTO 5.5.4.2)
$M_n = A_{ps} f_{ps} (d - a/2) =$	812.49 kft	
$FS = M_n/m_{cr} =$	1.32	

1 Section Properties

$h =$	47.00 in
$b_f =$	32.20 in
$t_d =$	5.00 in
$A =$	719 in ²
$I =$	196,298 in ⁴
$y_b =$	22.75 in
$f'_c{}^g =$	5.00 ksi
$f'_c{}^d =$	4.00 ksi
$f_y =$	60.00 ksi
$f_{pu} =$	270.00 ksi
$f_{pse} =$	172.50 ksi
Clearance centroid (x) =	4.00 in



$$S = I/y_b = 8,628 \text{ in}^3$$

$$f_r = 0.24 f'_c{}^{0.5} h^{-0.15} = 0.437 \text{ ksi} \quad \text{Theoretical}$$

2 AASHTO LRFD 5.6.3.3

$$M_r \geq M_{cr}$$

$$m_{cr} = S_b (f_r + f_{cpe}) = 1,129 \text{ kft} \quad \text{Theoretical}$$

$$M_{cr} = (\gamma_1 f_r + \gamma_2 f_{cpe}) S = 1,595 \text{ kft} \quad \text{Factored (AASHTO 5.6.3.3)}$$

$$f_{cpe} = P_f (1/A + e/S) = 1.13 \text{ ksi}$$

$$P_f = A_{ps} f_{pse} = 310.50 \text{ k}$$

$$e = h/2 - x = 19.50 \text{ in}$$

$$f_{ps} = f_{pu} (1 - 0.28 c/d_p) = 260.82 \text{ ksi} \quad \text{(AASHTO 5.6.3.3)}$$

$$c = a/0.85 = 5.22 \text{ in}$$

$$d = h - x = 43.00 \text{ in}$$

$$a = A_{ps} f_{ps} / (0.85 f'_c{}^d b) = 4.44 \text{ in}^2$$

$$A_{ps} = 1.800 \text{ in}^2$$

$$\gamma_1 = 1.6 \quad \text{A615 Grade 60}$$

$$\gamma_2 = 1.2$$

$$f_r = 0.24 f'_c{}^{0.5} = 0.537 \text{ psi} \quad \text{(AASHTO 5.4.2.6)}$$

$$M_r = \phi M_n = 1,595 \text{ kft} \quad \text{(AASHTO 5.7.3.2.2)}$$

$$\phi = 1 \quad \text{(AASHTO 5.5.4.2)}$$

$$M_n = A_{ps} f_{ps} (d - a/2) = 1,595 \text{ kft}$$

$$FS = M_n / m_{cr} = 1.41$$

3 Proposed

$$M_r \geq M_{cr}$$

$$m_{cr} = S_b (f_r + f_{cpe}) = 943.71 \text{ kft} \quad \text{Theoretical}$$

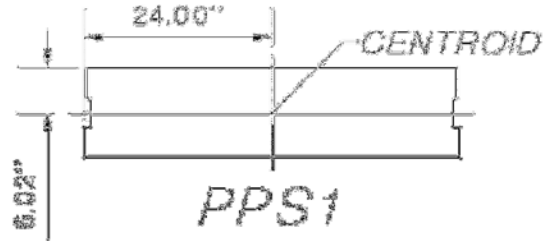
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PBB2

2018-02-01
JH

$M_{cr} = (\gamma_1 f_r + \gamma_2 f_{cpe}) S =$	1258.22 kft	Factored (AASHTO 5.6.3.3)
$f_{pce} = P_f (1/A + e/S) =$	0.88 ksi	
$P_f = A_{ps} f_{pse} =$	239.78 k	
$e = h/2-x =$	19.50 in	
$f_{ps} = f_{pu} (1 - 0.28 c/d_p) =$	262.91 ksi	(AASHTO 5.6.3.3)
$c = a/0.85 =$	4.03 in	
$d = h - x =$	43.00 in	
$a = A_{ps} f_{ps}/(0.85 f'c b) =$	3.43 in ²	
$A_{ps} =$	1.390 in ²	1.000728
$\gamma_1 =$	1.6	A615 Grade 60
$\gamma_2 =$	1.2	
$f_r = 0.24 f'c^{0.5} h^{-0.15} =$	0.437 psi	(AASHTO 5.4.2.6)
$M_r = \phi M_n =$	1257.31 kft	(AASHTO 5.7.3.2.2)
$\phi =$	1	(AASHTO 5.5.4.2)
$M_n = A_{ps} f_{ps} (d - a/2) =$	1257.31 kft	
$FS = M_n/m_{cr} =$	1.33	

1 Section Properties

h =	12.00 in
b =	48.00 in
A =	567 in ²
I =	6,852 in ⁴
y _b =	5.98 in
f' _c =	4.00 ksi
f _y =	60.00 ksi
f _{pu} =	270.00 ksi
f _{pse} =	172.50 ksi
Clearance centroid (x) =	4.00 in



$$S = I/y_b = 1,146 \text{ in}^3$$

$$f_r = 0.24 f'_c{}^{0.5} h^{-0.15} = 0.480 \text{ ksi} \quad \text{Theoretical}$$

2 AASHTO LRFD 5.6.3.3

$$M_r \geq M_{cr}$$

$$m_{cr} = s_b (f_r + f_{cpe}) = 91.49 \text{ kft} \quad \text{Theoretical}$$

$$M_{cr} = (\gamma_1 f_r + \gamma_2 f_{cpe}) S = 123.56 \text{ kft} \quad \text{Factored (AASHTO 5.6.3.3)}$$

$$f_{pce} = P_f (1/A + e/S) = 0.48 \text{ ksi}$$

$$P_f = A_{ps} f_{pse} = 136.28 \text{ k}$$

$$e = h/2 - x = 2.00 \text{ in}$$

$$f_{ps} = f_{pu} (1 - 0.28 c/d_p) = 255.47 \text{ ksi} \quad \text{(AASHTO 5.6.3.3)}$$

$$c = a/0.85 = 1.54 \text{ in}$$

$$d = h - x = 8.00 \text{ in}$$

$$a = A_{ps} f_{ps} / (0.85 f'_c b) = 1.31 \text{ in}^2$$

$$A_{ps} = 0.790 \text{ in}^2 \quad 1.00001$$

$$\gamma_1 = 1.6 \quad \text{A615 Grade 60}$$

$$\gamma_2 = 1.1$$

$$f_r = 0.24 f'_c{}^{0.5} = 0.480 \text{ psi} \quad \text{(AASHTO 5.4.2.6)}$$

$$M_r = \phi M_n = 123.56 \text{ kft} \quad \text{(AASHTO 5.7.3.2.2)}$$

$$\phi = 1 \quad \text{(AASHTO 5.5.4.2)}$$

$$M_n = A_{ps} f_{ps} (d - a/2) = 123.56 \text{ kft}$$

$$FS = M_n / m_{cr} = 1.35$$

3 Proposed

$$M_r \geq M_{cr}$$

$$m_{cr} = s_b (f_r + f_{cpe}) = 91.49 \text{ kft} \quad \text{Theoretical}$$

$$M_{cr} = (\gamma_1 f_r + \gamma_2 f_{cpe}) S = 123.56 \text{ kft} \quad \text{Factored (AASHTO 5.6.3.3)}$$

$$f_{pce} = P_f (1/A + e/S) = 0.48 \text{ ksi}$$

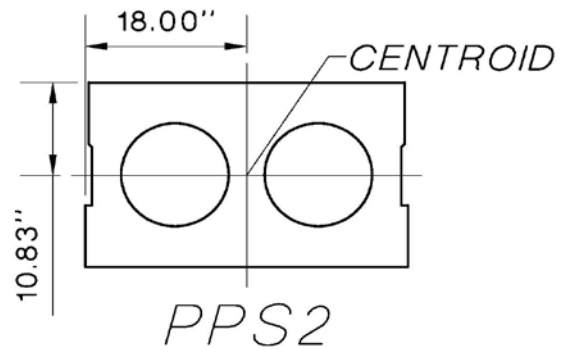
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$P_f = A_{ps} f_{pse} =$	136.28 k	
$e = h/2 - x =$	2.00 in	
$f_{ps} = f_{pu} (1 - 0.28 c/d_p) =$	255.47 ksi	(AASHTO 5.6.3.3)
$c = a/0.85 =$	1.54 in	
$d = h - x =$	8.00 in	
$a = A_{ps} f_{ps} / (0.85 f'_c b) =$	1.31 in ²	
$A_{ps} =$	0.790 in ²	1.00001
$\gamma_1 =$	1.6	A615 Grade 60
$\gamma_2 =$	1.1	
$f_r = 0.24 f'_c{}^{0.5} h^{-0.15} =$	0.480 psi	(AASHTO 5.4.2.6)
$M_r = \phi M_n =$	123.56 kft	(AASHTO 5.7.3.2.2)
$\phi =$	1	(AASHTO 5.5.4.2)
$M_n = A_{ps} f_{ps} (d - a/2) =$	123.56 kft	
$FS = M_n / m_{cr} =$	1.35	

1 Section Properties

$h =$	21.50 in
$b =$	36.00 in
$A =$	532 in ²
$I =$	27,433 in ⁴
$y_b =$	10.67 in
$f'_c =$	4.00 ksi
$f_y =$	60.00 ksi
$f_{pu} =$	270.00 ksi
$f_{pse} =$	172.50 ksi
Clearance centroid (x) =	4.00 in



$$S = I/y_b = 2,571 \text{ in}^3$$

$$f_r = 0.24 f'_c{}^{0.5} h^{-0.15} = 0.440 \text{ ksi} \quad \text{Theoretical}$$

2 AASHTO LRFD 5.6.3.3

$$M_r \geq M_{cr}$$

$$m_{cr} = s_b (f_r + f_{cpe}) = 314.88 \text{ kft} \quad \text{Theoretical}$$

$$M_{cr} = (\gamma_1 f_r + \gamma_2 f_{cpe}) S = 407.26 \text{ kft} \quad \text{Factored (AASHTO 5.6.3.3)}$$

$$f_{pce} = P_f (1/A + e/S) = 1.03 \text{ ksi}$$

$$P_f = A_{ps} f_{pse} = 228.56 \text{ k}$$

$$e = h/2 - x = 6.75 \text{ in}$$

$$f_{ps} = f_{pu} (1 - 0.28 c/d_p) = 255.15 \text{ ksi} \quad \text{(AASHTO 5.6.3.3)}$$

$$c = a/0.85 = 3.44 \text{ in}$$

$$d = h - x = 17.50 \text{ in}$$

$$a = A_{ps} f_{ps} / (0.85 f'_c b) = 2.92 \text{ in}^2$$

$$A_{ps} = 1.325 \text{ in}^2$$

$$\gamma_1 = 1.6 \quad \text{A615 Grade 60}$$

$$\gamma_2 = 1.1$$

$$f_r = 0.24 f'_c{}^{0.5} = 0.480 \text{ psi} \quad \text{(AASHTO 5.4.2.6)}$$

$$M_r = \phi M_n = 451.84 \text{ kft} \quad \text{(AASHTO 5.7.3.2.2)}$$

$$\phi = 1 \quad \text{(AASHTO 5.5.4.2)}$$

$$M_n = A_{ps} f_{ps} (d - a/2) = 451.84 \text{ kft}$$

$$FS = M_n / m_{cr} = 1.43$$

3 Proposed

$$M_r \geq M_{cr}$$

$$m_{cr} = s_b (f_r + f_{cpe}) = 286.90 \text{ kft} \quad \text{Theoretical}$$

$$M_{cr} = (\gamma_1 f_r + \gamma_2 f_{cpe}) S = 362.70 \text{ kft} \quad \text{Factored (AASHTO 5.6.3.3)}$$

$$f_{pce} = P_f (1/A + e/S) = 0.90 \text{ ksi}$$

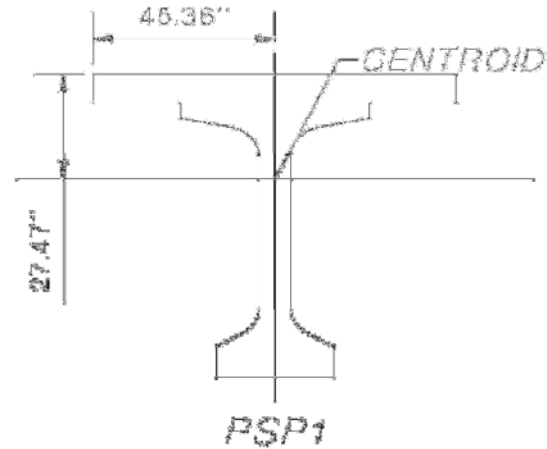
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PPS2

2018-02-01
JH

$P_f = A_{ps} f_{pse} =$	199.58 k	
$e = h/2 - x =$	6.75 in	
$f_{ps} = f_{pu} (1 - 0.28 c/d_p) =$	257.03 ksi	(AASHTO 5.6.3.3)
$c = a/0.85 =$	3.00 in	
$d = h - x =$	17.50 in	
$a = A_{ps} f_{ps} / (0.85 f'_c b) =$	2.55 in ²	
$A_{ps} =$	1.157 in ²	
$\gamma_1 =$	1.6	A615 Grade 60
$\gamma_2 =$	1.1	
$f_r = 0.24 f'_c{}^{0.5} h^{-0.15} =$	0.440 psi	(AASHTO 5.4.2.6)
$M_r = \phi M_n =$	402.06 kft	(AASHTO 5.7.3.2.2)
$\phi =$	1	(AASHTO 5.5.4.2)
$M_n = A_{ps} f_{ps} (d - a/2) =$	402.06 kft	
$FS = M_n / m_{cr} =$	1.40	

1 Section Properties

$h =$	79.50 in
$b_f =$	90.71 in
$t_d =$	7.50 in
$A =$	1,738 in ²
$I =$	1,365,255 in ⁴
$y_b =$	52.03 in
$f'_c{}^g =$	7.00 ksi
$f'_c{}^d =$	4.00 ksi
$f_y =$	60.00 ksi
$f_{pu} =$	270.00 ksi
$f_{pse} =$	172.50 ksi
Clearance centroid (x) =	8.00 in



$$S = I/y_b = 26,240 \text{ in}^3$$

$$f_r = 0.24 f'_c{}^{0.5} h^{-0.15} = 0.478 \text{ ksi} \quad \text{Theoretical}$$

2 AASHTO LRFD 5.6.3.3

$$M_r \geq M_{cr}$$

$$m_{cr} = S_b (f_r + f_{cpe}) = 3,032 \text{ kft} \quad \text{Theoretical}$$

$$M_{cr} = (\gamma_1 f_r + \gamma_2 f_{cpe}) S = 4,606 \text{ kft} \quad \text{Factored (AASHTO 5.6.3.3)}$$

$$f_{pce} = P_f (1/A + e/S) = 0.91 \text{ ksi}$$

$$P_f = A_{ps} f_{pse} = 508.88 \text{ k}$$

$$e = h/2 - x = 31.75 \text{ in}$$

$$f_{ps} = f_{pu} (1 - 0.28 c/d_p) = 266.79 \text{ ksi} \quad \text{(AASHTO 5.6.3.3)}$$

$$c = a/0.85 = 3.04 \text{ in}$$

$$d = h - x = 71.50 \text{ in}$$

$$a = A_{ps} f_{ps} / (0.85 f'_c{}^d b) = 2.58 \text{ in}^2$$

$$A_{ps} = 2.950 \text{ in}^2 \quad 1.0002$$

$$\gamma_1 = 1.6 \quad \text{A615 Grade 60}$$

$$\gamma_2 = 1.2$$

$$f_r = 0.24 f'_c{}^{0.5} = 0.635 \text{ psi} \quad \text{(AASHTO 5.4.2.6)}$$

$$M_r = \phi M_n = 4,605 \text{ kft} \quad \text{(AASHTO 5.7.3.2.2)}$$

$$\phi = 1 \quad \text{(AASHTO 5.5.4.2)}$$

$$M_n = A_{ps} f_{ps} (d - a/2) = 4,605 \text{ kft}$$

$$FS = M_n / m_{cr} = 1.52$$

3 Proposed

$$M_r \geq M_{cr}$$

$$m_{cr} = S_b (f_r + f_{cpe}) = 2517.08 \text{ kft} \quad \text{Theoretical}$$

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$M_{cr} = (\gamma_1 f_r + \gamma_2 f_{cpe}) S =$	3438.73 kft	Factored (AASHTO 5.6.3.3)
$f_{pce} = P_f (1/A + e/S) =$	0.67 ksi	
$P_f = A_{ps} f_{pse} =$	376.91 k	
$e = h/2-x =$	31.75 in	
$f_{ps} = f_{pu} (1 - 0.28 c/d_p) =$	267.62 ksi	(AASHTO 5.6.3.3)
$c = a/0.85 =$	2.25 in	
$d = h - x =$	71.50 in	
$a = A_{ps} f_{ps}/(0.85 f'c b) =$	1.91 in ²	
$A_{ps} =$	2.185 in ²	1.000347
$\gamma_1 =$	1.6	A615 Grade 60
$\gamma_2 =$	1.2	
$f_r = 0.24 f'c^{0.5} h^{-0.15} =$	0.478 psi	(AASHTO 5.4.2.6)
$M_r = \phi M_n =$	3437.54 kft	(AASHTO 5.7.3.2.2)
$\phi =$	1	(AASHTO 5.5.4.2)
$M_n = A_{ps} f_{ps} (d - a/2) =$	3437.54 kft	
$FS = M_n/m_{cr} =$	1.37	

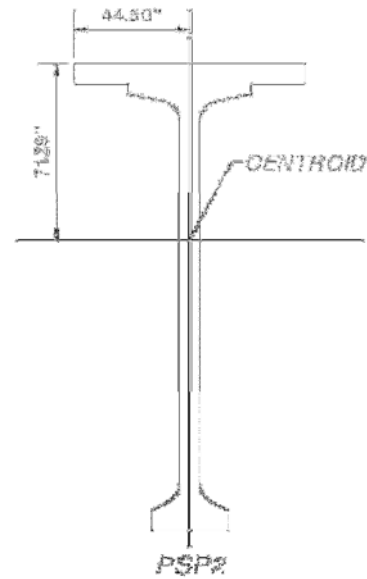
1 Section Properties

$h =$	188.50 in
$b_f =$	88.99 in
$t_d =$	8.50 in
$A =$	2,664 in ²
$I =$	12,160,104 in ⁴
$y_b =$	117.21 in
$f'_c{}^g =$	10.00 ksi
$f'_c{}^d =$	5.50 ksi
$f_y =$	60.00 ksi
$f_{pu} =$	270.00 ksi
$f_{pse} =$	172.50 ksi
Clearance centroid (x) =	12.00 in

$$S = I/y_b = 103,746 \text{ in}^3$$

$$f_r = 0.24 f'_c{}^{0.5} h^{-0.15} = 0.502 \text{ ksi}$$

Theoretical



2 AASHTO LRFD 5.6.3.3

$M_r \geq M_{cr}$		
$m_{cr} = S_b (f_r + f_{cpe}) =$	14,436 kft	Theoretical
$M_{cr} = (\gamma_1 f_r + \gamma_2 f_{cpe}) S =$	22,613 kft	Factored (AASHTO 5.6.3.3)
$f_{pce} = P_f (1/A + e/S) =$	1.17 ksi	
$P_f = A_{ps} f_{pse} =$	999.64 k	
$e = h/2 - x =$	82.25 in	
$f_{ps} = f_{pu} (1 - 0.28 c/d_p) =$	268.10 ksi	(AASHTO 5.6.3.3)
$c = a/0.85 =$	4.42 in	
$d = h - x =$	176.50 in	
$a = A_{ps} f_{ps} / (0.85 f'_c{}^d b) =$	3.76 in ²	
$A_{ps} =$	5.795 in ²	1.000196
$\gamma_1 =$	1.6	A615 Grade 60
$\gamma_2 =$	1.2	
$f_r = 0.24 f'_c{}^{0.5} =$	0.759 psi	(AASHTO 5.4.2.6)
$M_r = \phi M_n =$	22,608 kft	(AASHTO 5.7.3.2.2)
$\phi =$	1	(AASHTO 5.5.4.2)
$M_n = A_{ps} f_{ps} (d - a/2) =$	22,608 kft	
$FS = M_n / m_{cr} =$	1.57	

3 Proposed

$M_r \geq M_{cr}$		
$m_{cr} = S_b (f_r + f_{cpe}) =$	10,935 kft	Theoretical

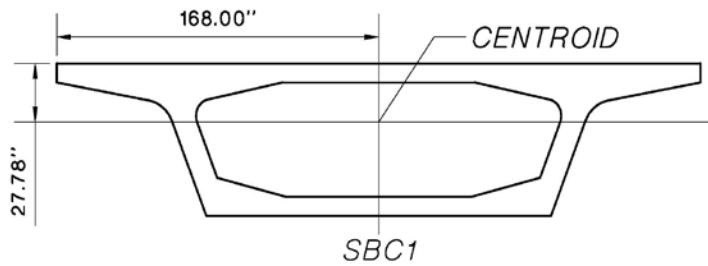
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$M_{cr} = (\gamma_1 f_r + \gamma_2 f_{cpe}) S =$	14,858 kft	Factored (AASHTO 5.6.3.3)
$f_{pce} = P_f (1/A + e/S) =$	0.76 ksi	
$P_f = A_{ps} f_{pse} =$	652.91 k	
$e = h/2-x =$	82.25 in	
$f_{ps} = f_{pu} (1 - 0.28 c/d_p) =$	268.76 ksi	(AASHTO 5.6.3.3)
$c = a/0.85 =$	2.89 in	
$d = h - x =$	176.50 in	
$a = A_{ps} f_{ps}/(0.85 f'c b) =$	2.46 in ²	
$A_{ps} =$	3.785 in ²	0.999992
$\gamma_1 =$	1.6	A615 Grade 60
$\gamma_2 =$	1.2	
$f_r = 0.24 f'c^{0.5} h^{-0.15} =$	0.502 psi	(AASHTO 5.4.2.6)
$M_r = \phi M_n =$	14,858 kft	(AASHTO 5.7.3.2.2)
$\phi =$	1	(AASHTO 5.5.4.2)
$M_n = A_{ps} f_{ps} (d - a/2) =$	14,858 kft	
$FS = M_n/m_{cr} =$	1.36	

1 Section Properties

h =	72.00 in
b =	336.00 in
A =	7,471 in ²
I =	5,269,584 in ⁴
y _b =	44.29 in
f' _c =	4.00 ksi
f _y =	60.00 ksi
f _{pu} =	270.00 ksi
f _{pse} =	172.50 ksi
Clearance centroid (x) =	4.00 in



$S = I/y_b =$	118,979 in ³	
$f_r = 0.24 f'_c{}^{0.5} h^{-0.15} =$	0.367 ksi	Theoretical

2 AASHTO LRFD 5.6.3.3

$M_r \geq M_{cr}$			
$m_{cr} = s_b (f_r + f_{cpe}) =$	8,949 kft	Theoretical	
$M_{cr} = (\gamma_1 f_r + \gamma_2 f_{cpe}) S =$	11,554 kft	Factored (AASHTO 5.6.3.3)	
$f_{pce} = P_f (1/A + e/S) =$	0.54 ksi		
$P_f = A_{ps} f_{pse} =$	1329.98 k		
$e = h/2 - x =$	32.00 in		
$f_{ps} = f_{pu} (1 - 0.28 c/d_p) =$	267.62 ksi	(AASHTO 5.6.3.3)	
$c = a/0.85 =$	2.14 in		
$d = h - x =$	68.00 in		
$a = A_{ps} f_{ps} / (0.85 f'_c b) =$	1.82 in ²		
$A_{ps} =$	7.710 in ²		
$\gamma_1 =$	1.2		
$\gamma_2 =$	1.1		
$f_r = 0.24 f'_c{}^{0.5} =$	0.480 psi	(AASHTO 5.4.2.6)	7.64853
$M_r = \phi M_n =$	11,536 kft	(AASHTO 5.7.3.2.2)	
$\phi =$	1	(AASHTO 5.5.4.2)	
$M_n = A_{ps} f_{ps} (d - a/2) =$	11,536 kft		
$FS = M_n / m_{cr} =$	1.29		

3 Proposed

$M_r \geq M_{cr}$		
$m_{cr} = s_b (f_r + f_{cpe}) =$	7,647 kft	Theoretical
$f_{pce} = P_f (1/A + e/S) =$	0.40 ksi	

$$M_{cr} = (\gamma_1 f_r + \gamma_2 f_{cpe}) S =$$

8,776 kft

Factored (AASHTO 5.6.3.3)

$$f_{pce} = P_f (1/A + e/S) =$$

0.40 ksi

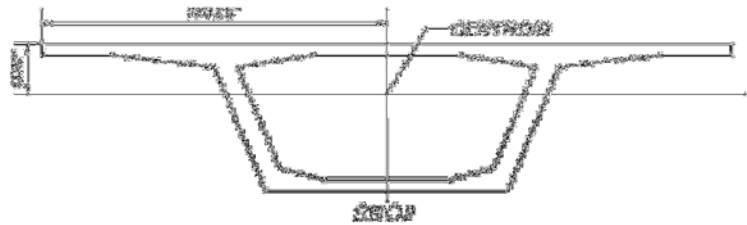
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$$\begin{aligned} P_f &= A_{ps} f_{pse} = && 1003.95 \text{ k} \\ e &= h/2 - x = && 32.00 \text{ in} \\ f_{ps} &= f_{pu} (1 - 0.28 c/d_p) = && 268.20 \text{ ksi} && (\text{AASHTO 5.6.3.3}) \\ c &= a/0.85 = && 1.62 \text{ in} \\ d &= h - x = && 68.00 \text{ in} \\ a &= A_{ps} f_{ps} / (0.85 f'_c b) = && 1.38 \text{ in}^2 \\ A_{ps} &= && 5.820 \text{ in}^2 \\ \gamma_1 &= && 1.2 \\ \gamma_2 &= && 1.1 \\ f_r &= 0.24 f'_c{}^{0.5} h^{-0.15} = && 0.367 \text{ psi} && (\text{AASHTO 5.4.2.6}) \\ M_r &= \phi M_n = && 8,756 \text{ kft} && (\text{AASHTO 5.7.3.2.2}) \\ \phi &= && 1 && (\text{AASHTO 5.5.4.2}) \\ M_n &= A_{ps} f_{ps} (d - a/2) = && 8,756 \text{ kft} \\ FS &= M_n / m_{cr} = && 1.14 \end{aligned}$$

1 Section Properties

$h =$	120.00 in
$b =$	540.00 in
$A =$	12,020 in ²
$I =$	23,216,473 in ⁴
$y_b =$	78.78 in
$f'_c =$	7.00 ksi
$f_y =$	60.00 ksi
$f_{pu} =$	270.00 ksi
$f_{pse} =$	172.50 ksi
Clearance centroid (x) =	10.00 in



$S = I/y_b =$	294,700 in ³	
$f_r = 0.24 f'_c{}^{0.5} h^{-0.15} =$	0.450 ksi	Theoretical

2 AASHTO LRFD 5.6.3.3

$M_r \geq M_{cr}$		
$m_{cr} = s_b (f_r + f_{cpe}) =$	26,786 kft	Theoretical
$M_{cr} = (\gamma_1 f_r + \gamma_2 f_{cpe}) S =$	36,034 kft	Factored (AASHTO 5.6.3.3)
$f_{pce} = P_f (1/A + e/S) =$	0.64 ksi	
$P_f = A_{ps} f_{pse} =$	2535.75 k	
$e = h/2 - x =$	50.00 in	
$f_{ps} = f_{pu} (1 - 0.28 c/d_p) =$	269.00 ksi	(AASHTO 5.6.3.3)
$c = a/0.85 =$	1.45 in	
$d = h - x =$	110.00 in	
$a = A_{ps} f_{ps} / (0.85 f'_c b) =$	1.24 in ²	
$A_{ps} =$	14.700 in ²	
$\gamma_1 =$	1.2	
$\gamma_2 =$	1.1	
$f_r = 0.24 f'_c{}^{0.5} =$	0.635 psi	(AASHTO 5.4.2.6)
$M_r = \phi M_n =$	36,044 kft	(AASHTO 5.7.3.2.2)
$\phi =$	1	(AASHTO 5.5.4.2)
$M_n = A_{ps} f_{ps} (d - a/2) =$	36,044 kft	
$FS = M_n / m_{cr} =$	1.35	

3 Proposed

$M_r \geq M_{cr}$		
$m_{cr} = s_b (f_r + f_{cpe}) =$	22,127 kft	Theoretical
$M_{cr} = (\gamma_1 f_r + \gamma_2 f_{cpe}) S =$	25,443 kft	Factored (AASHTO 5.6.3.3)
$f_{pce} = P_f (1/A + e/S) =$	0.45 ksi	

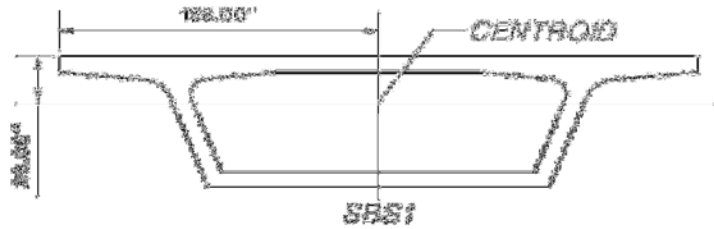
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$$\begin{aligned} P_f &= A_{ps} f_{pse} = 1785.38 \text{ k} \\ e &= h/2 - x = 50.00 \text{ in} \\ f_{ps} &= f_{pu} (1 - 0.28 c/d_p) = 269.30 \text{ ksi} \quad (\text{AASHTO 5.6.3.3}) \\ c &= a/0.85 = 1.02 \text{ in} \\ d &= h - x = 110.00 \text{ in} \\ a &= A_{ps} f_{ps} / (0.85 f'_c b) = 0.87 \text{ in}^2 \\ A_{ps} &= 10.350 \text{ in}^2 \\ \gamma_1 &= 1.2 \\ \gamma_2 &= 1.1 \\ f_r &= 0.24 f'_c{}^{0.5} h^{-0.15} = 0.450 \text{ psi} \quad (\text{AASHTO 5.4.2.6}) \\ M_r &= \phi M_n = 25,449 \text{ kft} \quad (\text{AASHTO 5.7.3.2.2}) \\ \phi &= 1 \quad (\text{AASHTO 5.5.4.2}) \\ M_n &= A_{ps} f_{ps} (d - a/2) = 25,449 \text{ kft} \\ FS &= M_n / m_{cr} = 1.15 \end{aligned}$$

1 Section Properties

$h =$	72.00 in
$b =$	336.00 in
$A =$	6,259 in ²
$I =$	4,565,870 in ⁴
$y_b =$	45.94 in
$f'_c =$	7.00 ksi
$f_y =$	60.00 ksi
$f_{pu} =$	270.00 ksi
$f_{pse} =$	172.50 ksi
$l_e =$	100.00 ft
Clearance centroid (x) =	10.00 in



$S = I/y_b =$	99,388 in ³	
$f_r = 0.24 f'_c{}^{0.5} h^{-0.15} =$	0.485 ksi	Theoretical

2 AASHTO LRFD 5.6.3.3

$M_r \geq M_{cr}$		
$m_{cr} = S_b (f_r + f_{cpe}) =$	11,515 kft	Theoretical
$M_{cr} = (\gamma_1 f_r + \gamma_2 f_{cpe}) S =$	13,806 kft	Factored (AASHTO 5.6.3.3)
$f_{pce} = P_f (1/A + e/S) =$	0.90 ksi	
$P_f = A_{ps} f_{pse} =$	2147.63 k	
$e = h/2 - x =$	26.00 in	
$f_{ps} = f_{pe} + 900 (d - c)/l_e =$	217.52 ksi	(AASHTO 5.6.3.3)
$c = a/0.85 =$	1.98 in	
$d = h - x =$	62.00 in	
$a = A_{ps} f_{ps} / (0.85 f'_c b) =$	1.68 in ²	
$A_{ps} =$	12.450 in ²	
$\gamma_1 =$	1.2	
$\gamma_2 =$	1	
$f_r = 0.24 f'_c{}^{0.5} =$	0.635 psi	(AASHTO 5.4.2.6)
$M_r = \phi M_n =$	13,802 kft	(AASHTO 5.7.3.2.2)
$\phi =$	1	(AASHTO 5.5.4.2)
$M_n = A_{ps} f_{ps} (d - a/2) =$	13,802 kft	
$FS = M_n / m_{cr} =$	1.20	

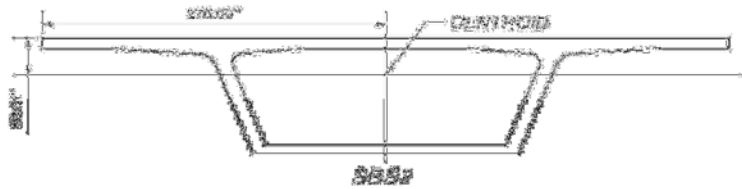
3 Proposed

$M_r \geq M_{cr}$		
$m_{cr} = S_b (f_r + f_{cpe}) =$	10,479 kft	Theoretical
$M_{cr} = (\gamma_1 f_r + \gamma_2 f_{cpe}) S =$	11,929 kft	Factored (AASHTO 5.6.3.3)

$$\begin{aligned}
 f_{pce} &= P_f (1/A + e/S) = && 0.78 \text{ ksi} \\
 P_f &= A_{ps} f_{pse} = && 1850.93 \text{ k} \\
 e &= h/2-x = && 26.00 \text{ in} \\
 f_{ps} &= f_{pe} + 900 (d - c)/l_e = && 217.72 \text{ ksi} && (\text{AASHTO 5.6.3.3}) \\
 c &= a/0.85 = && 1.70 \text{ in} \\
 d &= h - x = && 62.00 \text{ in} \\
 a &= A_{ps} f_{ps}/(0.85 f'c b) = && 1.45 \text{ in}^2 \\
 A_{ps} &= && 10.730 \text{ in}^2 \\
 \gamma_1 &= && 1.2 \\
 \gamma_2 &= && 1.1 \\
 f_r &= 0.24 f'c^{0.5} h^{-0.15} = && 0.485 \text{ psi} && (\text{AASHTO 5.4.2.6}) \\
 \\
 M_r &= \phi M_n = && 11,929 \text{ kft} && (\text{AASHTO 5.7.3.2.2}) \\
 \phi &= && 1 && (\text{AASHTO 5.5.4.2}) \\
 M_n &= A_{ps} f_{ps} (d - a/2) = && 11,929 \text{ kft} \\
 \\
 FS &= M_n/m_{cr} = && 1.14
 \end{aligned}$$

1 Section Properties

$h =$	96.00 in
$b =$	540.00 in
$A =$	9,355 in ²
$I =$	11,744,490 in ⁴
$y_b =$	65.49 in
$f'_c =$	7.00 ksi
$f_y =$	60.00 ksi
$f_{pu} =$	270.00 ksi
$f_{pse} =$	172.50 ksi
$l_e =$	150.00 ft
Clearance centroid (x) =	10.00 in



$S = I/y_b =$	179,333 in ³	
$f_r = 0.24 f'_c{}^{0.5} h^{-0.15} =$	0.465 ksi	Theoretical

2 AASHTO LRFD 5.6.3.3

$M_r \geq M_{cr}$		
$m_{cr} = S_b (f_r + f_{cpe}) =$	20,227 kft	Theoretical
$M_{cr} = (\gamma_1 f_r + \gamma_2 f_{cpe}) S =$	24,668 kft	Factored (AASHTO 5.6.3.3)
$f_{pce} = P_f (1/A + e/S) =$	0.89 ksi	
$P_f = A_{ps} f_{pse} =$	2787.60 k	
$e = h/2 - x =$	38.00 in	
$f_{ps} = f_{pe} + 900 (d - c)/l_e =$	214.70 ksi	(AASHTO 5.6.3.3)
$c = a/0.85 =$	1.60 in	
$d = h - x =$	86.00 in	
$a = A_{ps} f_{ps}/(0.85 f'_c b) =$	1.36 in ²	
$A_{ps} =$	16.160 in ²	
$\gamma_1 =$	1.2	
$\gamma_2 =$	1	
$f_r = 0.24 f'_c{}^{0.5} =$	0.635 psi	(AASHTO 5.4.2.6)
$M_r = \phi M_n =$	24,669 kft	(AASHTO 5.7.3.2.2)
$\phi =$	1	(AASHTO 5.5.4.2)
$M_n = A_{ps} f_{ps} (d - a/2) =$	24,669 kft	
$FS = M_n/m_{cr} =$	1.22	

3 Proposed

$M_r \geq M_{cr}$		
$m_{cr} = S_b (f_r + f_{cpe}) =$	17,877 kft	Theoretical
$M_{cr} = (\gamma_1 f_r + \gamma_2 f_{cpe}) S =$	20,359 kft	Factored (AASHTO 5.6.3.3)

$$\begin{aligned}
 f_{pce} &= P_f (1/A + e/S) = && 0.73 \text{ ksi} \\
 P_f &= A_{ps} f_{pse} = && 2294.25 \text{ k} \\
 e &= h/2-x = && 38.00 \text{ in} \\
 f_{ps} &= f_{pe} + 900 (d - c)/l_e = && 214.84 \text{ ksi} && (\text{AASHTO 5.6.3.3}) \\
 c &= a/0.85 = && 1.31 \text{ in} \\
 d &= h - x = && 86.00 \text{ in} \\
 a &= A_{ps} f_{ps}/(0.85 f'c b) = && 1.12 \text{ in}^2 \\
 A_{ps} &= && 13.300 \text{ in}^2 \\
 \gamma_1 &= && 1.2 \\
 \gamma_2 &= && 1.1 \\
 f_r &= 0.24 f'c^{0.5} h^{-0.15} = && 0.465 \text{ psi} && (\text{AASHTO 5.4.2.6}) \\
 \\ \\
 M_r &= \phi M_n = && 20,345 \text{ kft} && (\text{AASHTO 5.7.3.2.2}) \\
 \phi &= && 1 && (\text{AASHTO 5.5.4.2}) \\
 M_n &= A_{ps} f_{ps} (d - a/2) = && 20,345 \text{ kft} \\
 \\ \\
 FS &= M_n/m_{cr} = && 1.14
 \end{aligned}$$