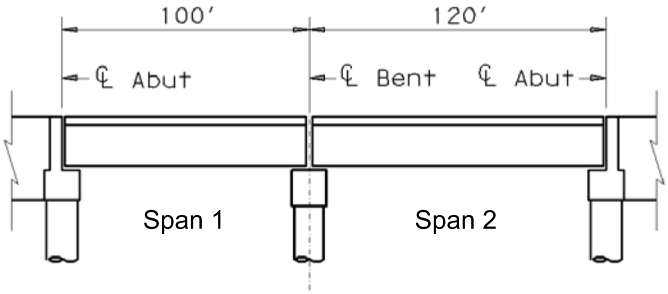
Design Parameters



Span 1

100' Type IV Beams (0.821 $^{k}/_{ft}$)

5 Beams Spaced @ 8.50' with 3' overhangs

Span 2

120' Type IV Beams (0.821 $^{k}/_{ft}$)

6 Beams Spaced @ 6.80' with 3' overhangs

All Spans

The basic bridge geometry can be found on the Bridge Layout (in the Appendixes).

Deck is 40ft wide
Type T501 Rail (0.326k/ft)
8" Thick Slab (0.100 ksf)
Assume 2" Overlay @ 140 pcf (0.023 ksf)
Use Class "C" Concrete

f'_c=3.60 ksi

w_c=150 pcf (for weight)

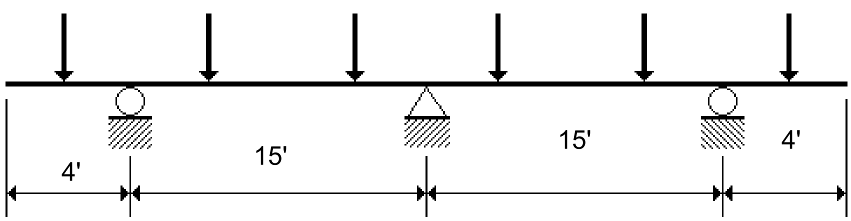
w_c=145 pcf (for Modulus of Elasticity calculation)

Grade 60 Reinforcing

F_y=60 ksi

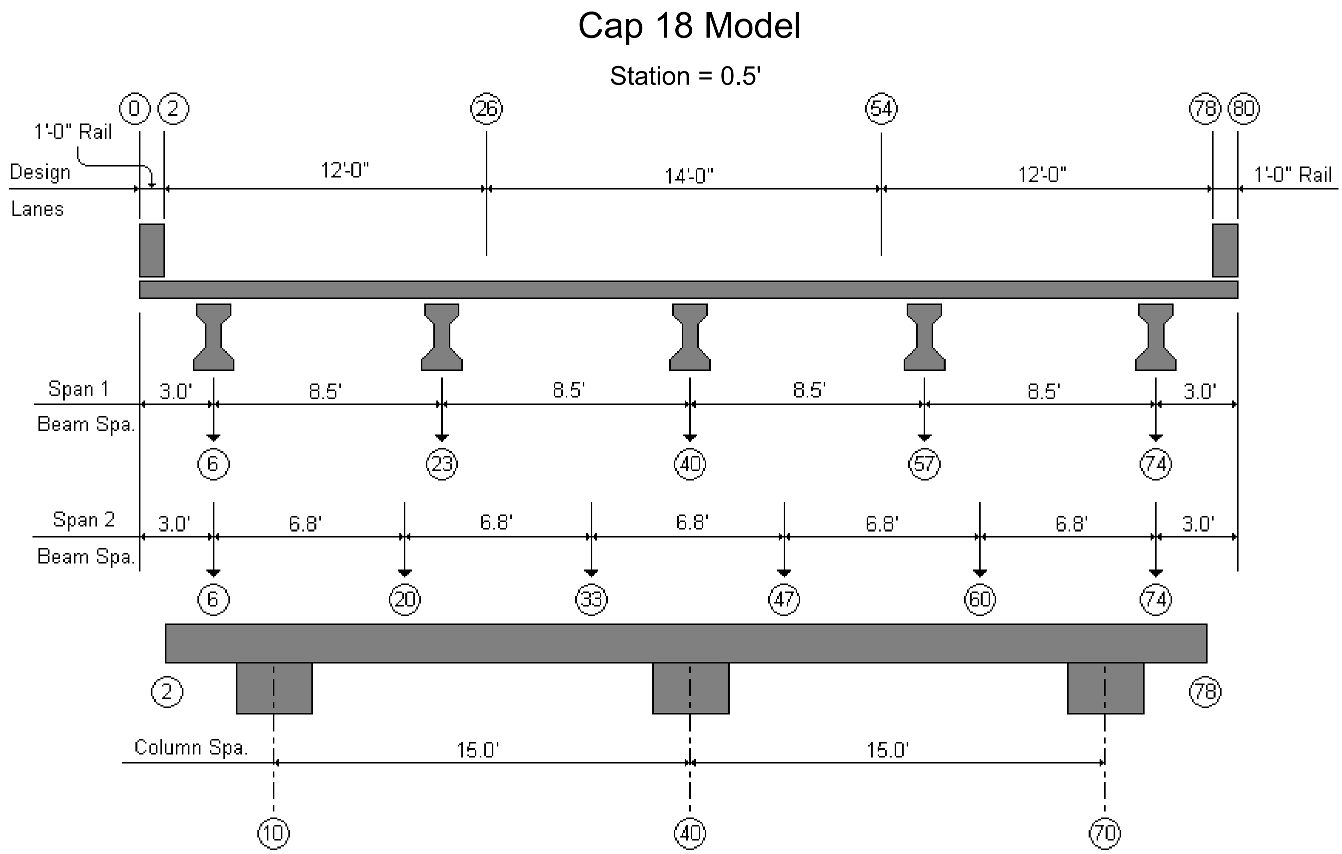
Assume

3'-3" X 3'-6" Cap
3 Columns Spaced @ 15'-0"
Cap will be modeled as a continuous beam with simple supports using TxDOT's CAP18 program.



TxDOT does not consider frame action for typical multi-column bents.

LRFD Cap Design Example



The circled numbers are the stations that will be used in the CAP 18 input file. One station is 0.5ft in the direction perpendicular to the pgl, not parallel to the bent.

Back Span	Forward Span		
Span1 := 100ft	Span2 := 120ft	RailWt := 0.326klf	
BmSpa1 := 8.5ft	BmSpa2 := 6.8ft	SlabThk := 8in	
BmNo1 := 5	BmNo2 := 6	OverlayThk := 2in	
BmWt1 := 0.821klf	BmWt2 := 0.821klf	IM := 0.33	*Dynamic load allowance, LRFD 3.6.2*

Cap Properties:

CapWidth := 3ft + 3in — CapWidth = 39.00 in

CapDepth := 3ft + 6in — CapDepth = 42.00 in

cover := 2.25in — *Measured from Center of stirrup.*

station := 0.5ft — *Station increment for CAP18.*

$f_c := 3.60\text{ksi}$

$w_c := 0.145\text{kcf}$ — *This w_c is used for the calculation of the Modulus of Elasticity only.*

$$E_c := 33000\text{ksi}\cdot\left(\frac{w_c}{1\text{kcf}}\right)^{1.5}\cdot\sqrt{\frac{f_c}{\text{ksi}}} \qquad E_c = 3457\,\text{ksi}$$

LRFD Eq. 5.4.2.4-1

$E_s := 29000\text{ksi}$

$$I_{cap} := \frac{1}{12}\cdot CapWidth\cdot CapDepth^3 \qquad I_{cap} = 2.41\times10^5\,\text{in}^4$$

$$E_c\cdot I_{cap} = 8.32\times10^8\,\text{kip}\cdot\text{in}^2 \;/\; \left(12\,\frac{\text{in}}{\text{ft}}\right)^2 = \qquad E_c\cdot I_{cap} = 5.78\times10^6\,\text{kip}\cdot\text{ft}^2$$

Dead Load

$$kcf := 1\frac{kip}{ft^3}$$

SPAN 1

$$Rail1 := \frac{2 \cdot RailWt \cdot \frac{Span1}{2}}{\min(BmNo1, 6)}$$ $$Rail1 = 6.52\frac{kip}{beam}$$

Rail weight is distributed evenly among stringers, up to 3 stringers per rail.

$$Slab1 := 0.150kcf\, BmSpa1 \cdot SlabThk \cdot \frac{Span1}{2} \cdot 1.05$$ $$Slab1 = 44.62\frac{kip}{beam}$$

Increase slab DL by 5% to account for haunch and thickened ends.

$$Beam1 := BmWt1 \cdot \frac{Span1}{2}$$ $$Beam1 = 41.05\frac{kip}{beam}$$

$$DLRxn1 := Rail1 + Slab1 + Beam1$$ $$DLRxn1 = 92.19\frac{kip}{beam}$$

Overlay is inputted separately, because it has a different load factor than the rest of the dead loads.

$$Overlay1 := 0.140kcf \cdot BmSpa1 \cdot OverlayThk \cdot \frac{Span1}{2}$$ $$Overlay1 = 9.92\frac{kip}{beam}$$

Design for future overlay.

SPAN 2

For bents with different beam spacings forward and back, TXDOT standard design procedure requires *two* *CAP18 problems as follows:*

Problem 1*, Table 3 describes stringers for SPAN 1 only.*

Problem 2*, same as problem 1 except hold envelopes from problem 1 and on Table 3 describe stringers for SPAN 2 only. Use problem 2 results.*

$$Rail2 := \frac{2 \cdot RailWt \cdot \frac{Span2}{2}}{\min(BmNo2, 6)}$$ $$Rail2 = 6.52\frac{kip}{beam}$$

$$Slab2 := 0.150kcf \cdot BmSpa2 \cdot SlabThk \cdot \frac{Span2}{2} \cdot 1.05$$ $$Slab2 = 42.84\frac{kip}{beam}$$

$$Beam2 := BmWt2 \cdot \frac{Span2}{2}$$ $$Beam2 = 49.26\frac{kip}{beam}$$

$$DLRxn2 := Rail2 + Slab2 + Beam2$$ $$DLRxn2 = 98.62\frac{kip}{beam}$$

$$Overlay2 := 0.140kcf \cdot BmSpa2 \cdot OverlayThk \cdot \frac{Span2}{2}$$ $$Overlay2 = 9.52\frac{kip}{beam}$$

CAP

$$Cap := 0.150kcf \cdot CapWidth \cdot CapDepth$$ $$Cap = 1.706\frac{kip}{ft} * \frac{0.5ft}{station} = Cap = 0.853\frac{kip}{station}$$

Cap 18 Live Load Model

Live Load *LRFD 3.6.1.2.2 and 3.6.1.2.4*

LongSpan := max(Span1, Span2)

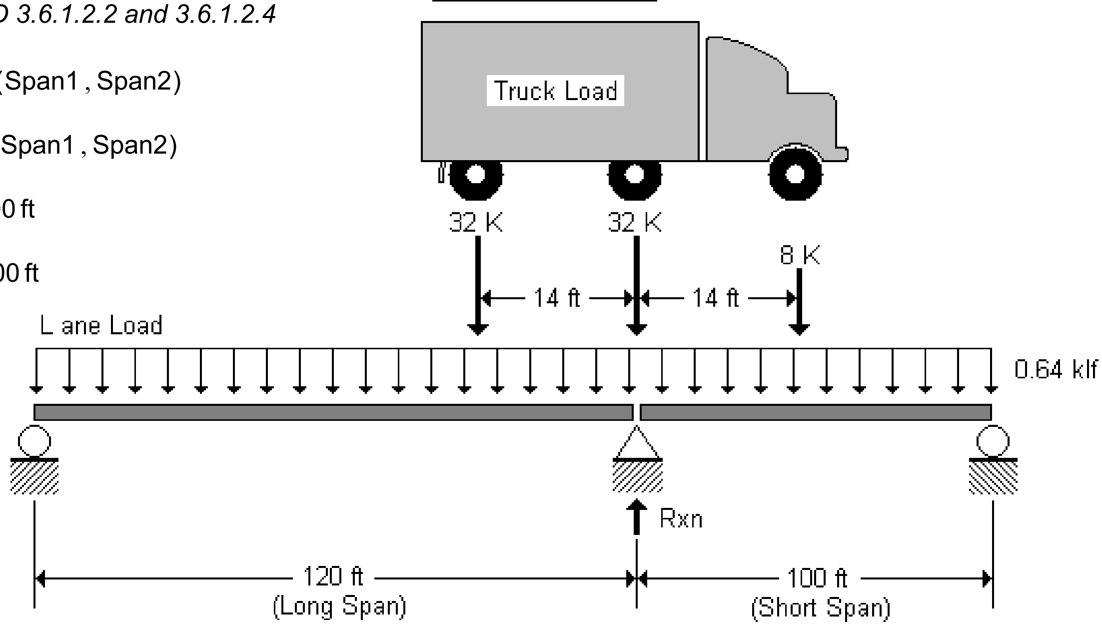
ShortSpan := min(Span1, Span2)

LongSpan = 120.00 ft

ShortSpan = 100.00 ft

IM = 0.33

Live Load Model



$$Lane := 0.64klf \cdot \left(\frac{LongSpan + ShortSpan}{2}\right)$$

$$Lane = 70.40 \frac{kip}{lane}$$

$$Truck := 32.0kip + 32.0kip \cdot \left(\frac{LongSpan - 14ft}{LongSpan}\right) + 8.0kip \cdot \left(\frac{ShortSpan - 14ft}{ShortSpan}\right)$$

$$Truck = 67.15 \frac{kip}{lane}$$

$$LLRxn := Lane + Truck \cdot (1 + IM)$$

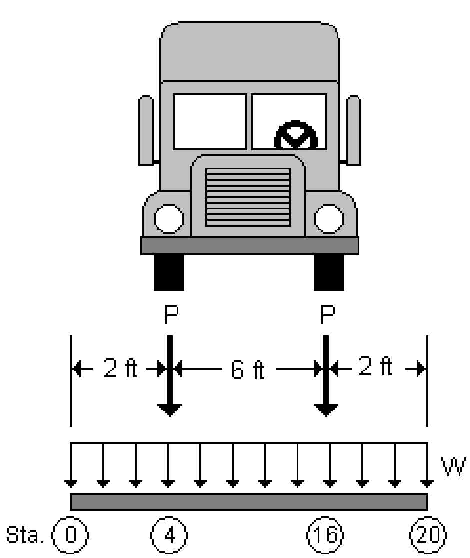
$$LLRxn = 159.71 \frac{kip}{lane}$$

Use HL-93 Live Load. For maximum reaction at interior bents, "Design Truck" will always govern over "Design Tandem". For the maximum reaction, place the middle (32 kip) axle over the support, the front (8 kip) axle on the short span and the rear (32 kip) axle on the long span.

Combine "Design Truck" and "Design Lane" loadings. LRFD 3.6.1.3

Dynamic load allowance, IM, does not apply to "Design Lane." LRFD 3.6.1.2.4

Cap 18 Live Load Model



$$P := 16.0kip \cdot (1 + IM)$$

$$P = 21.28\ kip$$

$$W := \frac{LLRxn - (2 \cdot P)}{10ft}$$

$$W = 11.71 \frac{kip}{ft} * \frac{0.5ft}{station} =$$

$$W = 5.86 \frac{kip}{station}$$

TXDOT practice has been to model live load as two 16kip wheel loads increased by maximum impact with the remainder of the live load to be distributed over a 10ft design lane width. It is reasonable to continue this for LRFD.

Cap 18 Data Input

Input "Multiple Presence Factors" into Cap18 as "Load Reduction Factors".

Multiple Presence Factors, m *LRFD 3.6.1.1.2*

No. of Lanes	Factor "m"
1	1.20
2	1.00
3	0.85
>3	0.65

Limit States *LRFD 3.4.1*

For cap design, need only to consider Strength I and Service I.

Strength I

Live Load and Dynamic Load Allowance LL + IM = 1.75

Dead Load Components DC = 1.25

Dead Load Wearing Surface (Overlay) DW = 1.50

Use Dead Load factor = 1.25, Dead Load Wearing Surface factor = 1.50 and Live Load factor = 1.75.

Service I

Live Load and Dynamic Load Allowance LL + IM = 1.00

Dead Load and Wearing Surface DC & DW = 1.00

Use Dead Load factor = 1.00 and Live Load factor = 1.00.

Dead Load

TXDOT considers Service level Dead Load only.

The Cap 18 input file is located in the appendixes.

Summary of CAP18 Input problem cards:

Problem 1- *Bridge defined with Span 1 beam spacing.*

Problem 2- *Bridge defined with Span 2 beam spacing and envelopes held from previous problem.*

Cap 18 Output

	Max +M	Max -M
Dead Load	posDL := 389.0kip·ft	negDL := –596.9kip·ft
Service	posServ := 778.0kip·ft	negServ := –906.8kip·ft
Ultimate	posUlt := 1175.5kip·ft	negUlt := –1301.0kip·ft

These loads are the maximum loads form the Cap 18 Output File located in the appendixes.

$M_{dl} := \max(\text{posDL}, |\text{negDL}|)$ $M_{dl} = 596.9\ \text{kip}\cdot\text{ft}$

$M_s := \max(\text{posServ}, |\text{negServ}|)$ $M_s = 906.8\ \text{kip}\cdot\text{ft}$

$M_u := \max(\text{posUlt}, |\text{negUlt}|)$ $M_u = 1301.0\ \text{kip}\cdot\text{ft}$

Minimum Flexural Reinforcement *LRFD 5.7.3.3.2*

Factored Flexural Resistance, M_r, must be greater than or equal to the lesser of 1.2 M_{cr} (Cracking Moment) or 1.33 Mu (Ultimate Moment)

where

Gross Moment of Inertia:

$$I_g := \frac{CapWidth \cdot CapDepth^3}{12} \qquad I_g = 2.41 \times 10^5\,in^4$$

Modulus of Rupture:

$$f_r := 0.24ksi \cdot \sqrt{\frac{f_c}{ksi}} \qquad f_r = 0.455\,ksi$$

LRFD 5.4.2.6

Distance from Center of Gravity to extreme tension fiber:

$$y_t := \frac{1}{2} \cdot CapDepth \qquad y_t = 21.00\,in$$

Section Modulus:

$$S := \frac{I_g}{y_t} \qquad S = 1.15 \times 10^4\,in^3$$

Cracking Moment:

$$M_{cr} := S \cdot f_r \cdot \frac{1ft}{12in} \qquad M_{cr} = 435.10\,kip \cdot ft$$

Therefore,

$$M_{cr1} := 1.2 \cdot M_{cr} \qquad M_{cr1} = 522.1\,kip \cdot ft$$

$$M_{cr2} := 1.33 \cdot M_u \qquad M_{cr2} = 1730.3\,kip \cdot ft$$

Design for the lesser of 1.2M_{cr} or 1.33Mu when determining minimum area of steel required. TXDOT's typical practice is to provide at least 1.2 M_{cr} in bent caps.

$$M_f := \min\left(M_{cr1}, M_{cr2}\right)$$

Thus, M_r must be greater than $M_f = 522.1\,kip \cdot ft$

Moment Capacity Design

LRFD 5.7.3.2

Try, 7 #11's Top & Bottom

$BarNo := 7$ — *Number of bars in tension.*

$d_{bar} := 1.41in$ — *Diameter of main reinforcing bars.*

$A_{bar} := 1.56in^2$ — *Area of one main reinforcing bar.*

$A_s := (BarNo) \cdot A_{bar}$ $\quad A_s = 10.92\,in^2$ — *Area of steel in tension.*

$d_{stirrup} := \frac{5}{8}in$ — *Diameter of shear reinforcing bars.*

$d := CapDepth - cover - \frac{1}{2}d_{stirrup} - \frac{1}{2}d_{bar}$ $\quad d = 38.73\,in$ — *"cover" is measured to center of shear reinforcement.*

$b := CapWidth$ $\quad b = 39\,in$

Compressive Strength of Concrete:

$f_c = 3.60\,ksi$

Yield Strength of Rebar:

$f_y := 60ksi$

$\beta_1 := \min\left[0.85, \max\left[0.65, 0.85 - \frac{0.05}{1ksi} \cdot (f_c - 4ksi)\right]\right]$ $\quad \beta_1 = 0.85$ — *LRFD 5.7.2.2*

Resistance Factor:

$\phi_M := 0.9$ — *LRFD 5.5.4.2.1*

Depth of Cross Section under Compression under Ultimate Load:

$c := \frac{A_s \cdot f_y}{0.85 \cdot f_c \cdot \beta_1 \cdot b}$ $\quad c = 6.46\,in$ — *LRFD Eq. 5.7.3.1.2-4*

Depth of Equivalent Stress Block:

$a := c \cdot \beta_1$ $\quad a = 5.49\,in$

Thus,

Nominal Flexural Resistance:

$M_n := A_s \cdot f_y \cdot \left(d - \frac{a}{2}\right) \cdot \frac{1ft}{12in}$ $\quad M_n = 1964.91\,kip \cdot ft$ — *LRFD Eq. 5.7.3.2.2-1*

Factored Flexural Resistance:

$M_r := \phi_M \cdot M_n$ $\quad M_r = 1768.42\,kip \cdot ft$

$M_u = 1301.00\,kip \cdot ft$

$MinReinfChk := if\left[(M_r \geq M_f), OK, NG\right]$ $\quad MinReinfChk = "OK!"$

$UltimateMom := if\left[(M_r \geq M_u), OK, NG\right]$ $\quad UltimateMom = "OK!"$

Check Serviceability *"Control of cracking by Distribution of Reinforcement", LRFD 5.7.3.4*

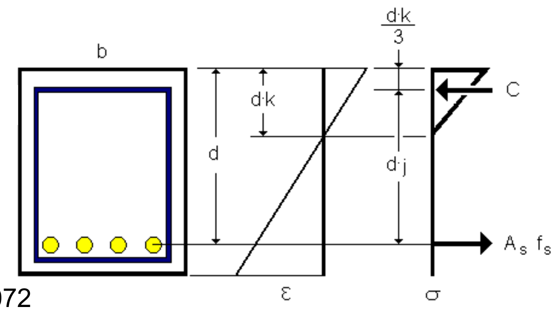
To find s_{max} :

$$d_c := cover + \frac{1}{2} \cdot d_{stirrup} + \frac{1}{2} \cdot d_{bar} \qquad d_c = 3.27\,in$$

"cover" is measured to center of shear reinforcement.

$$h := CapDepth \qquad h = 42.00\,in$$

For service loads, the stress on the cross-section is located as drawn:



Modular Ratio:

$$n := \frac{E_s}{E_c} \qquad n = 8.39$$

Tension Reinforcement Ratio:

$$\rho := \frac{A_s}{b \cdot d} \qquad \rho = 0.0072$$

$$k := \sqrt{(2 \cdot \rho \cdot n) + (\rho \cdot n)^2} - (\rho \cdot n) \qquad k = 0.293$$

$$j := 1 - \frac{k}{3} \qquad j = 0.902$$

For simplicity one can take j=0.9 for "typical" rectangular bent caps.

Service Load Bending Stress:

$$f_s := \frac{M_s}{A_s \cdot j \cdot d} \cdot \frac{12in}{1ft} \qquad f_s = 28.51\,ksi$$

Exposure Condition Factor:

$$\gamma_e := 1.00$$

For class 1 exposure conditions.

$$\beta_s := 1 + \frac{d_c}{0.7 \cdot (h - d_c)} \qquad \beta_s = 1.12$$

$$s_{max} := \frac{700 \frac{kip}{in} \gamma_e}{\beta_s \cdot f_s} - 2d_c \qquad s_{max} = 15.38\,in$$

LRFD Eq. 5.7.3.4-1

$$s_{Actual} := \frac{b - 2 \cdot \left(cover + \frac{1}{2} \cdot d_{stirrup} + \frac{1}{2} \cdot d_{bar}\right)}{BarNo - 1} \qquad s_{Actual} = 5.41\,in$$

$$ServiceabilityCheck := if\left[\left(s_{max} \geq s_{Actual}\right), OK, NG\right]$$

ServiceabilityCheck = "OK!"

Check Dead Load

TxDOT LRFD Bridge Design 4-6

Check allowable M_{dl}: $f_{dl} := 22ksi$

TXDOT limits dead load stress to 22 ksi. This is due to observed cracking under dead load.

$$AllowMdl := A_s \cdot d \cdot j \cdot f_{dl} \cdot \frac{1ft}{12in}$$

$AllowMdl = 699.73\,kip \cdot ft$

$M_{dl} = 596.90\,kip \cdot ft$

$DeadLoadMom := if[(AllowMdl \geq M_{dl}), OK, NG]$

$DeadLoadMom = "OK!"$

Flexural Steel Summary:

Use 7~#11 Bars (Top & Bottom)

TXDOT typically uses the same reinforcement top and bottom for simplicity.

Shear Design

LRFD 5.8 (For flow chart of shear design procedure see Figure C5.8.3.4.2-5)

V_u (Ultimate Shear) must be <u>less</u> than V_r (Shear Resistance)

$V_r = \phi_v \cdot V_n$

$\phi_v := 0.9$ — *LRFD 5.5.4.2.1*

V_n is the <u>lesser</u> of V_{n1} and V_{n2}

Where,

$V_{n1} = 0.25\, f_c b_v d_v + V_p$ — *LRFD Eq. 5.8.3.3-2*

$V_{n2} = V_c + V_s + V_p$ — *LRFD Eq. 5.8.3.3-1*

V_c is the Shear Resistance of the Concrete

$Vc = 0.0316 \cdot \beta \cdot \sqrt{f_c} \cdot b_v \cdot d_v$ — *LRFD Eq. 5.8.3.3-3*

V_s is the Shear Resistance of the Transverse Steel

$$Vs = \frac{A_v \cdot f_y \cdot d_v \cdot \cot(\theta)}{s}$$ — *LRFD Eq. C5.8.3.3-1*

V_p is the Vertical Component of the Prestress Force

$V_p := 0kip$

There is no prestressing steel in this cap.

Since shear is dependent on location, let's look at <u>STA 12</u>:

$V_u := 348.1kip$

$M_u := 695.1kip \cdot ft$

$N_u := 0kip$

Shear Design (Continued)

$b_v := CapWidth$ $\qquad$ $b_v = 39.00\,in$

Find d_v:

d_{v1} need not be less than the greater of d_{v2} and d_{v3}:

$M_n = 1964.91\,kip \cdot ft$ $\qquad$ w/ 7~#11's (Top & Bottom) [Refer to page 7]

$d_{v1} := \frac{M_n}{A_s \cdot f_y}$ $\qquad$ $d_{v1} = 35.99\,in$ $\qquad$ *LRFD Eq. C5.8.2.9-1*

$d_{v2} := 0.9 \cdot d$ $\qquad$ $d_{v2} = 34.86\,in$

$d_{v3} := 0.72 \cdot CapDepth$ $\qquad$ $d_{v3} = 30.24\,in$

$d_v := \max(d_{v1}, d_{v2}, d_{v3})$ $\qquad$ $d_v = 35.99\,in$

Since V_n must be the lesser of V_{n1} and V_{n2} (as per *LRFD 5.8.3.3*), therefore V_u must be less than *both* ϕV_{n1} and ϕV_{n2}. V_{n1} is dependent on the section properties and the flexural reinforcement. V_{n2} is dependent on the section properties, the flexural reinforcement, and the shear reinforcement. V_{n1} is independent of the shear steel, therefore if V_u is greater than ϕV_{n1} the cap fails in shear regardless of the transverse steel.

$V_{n1} := 0.25 \cdot f_c \cdot b_v \cdot d_v + V_p$ $\qquad$ $V_{n1} = 1263.16\,kip$ $\qquad$ *LRFD Eq. 5.8.3.3-2*

V_{r1} must be greater than V_u

$V_u = 348.10\,kip$

$V_{r1} := \phi_v \cdot V_{n1}$ $\qquad$ $V_{r1} = 1136.84\,kip$ $\qquad$ *LRFD Eq. 5.8.2.1-2*

$Vr1check := if[(V_{r1} \ge V_u), OK, NG]$ $\qquad$ Vr1check = "OK!"

If $V_{r1} < V_{u1,}$ then use a LARGER cap depth in order to satisfy shear requirements. LRFD 5.8.2.9-1

To find V_c & V_s we need to determine *θ and β*: $\qquad$ *LRFD 5.8.2.9*

Shear Stress:

$v := \frac{V_u - (\phi_v \cdot V_p)}{\phi_v \cdot b \cdot d_v}$ $\qquad$ $v = 0.28\,ksi$

$ratio := \frac{v}{f_c}$ $\qquad$ $ratio = 0.077$

Using Table 5.8.3.4.2-1: with $ratio = 0.077$ and $\varepsilon_{x1} := 0.001$

$\theta := 36.7deg$ and $\beta := 2.18$

Determining θ and β is an iterative process, therefore, assume initial shear strain value (ε_{x1}) of 0.001 per LRFD 5.8.3.4.2 and then verify that the assumption was valid.

Shear Design (Continued)

Verify assumed value of ε_x:

Recall,

$N_u = 0\,kip$ $\quad$ $V_u = 348.1\,kip$

$V_p = 0\,kip$ $\quad$ $M_u = 695.1\,kip \cdot ft * 12\frac{in}{ft} = M_u = 8341.20\,kip \cdot in$

$d_v = 35.99\,in$ $\quad$ $\theta = 36.70\,deg$

$E_s = 29000\,ksi$ $\quad$ $A_s = 10.92\,in^2$

However, Mu must be <u>greater than or equal to</u> $V_u d_v$ so: *LRFD 5.8.3.4.2*

$$V_u \cdot d_v = 1.25 \times 10^4\,kip \cdot in$$

$$M_u := \max(M_u, V_u \cdot d_v) \qquad M_u = 1.25 \times 10^4\,kip \cdot in$$

$$\varepsilon_x := \frac{\left(\frac{M_u}{d_v}\right) + 0.5 \cdot N_u + 0.5 \cdot (V_u - V_p) \cdot \cot(\theta)}{2 \cdot E_s \cdot A_s} \qquad \varepsilon_x = 918.29 \times 10^{-6}$$

LRFD Eq. 5.8.3.4.2-1
If ε_x < 0, then use equation 5.8.3.4.2-3 and re-solve for ε_x.

$$Ex := \text{if}(0.75 \le \varepsilon_x \cdot 1000, OK, Recalculate) \qquad Ex = \text{"OK!"}$$

The table values for θ and β can be applied over a range, thus, no interpolation is required.
*(*Note: Shear spreadsheet will automatically interpolate θ and β values so results will slightly vary from hand calculations.)*

$\theta = 36.70\,deg$ and $\beta = 2.18$

Recall,

$f_c = 3.60\,ksi$ $\quad$ $f_y = 60.00\,ksi$

$b = 39.00\,in$ $\quad$ $d_v = 35.99\,in$

$d_v = 35.99\,in$

Find Vc:

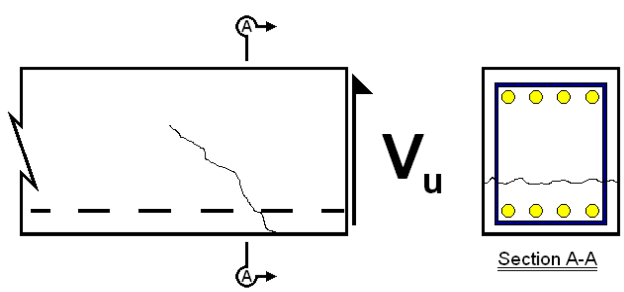
$$V_c := 0.0316 \cdot \beta \cdot \sqrt{f_c \cdot ksi} \cdot b_v \cdot d_v \qquad V_c = 183.45\,kip$$

LRFD Eq. 5.8.3.3-3

Assuming #5 stirrups at $s := 8.5in$ spacing,

$$A_v := 2 \cdot (0.31)\,in^2 \qquad A_v = 0.62\,in^2$$

The transverse reinforcement is a closed stirrup and the failure surface intersects two legs of the stirrup, therefore the area of the shear steel is two times the stirrup bar's area (0.31in²). See the sketch of the failure plane to the left.



Shear Design (Continued)

Find Vs: $V_s := \frac{A_v \cdot f_y \cdot d_v \cdot \cot(\theta)}{s}$ $V_s = 211.30\,\text{kip}$ *LRFD Eq. 5.8.3.3-1*

Find Vn: $V_p = 0\,\text{kip}$

$V_{n1} = 1263.16\,\text{kip}$ *(Refer to page 10)*

$V_{n2} := V_c + V_s + V_p$ $V_{n2} = 394.75\,\text{kip}$ *LRFD Eq. 5.8.3.3-1*

Thus,

$V_n := \min(V_{n1}, V_{n2})$ $V_n = 394.75\,\text{kip}$

Shear Resistance:

$\phi_v := 0.9$

$V_r := \phi_v \cdot V_n$ $V_r = 355.27\,\text{kip}$ *LRFD Eq. 5.8.2.1-2*

$V_u = 348.10\,\text{kip}$

$\text{ShearResistance} := \text{if}(V_r \geq V_u, \text{OK}, \text{NG})$ ShearResistance = "OK!"

Therefore, use #5 stirrups @ 8.5 in spacing.

This process should be repeated at ALL points of critical shear. The Concrete Section Shear Capacity spreadsheet can be used in lieu of hand calculations. Note: in the overhangs, the stirrups need to be spaced @ 4in because the shear is higher. Similarly the stirrups need to be spaced @ 5in near the center column. (See the Shear Spreadsheet). When the spacing needed is less than 4in, use double stirrups. When using double stirrups, A_v is four times the stirrup bar's area.

Skin Reinforcement (Bars T)

Try 5~#5 bars on each side

Actual Area of Skin Reinforcement:

$A_{Tbar} := 0.31in^2$ (# 5) NoTBars := 5

$A_{sk} := A_{Tbar} \cdot NoTBars$ $A_{sk} = 1.55\,in^2$

Required Area of Skin Reinforcement:

$h_{skin} := CapDepth - (2 \cdot cover + d_{stirrup} + d_{bar})$ $h_{skin} = 2.96\,ft$

$A_{skReq} := \min\left[0.012\,\frac{in}{ft} \cdot (d - 30\ in) \cdot h_{skin}, \frac{A_s}{4}\right]$ $A_{skReq} = 0.31\,in^2$ *LRFD Eq. 5.7.3.4-4*

Actual Spacing of Skin Reinforcement:

$$s_{sk} := \frac{h - 2 \cdot \left(cover + \frac{1}{2} \cdot d_{stirrup} + \frac{1}{2} \cdot d_{bar}\right)}{NoTBars + 1}$$ $s_{sk} = 5.91\,in$

"cover" is measured to center of shear reinforcement.

Required Spacing of Skin Reinforcement:

$s_{sk\_req} := \min\left(12 \cdot in, \frac{d}{6}\right)$ $s_{sk\_req} = 6.46\,in$

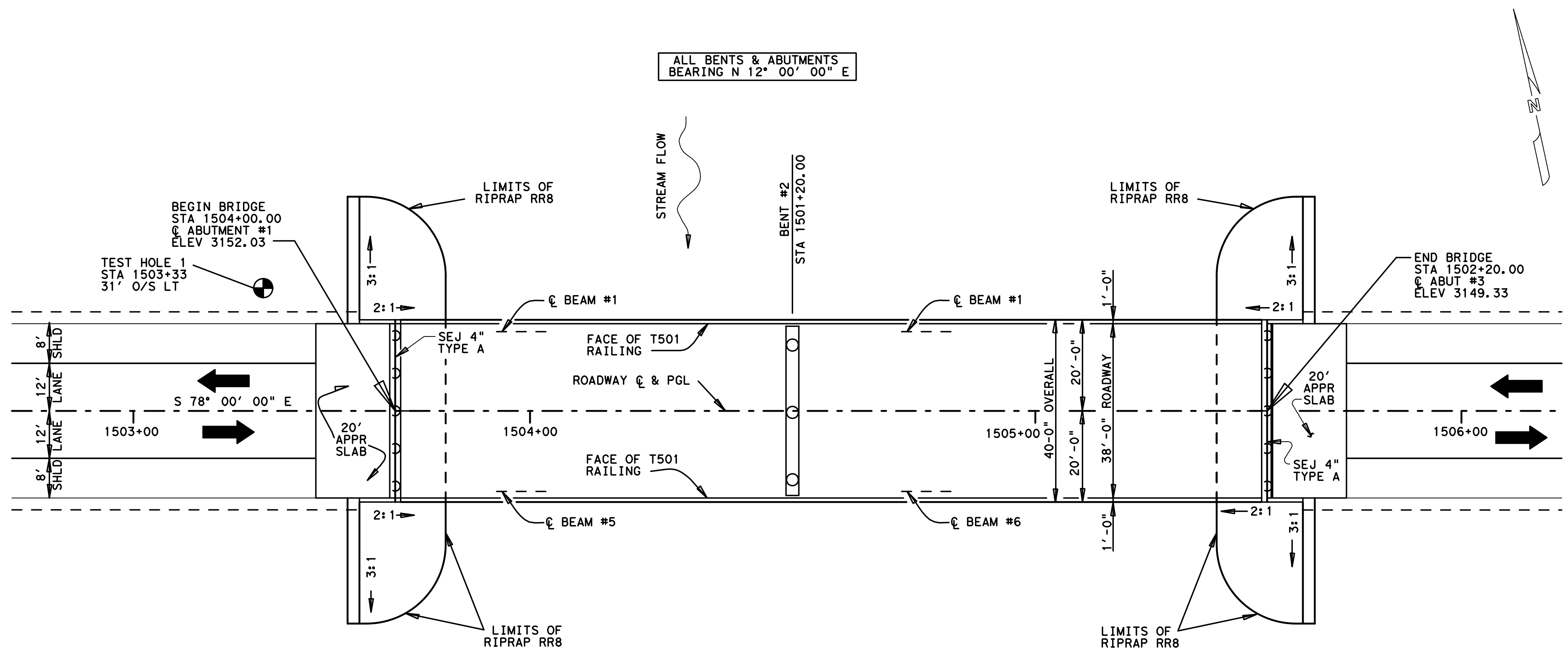
$SkinReinforcement := if(A_{sk} \geq A_{skReq}, OK, NG)$ SkinReinforcement = "OK!"

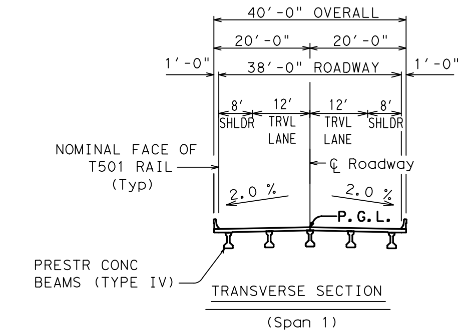
$SkinSpacing := if\left(s_{sk} \leq \min\left(12 \cdot in, \frac{d}{6}\right), OK, NG\right)$ SkinSpacing = "OK!" *LRFD 5.7.3.4*

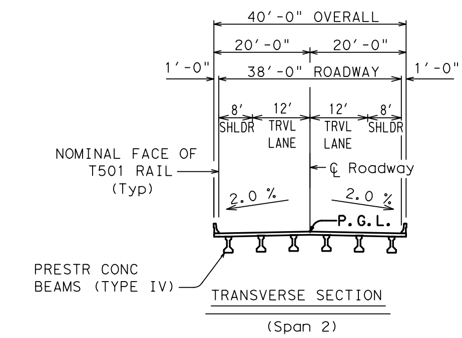
Therefore, use 5~# 5 on each side.

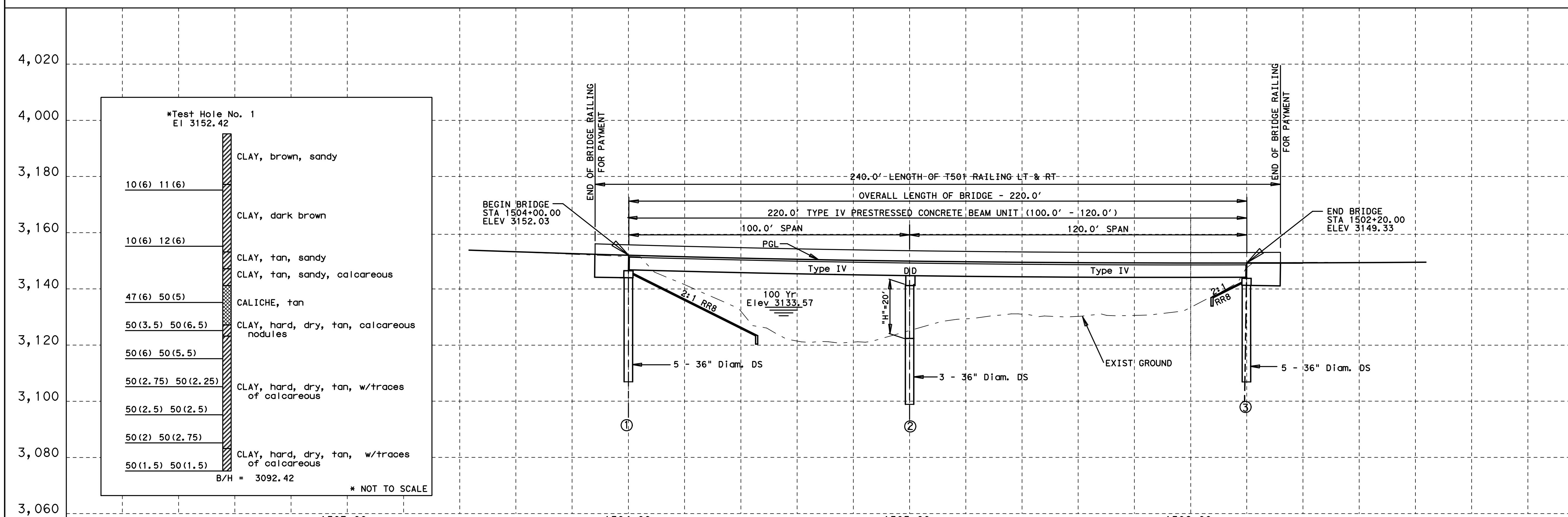
See the Bent Cap Detail Sheet in the Appendixes for the resulting design of these calculations.

Appendices









BRIDGE LAYOUT

EXAMPLE BRIDGE

DESIGN SPEED: 60 MPH
2002 ADT = 2350
2022 ADT = 2550

Functional Classification:
Rural Minor Arterial

Scale:
Horiz. 1"=40'
Vert. 1"=40'

FED. RD. DIV. NO.	FEDERAL AID PROJECT NO.		SHEET NO.
STATE	STATE DIST. NO.	COUNTY	
CONT.	SECT.	JOB	HIGHWAY NO.

```
00001  ___County____  Highwy  Pro#  0000-00-000  BRG                Comment
CAP18 Version 6.00 LRFD Example input file.  Rect Transistion Bent, Skew = 0.00
    1 E   Span 1 (L=100', Type IV Beam @ 8.5', 8" Slab, 2" O'lay)
Table 1                                         15                         0.0
Table 2           80 5.000E-01        20    2   58    1    3    1.25      1.75
     1.50          3  1.2       1.0        0.85      0.65      0.65
Table 3            3    5    3   11    6
  (Lane Left)      2   26   54
  (Lane Right)    26   54   78
  (Stringers)      6   23   40   57   74
  (Supports)      10   40   70
  (Mom CP)         6   10   19   23   33   40   47   57   60   65
  (Mom CP)        70
  (Shear CP)       8   12   38   42   68   72
Table 4 (Cap)      2   78      5.780E+06             -0.853
(DL Span1, Bm1)    6    6                            -92.19              -9.92
(DL Span1, Bm2)   23   23                            -92.19              -9.92
(DL Span1, Bm3)   40   40                            -92.19              -9.92
(DL Span1, Bm4)   57   57                            -92.19              -9.92
(DL Span1, Bm5)   74   74                            -92.19              -9.92
(DL Span2, Bm1)    6    6                            -98.62              -9.52
(DL Span2, Bm2)   20   20                            -98.62              -9.52
(DL Span2, Bm3)   33   33                            -98.62              -9.52
(DL Span2, Bm4)   47   47                            -98.62              -9.52
(DL Span2, Bm5)   60   60                            -98.62              -9.52
(DL Span2, Bm6)   74   74                            -98.62              -9.52
(Dist. Lane Ld)    0   20                                      -5.86
(Conc. Lane Ld)    4    4                                      -21.3
(Conc. Lane Ld)   16   16                                      -21.3
    2 E   Span 2 (L=120', Type IV Beam @ 6.8', 8" Slab, 2" O'lay)-Hold Envp
Table 1            1    1         1                                    0.000E+00
Table 3            3    6    3   11    6
  (Lane Left)      2   26   54
  (Lane Right)    26   54   78
  (Stringers)      6   20   33   47   60   74
  (Supports)      10   40   70
  (Mom CP)         6   10   19   23   33   40   47   57   60   65
  (Mom CP)        70
  (Shear CP)       8   12   38   42   68   72
```

PSF NO	COUNTY	HIGHWAY NO	PD-IPE	CONTROL-SECTION-JOB	CODED BY	DATE	
00001	___County____	Highwy	Pro#	0000-00-000	BRG	JUL 07, 2006	Comment

CAP18 Version 6.00 LRFD Example input file. Rect Transistion Bent, Skew = 0.00
PROB 1 Span 1 (L=100', Type IV Beam @ 8.5', 8" Slab, 2" O'lay)

ENGLISH SYSTEM UNITS

TABLE 1. CONTROL DATA

	ENVELOPES OF MAXIMUMS	TABLE NUMBER 2	3	4
KEEP FROM PRECEDING PROBLEM (1=YES)	0	0	0	0
CARDS INPUT THIS PROBLEM				15

OPTION TO CLEAR ENVELOPES BEFORE LANE LOADINGS (1=YES)	0
OPTION TO OMIT PRINT (-1=TABLE 4A, -2=TABLE 5, -3=BOTH)	0
SKEW ANGLE, DEGREES	0.000

TABLE 2. CONSTANTS

NUMBER OF INCREMENTS FOR SLAB AND CAP	80
INCREMENT LENGTH, FT	0.500
NUMBER OF INCREMENTS FOR MOVABLE LOAD	20
START POSITION OF MOVABLE-LOAD STA ZERO	2
STOP POSITION OF MOVABLE-LOAD STA ZERO	58
NUMBER OF INCREMENTS BETWEEN EACH POSITION OF MOVABLE LOAD	1
ANALYSIS OPTION (1=WORKING STRESS, 2=LOAD FACTOR, 3=BOTH)	3
LOAD FACTOR FOR DEAD LOAD	1.25
LOAD FACTOR FOR OVERLAY LOAD	1.50
LOAD FACTOR FOR LIVE LOAD	1.75
MAXIMUM NUMBER OF LANES TO BE LOADED SIMULTANEOUSLY	3

LIST OF LOAD COEFFICIENTS CORRESPONDING TO NUMBER OF LANES LOADED

1	2	3	4	5
1.200	1.000	0.850		

PROB 1 Span 1 (L=100', Type IV Beam @ 8.5', 8" Slab, 2" O'lay)
(CONTINUED)

TABLE 3. LISTS OF STATIONS

	NUM OF LANES	NUM OF STRINGERS	NUM OF SUPPORTS	NUM MOM CONTR PTS	NUM SHEAR CONTR PTS
TOTAL	3	5	3	11	6

LANE LEFT	2	26	54							
LANE RIGHT	26	54	78							
STRINGERS	6.0	23.0	40.0	57.0	74.0					
SUPPORTS	10	40	70							
MOM CONTR	6	10	19	23	33	40	47	57	60	65
	70									
SHEAR CONTR	8	12	38	42	68	72				

TABLE 4. STIFFNESS AND LOAD DATA

FIXED-OR-MOVABLE STA FROM	STA TO	CONTD IF=1	FIXED-POSITION DATA: CAP BENDING STIFFNESS (K-FT*FT)	SIDEWALK, SLAB LOADS (K)	STRINGER, CAP LOADS (K)	OVERLAY LOADS (K)	MOVABLE-POSITION SLAB LOADS (K)
2	78	0	5780000.000	0.000	-0.853	0.000	0.000
6	6	0	0.000	0.000	-92.190	-9.920	0.000
23	23	0	0.000	0.000	-92.190	-9.920	0.000
40	40	0	0.000	0.000	-92.190	-9.920	0.000
57	57	0	0.000	0.000	-92.190	-9.920	0.000
74	74	0	0.000	0.000	-92.190	-9.920	0.000
6	6	0	0.000	0.000	-98.620	-9.520	0.000
20	20	0	0.000	0.000	-98.620	-9.520	0.000
33	33	0	0.000	0.000	-98.620	-9.520	0.000
47	47	0	0.000	0.000	-98.620	-9.520	0.000
60	60	0	0.000	0.000	-98.620	-9.520	0.000
74	74	0	0.000	0.000	-98.620	-9.520	0.000
0	20	0	0.000	0.000	0.000	0.000	-5.860
4	4	0	0.000	0.000	0.000	0.000	-21.300
16	16	0	0.000	0.000	0.000	0.000	-21.300

PROB 1 Span 1 (L=100', Type IV Beam @ 8.5', 8" Slab, 2" O'lay)
(CONTINUED)

TABLE 4A. DEAD LOAD RESULTS (WORKING STRESS)

STA	DIST X (FT)	DEFLECTION (FT)	MOMENT (K-FT)	SHEAR (K)
-1	-0.50	0.000000	0.0	0.0
0	0.00	0.000000	0.0	0.0
1	0.50	0.000055	0.0	0.0
2	1.00	0.000054	0.0	-0.2
3	1.50	0.000053	-0.2	-0.9
4	2.00	0.000053	-0.9	-1.7
5	2.50	0.000052	-1.9	-2.6
6	3.00	0.000051	-3.4	-108.5
7	3.50	0.000050	-110.5	-214.5
8	4.00	0.000044	-217.9	-215.4
9	4.50	0.000029	-325.8	-216.2
10	5.00	0.000000	-434.1	-30.0
11	5.50	-0.000048	-355.8	156.3
12	6.00	-0.000111	-277.9	155.4
13	6.50	-0.000187	-200.4	154.6
14	7.00	-0.000271	-123.3	153.7
15	7.50	-0.000360	-46.7	152.9
16	8.00	-0.000452	29.6	152.0
17	8.50	-0.000542	105.4	151.2
18	9.00	-0.000628	180.7	150.3
19	9.50	-0.000706	255.7	149.5
20	10.00	-0.000772	330.2	94.5
21	10.50	-0.000825	350.2	39.6
22	11.00	-0.000862	369.8	38.8
23	11.50	-0.000883	389.0	-13.2
24	12.00	-0.000888	356.6	-65.1
25	12.50	-0.000877	323.9	-65.9
26	13.00	-0.000852	290.7	-66.8
27	13.50	-0.000815	257.1	-67.6
28	14.00	-0.000766	223.1	-68.5
29	14.50	-0.000708	188.6	-69.3
30	15.00	-0.000641	153.8	-70.2
31	15.50	-0.000568	118.5	-71.0
32	16.00	-0.000490	82.7	-71.9
33	16.50	-0.000408	46.6	-126.8
34	17.00	-0.000324	-44.1	-181.7
35	17.50	-0.000242	-135.1	-182.6
36	18.00	-0.000166	-226.7	-183.4
37	18.50	-0.000100	-318.6	-184.3
38	19.00	-0.000048	-410.9	-185.1
39	19.50	-0.000013	-503.7	-186.0
40	20.00	0.000000	-596.9	0.0
41	20.50	-0.000013	-503.7	186.0
42	21.00	-0.000048	-410.9	185.1
43	21.50	-0.000100	-318.6	184.3

PROB 1 Span 1 (L=100', Type IV Beam @ 8.5', 8" Slab, 2" O'lay)
(CONTINUED)

TABLE 4A. DEAD LOAD RESULTS (WORKING STRESS)

STA	DIST X (FT)	DEFLECTION (FT)	MOMENT (K-FT)	SHEAR (K)
44	22.00	-0.000166	-226.7	183.4
45	22.50	-0.000242	-135.1	182.6
46	23.00	-0.000324	-44.1	181.7
47	23.50	-0.000408	46.6	126.8
48	24.00	-0.000490	82.7	71.9
49	24.50	-0.000568	118.5	71.0
50	25.00	-0.000641	153.8	70.2
51	25.50	-0.000708	188.6	69.3
52	26.00	-0.000766	223.1	68.5
53	26.50	-0.000815	257.1	67.6
54	27.00	-0.000852	290.7	66.8
55	27.50	-0.000877	323.9	65.9
56	28.00	-0.000888	356.6	65.1
57	28.50	-0.000883	389.0	13.2
58	29.00	-0.000862	369.8	-38.8
59	29.50	-0.000825	350.2	-39.6
60	30.00	-0.000772	330.2	-94.5
61	30.50	-0.000706	255.7	-149.5
62	31.00	-0.000628	180.7	-150.3
63	31.50	-0.000542	105.4	-151.2
64	32.00	-0.000452	29.6	-152.0
65	32.50	-0.000360	-46.7	-152.9
66	33.00	-0.000271	-123.3	-153.7
67	33.50	-0.000187	-200.4	-154.6
68	34.00	-0.000111	-277.9	-155.4
69	34.50	-0.000048	-355.8	-156.3
70	35.00	0.000000	-434.1	30.0
71	35.50	0.000029	-325.8	216.2
72	36.00	0.000044	-217.9	215.4
73	36.50	0.000050	-110.5	214.5
74	37.00	0.000051	-3.4	108.5
75	37.50	0.000052	-1.9	2.6
76	38.00	0.000053	-0.9	1.7
77	38.50	0.000053	-0.2	0.9
78	39.00	0.000054	0.0	0.2
79	39.50	0.000055	0.0	0.0
80	40.00	0.000000	0.0	0.0
81	40.50	0.000000	0.0	0.0

PROB 1 Span 1 (L=100', Type IV Beam @ 8.5', 8" Slab, 2" O'lay)
(CONTINUED)

TABLE 5. MULTI-LANE LOADING SUMMARY (WORKING STRESS)
(*--CRITICAL NUMBER OF LANE LOADS)

MOMENT (FT-K)

AT STA	DEAD LD EFFECT	LANE ORDER	POSITIVE MAXIMUM	LOAD LANE	AT STA	LANE ORDER	NEGATIVE MAXIMUM	LOAD LANE	AT STA
6	-3.4								
		0	0.0			0	0.0		
		1	0.0			1	0.0		
		2	0.0			2	0.0		
		3	0.0			3	0.0		
		0*				0*			
10	-434.1								
		0	0.0			0	-206.8	1	2
		1	0.0			1	-206.8	1	2
		2	0.0			2	0.0		
		3	0.0			3	0.0		
		0*				0*			
19	255.7								
		0	215.7	0	16	0	-40.7	0	45
		1	111.6	1	6	1	-25.9	3	54
		2	96.3	2	26	2	-7.8	1	2
		3	0.0			3	0.0		
		0*				0*			
23	389.0								
		0	324.2	0	15	0	-58.8	0	45
		1	221.1	1	6	1	-37.4	3	54
		2	139.1	2	26	2	0.0		
		3	0.0			3	0.0		
		0*				0*			
33	46.6								
		0	53.9	0	14	0	-104.0	0	45
		1	40.3	1	6	1	-66.2	3	54
		2	14.6	2	26	2	-42.4	2	34
		3	0.0			3	0.0		
		0*				0*			
40	-596.9								
		0	0.0			0	-135.7	0	15
		1	0.0			1	-86.3	1	6
		2	0.0			2	-86.3	3	54
		3	0.0			3	-72.6	2	26
		0*				3*			

PROB 1 Span 1 (L=100', Type IV Beam @ 8.5', 8" Slab, 2" O'lay)
(CONTINUED)

MOMENT (FT-K)

AT STA	DEAD LD EFFECT	LANE ORDER	POSITIVE MAXIMUM	LOAD LANE	AT STA	LANE ORDER	NEGATIVE MAXIMUM	LOAD LANE	AT STA
47	46.6								
		0	53.9	0	46	0	-104.0	0	15
		1	40.3	3	54	1	-66.2	1	6
		2	14.6	2	34	2	-42.4	2	26
		3	0.0			3	0.0		
		0*				0*			
57	389.0								
		0	324.2	0	45	0	-58.8	0	15
		1	221.1	3	54	1	-37.4	1	6
		2	139.1	2	34	2	0.0		
		3	0.0			3	0.0		
		0*				0*			
60	330.2								
		0	242.3	0	44	0	-45.2	0	15
		1	139.0	3	54	1	-28.8	1	6
		2	107.0	2	34	2	0.0		
		3	0.0			3	0.0		
		0*				0*			
65	-46.7								
		0	112.9	0	42	0	-96.2	3	58
		1	53.5	2	34	1	-96.2	3	58
		2	2.1	3	54	2	-14.4	1	6
		3	0.0			3	0.0		
		0*				0*			
70	-434.1								
		0	0.0			0	-206.8	3	58
		1	0.0			1	-206.8	3	58
		2	0.0			2	0.0		
		3	0.0			3	0.0		
		0*				0*			

PROB 1 Span 1 (L=100', Type IV Beam @ 8.5', 8" Slab, 2" O'lay)
(CONTINUED)

SHEAR (K)

AT STA	DEAD LD EFFECT	LANE ORDER	POSITIVE MAXIMUM	LOAD LANE	AT STA	LANE ORDER	NEGATIVE MAXIMUM	LOAD LANE	AT STA
8	-215.4								
		0	0.0			0	-103.4	1	2
		1	0.0			1	-103.4	1	2
		2	0.0			2	0.0		
		3	0.0			3	0.0		
		0*				0*			
12	155.4								
		0	58.0	0	10	0	-9.0	0	45
		1	54.7	1	6	1	-5.8	3	54
		2	21.4	2	26	2	0.0		
		3	0.0			3	0.0		
		2*				0*			
38	-185.1								
		0	0.0			0	-54.1	0	15
		1	0.0			1	-36.2	1	6
		2	0.0			2	-24.9	2	26
		3	0.0			3	-5.8	3	54
		0*				0*			
42	185.1								
		0	54.1	0	45	0	0.0		
		1	36.2	3	54	1	0.0		
		2	24.9	2	34	2	0.0		
		3	5.8	1	6	3	0.0		
		0*				0*			
68	-155.4								
		0	9.0	0	15	0	-58.0	0	50
		1	5.8	1	6	1	-54.7	3	54
		2	0.0			2	-21.4	2	34
		3	0.0			3	0.0		
		0*				2*			
72	215.4								
		0	103.4	3	58	0	0.0		
		1	103.4	3	58	1	0.0		
		2	0.0			2	0.0		
		3	0.0			3	0.0		
		0*				0*			

PROB 1 Span 1 (L=100', Type IV Beam @ 8.5', 8" Slab, 2" O'lay)
(CONTINUED)

REACTION (K)

AT STA	DEAD LD EFFECT	LANE ORDER	POSITIVE MAXIMUM	LOAD LANE	AT STA	LANE ORDER	NEGATIVE MAXIMUM	LOAD LANE	AT STA
10	374.2								
		0	147.6	1	2	0	-9.0	0	45
		1	147.6	1	2	1	-5.8	3	54
		2	21.4	2	26	2	0.0		
		3	0.0			3	0.0		
		0*				0*			
40	475.8								
		0	140.5	2	30	0	0.0		
		1	140.5	2	30	1	0.0		
		2	43.5	1	6	2	0.0		
		3	43.5	3	54	3	0.0		
		3*				0*			
70	374.2								
		0	147.6	3	58	0	-9.0	0	15
		1	147.6	3	58	1	-5.8	1	6
		2	21.4	2	34	2	0.0		
		3	0.0			3	0.0		
		0*				0*			

PROB 1 Span 1 (L=100', Type IV Beam @ 8.5', 8" Slab, 2" O'lay)
(CONTINUED)

TABLE 6. ENVELOPES OF MAXIMUM VALUES (WORKING STRESS)

STA	DIST X (FT)	MAX + MOM (FT-K)	MAX - MOM (FT-K)	MAX + SHEAR (K)	MAX - SHEAR (K)
-1	-0.50	0.0	0.0	0.0	0.0
0	0.00	0.0	0.0	0.0	0.0
1	0.50	0.0	0.0	0.0	0.0
2	1.00	0.0	0.0	-0.2	-0.2
3	1.50	-0.2	-0.2	-0.9	-0.9
4	2.00	-0.9	-0.9	-1.7	-1.7
5	2.50	-1.9	-1.9	-2.6	-2.6
6	3.00	-3.4	-3.4	-108.5	-170.6
7	3.50	-110.5	-172.5	-214.5	-338.6
8	4.00	-217.9	-342.0	-215.4	-339.4
9	4.50	-325.8	-511.9	-216.2	-340.3
10	5.00	-434.1	-682.3	-3.2	-65.5
11	5.50	-333.3	-577.4	232.4	145.4
12	6.00	-227.7	-473.0	231.6	144.6
13	6.50	-121.8	-368.9	230.7	143.7
14	7.00	-16.4	-265.3	229.9	142.9
15	7.50	88.8	-162.1	229.0	142.0
16	8.00	194.8	-59.4	228.2	141.2
17	8.50	301.2	43.0	227.3	140.3
18	9.00	407.6	137.3	226.4	139.5
19	9.50	514.5	206.8	225.6	138.6
20	10.00	621.0	275.9	170.7	83.7
21	10.50	673.5	290.5	115.7	28.8
22	11.00	725.9	304.7	114.9	27.9
23	11.50	778.0	318.4	6.1	-24.0
24	12.00	713.2	280.7	-65.1	-130.0
25	12.50	648.0	242.5	-65.9	-130.8
26	13.00	582.4	203.9	-66.8	-131.7
27	13.50	516.3	164.9	-67.6	-132.5
28	14.00	449.8	125.4	-68.5	-133.4
29	14.50	382.9	85.5	-69.3	-134.2
30	15.00	315.6	45.2	-70.2	-135.1
31	15.50	247.8	4.5	-71.0	-136.0
32	16.00	179.7	-36.6	-71.9	-136.8
33	16.50	111.2	-78.2	-126.8	-191.7
34	17.00	-11.7	-174.3	-181.7	-246.7
35	17.50	-126.0	-270.8	-182.6	-247.5
36	18.00	-224.8	-367.7	-183.4	-248.4
37	18.50	-318.6	-465.1	-184.3	-249.2
38	19.00	-410.9	-564.7	-185.1	-250.1
39	19.50	-503.7	-683.7	-186.0	-250.9
40	20.00	-596.9	-805.3	27.0	-27.0
41	20.50	-503.7	-690.6	250.9	186.0
42	21.00	-410.9	-576.4	250.1	185.1

PROB 1 Span 1 (L=100', Type IV Beam @ 8.5', 8" Slab, 2" O'lay)
(CONTINUED)

TABLE 6. ENVELOPES OF MAXIMUM VALUES (WORKING STRESS)

STA	DIST X (FT)	MAX + MOM (FT-K)	MAX - MOM (FT-K)	MAX + SHEAR (K)	MAX - SHEAR (K)
43	21.50	-318.6	-465.1	249.2	184.3
44	22.00	-224.8	-367.7	248.4	183.4
45	22.50	-126.0	-270.8	247.5	182.6
46	23.00	-11.7	-174.3	246.7	181.7
47	23.50	111.2	-78.2	191.7	126.8
48	24.00	179.7	-36.6	136.8	71.9
49	24.50	247.8	4.5	136.0	71.0
50	25.00	315.6	45.2	135.1	70.2
51	25.50	382.9	85.5	134.2	69.3
52	26.00	449.8	125.4	133.4	68.5
53	26.50	516.3	164.9	132.5	67.6
54	27.00	582.4	203.9	131.7	66.8
55	27.50	648.0	242.5	130.8	65.9
56	28.00	713.2	280.7	130.0	65.1
57	28.50	778.0	318.4	24.0	-6.1
58	29.00	725.9	304.7	-27.9	-114.9
59	29.50	673.5	290.5	-28.8	-115.7
60	30.00	621.0	275.9	-83.7	-170.7
61	30.50	514.5	206.8	-138.6	-225.6
62	31.00	407.6	137.3	-139.5	-226.4
63	31.50	301.2	43.0	-140.3	-227.3
64	32.00	194.8	-59.4	-141.2	-228.2
65	32.50	88.8	-162.1	-142.0	-229.0
66	33.00	-16.4	-265.3	-142.9	-229.9
67	33.50	-121.8	-368.9	-143.7	-230.7
68	34.00	-227.7	-473.0	-144.6	-231.6
69	34.50	-333.3	-577.4	-145.4	-232.4
70	35.00	-434.1	-682.3	65.5	3.2
71	35.50	-325.8	-511.9	340.3	216.2
72	36.00	-217.9	-342.0	339.4	215.4
73	36.50	-110.5	-172.5	338.6	214.5
74	37.00	-3.4	-3.4	170.6	108.5
75	37.50	-1.9	-1.9	2.6	2.6
76	38.00	-0.9	-0.9	1.7	1.7
77	38.50	-0.2	-0.2	0.9	0.9
78	39.00	0.0	0.0	0.2	0.2
79	39.50	0.0	0.0	0.0	0.0
80	40.00	0.0	0.0	0.0	0.0
81	40.50	0.0	0.0	0.0	0.0

PROB 1 Span 1 (L=100', Type IV Beam @ 8.5', 8" Slab, 2" O'lay)
(CONTINUED)

TABLE 7. MAXIMUM SUPPORT REACTIONS (WORKING STRESS)

STA	DIST X (FT)	MAX + REACT (K)	MAX - REACT (K)
10	5.00	551.4	363.4
40	20.00	669.1	475.8
70	35.00	551.4	363.4

PROB 1 Span 1 (L=100', Type IV Beam @ 8.5', 8" Slab, 2" O'lay)
(CONTINUED)

TABLE 5. MULTI-LANE LOADING SUMMARY (LOAD FACTOR)
(*--CRITICAL NUMBER OF LANE LOADS)

MOMENT (FT-K)

AT STA	DEAD LD EFFECT	LANE ORDER	POSITIVE MAXIMUM	LOAD LANE	AT STA	LANE ORDER	NEGATIVE MAXIMUM	LOAD LANE	AT STA
6	-4.3								
		0	0.0			0	0.0		
		1	0.0			1	0.0		
		2	0.0			2	0.0		
		3	0.0			3	0.0		
		0*				0*			
10	-552.4								
		0	0.0			0	-361.9	1	2
		1	0.0			1	-361.9	1	2
		2	0.0			2	0.0		
		3	0.0			3	0.0		
		0*				0*			
19	325.0								
		0	377.4	0	16	0	-71.2	0	45
		1	195.3	1	6	1	-45.3	3	54
		2	168.6	2	26	2	-13.6	1	2
		3	0.0			3	0.0		
		0*				0*			
23	494.7								
		0	567.4	0	15	0	-102.9	0	45
		1	386.9	1	6	1	-65.4	3	54
		2	243.5	2	26	2	0.0		
		3	0.0			3	0.0		
		0*				0*			
33	59.2								
		0	94.3	0	14	0	-182.0	0	45
		1	70.5	1	6	1	-115.8	3	54
		2	25.5	2	26	2	-74.3	2	34
		3	0.0			3	0.0		
		0*				0*			
40	-758.8								
		0	0.0			0	-237.4	0	15
		1	0.0			1	-151.0	1	6
		2	0.0			2	-151.0	3	54
		3	0.0			3	-127.0	2	26
		0*				3*			

PROB 1 Span 1 (L=100', Type IV Beam @ 8.5', 8" Slab, 2" O'lay)
(CONTINUED)

MOMENT (FT-K)

AT STA	DEAD LD EFFECT	LANE ORDER	POSITIVE MAXIMUM	LOAD LANE	AT STA	LANE ORDER	NEGATIVE MAXIMUM	LOAD LANE	AT STA
47	59.2								
		0	94.3	0	46	0	-182.0	0	15
		1	70.5	3	54	1	-115.8	1	6
		2	25.5	2	34	2	-74.3	2	26
		3	0.0			3	0.0		
		0*				0*			
57	494.7								
		0	567.4	0	45	0	-102.9	0	15
		1	386.9	3	54	1	-65.4	1	6
		2	243.5	2	34	2	0.0		
		3	0.0			3	0.0		
		0*				0*			
60	419.8								
		0	424.1	0	44	0	-79.1	0	15
		1	243.2	3	54	1	-50.3	1	6
		2	187.3	2	34	2	0.0		
		3	0.0			3	0.0		
		0*				0*			
65	-59.6								
		0	197.5	0	42	0	-168.4	3	58
		1	93.6	2	34	1	-168.4	3	58
		2	3.7	3	54	2	-25.2	1	6
		3	0.0			3	0.0		
		0*				0*			
70	-552.4								
		0	0.0			0	-361.9	3	58
		1	0.0			1	-361.9	3	58
		2	0.0			2	0.0		
		3	0.0			3	0.0		
		0*				0*			

PROB 1 Span 1 (L=100', Type IV Beam @ 8.5', 8" Slab, 2" O'lay)
(CONTINUED)

SHEAR (K)

AT STA	DEAD LD EFFECT	LANE ORDER	POSITIVE MAXIMUM	LOAD LANE	AT STA	LANE ORDER	NEGATIVE MAXIMUM	LOAD LANE	AT STA
8	-274.1								
		0	0.0			0	-180.9	1	2
		1	0.0			1	-180.9	1	2
		2	0.0			2	0.0		
		3	0.0			3	0.0		
		0*				0*			
12	197.6								
		0	101.6	0	10	0	-15.8	0	45
		1	95.8	1	6	1	-10.1	3	54
		2	37.5	2	26	2	0.0		
		3	0.0			3	0.0		
		2*				0*			
38	-235.3								
		0	0.0			0	-94.7	0	15
		1	0.0			1	-63.3	1	6
		2	0.0			2	-43.6	2	26
		3	0.0			3	-10.1	3	54
		0*				0*			
42	235.3								
		0	94.7	0	45	0	0.0		
		1	63.3	3	54	1	0.0		
		2	43.6	2	34	2	0.0		
		3	10.1	1	6	3	0.0		
		0*				0*			
68	-197.6								
		0	15.8	0	15	0	-101.6	0	50
		1	10.1	1	6	1	-95.8	3	54
		2	0.0			2	-37.5	2	34
		3	0.0			3	0.0		
		0*				2*			
72	274.1								
		0	180.9	3	58	0	0.0		
		1	180.9	3	58	1	0.0		
		2	0.0			2	0.0		
		3	0.0			3	0.0		
		0*				0*			

PROB 1 Span 1 (L=100', Type IV Beam @ 8.5', 8" Slab, 2" O'lay)
(CONTINUED)

REACTION (K)

AT STA	DEAD LD EFFECT	LANE ORDER	POSITIVE MAXIMUM	LOAD LANE	AT STA	LANE ORDER	NEGATIVE MAXIMUM	LOAD LANE	AT STA
10	476.0								
		0	258.3	1	2	0	-15.8	0	45
		1	258.3	1	2	1	-10.1	3	54
		2	37.5	2	26	2	0.0		
		3	0.0			3	0.0		
		0*				0*			
40	605.0								
		0	245.8	2	30	0	0.0		
		1	245.8	2	30	1	0.0		
		2	76.1	1	6	2	0.0		
		3	76.1	3	54	3	0.0		
		3*				0*			
70	476.0								
		0	258.3	3	58	0	-15.8	0	15
		1	258.3	3	58	1	-10.1	1	6
		2	37.5	2	34	2	0.0		
		3	0.0			3	0.0		
		0*				0*			

PROB 1 Span 1 (L=100', Type IV Beam @ 8.5', 8" Slab, 2" O'lay)
(CONTINUED)

TABLE 6. ENVELOPES OF MAXIMUM VALUES (LOAD FACTOR)

STA	DIST X (FT)	MAX + MOM (FT-K)	MAX - MOM (FT-K)	MAX + SHEAR (K)	MAX - SHEAR (K)
-1	-0.50	0.0	0.0	0.0	0.0
0	0.00	0.0	0.0	0.0	0.0
1	0.50	0.0	0.0	0.0	0.0
2	1.00	0.0	0.0	-0.3	-0.3
3	1.50	-0.3	-0.3	-1.1	-1.1
4	2.00	-1.1	-1.1	-2.1	-2.1
5	2.50	-2.4	-2.4	-3.2	-3.2
6	3.00	-4.3	-4.3	-138.1	-246.7
7	3.50	-140.5	-249.1	-273.0	-490.1
8	4.00	-277.3	-494.4	-274.1	-491.2
9	4.50	-414.6	-740.3	-275.1	-492.3
10	5.00	-552.4	-986.7	8.6	-100.3
11	5.50	-413.3	-840.6	331.9	179.7
12	6.00	-265.9	-695.1	330.9	178.6
13	6.50	-117.7	-550.1	329.8	177.6
14	7.00	30.0	-405.7	328.7	176.5
15	7.50	177.4	-261.7	327.7	175.4
16	8.00	326.4	-118.3	326.6	174.4
17	8.50	476.5	24.5	325.5	173.3
18	9.00	626.6	153.6	324.5	172.2
19	9.50	777.8	239.5	323.4	171.2
20	10.00	928.7	324.8	253.6	101.3
21	10.50	1011.0	340.8	183.7	31.5
22	11.00	1093.5	356.3	182.7	30.4
23	11.50	1175.5	371.2	17.0	-35.7
24	12.00	1077.6	320.6	-82.8	-196.4
25	12.50	979.1	269.4	-83.9	-197.5
26	13.00	880.1	217.7	-85.0	-198.6
27	13.50	780.5	165.5	-86.0	-199.6
28	14.00	680.4	112.7	-87.1	-200.7
29	14.50	579.8	59.4	-88.2	-201.8
30	15.00	478.6	5.5	-89.2	-202.8
31	15.50	377.0	-48.8	-90.3	-203.9
32	16.00	274.9	-103.8	-91.4	-205.0
33	16.50	172.3	-159.2	-161.2	-274.8
34	17.00	0.6	-284.0	-231.0	-344.7
35	17.50	-155.8	-409.2	-232.1	-345.7
36	18.00	-284.9	-535.1	-233.2	-346.8
37	18.50	-405.0	-661.4	-234.2	-347.9
38	19.00	-522.4	-791.5	-235.3	-348.9
39	19.50	-640.3	-955.3	-236.4	-350.0
40	20.00	-758.8	-1123.5	47.3	-47.3
41	20.50	-640.3	-967.4	350.0	236.4
42	21.00	-522.4	-811.9	348.9	235.3
43	21.50	-405.0	-661.4	347.9	234.2

PROB 1 Span 1 (L=100', Type IV Beam @ 8.5', 8" Slab, 2" O'lay)
(CONTINUED)

TABLE 6. ENVELOPES OF MAXIMUM VALUES (LOAD FACTOR)

STA	DIST X (FT)	MAX + MOM (FT-K)	MAX - MOM (FT-K)	MAX + SHEAR (K)	MAX - SHEAR (K)
44	22.00	-284.9	-535.1	346.8	233.2
45	22.50	-155.8	-409.2	345.7	232.1
46	23.00	0.6	-284.0	344.7	231.0
47	23.50	172.3	-159.2	274.8	161.2
48	24.00	274.9	-103.8	205.0	91.4
49	24.50	377.0	-48.8	203.9	90.3
50	25.00	478.6	5.5	202.8	89.2
51	25.50	579.8	59.4	201.8	88.2
52	26.00	680.4	112.7	200.7	87.1
53	26.50	780.5	165.5	199.6	86.0
54	27.00	880.1	217.7	198.6	85.0
55	27.50	979.1	269.4	197.5	83.9
56	28.00	1077.6	320.6	196.4	82.8
57	28.50	1175.5	371.2	35.7	-17.0
58	29.00	1093.5	356.3	-30.4	-182.7
59	29.50	1011.0	340.8	-31.5	-183.7
60	30.00	928.7	324.8	-101.3	-253.6
61	30.50	777.8	239.5	-171.2	-323.4
62	31.00	626.6	153.6	-172.2	-324.5
63	31.50	476.5	24.5	-173.3	-325.5
64	32.00	326.4	-118.3	-174.4	-326.6
65	32.50	177.4	-261.7	-175.4	-327.7
66	33.00	30.0	-405.7	-176.5	-328.7
67	33.50	-117.7	-550.1	-177.6	-329.8
68	34.00	-265.9	-695.1	-178.6	-330.9
69	34.50	-413.3	-840.6	-179.7	-331.9
70	35.00	-552.4	-986.7	100.3	-8.6
71	35.50	-414.6	-740.3	492.3	275.1
72	36.00	-277.3	-494.4	491.2	274.1
73	36.50	-140.5	-249.1	490.1	273.0
74	37.00	-4.3	-4.3	246.7	138.1
75	37.50	-2.4	-2.4	3.2	3.2
76	38.00	-1.1	-1.1	2.1	2.1
77	38.50	-0.3	-0.3	1.1	1.1
78	39.00	0.0	0.0	0.3	0.3
79	39.50	0.0	0.0	0.0	0.0
80	40.00	0.0	0.0	0.0	0.0
81	40.50	0.0	0.0	0.0	0.0

PROB 1 Span 1 (L=100', Type IV Beam @ 8.5', 8" Slab, 2" O'lay)
(CONTINUED)

TABLE 7. MAXIMUM SUPPORT REACTIONS (LOAD FACTOR)

STA	DIST X (FT)	MAX + REACT (K)	MAX - REACT (K)
10	5.00	786.0	457.0
40	20.00	943.2	605.0
70	35.00	786.0	457.0

PSF NO	COUNTY	HIGHWAY NO	PD-IPE	CONTROL-SECTION-JOB	CODED BY	DATE	
00001	___County____	Highwy	Pro#	0000-00-000	BRG	JUL 07, 2006	Comment

CAP18 Version 6.00 LRFD Example input file. Rect Transistion Bent, Skew = 0.00
PROB 2 Span 2 (L=120', Type IV Beam @ 6.8', 8" Slab, 2" O'lay)-Hold Envp

ENGLISH SYSTEM UNITS

TABLE 1. CONTROL DATA

	ENVELOPES OF MAXIMUMS	TABLE NUMBER 2	3	4
KEEP FROM PRECEDING PROBLEM (1=YES)	1	1	0	1
CARDS INPUT THIS PROBLEM				0

OPTION TO CLEAR ENVELOPES BEFORE LANE LOADINGS (1=YES) 0

OPTION TO OMIT PRINT (-1=TABLE 4A, -2=TABLE 5, -3=BOTH) 0

SKEW ANGLE, DEGREES 0.000

TABLE 2. CONSTANTS

USING DATA FROM THE PREVIOUS PROBLEM

PROB 2 Span 2 (L=120', Type IV Beam @ 6.8', 8" Slab, 2" O'lay)-Hold Envp
(CONTINUED)

TABLE 3. LISTS OF STATIONS

	NUM OF LANES	NUM OF STRINGERS	NUM OF SUPPORTS	NUM MOM CONTR PTS	NUM SHEAR CONTR PTS
TOTAL	3	6	3	11	6

LANE LEFT	2	26	54							
LANE RIGHT	26	54	78							
STRINGERS	6.0	20.0	33.0	47.0	60.0	74.0				
SUPPORTS	10	40	70							
MOM CONTR	6	10	19	23	33	40	47	57	60	65
	70									
SHEAR CONTR	8	12	38	42	68	72				

TABLE 4. STIFFNESS AND LOAD DATA

USING DATA FROM THE PREVIOUS PROBLEM PLUS

NONE

PROB 2 Span 2 (L=120', Type IV Beam @ 6.8', 8" Slab, 2" O'lay)-Hold Envp
(CONTINUED)

TABLE 4A. DEAD LOAD RESULTS (WORKING STRESS)

STA	DIST X (FT)	DEFLECTION (FT)	MOMENT (K-FT)	SHEAR (K)
-1	-0.50	0.000000	0.0	0.0
0	0.00	0.000000	0.0	0.0
1	0.50	0.000055	0.0	0.0
2	1.00	0.000054	0.0	-0.2
3	1.50	0.000053	-0.2	-0.9
4	2.00	0.000053	-0.9	-1.7
5	2.50	0.000052	-1.9	-2.6
6	3.00	0.000051	-3.4	-108.5
7	3.50	0.000050	-110.5	-214.5
8	4.00	0.000044	-217.9	-215.4
9	4.50	0.000029	-325.8	-216.2
10	5.00	0.000000	-434.1	-30.0
11	5.50	-0.000048	-355.8	156.3
12	6.00	-0.000111	-277.9	155.4
13	6.50	-0.000187	-200.4	154.6
14	7.00	-0.000271	-123.3	153.7
15	7.50	-0.000360	-46.7	152.9
16	8.00	-0.000452	29.6	152.0
17	8.50	-0.000542	105.4	151.2
18	9.00	-0.000628	180.7	150.3
19	9.50	-0.000706	255.7	149.5
20	10.00	-0.000772	330.2	94.5
21	10.50	-0.000825	350.2	39.6
22	11.00	-0.000862	369.8	38.8
23	11.50	-0.000883	→ 389.0	-13.2
24	12.00	-0.000888	356.6	-65.1
25	12.50	-0.000877	323.9	-65.9
26	13.00	-0.000852	290.7	-66.8
27	13.50	-0.000815	257.1	-67.6
28	14.00	-0.000766	223.1	-68.5
29	14.50	-0.000708	188.6	-69.3
30	15.00	-0.000641	153.8	-70.2
31	15.50	-0.000568	118.5	-71.0
32	16.00	-0.000490	82.7	-71.9
33	16.50	-0.000408	46.6	-126.8
34	17.00	-0.000324	-44.1	-181.7
35	17.50	-0.000242	-135.1	-182.6
36	18.00	-0.000166	-226.7	-183.4
37	18.50	-0.000100	-318.6	-184.3
38	19.00	-0.000048	-410.9	-185.1
39	19.50	-0.000013	-503.7	-186.0
40	20.00	0.000000	→ -596.9	0.0
41	20.50	-0.000013	-503.7	186.0
42	21.00	-0.000048	-410.9	185.1
43	21.50	-0.000100	-318.6	184.3

PROB 2 Span 2 (L=120', Type IV Beam @ 6.8', 8" Slab, 2" O'lay)-Hold Envp
(CONTINUED)

TABLE 4A. DEAD LOAD RESULTS (WORKING STRESS)

STA	DIST X (FT)	DEFLECTION (FT)	MOMENT (K-FT)	SHEAR (K)
44	22.00	-0.000166	-226.7	183.4
45	22.50	-0.000242	-135.1	182.6
46	23.00	-0.000324	-44.1	181.7
47	23.50	-0.000408	46.6	126.8
48	24.00	-0.000490	82.7	71.9
49	24.50	-0.000568	118.5	71.0
50	25.00	-0.000641	153.8	70.2
51	25.50	-0.000708	188.6	69.3
52	26.00	-0.000766	223.1	68.5
53	26.50	-0.000815	257.1	67.6
54	27.00	-0.000852	290.7	66.8
55	27.50	-0.000877	323.9	65.9
56	28.00	-0.000888	356.6	65.1
57	28.50	-0.000883	389.0	13.2
58	29.00	-0.000862	369.8	-38.8
59	29.50	-0.000825	350.2	-39.6
60	30.00	-0.000772	330.2	-94.5
61	30.50	-0.000706	255.7	-149.5
62	31.00	-0.000628	180.7	-150.3
63	31.50	-0.000542	105.4	-151.2
64	32.00	-0.000452	29.6	-152.0
65	32.50	-0.000360	-46.7	-152.9
66	33.00	-0.000271	-123.3	-153.7
67	33.50	-0.000187	-200.4	-154.6
68	34.00	-0.000111	-277.9	-155.4
69	34.50	-0.000048	-355.8	-156.3
70	35.00	0.000000	-434.1	30.0
71	35.50	0.000029	-325.8	216.2
72	36.00	0.000044	-217.9	215.4
73	36.50	0.000050	-110.5	214.5
74	37.00	0.000051	-3.4	108.5
75	37.50	0.000052	-1.9	2.6
76	38.00	0.000053	-0.9	1.7
77	38.50	0.000053	-0.2	0.9
78	39.00	0.000054	0.0	0.2
79	39.50	0.000055	0.0	0.0
80	40.00	0.000000	0.0	0.0
81	40.50	0.000000	0.0	0.0

PROB 2 Span 2 (L=120', Type IV Beam @ 6.8', 8" Slab, 2" O'lay)-Hold Envp
(CONTINUED)

TABLE 5. MULTI-LANE LOADING SUMMARY (WORKING STRESS)
(*--CRITICAL NUMBER OF LANE LOADS)

MOMENT (FT-K)

AT STA	DEAD LD EFFECT	LANE ORDER	POSITIVE MAXIMUM	LOAD LANE	AT STA	LANE ORDER	NEGATIVE MAXIMUM	LOAD LANE	AT STA
6	-3.4								
		0	0.0			0	0.0		
		1	0.0			1	0.0		
		2	0.0			2	0.0		
		3	0.0			3	0.0		
		0*				0*			
10	-434.1								
		0	0.0			0	-184.3	1	2
		1	0.0			1	-184.3	1	2
		2	0.0			2	0.0		
		3	0.0			3	0.0		
		0*				0*			
19	255.7								
		0	265.5	0	14	0	-51.3	0	44
		1	183.4	1	6	1	-26.3	3	54
		2	91.0	2	26	2	-4.9	2	34
		3	0.0			3	0.0		
		0*				0*			
23	389.0								
		0	261.0	0	15	0	-74.1	0	44
		1	176.7	1	6	1	-38.0	3	54
		2	107.5	2	26	2	-7.1	2	34
		3	0.0			3	0.0		
		0*				0*			
33	46.6								
		0	167.1	0	19	0	-131.1	0	44
		1	128.7	2	26	1	-67.3	3	54
		2	44.6	1	6	2	-12.6	2	34
		3	0.0			3	0.0		
		0*				0*			
40	-596.9								
		0	0.0			0	-189.0	2	30
		1	0.0			1	-189.0	2	30
		2	0.0			2	-87.8	1	6
		3	0.0			3	-87.8	3	54
		0*				3*			

PROB 2 Span 2 (L=120', Type IV Beam @ 6.8', 8" Slab, 2" O'lay)-Hold Envp
(CONTINUED)

MOMENT (FT-K)

AT STA	DEAD LD EFFECT	LANE ORDER	POSITIVE MAXIMUM	LOAD LANE	AT STA	LANE ORDER	NEGATIVE MAXIMUM	LOAD LANE	AT STA
47	46.6								
		0	167.1	0	41	0	-131.1	0	16
		1	128.7	2	34	1	-67.3	1	6
		2	44.6	3	54	2	-12.6	2	26
		3	0.0			3	0.0		
		0*				0*			
57	389.0								
		0	261.0	0	45	0	-74.1	0	16
		1	176.7	3	54	1	-38.0	1	6
		2	107.5	2	34	2	-7.1	2	26
		3	0.0			3	0.0		
		0*				0*			
60	330.2								
		0	297.4	0	46	0	-57.0	0	16
		1	216.3	3	54	1	-29.3	1	6
		2	101.1	2	34	2	-5.5	2	26
		3	0.0			3	0.0		
		0*				0*			
65	-46.7								
		0	142.9	0	44	0	-46.7	3	58
		1	51.9	3	54	1	-46.7	3	58
		2	50.5	2	34	2	-14.6	1	6
		3	0.0			3	-2.7	2	26
		0*				2*			
70	-434.1								
		0	0.0			0	-184.3	3	58
		1	0.0			1	-184.3	3	58
		2	0.0			2	0.0		
		3	0.0			3	0.0		
		0*				0*			

PROB 2 Span 2 (L=120', Type IV Beam @ 6.8', 8" Slab, 2" O'lay)-Hold Envp
(CONTINUED)

SHEAR (K)

AT STA	DEAD LD EFFECT	LANE ORDER	POSITIVE MAXIMUM	LOAD LANE	AT STA	LANE ORDER	NEGATIVE MAXIMUM	LOAD LANE	AT STA
8	-215.4								
		0	0.0			0	-92.2	1	2
		1	0.0			1	-92.2	1	2
		2	0.0			2	0.0		
		3	0.0			3	0.0		
		0*				0*			
12	155.4								
		0	67.8	0	9	0	-11.4	0	44
		1	65.8	1	6	1	-5.9	3	54
		2	20.2	2	26	2	-1.1	2	34
		3	0.0			3	0.0		
		2*				0*			
38	-185.1								
		0	0.0			0	-100.6	0	20
		1	0.0			1	-90.5	2	26
		2	0.0			2	-37.8	1	6
		3	0.0			3	-5.9	3	54
		0*				2*			
42	185.1								
		0	100.6	0	40	0	0.0		
		1	90.5	2	34	1	0.0		
		2	37.8	3	54	2	0.0		
		3	5.9	1	6	3	0.0		
		2*				0*			
68	-155.4								
		0	11.4	0	16	0	-67.8	0	51
		1	5.9	1	6	1	-65.8	3	54
		2	1.1	2	26	2	-20.2	2	34
		3	0.0			3	0.0		
		0*				2*			
72	215.4								
		0	92.2	3	58	0	0.0		
		1	92.2	3	58	1	0.0		
		2	0.0			2	0.0		
		3	0.0			3	0.0		
		0*				0*			

PROB 2 Span 2 (L=120', Type IV Beam @ 6.8', 8" Slab, 2" O'lay)-Hold Envp
(CONTINUED)

REACTION (K)

AT STA	DEAD LD EFFECT	LANE ORDER	POSITIVE MAXIMUM	LOAD LANE	AT STA	LANE ORDER	NEGATIVE MAXIMUM	LOAD LANE	AT STA
10	374.2								
		0	147.2	1	2	0	-11.4	0	44
		1	147.2	1	2	1	-5.9	3	54
		2	20.2	2	26	2	-1.1	2	34
		3	0.0			3	0.0		
		0*				0*			
40	475.8								
		0	146.0	2	30	0	0.0		
		1	146.0	2	30	1	0.0		
		2	43.7	1	6	2	0.0		
		3	43.7	3	54	3	0.0		
		3*				0*			
70	374.2								
		0	147.2	3	58	0	-11.4	0	16
		1	147.2	3	58	1	-5.9	1	6
		2	20.2	2	34	2	-1.1	2	26
		3	0.0			3	0.0		
		0*				0*			

PROB 2 Span 2 (L=120', Type IV Beam @ 6.8', 8" Slab, 2" O'lay)-Hold Envp
(CONTINUED)

TABLE 6. ENVELOPES OF MAXIMUM VALUES (WORKING STRESS)

STA	DIST X (FT)	MAX + MOM (FT-K)	MAX - MOM (FT-K)	MAX + SHEAR (K)	MAX - SHEAR (K)
-1	-0.50	0.0	0.0	0.0	0.0
0	0.00	0.0	0.0	0.0	0.0
1	0.50	0.0	0.0	0.0	0.0
2	1.00	0.0	0.0	-0.2	-0.2
3	1.50	-0.2	-0.2	-0.9	-0.9
4	2.00	-0.9	-0.9	-1.7	-1.7
5	2.50	-1.9	-1.9	-2.6	-2.6
6	3.00	-3.4	-3.4	-108.5	-170.6
7	3.50	-110.5	-172.5	-214.5	-338.6
8	4.00	-217.9	-342.0	-215.4	-339.4
9	4.50	-325.8	-511.9	-216.2	-340.3
10	5.00	-434.1	-682.3	3.9	-65.5
11	5.50	-326.3	-577.4	242.2	142.6
12	6.00	-214.1	-473.0	241.4	141.7
13	6.50	-100.7	-368.9	240.5	140.9
14	7.00	12.2	-265.3	239.7	140.0
15	7.50	124.8	-162.1	238.8	139.2
16	8.00	236.9	-59.4	238.0	138.3
17	8.50	349.1	43.0	237.1	137.5
18	9.00	461.6	126.0	236.3	136.6
19	9.50	574.3	194.1	235.4	135.8
20	10.00	687.0	261.8	170.7	80.8
21	10.50	691.9	274.9	115.7	4.0
22	11.00	725.9	287.7	114.9	3.2
23	11.50	778.0	300.0	6.1	-48.7
24	12.00	713.2	260.8	-57.8	-130.0
25	12.50	648.0	221.3	-58.6	-130.8
26	13.00	582.4	181.2	-59.5	-131.7
27	13.50	518.6	140.8	-60.3	-132.5
28	14.00	471.9	99.9	-61.2	-133.4
29	14.50	427.0	58.7	-62.0	-134.2
30	15.00	381.8	16.9	-62.9	-135.1
31	15.50	336.0	-25.2	-63.7	-136.0
32	16.00	290.9	-67.8	-64.6	-136.8
33	16.50	247.1	-110.8	-126.8	-202.1
34	17.00	96.2	-209.4	-181.7	-310.1
35	17.50	-55.1	-308.5	-182.6	-310.9
36	18.00	-206.8	-408.4	-183.4	-311.8
37	18.50	-318.6	-510.5	-184.3	-312.6
38	19.00	-410.9	-630.8	-185.1	-313.5
39	19.50	-503.7	-764.0	-186.0	-314.3
40	20.00	-596.9	-906.8	50.3	-50.3
41	20.50	-503.7	-764.0	314.3	186.0
42	21.00	-410.9	-630.8	313.5	185.1

PROB 2 Span 2 (L=120', Type IV Beam @ 6.8', 8" Slab, 2" O'lay)-Hold Envp
(CONTINUED)

TABLE 6. ENVELOPES OF MAXIMUM VALUES (WORKING STRESS)

STA	DIST X (FT)	MAX + MOM (FT-K)	MAX - MOM (FT-K)	MAX + SHEAR (K)	MAX - SHEAR (K)
43	21.50	-318.6	-510.5	312.6	184.3
44	22.00	-206.8	-408.4	311.8	183.4
45	22.50	-55.1	-308.5	310.9	182.6
46	23.00	96.2	-209.4	310.1	181.7
47	23.50	247.1	-110.8	202.1	126.8
48	24.00	290.9	-67.8	136.8	64.6
49	24.50	336.0	-25.2	136.0	63.7
50	25.00	381.8	16.9	135.1	62.9
51	25.50	427.0	58.7	134.2	62.0
52	26.00	471.9	99.9	133.4	61.2
53	26.50	518.6	140.8	132.5	60.3
54	27.00	582.4	181.2	131.7	59.5
55	27.50	648.0	221.3	130.8	58.6
56	28.00	713.2	260.8	130.0	57.8
57	28.50	778.0	300.0	48.7	-6.1
58	29.00	725.9	287.7	-3.2	-114.9
59	29.50	691.9	274.9	-4.0	-115.7
60	30.00	687.0	261.8	-80.8	-170.7
61	30.50	574.3	194.1	-135.8	-235.4
62	31.00	461.6	126.0	-136.6	-236.3
63	31.50	349.1	43.0	-137.5	-237.1
64	32.00	236.9	-59.4	-138.3	-238.0
65	32.50	124.8	-162.1	-139.2	-238.8
66	33.00	12.2	-265.3	-140.0	-239.7
67	33.50	-100.7	-368.9	-140.9	-240.5
68	34.00	-214.1	-473.0	-141.7	-241.4
69	34.50	-326.3	-577.4	-142.6	-242.2
70	35.00	-434.1	-682.3	65.5	-3.9
71	35.50	-325.8	-511.9	340.3	216.2
72	36.00	-217.9	-342.0	339.4	215.4
73	36.50	-110.5	-172.5	338.6	214.5
74	37.00	-3.4	-3.4	170.6	108.5
75	37.50	-1.9	-1.9	2.6	2.6
76	38.00	-0.9	-0.9	1.7	1.7
77	38.50	-0.2	-0.2	0.9	0.9
78	39.00	0.0	0.0	0.2	0.2
79	39.50	0.0	0.0	0.0	0.0
80	40.00	0.0	0.0	0.0	0.0
81	40.50	0.0	0.0	0.0	0.0

PROB 2 Span 2 (L=120', Type IV Beam @ 6.8', 8" Slab, 2" O'lay)-Hold Envp
(CONTINUED)

TABLE 7. MAXIMUM SUPPORT REACTIONS (WORKING STRESS)

STA	DIST X (FT)	MAX + REACT (K)	MAX - REACT (K)
10	5.00	551.4	360.5
40	20.00	674.1	475.8
70	35.00	551.4	360.5

PROB 2 Span 2 (L=120', Type IV Beam @ 6.8', 8" Slab, 2" O'lay)-Hold Envp
(CONTINUED)

TABLE 5. MULTI-LANE LOADING SUMMARY (LOAD FACTOR)
(*--CRITICAL NUMBER OF LANE LOADS)

MOMENT (FT-K)

AT STA	DEAD LD EFFECT	LANE ORDER	POSITIVE MAXIMUM	LOAD LANE	AT STA	LANE ORDER	NEGATIVE MAXIMUM	LOAD LANE	AT STA
6	-4.3								
		0	0.0			0	0.0		
		1	0.0			1	0.0		
		2	0.0			2	0.0		
		3	0.0			3	0.0		
		0*				0*			
10	-552.4								
		0	0.0			0	-322.5	1	2
		1	0.0			1	-322.5	1	2
		2	0.0			2	0.0		
		3	0.0			3	0.0		
		0*				0*			
19	325.0								
		0	464.7	0	14	0	-89.8	0	44
		1	321.0	1	6	1	-46.1	3	54
		2	159.2	2	26	2	-8.6	2	34
		3	0.0			3	0.0		
		0*				0*			
23	494.7								
		0	456.8	0	15	0	-129.7	0	44
		1	309.2	1	6	1	-66.6	3	54
		2	188.0	2	26	2	-12.4	2	34
		3	0.0			3	0.0		
		0*				0*			
33	59.2								
		0	292.5	0	19	0	-229.5	0	44
		1	225.3	2	26	1	-117.8	3	54
		2	78.0	1	6	2	-22.0	2	34
		3	0.0			3	0.0		
		0*				0*			
40	-758.8								
		0	0.0			0	-330.7	2	30
		1	0.0			1	-330.7	2	30
		2	0.0			2	-153.6	1	6
		3	0.0			3	-153.6	3	54
		0*				3*			

PROB 2 Span 2 (L=120', Type IV Beam @ 6.8', 8" Slab, 2" O'lay)-Hold Envp
(CONTINUED)

MOMENT (FT-K)

AT STA	DEAD LD EFFECT	LANE ORDER	POSITIVE MAXIMUM	LOAD LANE	AT STA	LANE ORDER	NEGATIVE MAXIMUM	LOAD LANE	AT STA
47	59.2								
		0	292.5	0	41	0	-229.5	0	16
		1	225.3	2	34	1	-117.8	1	6
		2	78.0	3	54	2	-22.0	2	26
		3	0.0			3	0.0		
		0*				0*			
57	494.7								
		0	456.8	0	45	0	-129.7	0	16
		1	309.2	3	54	1	-66.6	1	6
		2	188.0	2	34	2	-12.4	2	26
		3	0.0			3	0.0		
		0*				0*			
60	419.8								
		0	520.4	0	46	0	-99.8	0	16
		1	378.5	3	54	1	-51.2	1	6
		2	176.9	2	34	2	-9.6	2	26
		3	0.0			3	0.0		
		0*				0*			
65	-59.6								
		0	250.0	0	44	0	-81.7	3	58
		1	90.9	3	54	1	-81.7	3	58
		2	88.4	2	34	2	-25.6	1	6
		3	0.0			3	-4.8	2	26
		0*				2*			
70	-552.4								
		0	0.0			0	-322.5	3	58
		1	0.0			1	-322.5	3	58
		2	0.0			2	0.0		
		3	0.0			3	0.0		
		0*				0*			

PROB 2 Span 2 (L=120', Type IV Beam @ 6.8', 8" Slab, 2" O'lay)-Hold Envp
(CONTINUED)

SHEAR (K)

AT STA	DEAD LD EFFECT	LANE ORDER	POSITIVE MAXIMUM	LOAD LANE	AT STA	LANE ORDER	NEGATIVE MAXIMUM	LOAD LANE	AT STA
8	-274.1								
		0	0.0			0	-161.3	1	2
		1	0.0			1	-161.3	1	2
		2	0.0			2	0.0		
		3	0.0			3	0.0		
		0*				0*			
12	197.6								
		0	118.6	0	9	0	-20.0	0	44
		1	115.1	1	6	1	-10.2	3	54
		2	35.4	2	26	2	-1.9	2	34
		3	0.0			3	0.0		
		2*				0*			
38	-235.3								
		0	0.0			0	-176.1	0	20
		1	0.0			1	-158.4	2	26
		2	0.0			2	-66.2	1	6
		3	0.0			3	-10.2	3	54
		0*				2*			
42	235.3								
		0	176.1	0	40	0	0.0		
		1	158.4	2	34	1	0.0		
		2	66.2	3	54	2	0.0		
		3	10.2	1	6	3	0.0		
		2*				0*			
68	-197.6								
		0	20.0	0	16	0	-118.6	0	51
		1	10.2	1	6	1	-115.1	3	54
		2	1.9	2	26	2	-35.4	2	34
		3	0.0			3	0.0		
		0*				2*			
72	274.1								
		0	161.3	3	58	0	0.0		
		1	161.3	3	58	1	0.0		
		2	0.0			2	0.0		
		3	0.0			3	0.0		
		0*				0*			

PROB 2 Span 2 (L=120', Type IV Beam @ 6.8', 8" Slab, 2" O'lay)-Hold Envp
(CONTINUED)

REACTION (K)

AT STA	DEAD LD EFFECT	LANE ORDER	POSITIVE MAXIMUM	LOAD LANE	AT STA	LANE ORDER	NEGATIVE MAXIMUM	LOAD LANE	AT STA
10	476.0								
		0	257.6	1	2	0	-20.0	0	44
		1	257.6	1	2	1	-10.2	3	54
		2	35.4	2	26	2	-1.9	2	34
		3	0.0			3	0.0		
		0*				0*			
40	605.0								
		0	255.4	2	30	0	0.0		
		1	255.4	2	30	1	0.0		
		2	76.4	1	6	2	0.0		
		3	76.4	3	54	3	0.0		
		3*				0*			
70	476.0								
		0	257.6	3	58	0	-20.0	0	16
		1	257.6	3	58	1	-10.2	1	6
		2	35.4	2	34	2	-1.9	2	26
		3	0.0			3	0.0		
		0*				0*			

PROB 2 Span 2 (L=120', Type IV Beam @ 6.8', 8" Slab, 2" O'lay)-Hold Envp
(CONTINUED)

TABLE 6. ENVELOPES OF MAXIMUM VALUES (LOAD FACTOR)

STA	DIST X (FT)	MAX + MOM (FT-K)	MAX - MOM (FT-K)	MAX + SHEAR (K)	MAX - SHEAR (K)
-1	-0.50	0.0	0.0	0.0	0.0
0	0.00	0.0	0.0	0.0	0.0
1	0.50	0.0	0.0	0.0	0.0
2	1.00	0.0	0.0	-0.3	-0.3
3	1.50	-0.3	-0.3	-1.1	-1.1
4	2.00	-1.1	-1.1	-2.1	-2.1
5	2.50	-2.4	-2.4	-3.2	-3.2
6	3.00	-4.3	-4.3	-138.1	-246.7
7	3.50	-140.5	-249.1	-273.0	-490.1
8	4.00	-277.3	-494.4	-274.1	-491.2
9	4.50	-414.6	-740.3	-275.1	-492.3
10	5.00	-552.4	-986.7	21.1	-100.3
11	5.50	-401.2	-840.6	349.1	174.8
12	6.00	-242.1	-695.1	348.1	173.7
13	6.50	-80.8	-550.1	347.0	172.6
14	7.00	80.1	-405.7	345.9	171.6
15	7.50	240.3	-261.7	344.9	170.5
16	8.00	400.1	-118.3	343.8	169.4
17	8.50	560.3	24.5	342.7	168.4
18	9.00	721.2	133.8	341.7	167.3
19	9.50	882.5	217.2	340.6	166.2
20	10.00	1044.3	300.0	253.6	96.4
21	10.50	1043.3	313.6	183.7	-11.8
22	11.00	1093.5	326.6	182.7	-12.9
23	11.50	1175.5	339.0	17.0	-79.0
24	12.00	1077.6	285.9	-70.1	-196.4
25	12.50	979.1	232.3	-71.1	-197.5
26	13.00	880.1	178.1	-72.2	-198.6
27	13.50	784.4	123.4	-73.3	-199.6
28	14.00	719.0	68.1	-74.3	-200.7
29	14.50	657.0	12.3	-75.4	-201.8
30	15.00	594.4	-44.0	-76.5	-202.8
31	15.50	531.3	-100.9	-77.5	-203.9
32	16.00	469.4	-158.3	-78.6	-205.0
33	16.50	410.2	-216.2	-161.2	-292.9
34	17.00	189.5	-345.4	-231.0	-455.6
35	17.50	-31.8	-475.1	-232.1	-456.7
36	18.00	-253.3	-606.2	-233.2	-457.8
37	18.50	-405.0	-740.8	-234.2	-458.8
38	19.00	-522.4	-907.2	-235.3	-459.9
39	19.50	-640.3	-1095.8	-236.4	-461.0
40	20.00	-758.8	-1301.0	88.0	-88.0
41	20.50	-640.3	-1095.8	461.0	236.4
42	21.00	-522.4	-907.2	459.9	235.3
43	21.50	-405.0	-740.8	458.8	234.2

PROB 2 Span 2 (L=120', Type IV Beam @ 6.8', 8" Slab, 2" O'lay)-Hold Envp
(CONTINUED)

TABLE 6. ENVELOPES OF MAXIMUM VALUES (LOAD FACTOR)

STA	DIST X (FT)	MAX + MOM (FT-K)	MAX - MOM (FT-K)	MAX + SHEAR (K)	MAX - SHEAR (K)
44	22.00	-253.3	-606.2	457.8	233.2
45	22.50	-31.8	-475.1	456.7	232.1
46	23.00	189.5	-345.4	455.6	231.0
47	23.50	410.2	-216.2	292.9	161.2
48	24.00	469.4	-158.3	205.0	78.6
49	24.50	531.3	-100.9	203.9	77.5
50	25.00	594.4	-44.0	202.8	76.5
51	25.50	657.0	12.3	201.8	75.4
52	26.00	719.0	68.1	200.7	74.3
53	26.50	784.4	123.4	199.6	73.3
54	27.00	880.1	178.1	198.6	72.2
55	27.50	979.1	232.3	197.5	71.1
56	28.00	1077.6	285.9	196.4	70.1
57	28.50	1175.5	339.0	79.0	-17.0
58	29.00	1093.5	326.6	12.9	-182.7
59	29.50	1043.3	313.6	11.8	-183.7
60	30.00	1044.3	300.0	-96.4	-253.6
61	30.50	882.5	217.2	-166.2	-340.6
62	31.00	721.2	133.8	-167.3	-341.7
63	31.50	560.3	24.5	-168.4	-342.7
64	32.00	400.1	-118.3	-169.4	-343.8
65	32.50	240.3	-261.7	-170.5	-344.9
66	33.00	80.1	-405.7	-171.6	-345.9
67	33.50	-80.8	-550.1	-172.6	-347.0
68	34.00	-242.1	-695.1	-173.7	-348.1
69	34.50	-401.2	-840.6	-174.8	-349.1
70	35.00	-552.4	-986.7	100.3	-21.1
71	35.50	-414.6	-740.3	492.3	275.1
72	36.00	-277.3	-494.4	491.2	274.1
73	36.50	-140.5	-249.1	490.1	273.0
74	37.00	-4.3	-4.3	246.7	138.1
75	37.50	-2.4	-2.4	3.2	3.2
76	38.00	-1.1	-1.1	2.1	2.1
77	38.50	-0.3	-0.3	1.1	1.1
78	39.00	0.0	0.0	0.3	0.3
79	39.50	0.0	0.0	0.0	0.0
80	40.00	0.0	0.0	0.0	0.0
81	40.50	0.0	0.0	0.0	0.0

PROB 2 Span 2 (L=120', Type IV Beam @ 6.8', 8" Slab, 2" O'lay)-Hold Envp
(CONTINUED)

TABLE 7. MAXIMUM SUPPORT REACTIONS (LOAD FACTOR)

STA	DIST X (FT)	MAX + REACT (K)	MAX - REACT (K)
10	5.00	786.0	452.0
40	20.00	952.0	605.0
70	35.00	786.0	452.0

County:	Any	Descrip:	LRFD Design for Shear: Rectangular Bent Cap De
Highway:	Any		
C-S-J:	Any	Design:	Brg
		Ck Dsn:	
Bridge Division	Rev: 8/27/04	Date:	

CONCRETE SECTION SHEAR CAPACITY BY AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS, THIRD EDITION, 2004

Resistance Factors:

Units: **US**

ϕ_V =	0.9
ϕ_M =	1
ϕ_N =	0.75

Concrete:			**Mild Steel:**			**Prestressed Steel:**		
f'c =	3.6	ksi	fy =	60	ksi	fps =	270	ksi
Ec =	3453	ksi	Es =	29000	ksi	Ep =	28500	ksi

		SECTIONS							
	Units	**Sta 8**	**Sta 12**	**Sta 15**	**Sta 18**	**Sta 23**	**Sta 28**	**Sta 33**	**Sta 38**
Input Data									
Bending moment, **Mu**	kip-ft	494.4	695.1	261.7	721.2	1175.5	719.0	410.2	907.2
Shear force, **Vu**	kip	491.2	348.1	344.9	341.7	79	200.7	292.9	459.9
Axial force, **Nu**	kip								
Web width, **bv**	in	39.00	39.00	39.00	39.00	39.00	39.00	39.00	39
Shear depth, **dv**	in	35.99	35.99	35.99	35.99	35.99	35.99	35.99	35.99
Mild steel reinf. area, **As**	in^2	10.92	10.92	10.92	10.92	10.92	10.92	10.92	10.92
Area of beam below h/2, **Ac**	in^2	819	819	819	819	819	819	819	819
Area of stirrups, **Av**	in^2	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62
Stirrup spacing, **s**	in	4	9	9	9	9	9	9	5
Prestressed steel area, **Aps**	in^2								
Prestress shear, **Vp**	kip								
Effective prestress, **fpe**	ksi								
Torsional moment, **Tu**	kip-ft								
Shear flow area, **Ao**	in^2								
Area of one leg of stirrup, **At**	in^2								
Perimeter of stirrup, **Ph**	in								
Area enclosed by stirrup, **Aoh**	in^2								
Calculated Values									
Vc	kip	181.8	191.0	191.0	191.9	202.8	208.7	197.8	183.5
Vs	kip	447.4	207.0	207.8	208.6	227.3	236.2	218.1	359.2
ϕ**Vn**	kip	**566**	**358**	**359**	**360**	**387**	**400**	**374**	**488**
ε_x		1.00E-03	9.32E-04	9.25E-04	9.18E-04	7.14E-04	6.30E-04	8.01E-04	1.00E-03
θ	deg	36.80	35.70	35.60	35.50	33.20	32.20	34.30	36.70
β		2.160	2.270	2.270	2.280	2.410	2.480	2.350	2.180
Req'd Shear reinf. **Av/S**	in^2/in	0.126	0.065	0.064	0.062	0.000	0.004	0.040	0.113
Req'd Torsion reinf. **At/S**	in^2/in	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Maximum stirrup spacing, **Smax**	in	4.9	9.5	9.7	10.0	☆ 24.0	☆ 15.9	☆ 15.4	5.5
Conclusion									
Shear Reinforcing		OK	OK	OK	OK	OK	OK	OK	OK
Longitudinal Reinforcing		OK	OK	OK	OK	OK	OK	OK	FAILED

Note: Longitudinal Reinforcing check can be ignored for typical multi-column bent caps. For straddle bents with no overhangs, this check must be considered. Refer to LRFD 5.8.3.5 for further information.

Spreadsheet columns must be used in consecutive order to work properly. DO NOT skip a column.

If torsion is not being considered, leave last five rows of input data blank.

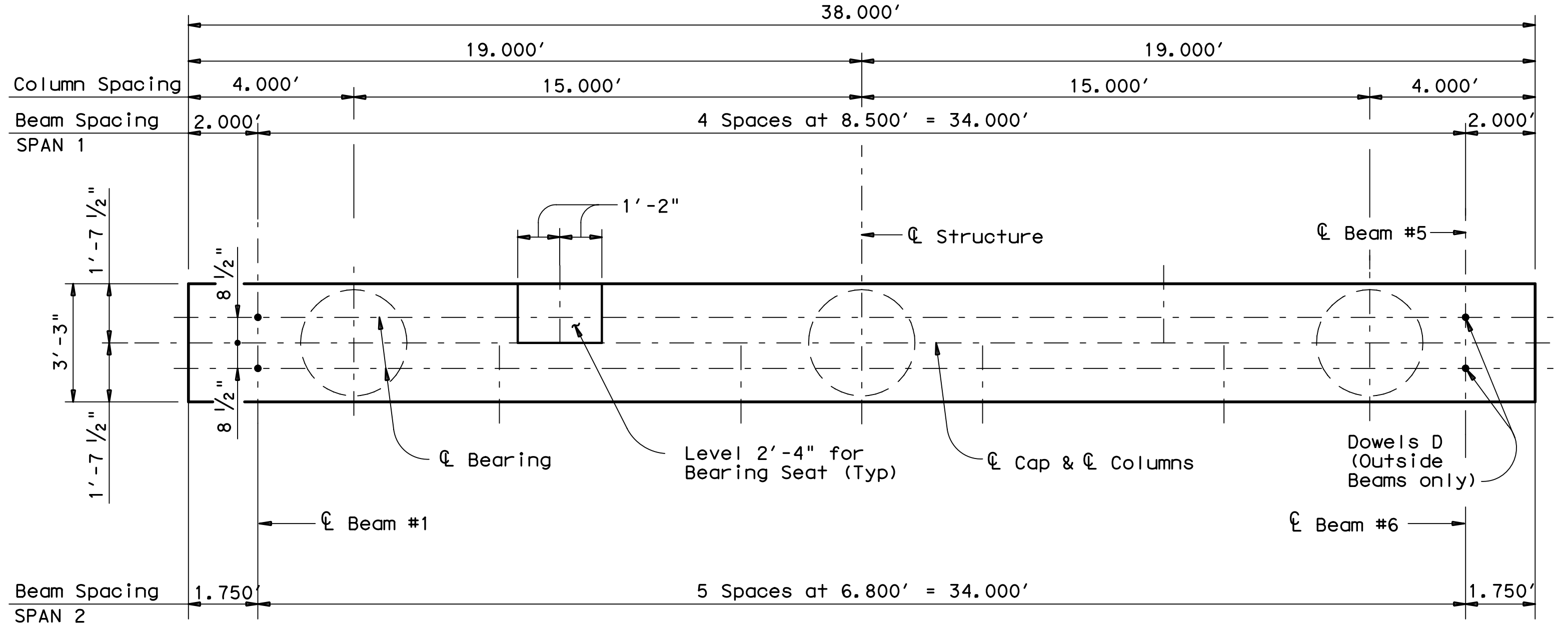
☆ TxDot Max Spa. = 12in

TABLES OF CONSTANT QUANTITIES				
Bar	No.	Size	Length	Weight
A	7	#11	37'-8"	1401
B	7	#11	37'-8"	1401
D	4	1¼"D	1'-8"	28
S	58	#5	13'-0"	786
T	10	#5	37'-8"	393
Reinforcing Steel			Lb	4,009
Class "C" Concrete			CY	16.0

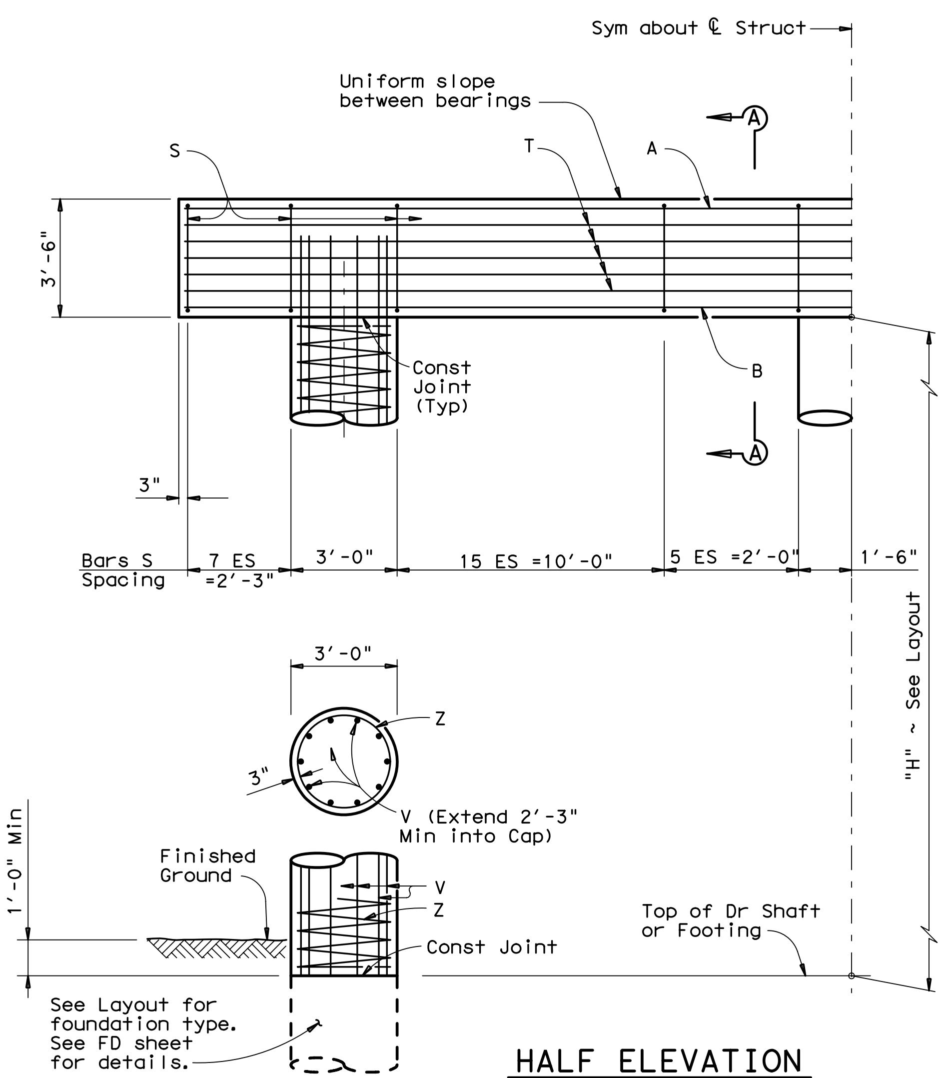
① TABLE OF VARIABLE QUANTITIES FOR 3 COLUMNS						② TOTAL ESTIMATED QUANTITIES	
"H"	Class "C" Conc (Cols)	Bars V 30 ~ #9		Bars Z 3 ~ #3 Spiral		Reinf Steel	Class "C" Conc
Ft	CY	Length	Weight	Length	Weight	Lb	CY
20	15.7	22'-3"	2,270	330'-6"	373	6,652	31.7

① Adjust Bars V length by 1 Ft and Bars Z length by 15.7398 Ft for each linear foot of variation in "H" value.

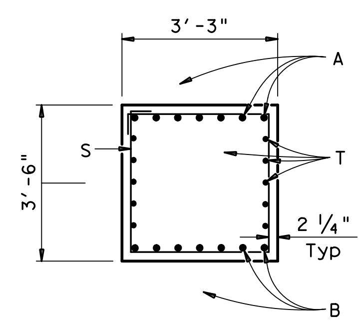
② Adjust Reinforcing Steel Total by 120 Lbs and Class "C" Conc by 0.7854 CY for each linear foot of variation in "H" value.



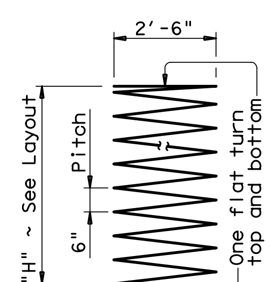
PLAN



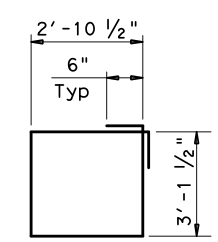
HALF ELEVATION



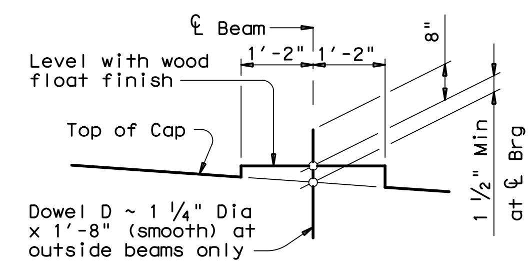
SECTIONS A-A



BARS Z



BARS S



BEARING SEAT DETAIL

(Bearing surface shall be clean and free of all loose material before placing bearing pad.)

GENERAL NOTES:

Bent selected shall be based on the average span length rounded up to the next 5 Ft increment.

Designed according to current AASHTO Standard and Interim Specifications.

Concrete strength f'c = 3,600 psi.

All Cap reinforcing shall be Grade 60.

Column and Drilled Shaft reinforcing may be Grade 40.

HL-93 LOADING

Texas Department of Transportation
Design Division (Bridge)

INTERIOR BENT

BENT CAP DESIGN EXAMPLE

FILE:	DN: BRG	CK:	DW: BRG	CK:
©TxDOT March 2006	DISTRICT	FEDERAL AID PROJECT		SHEET
REVISIONS	COUNTY	CONTROL	SECT JOB	HIGHWAY

LEVELS DISPLAYED
ACC:
1