THE ANALYSIS AND DESIGN OF SIMPLE SPAN PRESTRESSED BEAMS

COMPUTER PROGRAM

USER'S MANUAL

PRESENTED BY THE
GEORGIA DEPARTMENT OF TRANSPORTATION
BRIDGE DIVISION

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FORWARD

"The Analysis and Design of Simple Span Prestressed Beams" presented in this manual is a problem-oriented computer program that can be used in the design or analysis of prestressed concrete simple span beams. This write-up is primarily a user's manual and does not include flow charts or a program listing. The user of this program is assumed to be familiar with the standard terminology of concrete design and such terms as moment, stress, etc., are not defined in this write-up.

This manual explains in detail the functions of the program and how the program can be applied in the design or analysis of prestressed concrete simple span beams.

RESTRICTION

DISCLAIMER

ALTHOUGH THIS PROGRAM HAS BEEN SUBJECTED TO MANY RIGOROUS TESTS, NO WARRANTY, EXPRESSED OR IMPLIED, IS MADE BY THE GEORGIA DEPARTMENT OF TRANSPORTATION AS TO THE ACCURACY AND FUNCTIONING OF THE PROGRAM, NOR SHALL THE FACT OF DISTRIBUTION CONSTITUTE ANY SUCH WARRANTY, AND NO RESPONSIBILITY IS ASSUMED BY THE GEORGIA DEPARTMENT OF TRANSPORTATION IN ANY CONNECTION THEREWITH.

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1.0 DESCRIPTION OF PROGRAM BRPSBM1

The Prestressed Beam Design Program (BRPSBM1) is a problem-oriented computer program that can be used effectively in the design and analysis of simple span prestressed beams for highway bridges. However, the program is not limited to highway bridges since railroad and pedestrian live loads can be handled by the program. No capacity for continuous units is incorporated into the program. The program is not limited to design since a given beam section (or beam type) and strand arrangement can be analyzed for the specified loads. In a design problem the designated beam section remains constant throughout the design process (alternate beam sections are not tried). A design consists of selecting a strand arrangment with either straight, draped, or debonded strands, whichever is specified by the user. A analysis consists of using a specified strand arrangement with any combination of straight, draped, and debonded strands.

The program will perform the following functions:

1. Computes beam section properties (composite and non-composite).

2. Computes moments, shears, and gravity load stresses.

3. Selects a strand arrangement for a design (number and pattern at span center line). For a draped design the program will select the hold down point(s) and the raised height of draped strands. For a debond design the program will select the number of strands to be debonded and the distance they are to be shielded.

4. Computes eccentricity envelope of the strands along the beam.

5. Uses specified or computed initial and final prestress losses.

6. Computes dead load deflections, live load deflections, prestress deflections, and camber.

7. Computes development and transfer lengths of the prestress strands.

8. Computes actual number of strands that are active at 20th points along the beam when considering development lengths, transfer lengths, and debonded lengths.

9. Computes release and final stresses at 20th points along the beam.

10. Checks cracking load criteria.

11. Computes miscellaneous data (i.e., ultimate moment capacity, ultimate shear capacity, stirrup spacing, etc.).

2.0 DESCRIPTION OF CALCULATIONS

NOTATIONS

A = Horizontal distance from hold down point to end of beam, (ft).

AB = Area of non-composite beam, (in2).

AF′ = Area of adjusted effective flange, (in2).

As* = Total area of all prestressing steel, (in2).

Asf = 0.85(f′c)(WF′ - w)TF/(fsu*) Art. 9.17.3
= Steel area required to develop the ultimate compressive strength of the overhanging portions of the flange, (in2).

Asr = As* - Asf
= Steel area required to develop the ultimate compressive strength of the web, (in2).

AT = Total area of composite beam, (in2).

Av = Area of web reinforcement, (in2).

alpha = Factor for type of prestressing steel, (.40 for stress relieved strands and .28 for low relaxation strands.

beta = Factor for concrete strength, (.85 for f′c = 4 ksi concrete strength, reduce at a rate of .05 per increase of 1 ksi).

d = Distance from extreme compressive fiber (top of slab) to centroid of prestressing steel, (in).

DR = Vertical distance of raised strands, (in).

E′ = Distance from centroid of strands at end of beam to centroid of strand arrangement at hold down point, (in).

EBM = Modulus of elasticity of the beam concrete, (10EE3 ksi).

Eci = $33(wc)^{1.5}\,[(f'ci)(1000)]^{.5}/1000$
= Modulus of elasticity of concrete at transfer of stress, (ksi).

Ee = Distance from centroid of strands at end of beam to centroid of beam section, (in).

EF = Distance from centroid of non-composite beam cross section to centroid of the strand arrangement at final conditions, (in).

EI = Distance from centroid of non-composite beam cross section to centroid of the strand arrangement at initial conditions, (in).

Es = Modulus of elasticity of prestressed strand, program uses 28,000 ksi.

ESL = Modulus of elasticity of the slab concrete, (10EE3 ksi).

f′c = Compressive strength of beam concrete at 28 days, (ksi).

f′ci = Compressive strength of beam concrete at normal time of release, (ksi).

fcds = $WDT(L)^2\,EI/[8(IN)] + MPL(EI)/IN$
= Concrete stress at the center of gravity of the prestressing steel due to all dead loads except the dead load present at the time the prestressing force is applied, (ksi).

fcir = $IPF/AB + IPF(EI)^2/IN - Wb(L)^2 EI/[8(IN)]$
= concrete stress at the center of gravity of the prestressing steel due to prestress force and dead load of beam immediately after transfer, (ksi).

FD = Stress due to dead load, (ksi).

FPC = Compressive stress in concrete due to beam dead load and final prestress force at non-composite beam centroid, (ksi).

FPF = Prestress force after final losses, (kips).

fsy = Yield strength of non-prestressed reinforcement.

FPU = Ultimate strength of prestressing steel, (ksi).

fr = $7.5(f'c)^{.5}$
= Modulus of rupture, (ksi).

fsu* = Average stress in prestressing at ultimate load, (ksi).

H = Overall depth of composite member, (in).

HLR = Horizontal length of raised strands, (in).

IC = Composite moment of inertia of beam about centroid, (in4).

IN = Non-composite moment of inertia of beam about centroid, (in4).

IPF = Prestress force after initial losses, (kips).

L = Bearing to bearing length of beam, (ft).

M = Applied moment, (k-ft).

MB = Moment due to beam weight, (k-ft).

MC = Total moment due to all composite loads, (k-ft).

MDL = Total dead load moment, (k-ft).

MLL = Total live load moment, (k-ft).

MN = Total moment due to all non-composite loads, includes beam, (k-ft).

MPL = Moment due to P-load at center of beam, (k-ft).

MRR = Maximum railroad live load moment at center line, (k-ft).

MSR = Maximum steel ratio.

MU = Maximum factored ultimate moment due to externally applied loads, (k-ft).

Mu = Ultimate moment capacity of the beam, (k-ft.).

NP = Number of p-loads.

NRS = Number of raised strands.

p* = As*/(WF'(d)) , for rectangular section
= As*/(WT(d)) , for flanged section
= Ratio of prestressing steel.

QS = Moment area of composite slab, (in3).

RH = Mean relative humidity, program uses 70%.

SBC = Composite section modulus of bottom of beam, (in3).
SBN = Non-composite section modulus of bottom of beam, (in3).
SIT = Allowable stress in top of beam at initial conditions, (ksi).
SFB = Allowable stress in bottom of beam at final conditions, (ksi).
SFPF = Final Prestress Force based on final losses and the number of strands that are developed at ultimate conditions, (kips).
STC = Composite section modulus of top of beam, (in3).
STN = Non-composite section modulus of top of beam, (in3).

TF = Slab thickness, (in).

Vci = Shear strength provided by concrete when diagonal cracking occurs from combined shear and moment, (kips).
Vcw = Shear strength provided by concrete when diagonal cracking occurs from excessive principle tensile stress in web, (kips).
VDC = Total composite dead load shear, (kips).
VDL = Total dead load shear, (kips).
VLL = Total live load shear, (kips).
Vnh = Nominal horizontal shear strength, (kips).
VP = Vertical component of final prestress force, (ksi).
VU = Ultimate total shear force due to externally applied loads, (kips).
VUC = Factored shear force due to composite dead load and live loads, (kips).

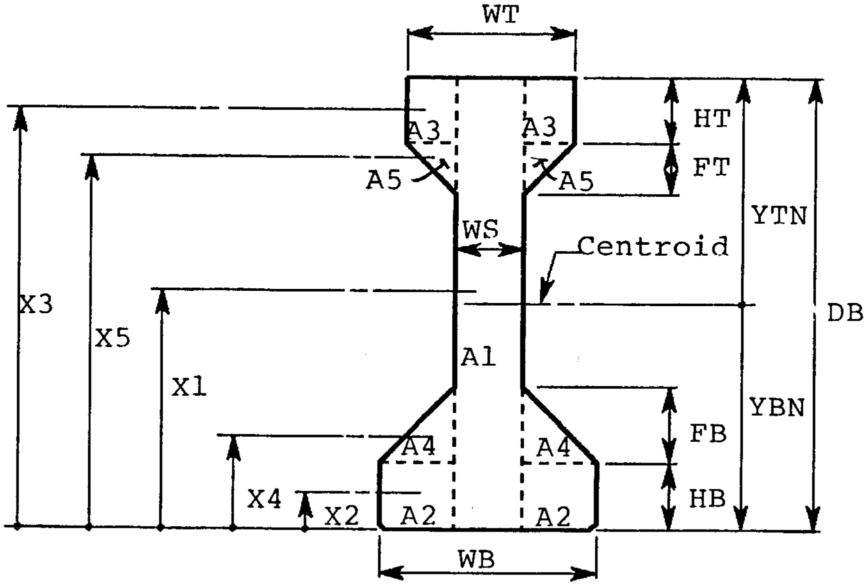
w = Width of web of a flanged member, see page 21, (in).
W = Uniform load, (k/ft).
Wb = Uniform weight of the beam, (k/ft).
WDT = Total dead load uniform weight, composite and non-composite, (k/ft).
wc = Unit weight of concrete, (lb-ft3).
WF = Effective flange width given in input, (in).
WF' = Adjusted flange width of effective slab, (in).
WR = Equivalent railroad uniform load, (k/ft).
WS = Web thickness, (in).
WT = Top non-composite beam flange width, (in).
WTe = WT - X" attributed to PSC deck panels, (in).
X is 6" for AASHTO TYPE 1 thru 4, and 8" for AASHTO TYPE 5.

YBC = Composite distance from centroid of beam to bottom of beam, (in).
YBN = Non-composite Distance from centroid of beam to bottom of beam, (in).
YTC = Composite distance from centroid of beam to top of beam, (in).

XF = Distance from bottom of beam to centroid of adjusted effective slab, (in).

BEAM SECTION PROPERTIES

A. Non-Composite Beam Properties



All dimensions are in inches.

Areas

$A1 = WS(DB)$

$A2 = (WB-WS)HB$

$A3 = (WT-WS)HT$

$A4 = FB(WB-WS)/2$

$A5 = FT(WT-WS)/2$

$AB = A1+A2+A3+A4+A5$

Distances to area centroids

$X1 = DB/2$

$X2 = HB/2$

$X3 = DB-HT/2$

$X4 = HB+FB/3$

$X5 = DB-HT-FT/3$

$$YBN = \left[\sum_{n=1}^{5} An(Xn) \right] / AB$$

$$YTN = DB - YBN$$

$$IN = [A1(DB)^2 + A2(HB)^2 + A3(HT)^2]/12 + [A4(FB)^2 + A5(FT)^2]/18 + \sum_{n=1}^{5} (YBN-Xn)^2 An$$

$$STN = IN/YTN$$

$$SBN = IN/YBN$$

B. AASHTO Beam Section Properties

In addition to computing the non-composite beam section properties for a given beam size, the program has the standard AASHTO Type Prestressed Beam or Box Sections stored. The designer can specify an AASHTO Type by referring to the beam type number. The following are the beam dimensions and section properties for the nine AASHTO Types (types I to VI, type I-modified and two boxes):

BEAM SECTION PROPERTIES

Beam Type	1	2	3	4	5	6
AASHTO Type	I	II	III	IV	V	VI
WT	12	12	16	20	42	42
HT	4	6	7	8	5	5
FT	3	3	4.5	6	N.A.	N.A.
WS	6	6	7	8	8	8
HB	5	6	7	8	8	8
WB	16	18	22	26	28	28
FB	5	6	7.5	9	10	10
DB	28	36	45	54	63	72
AB	276.0	369.0	559.5	789.0	1013.0	1085.0
YBN	12.59	15.83	20.27	24.73	31.95	36.38
YTN	15.41	20.17	24.73	29.27	31.05	35.62
IBN	22746	50979	125390	260741	521000	733123
SBN	1806.8	3220.5	6185.0	10542	16305	20153
STN	1476.0	2527.4	5071.1	8909.3	16781	20581

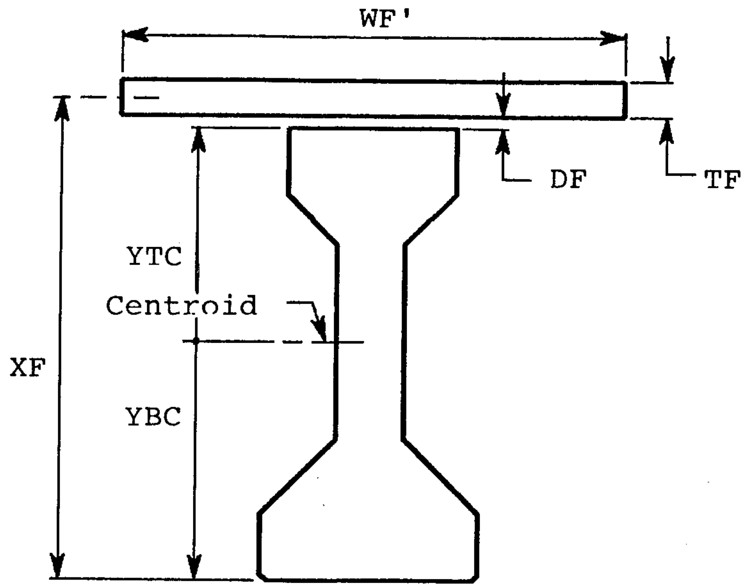
All dimensions and properties are given in inches, in2, in3, or in4.

BEAM SECTION PROPERTIES

Beam Type	7	8	9
AASHTO Type	I-MOD	17"-BOX	27"-BOX
WT	14	47.25	47.25
HT	4	5	5.5
FT	3	1.5	3.0
WS	8	11.5	10.0
HB	5	4.5	5.5
WB	18	48	48
FB	5	1.5	3.0
DB	28	17	27
AB	332.0	552.75	693.0
YBN	12.83	8.58	13.37
YTN	15.17	8.42	13.63
IBN	26495	18357	65941
SBN	2065.6	2139.3	4932.0
STN	1746.2	2180.5	4838.0

All dimensions and properties are given in inches, in2, in3, or in4.

C. Composite Beam Properties



$WF' = WF(ESL/EBM)$

$AF = WF'(TF)$ $\qquad AT = AF+AB$

$XF = DB+DF+TF/2$

$YBC = [AB(YBN) + AF(XF)]/AT$ $\qquad YTC = DB-YBC$

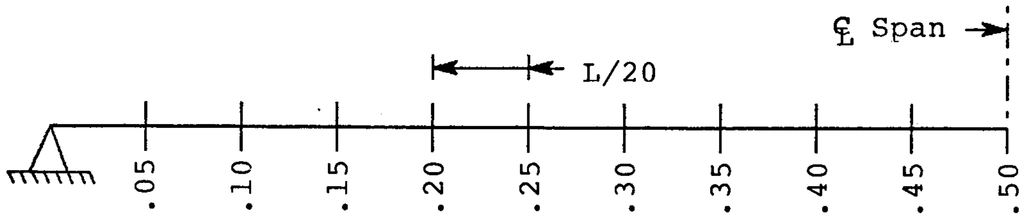
$QS = AF(XF-YBC)$

$$IC = IN + (YBC-YBN)^2 AB + (TF)^2 (AF)/12 + (XF-YBC)^2 AF$$

$STC = IC/YTC$ $\qquad SBC = IC/YBC$

MOMENT AND SHEARS

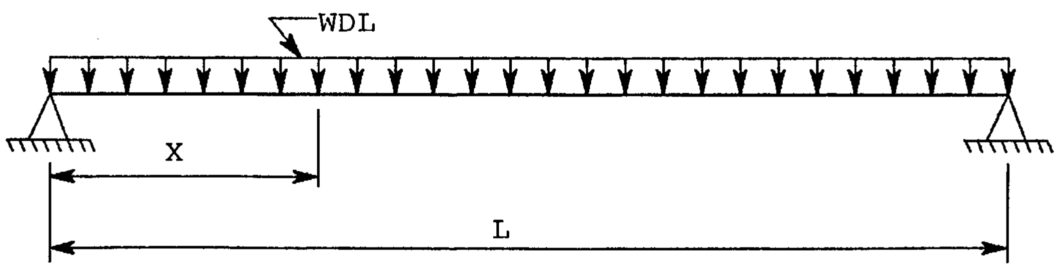
The program computes the dead load and live load moments and shears at the span one-twentieth points. Since all moments and shears are symmetrical about the center line of the span (except as noted), only the moments and shears in one-half the span are required. In addition, the reaction will be computed at the end of the span.



A. DEAD LOADS:

1. Uniform Loads

The uniform dead load will consist of the weight of the beam, non-composite, and composite dead loads. The moments and shears due to these loads are computed individually.

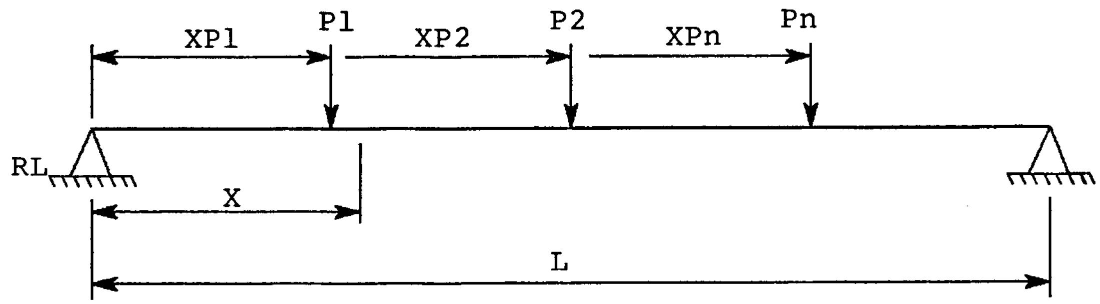


$$Vx = WDL(L/2 - X) \quad = \text{Shear at point X.}$$

$$Mx = WDL(X)(L - X)/2 = \text{Moment at point X.}$$

2. Concentrated Loads

Since the concentrated loads may not be symmetrical about the center line of the span, the P-loads should be referenced from the end of the span nearest the point of maximum P-load moment. The P-load moments and shears are computed only in one-half of the span. This span area is the area nearest the end of the span from which the P-loads are referenced. The P-loads are assumed to be referenced from the left end of the span.



$$RL = \left[\sum_{n=1}^{NP} Pn(L - XPn) \right] / L \qquad = \text{Left Reaction.}$$

NP = Number of P-loads.

$$Vx = RL - \sum_{n=1}^{NL} Pn = \text{Shear at point X.}$$

NL = Number of P-loads to the left of point X.

$$Mx = RL(X) - \sum_{n=1}^{NL} Pn(X - XPn) \quad = \text{Moment at point X.}$$

B. LIVE LOADS:

1. Highway Loads

The program computes the maximum moment and shear at the span twentieth points due to the truck, lane, and military live loads. Each load is optional, each load may be eliminated from the program computations by an input data code. The maximum moment and shear at each point of the live loads considered is selected for use in the design process. The distribution factors given as input data and impact are automatically included in the moment and shear. The following is the procedure for computing the impact factors:

$I = 50/[(L - X) + 125] \leq 30\%$ for shear (varying factor)

$I = 50/(L + 125) \leq 30\%$ for moment and deflections

When computing the maximum end reaction for truck, lane and military loads, the distribution factor for end shear (DFV) given in the input will be used to apply the concentrated or wheel load at the end of the span instead of the distribution factor for moment (DFM).

The type of live load that the program is to consider (H 15, HS15, H 20, HS20, etc.) will be required as part of the input data. The numeric portion of the live load type (15,20) is used to determine the magnitude of the wheel, uniform and concentrated loads. For example, HS20 loading is as follows:

Large truck wheel load	= (.8)(20)	= 16.0 kips
Small truck wheel load	= (.8)(20)/4	= 4.0 kips
Lane uniform load	= (.016)(20)	= 0.32 kips/ft
Lane conc. load for moment	= (.45)(20)	= 9.0 kips
Lane conc. load for shear	= (.65)(20)	= 13.0 kips

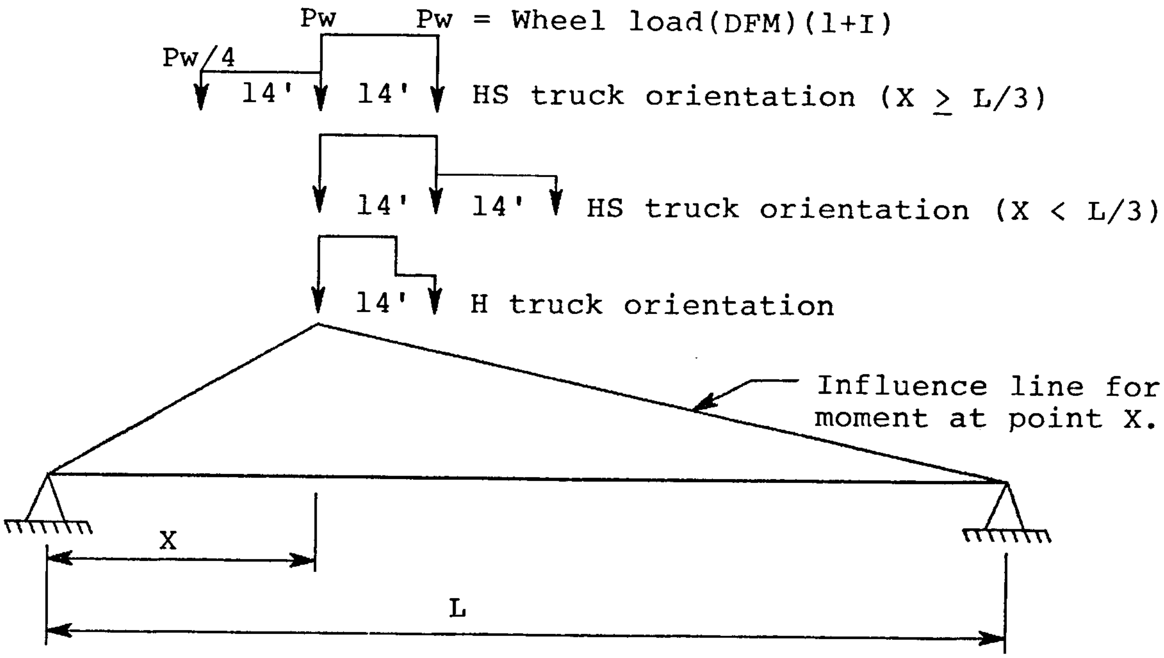
Only one-half the lane loads are considered, which is equivalent to a wheel or row of wheels.

B. LIVE LOADS (Cont.):

1. Highway Loads (Cont.)

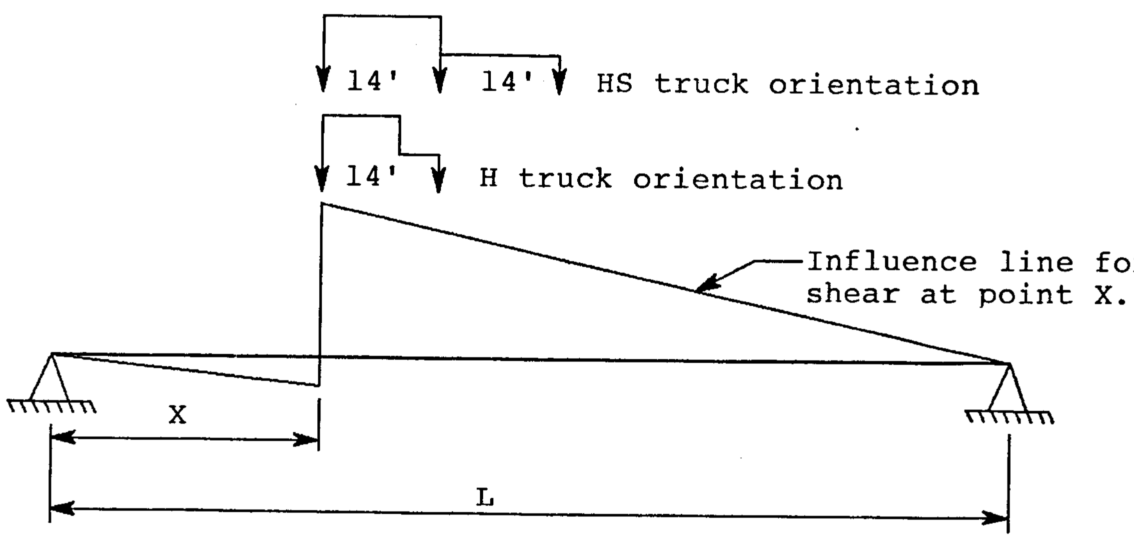
a. Truck Live Load (H or HS)

I. Moment



The maximum live load truck moment at each point is computed by orienting the truck as shown above.

II. Shear



The maximum live load truck shear at each point is computed by orienting the truck as shown above.

B. LIVE LOADS (Cont.):

1. Highway Loads (Cont.)

b. Lane Live Load

I. Moment

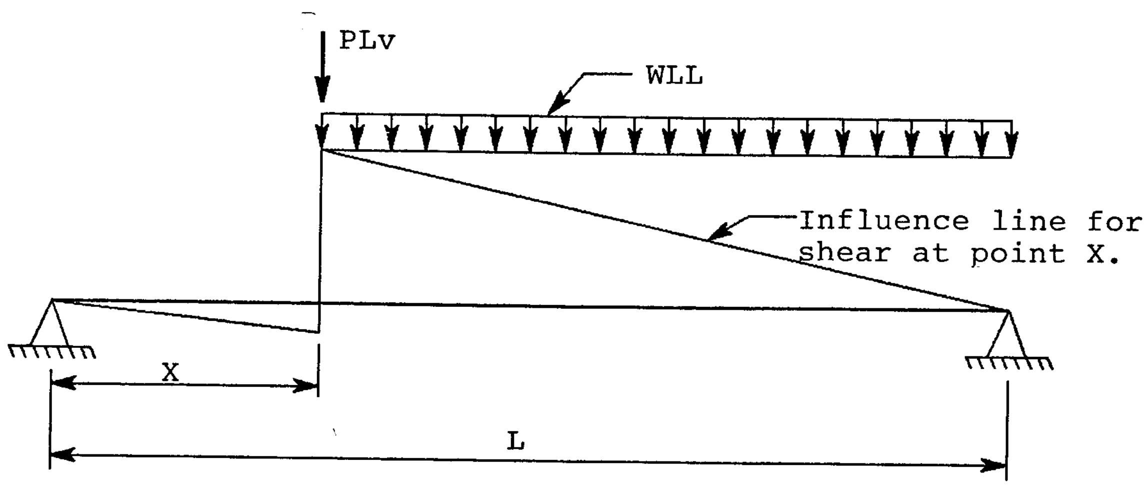
Mx = (WLL/2 + PLM/L) (X) (L - X) = Moment at point X.

WLL = Uniform lane load including the distribution factor and impact (placed on entire span length).

PLM = Lane concentrated load for moment including the distribution factor and impact (placed at point X).

The lane uniform and concentrated loads are multiplied by a factor of one-half to determine the equivalent wheel loads.

II. Shear



Vx = (L - X) [WLL(L-X)/2 + PLv]/X
= Shear on left of point X.

PLv = Lane concentrated load for shear including the distribution factor and impact.

B. LIVE LOADS (Cont.):

1. Highway Loads (Cont.)

c. Military Live Load (Special Interstate)

The program has provision for including special military loading (two 24,000 pound axles four feet apart) when live load class HS-20 is selected. Otherwise, no military loading is included.

I. Moment

$Mx = [2(Pm)(L - X - 2)(X)]/L$ = Moment at point X.

Pm = Military wheel load (12,000 lbs.) adjusted for distribution and impact.

For $L \geq 4$

II. Shear

$Vx = [2(Pm)(L - X - 2)]/L$ = Shear on left of point X.

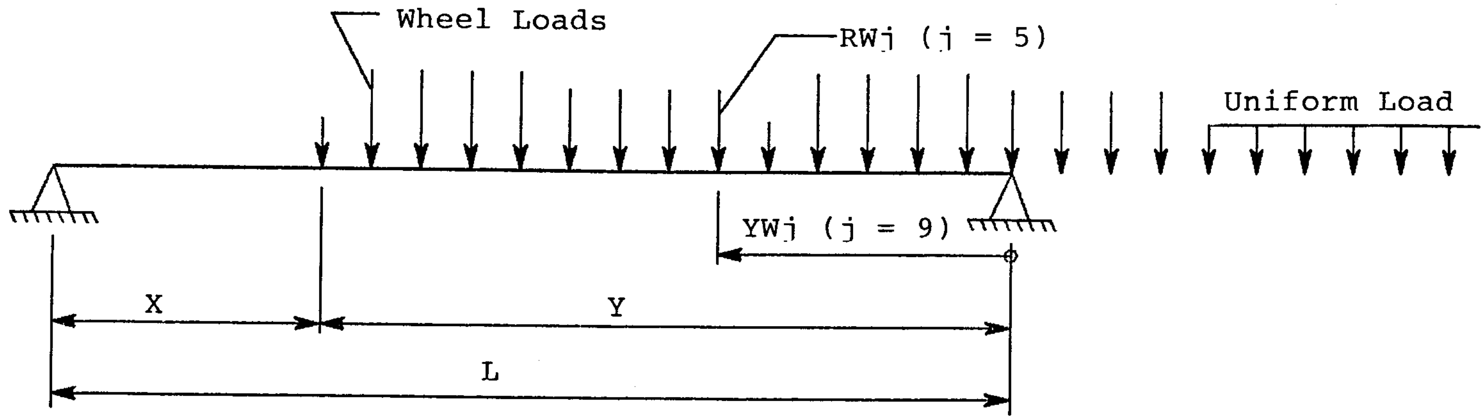
2. Sidewalk (Pedestrian) Live Load

The computations for the sidewalk live load moment and shear are the same as for the lane live load except that concentrated load, impact, and distribution are not considered.

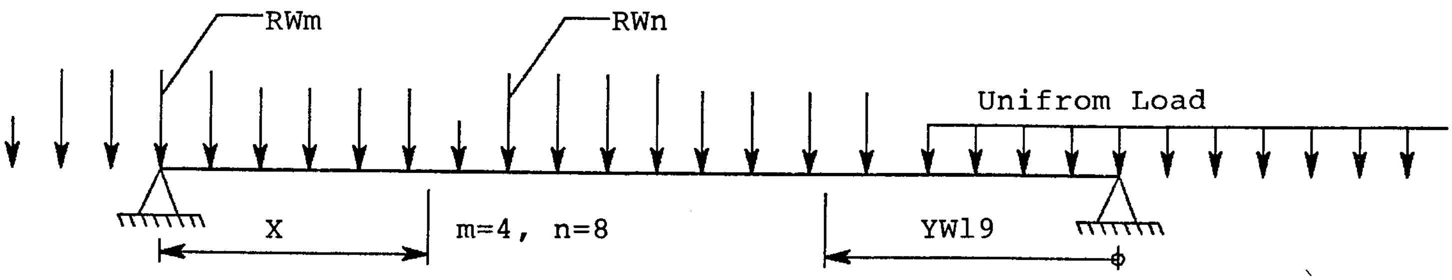
3. Railroad Live Load

The program solves for the maximum railroad live load shear and moment at the span twentieth points including the end of the span. The live load is the Cooper E series given in the AREA Specifications. In the following discussion point X is the position in the span where the moment and shear are being computed.

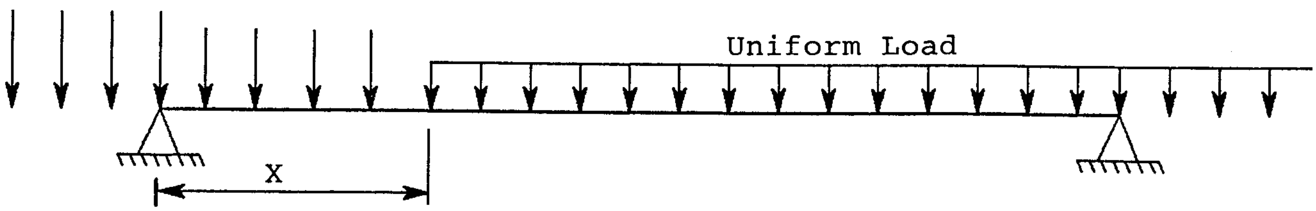
In order to insure that the maximum effect will be obtained, the live load is moved so that each wheel and the beginning of the uniform load is placed at point X. In addition, the uniform load is considered on the entire (or partial) span. Since the moments and shears are computed for one-half the span length, the live load must be moved across point X in both directions. First, the live load is moved from right to left, and then from left to right. The reversing of the live load direction is handled simply by interchanging the distances to point X from the ends of the span. The movement is started each time with the first or front wheel at point X. It can be shown that some wheel placements could be eliminated from consideration (for example the small wheels placed at point X) but it is questionable whether the efficiency of the program could be improved by eliminating these placements.



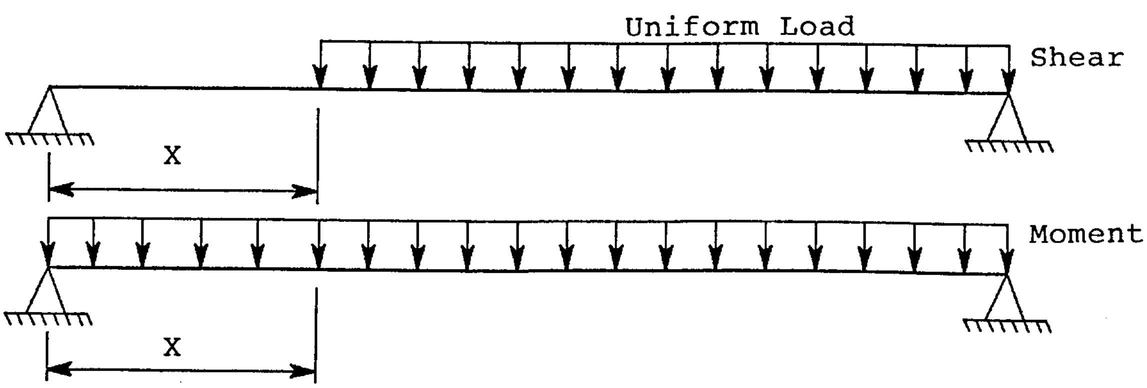
First Placement
RWj is the magnitude of the wheel loads including impact and distribution



Ninth Placement
YWj is the distance from the right end of the span to the wheel load.



Nineteenth Placement
See AREA Specifications for magnitude of loads and axle spacings.



Twentieth (last) Placement

The program does not consider moments and shears at any point other that the aforementioned points. Probably the absolute maximum live load moment will occur at some point other than the center line of the span. However, for design purposes, the difference between the maximum moment at the center line of the span and the absolute maximum is negligible.

$$RL = [\sum_{j=1}^{18} RWj(YWj)]/L + (YW19)^2 (RW19)/[2(L)]$$

= Reaction at left end of span.

YWj is not considered if greater than L or negative, i.e., wheel or uniform load is not on span. RW19 is the uniform load including impact and distribution.

$$Mx = RL(X) - \sum_{j=m}^{n} RWj(YWj - Y)$$

= moment at point X.

n = the number of wheels to the left of point X.

m = the number of wheels completely off the span (left end) plus 1.

$$Vx = RL - \sum_{j=m}^{n} RWj \qquad (\text{If } X=0,\ Vx = RL)$$

= shear at point X (left side).

The shear and moment for the twentieth placement, when only the uniform load is being considered, are computed similarly to the sidewalk and lane uniform live loads. Railroad live load impact will be required as part of the input data. It is not computed by the program.

The YWj array must be initialized for each live load placement and then adjusted by the appropriate wheel spacing for each movement.

YWj = Y - TWSj Initialization (j = 1, 19)

The YWj array is adjusted for wheel movements as follows:

YWj = YWj + WSk

k is the movement (1, 2, 3, ...19)

TWSj and WSk are defined on the following page.

The following is a list of the data that must be computed or stored before using the railroad live load routing:

TWS(J) array contains the accumulative wheel spacings in feet. (See AREA Specs.)

```
TWS(1)  =   0.0
TWS(2)  =   8.0
TWS(3)  =  13.0
   .
   .
   .
TWS(19) = 109.0
```

WS(J) array contains the wheel spacings in feet. (See AREA Specs.)

```
WS(1)  = 8.0
WS(2)  = 5.0
   .
   .
   .
WS(18) = 5.0
WS(19) = 0.0
```

RW(J) array contains the magnitude of the wheel loads in kips, distributed for moment and including impact. RW(1) = first or front wheel. RW(19) is one-half* the uniform load distributed for moment and impact in kips per foot.

After computations are completed the array RLLM(J) contains the maximum moments in kip-feet, and the array RLLV(J) contains the maximum shears in kips. J is equal to one at the end of the span, and equal to eleven at the span center line.

* to eliminate dividing by two in the moment and shear routine.

STRESSES

The stresses (excluding prestress) due to the following loads are computed and given in the formal output. The stresses are computed in the top and bottom of the beam at each twentieth point of the span. Stresses in the composite slab are not computed.

A. Non-Composite Loads

1. Weight of beam (Wb).
2. Uniform non-composite dead load (WDLnc).
3. Concentrated loads (P-loads).
4. Total non-composite dead load (1 + 2 + 3).

For top of beam the stress is:
$Ft = M/STN$

For bottom of beam the stress is:
$Fb = M/SBN$

B. Composite Loads

1. Uniform composite dead load (WDLc).
2. Sidewalk (Wsw).
3. Live Load (maximum from truck, lane, military or railroad).
4. Total composite (1 + 2 + 3).

For top of beam the stress is:
$Ft = M/STC$

For bottom of beam the stress is:
$Fb = M/SBC$

LOSSES

If the losses are not specified in the input, the program will calculate all the losses using the methods described in the 1989 AASHTO SPECIFICATIONS (Art. 9.16). The program will calculate the Shrinkage Loss (SH), Elastic Shortening Loss (ES), Creep Loss (CRc), and the Relaxation Loss (CRs). The following is a discussion of the above losses with a cooresponding AASHTO Article number:

a. Shrinkage Loss (SH) — Art. 9.16.2.1.1

SH = 17,000 - 150(RH) = 6.5 ksi

b. Elasitic Shortening Loss (ES) — Art. 9.16.2.1.2

ES = Es(fcir)/Eci

c. Creep Loss (CRc) — Art. 9.16.2.1.3

CRc = 12(fcir) - 7(fcds)

d. Relaxation Loss (CRs) — Art. 9.16.2.1.4

CRs = 20.0 - .4(ES) - .2(SH + CRc)

If low lax strands are used and the reduction factor for the ultimate stress for the strands (RFPU) is greater than .74, then the CRs will be adjusted as follows:

For RFPU	CRs adjusted
= .75	= CRs/4
= .76	= CRs(1.05)/4
= .77	= CRs(1.11)/4
= .78	= CRs(1.16)/4
= .79	= CRs(1.22)/4
$\geq$ .80	= CRs(1.28)/4

When the losses are to be calculated by the program, the initial loss will be ES+.3CRs and the final loss will be ES+CRs+CRc+SH. Since CRs is calculated using an initial loss, the program will initially assume a 10% initial loss to calculate CRc. The program will continue to recalculate the initial and final losses values until it converges on a set of values within a certain tolerance.

ULTIMATE MOMENT AND CRACKING MOMENT

A. Ultimate Moment Capacity

The program will determine if the beam section used for the ultimate moment capacity will be a rectangular section or a flanged section. The factor "Dna" is computed to determine if the neutral axis falls outside the beam flange (composite slab). If Dna is greater than the beam flange , the neutral axis falls outside the flange and the section is considered to be a flanged section. Otherwise, the section is considered a rectangular section.

Dna = [As*(fsu*)]/[.85(f'c)(WF')] Art. 9.17.2

fsu* = FPU(1 - (alpha/beta)(p*)(FPU)/f'c) Art. 9.17.4.1

1. Flanged Section (Dna > TF)

MSR = [Asr(fsu*)]/[w(d)(f'c)] Art. 9.18.1

For MSR $\leq$ 0.36(beta) Art. 9.17.3

Mu = [fsu*(Asr)(d)(1 - .6(Asr)(fsu*)/[w(d)(f'c)])

+ 0.85(f'c)(WF' - w)(TF)(d - TF/2)]/12.0

For MSR > 0.36(beta) Art. 9.18.1

Mu = [(.36(beta)-.08(beta)^2) (w)(d)^2 (f'c)

+ 0.85(f'c)(WF' - w)TF(d - .5(TF))]/12.0

For Dna $\leq$ TF + HT + DF ; w = WT

For Dna > TF + HT + DF ; w = WS

2. Rectangular Section (Dna $\leq$ TF)

MSR = p*(fsu*)/f'c Art. 9.18.1

For MSR $\leq$ 0.36(beta) Art. 9.17.2

Mu = [fsu*(As*)(d)(1 - .6(p*)(fsu*)/f'c)]/12.0

For MSR > 0.36(beta) Art. 9.18.1

Mu = [(.36(beta)-.08(beta)^2) (WF')(d)^2 (f'c)]/12.0

B. Ultimate Moment

The ultimate moment is computed as follows:

MU = 1.3(MDL) + 2.167(MLL)

C. Cracking Moment

The cracking moment is computed as follows:
Art. 9.18.2.1

MCR = (fr + FPF/AB + FPF(EF)/SBN)(SBC)

- MN((SBC/SBN) -1)

The program will check that the total amount of prestressing strands is adequate to develop an ultimate moment at the critical section of at least 1.2(MCR) at the center of the span. Strands will be added in a design problem if the section is not adequate. If the section is not adequate in a analysis problem, an error message will be printed to the output.

ULTIMATE COMPOSITE SHEAR, ULTIMATE TOTAL SHEAR,
BEAM SHEAR CAPACITY, STIRRUP SPACING, AND PERCENTAGE OF STEEL

A. Ultimate Composite Shear

The ultimate composite shear is computed as follows:

$$VUC = 1.3(VDC) + 2.167(VLL)$$

B. Ultimate Total Shear

The ultimate total shear is computed as follows:

$$VU = 1.3(VDL) + 2.167(VLL)$$

C. Beam Shear Capacity

The shear strength of the beam Vc, is taken as the lesser of Vci or Vcw.

Art. 9.20.2.2

$$Vci = .6(d)(WS)[(f'c)1000]^{.5}/1000 + VDL + VU(MCR)/MU$$

Vci will not be less than $1.7(WS)(d)[(f'c)1000]^{.5}/1000$ and d will not be less than .8(H)

$$MCR = IC[\ 6[(f'c)1000]^{.5}/1000 + FPE - FD\ ]/YBC$$

$$FPE = SFPF/AB + SFPF(EF)/SBN$$

$$FD = MDLcomp/SBC + MDLnoncomp/SBN$$

Art. 9.20.2.3

$$Vcw = [\ 3.5[(f'c)1000]^{.5}/1000 + 0.3(FPC)\ ]WS(d) + VP$$

$$FPC = FPF/AB - FPF(EF)(YBC-YBN)/IN + 12.0(YBC-YBN)(MN)/IN$$

d will not be less than .8(H)

$$VP = DR(NRS)(FPF)/RES$$

$$RES = [\ (DR)^2 + (HLR)^2\ ]^{.5}$$

D. Stirrup Spacing

a. The program will use the minimum spacing of the following vertical and horizontal shear criteria:

- Spacing based on vertical shear design
  Spacing = Av(fsy)d/Vs Art. 9.20.3.1

  The stirrup spacing shall not exceed .75H, 24 inches, or Av(fsy)/[(WS)(50)]

  $$Vs = VU/.9 - Vc$$

  If Vs is greater than $4(WS)(d)[(f'c)1000]^{.5}/1000$ then the maximum spacing is reduced by one-half.

  The program will write a message to the output file if Vs is greater than

  $$8(WS)(d)[(f'c)1000]^{.5}/1000$$

- Spacing based on horizontal shear design, Art. 9.20.4.3
  The program initially assumes that the top of the beam will be clean, free of laitance, and intentionally roughened (Art. 9.20.4.3.a). Minimum spacing (ms) of the stirrups shall not exceed 4(WS) or 24 inches.
  Min. Ast = [50(WTe)(ms)/fsy](12.0/ms) Art. 9.20.4.5

  The multiplication of 12./ms is to have Avmin in units of sq. in/ft..

  Vnh=.35(WTe)d Art. 9.20.4.3(c)

  If VUC > .9(Vnh) then each percent of reinforcement crossing the contact surface in excess of Avmin shall increase the shear strength by .16(WTe)d(fsy/40).
  Art. 9.20.4.3(d)

  Fraction = (VUC - .9(Vnh))/(.9(.16)(WTe)d(fsy/40))

  Therefore, the total area of stirrups needed is
  Needed Ast = Min. Ast + Fraction(.01)(12)(WTe)
  Spacing = (Av)(12)/(Needed Ast)

b. The program will compute the required area of steel (ASE) needed within the distance d/4 from the end of the beam.
   ASE = .04(IPF)/20 Art. 9.21.3

   The program then computes the maximum stirrup spacing and number of locations for number 5 and 6 bars using ASE.
   NOL = number of locations for a 5 bar = ASE/[2(.31)] + 1
   NOL = number of locations for a 6 bar = ASE/[2(.44)] + 1
   d = Ee + YTC
   Spacing = [(d/4) - 2"]/(NOL-1)

E. Percentage of Steel

The percentage of steel (PS) is computed as follows:
PS = AST(100)/AB

PRESTRESS STRESSES, INITIAL STRESSES, AND FINAL STRESSES

A. Prestress Stresses

The stress due to only prestressing after initial losses have occured is calculated as follows:

For top of beam the stress is:

Ft = IPF/AB - IPF(EI)/STN

For bottom of beam the stress is:

Fb = IPF/AB + IPF(EI)/SBN

B. Initial Stresses

The stress due to beam weight and prestressing after initial losses have occured is calculated as follows:

For top of beam the stress is:

Ft = IPF/AB - IPF(EI)/STN + MB/STN

For bottom of beam the stress is:

Fb = IPF/AB + IPF(EI)/SBN - MB/SBN

C. Final Stresses

The stress due to all applied loads and prestressing after final losses have occured is calculated as follows:

For top of beam the stress is:

Ft = FPF/AB - FPF(EF)/STN + MN/STN + MC/STC

For bottom of beam the stress is:

Fb = FPF/AB + FPF(EF)/SBN - MN/SBN - MC/SBC

MAXIMUM AND MINIMUM ECCENTRICITIES

The maximum and minimum number of strands and allowable range of eccentricity are computed by solving the following four equations:

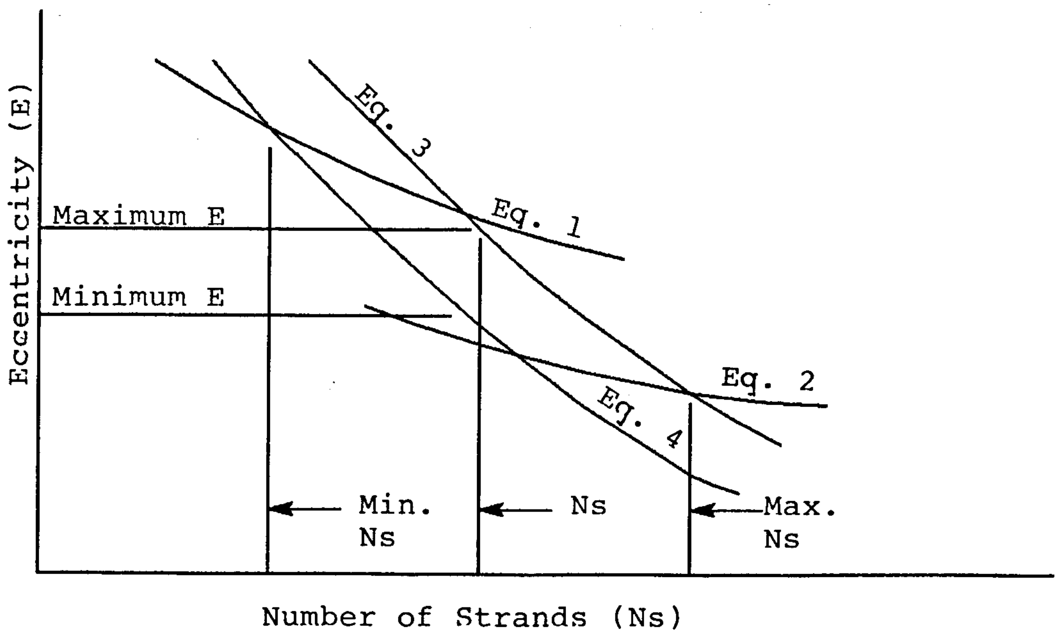
1. IPF/AB - IPF(EI)/STN + MB/STN = SIT
   The initial stress (after initial losses) in the top of the beam is set equal to SIT . This equation forms an upper boundary on the eccentricity.

2. FPF/AB - FPF(EF)/STN + MN/STN + MC/STC = .4(f'c)
   The final stress (after final losses) in the top of the beam is set equal to the allowable compressive stress. This equation forms a lower boundary for the eccentricity.

3. IPF/AB + IPF(EI)/SBN - MB/SBN = 0.6(f'ci)
   The initial stress (after initial losses) in the bottom of the beam is set equal to the allowable initial (temporary) concrete compressive stress. This equation forms an upper boundary on the eccentricity.

4. FPF/AB + FPF(EF)/SBN - MN/SBN - MC/SBC = SFB
   The final stress (after final losses) in the bottom of the beam is set equal SFB . This equation forms a lower boundary for the eccentricity.

In order to satisfy the four conditions (equations), the resultant values of Ns and E must be in the shaded area of Graph 1, shown below. Equations 1 and 4 are solved simultaneously to determine the absolute minimum number of stands. The absolute maximum number of strands is found by solving equations 2 and 3 simultaneously. The minimum number of strands is rounded up to the nearest even number, and the maximum number of strands is rounded down to the nearest even number.



GRAPH 1

A. Design Mode of Program

In the design mode the user has the option of draping strands of debonding strands, the program will not allow both. If neither of the options are specified the program will design the beam using only straight strands.

The program will begin by finding a strand arrangement at the center of the beam. Starting with a value of Ns equal to the minimum number of strands, the program computes the minimum and maximum eccentricity by using the value of Ns in the appropriate equations (equations 1 or 3 for maximum eccentricity and equations 2 or 4 for minimum eccentricity). After solving for the maximum and minimum eccentricity limitations of the Ns value, the program attempts to find a strand arrangement with an eccentricity within these limits. If no strand arrangement is found, the Ns value is increased by two and the process is repeated. This procedure is continued until a satisfactory strand arrangement is found or the Ns value reaches the maximum number of strands. If a suitable strand arrangement is still not found at the center of the beam, processing of the problem is terminated and the message, "NO SOLUTION POSSIBLE" is printed.

When selecting the strand arrangement the following assumptions are made:

1. The maximum number of strands per horizontal row is twenty (20).
2. The maximum number of horizontal rows is twenty (20).
3. Odd number of strands per horizontal row is not allowed for a design problem.
4. The number of strands in the top of the beam is given in the input and is not changed.
5. The number of strands (Ns) can not be less than:

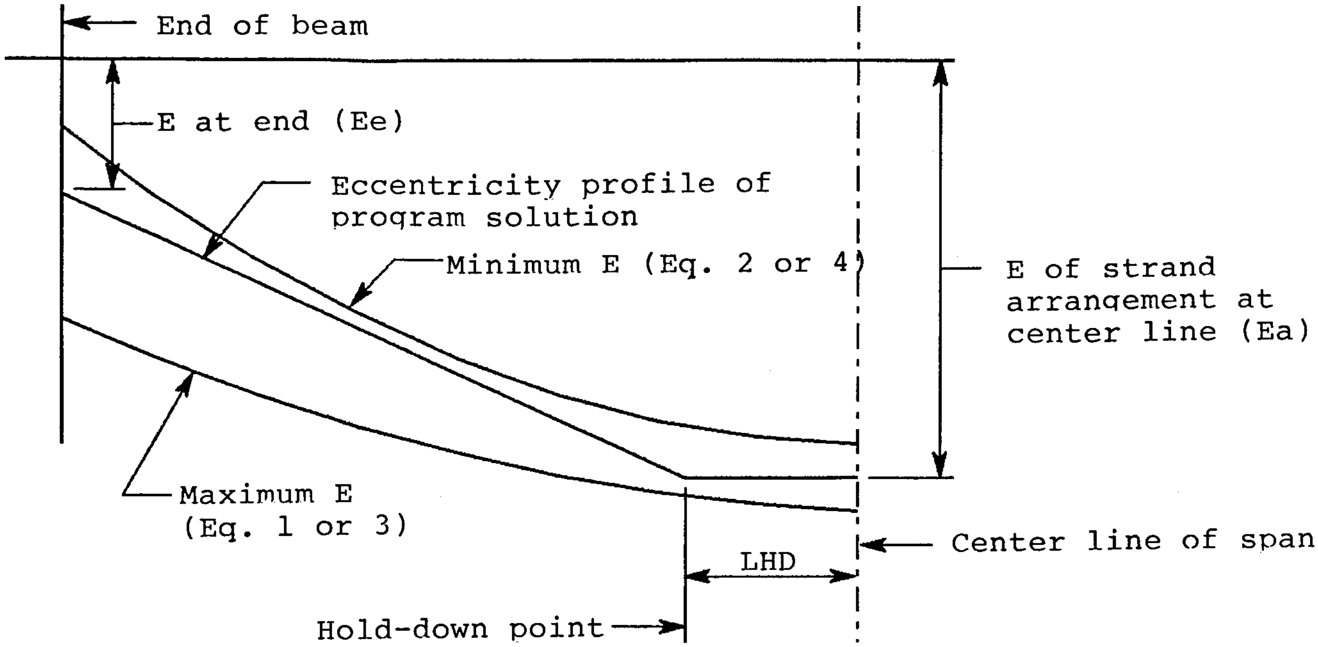
   Number of strands in top + 2 strands

   or

   Number of strands to develop an Ultimate moment capacity of the beam greater than 1.2MCR (where MCR is the cracking moment as discussed on page 22).

For the drape design the program will start at the .45L point of the beam and check all the eccentricity requirements at each 20th point to the end of the beam. When the eccentricity requirements are not satisfied at a 20th point, all of the allowable draped strands will be raised by two inches and the program will start the check over again at the .45L point of the beam. The program will continue until the requirements are satisfied or until all the allowable draped strands are raised to there maximum height and the requiremnts are not met. If the requirements are not satisfied, the program will set a new hold-down point for the draped strands at a distance .05L from the center of the beam and the check will begin again at the .45L point. If the requirements are never satisfied, a message "NO SOLUTION POSSIBLE" will be printed.

A satisfactory solution of the eccentricity requirements for a drape design is shown by Graph 2. This graph is plotted in the output data. Note that the designer can adjust the hold-down point without involving more computations by plotting the new hold-down point and keeping the resulting eccentricities within the eccentricity envelope. LHD is the distance from the span center line to the hold-down point and is a multiple of L/20, i.e., at a span twentieth point, but rounded to the nearest multiple of 3 inches. As discussed previously the program selects the nearest hold-down point to the center line that will satisfy the eccentricity limitations. That is, the center line of the span is considered first.



GRAPH 2

For the debonded design the program will start at the .45L point of the beam and check all of the eccentricity requirements at each 20th point to the end of the beam. When the eccentricity requirements are not satisfied at a 20th point, two strands at a time will be debonded until the requirements are met. If all the allowable debonded strands are wrapped to the maximum length and the requirements have not been satisfied, a message "NO SOLUTION POSSIBLE" will be printed.

B. Analysis Mode of Program

In the analysis mode the user has the option to drape strands, debond strands or both. If neither of the options are specified the program will analyze the strands as being straight.

In the analysis the program will calculate the actual eccentricity and the effective number of strands. The effective number of strands are a result of considering transfer and development lengths. The program will then check the eccentricity requirements with the actual eccentricity at the given 20th points. The program will continue if the requirements are not met.

DEFLECTIONS AND CAMBER

The program computes the dead load, live load and prestress deflections at the center line of the span. Effects due to creep and other material characteristics are not considered since they are time-dependent. The deflections and camber values are in inches.

A. Dead Load Deflections:

1. Non-composite loads

The program computes the deflections at the center line of the span due to the weight of the beam (Wb), the concentrated loads (P-loads) and the uniform dead load (WDLnc). These deflections are listed separately in the output data.

Uniform load: $dwn = 5(W)(L^4)(12^3)/[384(EBM)(IN)]$

P-loads: $dpl = \sum_{i=1}^{Np} Pi(Xi)(C-Xi^2)(12^3)/[12(EBM)(IN)]$

$C = .75(L^2)$

Xi = Minimum of XPi and L-XPi

2. Composite loads

The deflection at the center line of the span due to the uniform composite dead load (WDLc) is computed as:

$dwc = 5(WDLc)(L^4)(12^3)/[384(EBM)(IC)]$

B. Prestress Deflection:

The upward deflection due to the eccentricity of the prestressing force IPF (initial conditions) is computed at the center line of the span. The varying eccentricity caused by draped strands is taken into account.

1. For straight strands

$dpr = IPF(EI)(L^2)(12^2)/[8(I)(EBM)]$

2. For draped strands with one hold down point at center span

$dpr = IPF(Ee)(L^2)(12^2)/[8(I)(EBM)]$

$+ IPF(E')(L^2)(12^2)/[12(I)(EBM)]$

3. For draped strands with two hold down points

$dpr = IPF(Ee)(L^2)(12^2)/[8(I)(EBM)]$

$+ IPF(E')(L^2/8 - A^2/6)(12^2)/[(I)(EBM)]$

C. Live Load Deflections:

The complete moment of inertia (IC) and modulus of elasticity (EBM) of the beam material are used to compute live load deflections. Impact and the live load deflection distribution factor (DFD) are used.

1. Truck live load.

   Influence line ordinates for the deflection at the center line of the span are computed. Then the truck is moved across these ordinates in one foot increments and the maximum value selected for listing in the input.

2. Military (Interstate) live load.

   The two axles are placed symmetrically about the center line of the span and the deflection computed at the center line.

3. Lane live load.

   The deflection due to the lane live load is computed similar to the composite uniform dead load except that the effect due to the concentrated load moment (placed at the line) is added.

4. Sidewalk live load.

   The deflection due to this load is similar to the uniform composite dead load.

5. Railroad live load.

   The railroad live load deflection is computed by assuming a parabolic moment diagram with the maximum railroad moment ordinate at the span center line. The deflection can then be computed similar to a uniform load. This procedure is usually conservative by approximately 5 per cent.

$$dr = 5(WR)(L^4)(12^3)/[384(EBM)(IC)]$$

$$WR = 8(MRR)/L^2$$

C. Camber

Camber due to the beam dead load and prestressing is calculated from the following procedure:

1. Adjust prestress deflection by the effect of loss of prestress over the period of time.

   a. This effect is the ratio of the average prestress force to the initial prestress force.

      Pavg = .5(FPF + IPF)

2. Adjust dead load deflection and prestress deflection due to effect of creep.

   a. This effect is the ratio of the short term modulus of eleasticity of concrete to the long term modulus of concrete and that the ratio equals 2.0, (EC/ECI).

      - Prestress final deflection

        PFD = (dpr)(Pavg)(2)/IPF

      - Dead load deflection due to beam weight

        DLFD = (beam weight dead load deflection)(2)

3. Camber = PFD + DLFD

   Note: The dead load final deflection will have a negative value, so the absolute value of the prestressed deflection will be substracted from the absolute value of the dead load final deflection to give the camber value.

3.0 INPUT DESCRIPTION OF PROGRAM BRPSBM1

In the following discussion of the input data, refer to the form on page 44 and the example problems. The input data is given on an input form. One page is required per problem (per beam, analysis/design). The position of the decimal is shown on the input form. However, the implied position can be overridden by placing a decimal in the appropriate column. The decimal is entered with the data and becomes the controlling position. Otherwise, the decimal is not entered.

The input form contains considerable instructional data. The designer usually will not have to refer to this manual for information after becoming familiar with the program. All input data will be printed out as part of the formal output data.

INDENTIFICATION (* in cc 1)

Columns (cc) one through four contain the data for program indentification and are of no significance to the user. Columns five through eight are reserved for the Problem Number. This assists in expediting the processing of the problem and also helps in subsequent runs of the problem if minor revisions have to be made. The Problem Number will be associated with any "Error Messages" received and will appear in the output listing. Columns nine through eighty are used to enter any pertinent alphabetic or numeric remarks that describes the beam. The project number, county, date, designer's name, etc., should always be given in the Identification. Only one row of this type can be used per problem.

SPAN DATA (1 in cc 1)

The digit one (1) in column one is for identification of the Span Data.

1. D/A (cc 2) Form: D or A

This input data field is used to indicate whether the problem is a design or an analysis. Enter an "A" for an analysis problem. Enter a "D" for a design problem. If the problem is an analysis, the actual strand arrangement will be required as part of the input data as explained in a later section.

2. Live Load Class (cc 3-6) Form: HS20, H15, RR80, etc.

Enter the live load classification in this data field. The alphabetic characters go in columns 3 and 4, and the numeric portion is entered in columns 5 and 6. If the loading is "H" type highway live load, enter the "H" in column 3. Column 4 would be left blank. The magnitude of the wheel, uniform, and concentrated live loads is computed as a proportion of the numeric portion of the live load classification. For example, the truck wheel load (large) is eight-tenths (0.8) of the numeric designation. A valid live load classification must always be entered. The procedure for omitting live loads from consideration is explained later. For Cooper E 72 railroad loading, enter RR72.

3. SKIP (T, L, M) (cc 7-9) Form: blank, zero (0), or 1

These columns are used to omit a particular portion of the live load. If a railroad live load has been specified, these skip codes have no meaning.

a. T (cc 7)

Enter the digit one (1) to skip (omit) the truck loading. Otherwise, leave blank or enter a zero (0).

b. L (cc 8)

Enter the digit one (1) to skip (omit) the lane loading. Otherwise, leave blank or enter a zero (0).

c. M (cc 9)

Enter the digit one (1) to skip (omit) the military loading. Otherwise, leave blank or enter a zero (0).

By skipping the truck, lane, and military loading a beam can be designed or analyzed for pedestrian loading alone (sidewalk).

4. L (cc 10-15) Form: xxx.xxx feet

Enter the span length in this data field, the distance from center line of bearing to center line of bearing. A value of zero (0) or blank is not acceptable.

5. DFM (cc 16-19) Form: x.xxx row of wheels

This data field is for entering the distribution factor (DFM) for moment and shear, that portion of a row of wheels that is applied to the beam. For a two lane bridge with an average stringer spacing of 7′-6″, DFM = 7.5/5.5 = 1.364. Enter the portion of a row of wheels for railroad live load also.

6. DFV (cc 20-23) Form: x.xxx row of wheels

Enter the distribution for end shear in this data field. This factor is usually computed as a simple beam distribution. See Art. 3.23.1.2 of the AASHTO Specifications. This factor is only applied to the load (wheel or concentrated) at the end of the span when computing shear at the end of the span.

7. DFD (cc 24-27) Form: x.xxx row of wheels

This data field is used to enter the distribution factor for live load deflections and is equal to the portion of a row of wheels resisted by the beam.

DFD = 2(Nl)(Rli)/(Nb)

Nl = number of lanes
Nb = number of beams
Rli = Reduction in load intensity (Art. 3.12)

This assumes all beams deflect equally and are the same size, etc.

8. WDLnc (cc 28-31) Form: x.xxx kips per foot

Enter the non-composite uniform dead load in this data field. Do not include the weight of the beam. The program computes the beam weight at 150 lbs. per cubic foot. This uniform load will normally consist of the weight of the slab and copings.

9. WDLc (cc 32-35) Form: x.xxx kips per foot

This data field is for entering the composite uniform dead load. "WDLc" consists of the weight due to barriers, railings, future wearing surface, etc.

Any weight due to utilities that is considered a uniform dead load must be included in the appropriate uniform dead load depending on the time of installation: composite or non-composite.

10. Wsw (cc 36-39) Form: x.xxx kips per foot

Enter the uniform sidewalk (Pedestrian) live load in this data field. If no sidewalk live load exists, leave this space blank.

11. f'c (cc 40-44) Form: xx.xxx kips per sq. in.

The 28-day compressive strength of the beam concrete should be given in this data field. A value of zero (0) or blank should not be used.

12. f'ci (cc 45-49) Form: xx.xxx kips per sq. in.

Enter the compressive strength of the beam concrete at the normal time of release in these columns. Do not enter zero (0) or leave blank.

13. NPL (cc 55,56) Form: xx P-loads

"NPL" is the number of concentrated non-composite dead loads acting on the beam. The magnitude and position of these loads will be discussed later. A value of zero (0) is acceptable. The maximum number is twenty (20).

14. SIT (cc 57-60) Form: x.xxx kips per sq. in.

SIT is the allowable initial stress in the top of the beam. The default is 0.000 ksi. A negative value designates tension.

15. SFB (cc 61-64) Form: x.xxx kips per sq. in.

SFB is the allowable final stress in the bottom of the beam. The default is 0.000 ksi. A negative value designates tension.

16. SFTe (cc 65-68) Form: x.xxx kips per sq. in.

SFTe is the allowable final end stress in the beam. For analysis, the default is -.200 ksi. For design, the default is -.001 ksi. A negative value designates tension.

BEAM DATA (2 in cc 1)

The digit two (2) in column one is for identification of the Beam Data.

BEAM DIMENSIONS (cc 2-36)

If the beam section is not an AASHTO Standard Section, the beam dimensions must be given. All dimensions are given in inches. The dimensions "FT" and "FB" are the only dimensions that may have a value of zero. Refer to a sketch of the beam cross-section when entering the beam dimensions. If the beam is an AASHTO Standard Section, leave the beam dimensions blank and indicate the Type as explained later. A sketch of a typical beam section is given of page 6.

COMPOSITE SLAB (cc 37-50)

These data fields are used to enter that part of the roadway slab that acts integrally with the beam under composite dead load and live load. A composite slab should always be entered. If there is no slab, enter a very small slab. For example, let "WF" equal "WT" and use a small value for "TF".

1. WF (cc 37-41) Form: xxx.xx inches

This dimension is the effective width of the concrete slab. See Art. 9.8 of the AASHTO Specifications. Do not adjust this width for a difference in the modulus of elasticity of the slab and beam concrete. The program will make this adjustment. Do not use a zero (0) value or leave blank.

2. TF (cc 42-46) Form: xx.xxx inches

Enter the thickness of the composite slab in this data field. Do not use a value of zero (0) or leave blank.

3. DF (cc 47-50) Form: x.xxx inches

"DF" is a varying distance from the top of the beam to the bottom of the slab. Enter the minimum "DF", the program uses it as a constant. A zero (0) value is acceptable.

MODULUS OF ELASTICITY (cc 51-56)

4. E BM (cc 51-53) Form: x.xx (10^3) ksi

Enter the modulus of elasticity of the beam material in this data field. This data is used to compute deflections and modify the width of the composite slab.

$$E\ BM = [(150)^{1.5}](33)[(f'c)1000]^{.5}/1000$$

5. E SLAB (cc 54-56) Form: x.xx (10^3) ksi

The modulus of elasticity of the composite slab material should be entered in this data field. It is used to modify the effective width of the composite slab.

$$E\ SLAB = [(150)^{1.5}](33)[(3000)^{.5}]/1000$$

6. ST SIZE (cc 58) Form: x

The stirrup bar size can be entered as a 4, 5, or 6. The default is a #5 bar.

7. DECK PANEL (cc 60) Form: x

Enter a "1" in cc 60 if deck panels are to be used. If deck panels are to be used, when calculating the horizontal shear capacity the top flange width will be reduced by 6" for AASHTO beams type 1 thru 4 and 8" for AASHTO beam type 5.

8. fsy (cc 61-62) Form: xx. ksi

Yield strength of non-prestressed reinforcement. Default is 40. Used in design of shear reinforcement.

STRAND DATA (3 in cc 1)

FIRST LINE

The digit three (3) is used to identify the Strand Data.

1. T (cc 2) Form: blank or 1-9

   If the beam section is an AASHTO Standard Section, the number (1,2,3,4,5,6,7,8 or 9) should be entered in this column for the AASHTO Type (1,2,3,4,5,6, 1-mod, 17" box or 27" box), respectively. If a number is entered in this field, then Beam Dimensions are omitted in the Beam Data. The properties and dimensions of the AASHTO Standards are stored in the program.

2. NST (cc 3 and 4) Form: xx strands

   Enter the number of strands in the top of the beam in this data field. If none exist, leave blank or enter zero (0).

3. XDIST (cc 5 and 8) Form: x.xxx ft.

   The distance from the end of the beam to the center line of bearing.

4. ACT. NO. OR MAX. NO. STRANDS PER ROW (cc 9-48)

   For analysis, enter in these data fields the actual number of strands per row. For design, the maximum number of strands per row is stored in the program. The user may enter maximum number of strands per row and override the defaults. Row one (1) is the bottom row. Always enter an even number of strands per row.

5. ASB (cc 49-52) Form: .xxxx sq. in.

   Enter the area of one bottom strand in this data field. The default is 0.1530 sq. in.

6. AST (cc 53-56) Form: .xxxx sq. in.

   Enter the area of one top strand in this data field. The default is 0.1530 sq. in.

7. DIAM (cc 57-60) Form: x.xxx inches

   Diameter of one strand. Default is 0.500 inches.

8. TCL (cc 61-63) Form: x.xx inches

"TCL" is the distance from the top of the beam to the centroid of the strands in the top of the beam. The default is 2.50 inches.

9. BCL (cc 64-66) Form: x.xx inches

"BCL" is the distance from the bottom of the beam to the centroid of the bottom row (horizontal layer) of strands. Default is 3.00 inches.

10. SPAC (cc 67-69) Form: x.xx inches

"SPAC" is the distance between the centroids of the rows of strands in the bottom of the beam and is a constant for all rows. A variable row spacing is not allowed. The default is 2.00 inches.

STRAND DATA (4 in cc 1)

SECOND LINE

1. RBFPU (cc 2-4) Form: x.xx

Reduction factor needed to multiply with the ultimate stress of a bottom strand to get the temporary stress for the bottom strands. Default is 0.70 when the LL code is left blank (stress relieved strands) and .75 when the LL code is used (low relaxation strands).

2. BFPU (cc 5-9) Form: xxx.xx ksi

Ultimate stress of a bottom strand. Default is 270.00 ksi.

3. IBLOSS (cc 10-13) Form: xx.xx %

Percent initial loss of the bottom strands. Default is the program computes "IBLOSS".

4. FBLOSS (cc 14-17) Form: xx.xx %

Percent final loss for bottom strands. Default is the program computes "FBLOSS".

5. RTFPU (cc 18-20) Form: x.xx

Reduction factor needed to multiply with the ultimate stress of a top strand to get the temporary stress for top strands. Default is 0.70 when the LL code is left blank (stress relieved strands) and .75 when the LL code is used (low relaxation strands).

6. TFPU (cc 21-25) Form: xxx.xx ksi

Ultimate stress of a top strand. Default is 270.00 ksi.

7. ITLOSS (cc 26-29) Form: xx.xx %

Percent initial loss for the top strands. Default is the program computes "ITLOSS".

8. FTLOSS (cc 30-33) Form: xx.xx %

Percent final loss for top strands. Default is the program computes "FTLOSS".

9. WTC (cc 34-37) Form: x.xxx kcf

Weight of concrete. Default is 0.150 kcf.

10. LL (cc 38) Form: zero (0), blank, or 1

Enter 1 for low relaxation strands. Default is zero (0) or blank for stress relieved strands.

11. ITLENGTH (cc 39-42) Form: xx.xx feet

Length for development of strands when considering initial conditions (transfer length).

ITLENGTH = (1/3)(Ifse)DIAM

12. FTLENGTH (cc 43-46) Form: xx.xx feet

Length for development of strands when considering final conditions (transfer length).

FTLENGTH = (1/3)(Ffse)DIAM

13. DLENGTH (cc 47-50) Form: xx.xx feet

Length for development of strands when considering ultimate moment and ultimate shear.

DLENGTH = [fsu - (2/3)Ffse]DIAM.

fsu = average ultimate stress in one strand
Ifse = effective prestress after initial losses
Ffse = effective prestress after all losses
DIAM = nominal diameter of prestressed strand

DEBONDED DATA (5 in cc 1)

FIRST LINE

1. DEBONDED (cc 2) Form: zero (0) or 1

   Enter 1 if debonded strands are to be used.

2. ACT. NO. AND LENGTH OR MAX. NO. AND LENGTH DEBONDED PER ROW 1st CHOICE (cc 3-82)

   For analysis, enter in this data field the actual number of strands to be debonded per row. For design, enter the maximum allowed number of strands debonded per row. "Nx" is the field where the above values are to be placed, "x" being the row number. Row one (1) is the bottom row.

   For analysis, this data field will also contain the length to be debonded per row. For design, it will contain the maximum allowed length to be debonded per row. "Lx" is the field where the lengths are to be placed, "x" being the row number. All the lengths should be multiples of .05L.

   For analysis, if in one data field .15 is entered or a debonded length then at the number of specified strands to be debonded are debonded to the .15L point, where L is the bearing to bearing length. For design, if .15 is entered for one row debonded length then the program will allow debonding up to .15L point but not farther.

   The row of strands that is to be debonded first in a design will be the one with the longest length possible. For example, if row 1 and row 2 were given debonding lengths of .10 and .15, respectively, then the program will first try to debond row 2 then row 1. If all the lengths are the same for all the rows, the debonding order would be row 1, row 2, etc.

DEBONDED DATA (6 in cc 1)

SECOND LINE

1. ACT. NO. AND LENGTH OR MAX. NO. AND LENGTH DEBONDED PER ROW - 2nd CHOICE (cc 2-81)

   Same description as previous line except this data will enable the user the option to give an additional debonding length for every row. For an analysis, the program will use both lines of input. For design, the first line will be tried and if it fails, the second line of input will be added.

   Do not make the mistake of having more strands debonded than the total number of strands in that row.

DRAPED DATA (7 in cc 1)

1. DRAPED (cc 2) Form: zero (0) or 1

Enter 1 if draped strands are to be used. For design, the program can only drape or debond, it can not do both. If the user tries to specify both drape and debonded for a design the drape input will be ignored. If neither the debond or drape options are specified, the program will use only straight strands.

2. RAISED HEIGHT (cc 3-6) Form: xx.xx inches

The distance from the bottom of the beam to the top row of the raised strands. Only needed for analysis.

3. HOLD POINT (cc 7 and 8) Form: .xx Fraction of L (multiples of .05)

The hold down point of the draped strands. If .50 is the input, then the hold down point would be at the center of the span. Only needed for analysis.

4. ACT. NO. OR MAX. NO. DRAPED STRANDS PER ROW (cc 9-48)

For analysis, enter the actual number of draped strands per row. For design, enter the allowable number of draped strands per row. Row one (1) is the bottom row.

P-LOADS (8 in cc 1)

The digit eight (8) in column one is used to identify the concentrated P-loads (Pn). Pn is assumed to be non-composite dead load. Such items as diaphragms, utility supports, etc., can be defined as Pn. A maximum of twenty loads is allowed although the form has space for only five. Use additional lines with the same format for any additional loads. Enter data only for the number of loads specified in the Span Data (NPL).

1. XPn (n = 1-20) (cc 2-7, 13-18, etc.) Form: xxx.xxx feet

Enter in these data fields the distance from the left end of the span (center line of bearing) to the Pn. The left end being the span end nearest the maximum Pn moment. The loads should be given in order from left to right.

2. Pn (n = 1-20) (cc 8-12, 19-23, etc.) Form: xx.xxx kips

Enter in these data fields the magnitude of the Pn.

PRESTRESSED BEAM DESIGN

GEORGIA DEPARTMENT OF TRANSPORTATION - OFFICE OF BRIDGE DESIGN

IDENTIFICATION

	PROG.	PROB. NO.	PROJECT NO., COUNTY, NAME, DATE, REMARKS, ETC.
*	B 0 5		

SPAN DATA

	D/A	℄ CASE	SKIP T	SKIP L	SKIP M	L (FT)	DFM	DFV	DFD	$W_{OL,NC}$	$W_{OL,C}$	W_{SW}	f'_c	f'_{ci}		NPL	SIT	SFB	SFT_E
1															X X X X X				

ENTER 1 TO SKIP ℄

BEAM DATA

	BEAM DIMENSIONS (INCHES)								COMPOSITE SLAB (INCHES)			E x 10^3				
	W_{TC}	H_T	F_T	W_S	H_B	W_B	F_B	D_B	W_F	T_F	D_F	E_{BM}	E_{SLAB}	ST SIZE	DECK PANEL	F_{SW}
2														X	X	

STRAND DATA

	T	NST	XDIST (FT)	ACT. NO. OR MAX. NO. STRANDS PER ROW																				AS_B	AS_T	DIAM	T_{CL}	B_{CL}	SPAC
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20						
3																													

	RB_{FPU}	B_{FPU} (KSI)	IB_{LOSS}	FB_{LOSS}	RT_{FPU}	T_{FPU} (KSI)	IT_{LOSS}	FT_{LOSS}	WT_C	LL	IT_{LENGTH}	FT_{LENGTH}	D_{LENGTH}
4													

DEBONDED DATA

ENTER 1 TO DEBOND

ACT. NO. AND LENGTH OR MAX. NO. AND LENGTH DEBONDED PER ROW (1ST CHOICE)

	D	N1	L1	N2	L2	N3	L3	N4	L4	N5	L5	N6	L6	N7	L7	N8	L8	N9	L9	N10	L10	N11	L11	N12	L12	N13	L13	N14	L14
5																													

ACT. NO. AND LENGTH OR MAX. NO. AND LENGTH DEBONDED PER ROW (2ND CHOICE)

	N1	L1	N2	L2	N3	L3	N4	L4	N5	L5	N6	L6	N7	L7	N8	L8	N9	L9	N10	L10	N11	L11	N12	L12	N13	L13	N14	L14
6																												

NOTE: LENGTHS ARE A MULTIPLE OF .05

DRAPED DATA

ENTER 1 TO DRAPED

	D	RAISED HEIGHT (IN)	HOLD PT.	ACT. NO. OR MAX. NO. STRANDS PER ROW															
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
7																			

P - LOADS

	XP_1	P_1	XP_2	P_2	XP_3	P_3	XP_4	P_4	XP_5	P_5
8										

5.0 OUTPUT DATA DESCRIPTION

The first page of the output data contains a listing of the input data. It is suggested that this data be checked for errors in input. All the data is edited with headings to assist in the data usage.

The second page of the output data will contain moments, stresses and shears caused by dead and live loads at the span twentieth points, and will be headed by the Identification data. Headings for the span points are shown as a fraction of the span length (L), i.e., 0.50 L is the center of the span.

MOMENTS AT SPAN TWENTIETH POINTS (K-FT)

1. UNIFORM D.L. BEAM

These moments are due to the weight of the beam excluding the composite slab.

2. UNIFORM D.L. NON-COMP.

These moments are due to the uniform non-composite dead load, "WDLnc" given in the input data.

3. CONCENTRATED P-LOADS

These moments are due to the P-Load data given in the input. Moments are not given at the points of loads unless the points occur on span twentieth points.

4. UNIFORM D.L. COMP.

These moments are due to the uniform composite dead load, "WDLc" given in the input data.

5. SIDEWALK LIVE LOAD

These moments are due to the uniform sidewalk live load, "Wsw" given in the input data.

6. LIVE LOAD + IMPACT

This line of output contains the maximum live load moments, including impact and distribution, from all live loads (truck, lane, military or railroad) considered by the program. Only the maximum moment is listed with no indication of which type of live load governed. The span length can be used to indicate which type of load controls. The absolute maximum live load moment in the span is not computed unless it happens to fall at a span twentieth point. Usually when dead load is added, the total maximum moment will be greatest at the span center line. Even if this is not correct, the difference is small enough to be ignored and the moments at the center line of span can be used satisfactorily for design purposes.

7. TOTAL D.L. + L.L.

These moments are the summation of all dead load and live load moments.

STRESSES AT SPAN TWENTIETH POINTS (KSI)

Stresses are computed in the top and bottom of the beam at the span twentieth points due to the following gravity loads. No effects due to prestress are included. These effects are listed later. The stresses in the top of the beam are listed first (TOP) followed by the stresses in the bottom of the beam (BOT) for each load. A negative value indicates tension; a positive stress is compression.

1. UNIFORM D.L. BEAM

   These stresses are due to the moment of the beam (excluding the composite slab). The non-composite properties of the beam are used to determine these stresses.

2. TOTAL NON-COMP. D.L.

   These stresses are due to the summation of the moments of the beam, the uniform non-composite dead load (WDLnc), and the concentrated dead load (Pn). The non-composite properties of the beam are used to determine these stresses.

3. TOTAL COMP. D.L. + L.L.

   These stresses are due to the summation of the moments of the uniform composite dead load (WDLc), the maximum live load (including impact and distribution factors), the uniform sidewalk live load (Wsw), and concentrated dead load (Pn). The composite properties of the beam are used to determine these stresses.

4. TOTAL COMP. + NON-COMP.

   The summation of all stresses is given, total of non-composite and composite stresses.

SHEARS AT SPAN TWENTIETH POINTS (KIPS)

Shears are computed and listed for all dead and live loads in the same manner as the moments. The shear at the end of the span is the end reaction and can be used in substructure design.

The third page of the output contains beam properties, strand and other miscellaneous data, and deflections.

BEAM PROPERTIES

Non-composite beam properties (beam) and composite beam properties (beam plus slab) are given as follows:

1. I is the moment of inertia of the cross-section, (in4).
2. YT is the distance from the centroid of area to the top of the beam, (in).
3. YB is the distance from the centroid of area to the bottom of the beam, (in).
4. ST is the section modulus of the top of the beam (I/YT), (in3).
5. SB is the section modulus of the bottom of the beam (I/YB), (in3).
6. A is the area of the cross-section, (in2).
7. W (non-composite properties) is the uniform weight of the beam, (k-ft).
8. QS (composite properties) is the moment of area of the composite slab about the centroid of area of the cross-section, (in3).

STRAND AND MISC. DATA

1. MAX. NO. STRANDS

The absolute maximum number of strands that can be used without exceeding allowable stress limitations is given in this column.

2. ACT. NO. STRANDS

The number of strands selected by the program to use is given here (including the top strands, "NST"). All data involving prestress are computed using this number of strands.

3. MIN. NO. STRANDS

The absolute minimum number of strands that can be used without exceeding allowable stress limitations is given in this column. If the actual number of strands selected by the program is greater than the minimum number of strands, it indicates that the beam dimensions prohibited an eccentricity sufficiently large enough so that the minimum number of strands would satisfy the stress limitations.

4. E AT C.L.

This value is the eccentricity of the strand arrangement selected by the program, the distance from the centroid of the beam to the centroid of the strands in inches. This eccentricity (Ea) is computed at the center line of span and includes the effects of the top strands.

5. E AT END

This value is the eccentricity of the strand arrangement selected by the program, the distance from the centroid of the beam to the centroid of the strands in inches. This eccentricity (Ee) is computed at the end of beam and includes the effects of the top strands.

6. PS

This percentage of steel value is the ratio of the total strand area to the area of the beam.

7. ASE

"ASE" is the required area of stirrups within the distance "DB/4" of the end of the beam, sq. in.

8. NS (EACT-EEND)

This output value is the product of the number of strands and the difference in eccentricity of the center line and end of span values. Consequently, it must also be equal to the product of the number of strands raised (Nsr) and the distance the strands are raised (Dsr).

$$Nsr\ (Dsr) = Ns\ (Ea - Ee)$$

Select "Nsr" and solve for "Dsr", or else, select "Dsr" and solve for "Nsr" (must be an even integer). Note that the depth of beam has a controlling influence on "Dsr", the number of rows and web width controls "Nsr".

9. BPI

"BPI" is the total prestress force in kips for the bottom strands after initial losses.

10. BPF

"BPF" is the total prestress force in the bottom strands after all losses have occured in kips.

11. TPI

"TPI" is the total prestress force in kips for the top strands after initial losses.

12. TPF

"TPF" is the total prestress force in the top strands after all losses have occured in kips.

MOMENTS(K-FT), SHEARS(KIPS), STIRRUP SPACING (IN), AND STRESSES(KSI) AT SPAN TWENTIETH POINTS

1. ULT. MOMENT REQD.

This line of output contains the ultimate moment requirements and is equal to 1.3 times the total dead load moment plus 2.167 times the total live load moment.

2. ULT. MOMENT FURN.

This line contains the ultimate moment capacities of the beam and should be greater than the ultimate moment required at all points in the span.

3. 1.2 x CRACKING MOMENT

This line contains the 1.2 x cracking moment based on the modulus of rupture. <u>This is not the same cracking moment used for shear resistance calculations.</u>

4. DIST. TO N.A. (IN.)

These distances are from the top of the composite slab to the neutral axis of the cross section at ultimate conditions, and are used to determine whether the cross-section is a "flanged" or "rectangular" section.

5. MAX STEEL RATIO

This max steel ratio (MSR) is used to determine the procedure for computing the ultimate moment capacity of the beam.

6. ULT. COMP. SHEAR

This line of data is the ultimate composite shear and is equal to 1.3 times the composite dead load shear plus 2.167 times the total live load shear. These shears are used to compute the slab-beam shear stress (bond).

7. ULT. TOTAL SHEAR

This line of data is the ultimate shear which is equal to 1.3 times the total dead load shear plus 2.167 times the total live load shear. These shears are used to compute stirrup spacings.

8. BEAM SHEAR CAPACITY

These values are the shear capacity of the beam without web reinforcement.

9. MIN. STIRRUP AREA (IN.^2)

Minimum stirrup area required.

10. STRP.(#4, #5, or #6) SPAC. (IN.)

The required stirrup spacings, assuming two bars are given in inches on this output line. The effect of prestress is considered.

11. PRESTRESS STRESS

The prestress stress (after initial losses) is given in the top (TOP) and bottom (BOT) of the beam. These stresses do not include any loads. The actual eccentricities (selected by program) are used to compute these stresses.

12. INITIAL STRESSES

These stresses are the sum of the stresses due to prestress (after initial losses) and the weight of the beam, given at the top and bottom of the beam. This represents the condition when the strands are released.

13. FINAL STRESSES

These stresses are the sum of the stresses due to prestress (after final losses) and all loads and are given at the top and bottom of the beam. This represents the condition of maximum service loading.

14. FINAL # TOP STRANDS

The actual number of top strands that are active at the 20th point when considering debonding and final transfer length.

15. FINAL # BOT STRANDS

The actual number of bottom strands that are active at the 20th point when considering debonding and final transfer length.

16. DEVELOP. # TOP STRNDS

The actual number of top strands that are active at that 20th point when considering debonding and development lengths. Used for ultimate moment furnished calculations.

17. DEVELOP. # BOT STRNDS

The actual number of bottom strands that are active at that 20th point when considering debonding and development lengths. Used for ultimate moment furnished calculations.

Note: A debonded strand at ultimate conditions is considered to be fully developed at 2 times the development length past the end of the wrap.

A non-debonded strand at ultimate conditions is considered to be fully developed at the development length past the end of the strand.

DEFLECTIONS AT CENTER LINE OF SPAN (INCHES)

Deflections are computed and listed at the span center line for the following loads:

1. BEAM

   This deflection is due to the weight of the beam. No prestress is included.

2. WDLnc

   This deflection is due to the uniform non-composite dead load, "WDLnc".

3. P-LOADS

   This deflection is due to the concentrated P-loads, "Pn".

4. WDLc

   This deflection is due to the uniform composite dead load, "WDLc".

5. INITIAL

   This deflection is due to the weight of the beam and the effects of prestressing (after initial losses). A negative value indicates an upward resultant deflection.

6. FINAL

   This deflection is due to the prestress force (after losses) and all dead loads.

7. SIDEWALK

   This deflection is due to the sidewalk live load, "Wsw".

8. TRUCK

   This deflection is due to the truck live load (includes impact and "DFD").

9. LANE

This deflection is due to the uniform and concentrated live lane loads (includes impact and "DFD").

10. MILITARY

This deflection is due to Military live load (includes impact and "DFD").

11. RAILROAD

This deflection is due to the railroad live load (includes impact and "DFD").

12. PRESTR.

This deflection is due to the prestress force (before losses). This is an upward deflection and is always listed as negative.

13. CAMBER

This value is for 45 days after casting.

MAXIMUM, ACTUAL AND MINIMUM ECCENTRICITIES (INCHES) AT SPAN TWENTIETH POINTS

Six eccentricities are listed for the span twentieth points including the end of the span. The first two are maximum eccentricities which are determined from the initial stress conditions (prestress plus beam weight). The maximum eccentricity controlled by the stress in the top of the beam (SIT = 0) is listed first, and the maximum eccentricity controlled by the initial compressive stress in the bottom of the beam (SIB = 0.6f'ci) is listed next. The minimum of the two maximum eccentricities is the actual maximum eccentricity. This value is the one plotted in the eccentricites plot.

The actual initial eccentricity of the strands is listed next. This value is found by taking into account the transfer length, raised strands and debonded strands. This value should be less than or equal to the maximum eccentricity values.

The following line contains the actual final eccentricity. This value is found by taking into account the development length, raised strands and debonded strands. This value should be greater than or equal to the minimum eccentricity values.

The next two lines contain the minimum eccentricities. These values are determined from the final stress condition (prestress minus losses plus all loads). The minimum eccentricity controlled by the stress in the top of the beam (SFT = 0.4f'c) is listed after the actual eccentricities, and the minimum eccentricity controlled by the final is listed next. The maximum of the two minimum eccentricities is the actual minimum eccentricity. This value is the one plotted in the eccentricity plot.

ECCENTRICITY PLOT (INCHES)

The output contains a plot of the maximum, actual, and minimum eccentricities. The abscissa scale is one inch equals two inches (one-half scale) and remains constant (zero to 24 inches). The vertical (ordinate) scale varies with the span length and is equal to: One inch equals 0.15L or, point. Beginning with the end of the span (0.0L), the span points are listed with the center line of the span listed last. An asterisk indicates the minimum and maximum eccentricities points, and a plus sign (+) denotes the actual initial and final eccentricities points. The distance from the center line of the span to the hold-down point is given at the bottom of the plot. This value is rounded to the nearest three inches. Note that only span twentieth points are considered as hold-down points. If a maximum or minimum eccentricity point has the same print position as the actual eccentricity value, the actual final eccentricity (+) is printed and the asterisk omitted.

STRAND ARRANGEMENT (TOP STRANDS NOT SHOWN)

The strand arrangement selected by the program at the span center line is listed. Strands that are not debonded or draped are represented by a plus sign (+). Strands which are draped and debonded are represented by the letters "R" and "D", respectively.

STRAND ARRANGEMENT (TOP STRANDS NOT SHOWN) ALONG THE BEAM

This illustrates the actual strand arrangement along the beam from the end to the center. The rows that are debonded with their respective debonding lengths will be shown. The draped rows are also illustrated.

STRAND ARRANGEMENT @ END

Gives the final number of strands, the number debonded and the number draped. The distance from the bottom of the beam to the center of the respective strands will also be given.

TRANSFER AND DEVELOPMENT LENGTHS (FT)

INITIAL TRANSFER LENGTH (ITLENGTH)

The output contains the length used for development of strands when considering initial conditions.

FINAL TRANSFER LENGTH (FTLENGTH)

The output contains the length used for development of strands when considering final conditions.

DEVELOPMENT LENGTH (DLENGTH)

The output contains the length used for development of strands when considering ultimate moments.

LOSSES (KSI)

INITIAL LOSSES

Losses used in initial conditions.

ADDITIONAL LOSSES

Losses added to initial losses to get final losses.

FINAL LOSSES

Losses used in final conditions.

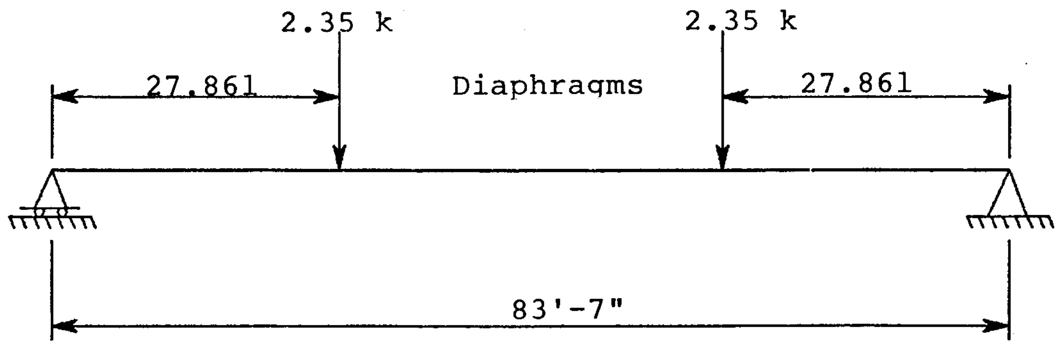
6.0 EXAMPLE PROBLEMS

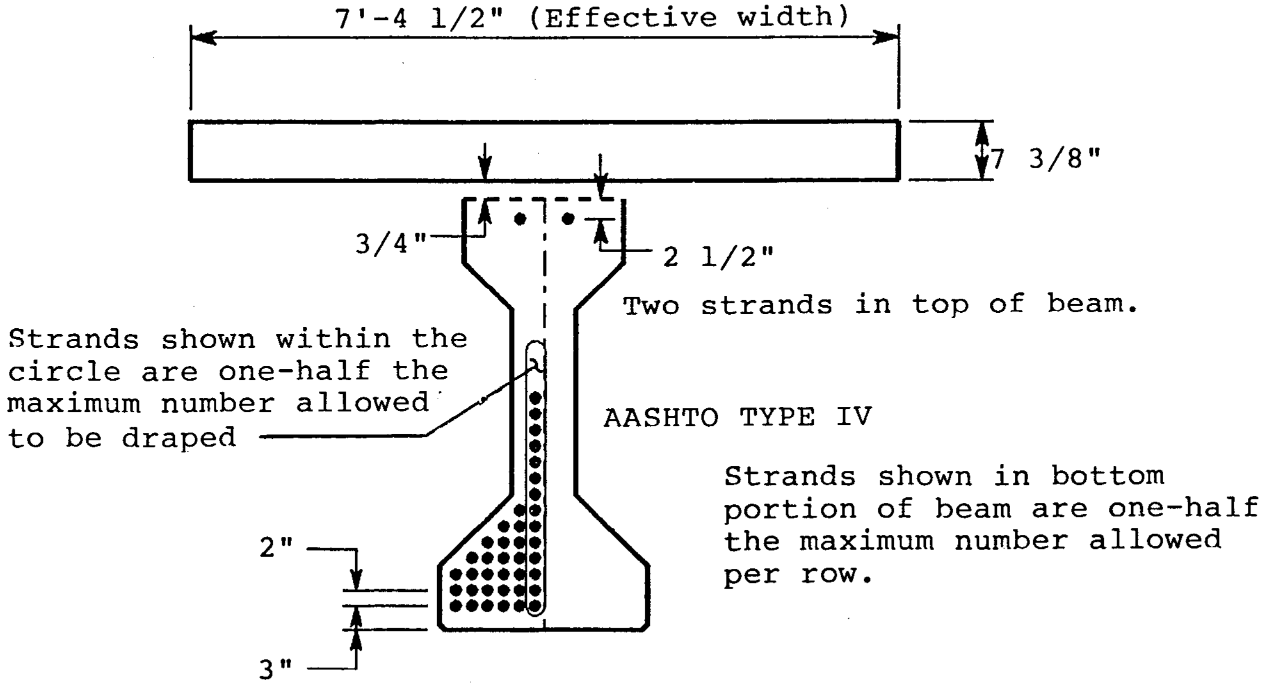
Example Number One: Drape Design

Given Data:
Live Load: HS20 and/or military, no sidewalk
Dead Load: Non-composite = .739 kips/ft.
Composite = .271 kips/ft.
AASHTO Type IV interior beam of two lane bridge with four beams.
Span length = 83′- 7"
Beam spacing = 7′ - 9 5/8"
Distribution factors: DFM = 7.8/5.5 = 1.418
DFV = 1.418
DFD = 1.000
Beam concrete : f′c = 5.0 ksi EBM = 4,300 ksi
f′ci = 4.0 ksi
Modulus of elasticity of slab concrete = 3,500 ksi
Strand information:

ASB	.153 in2	AST =	.153 in2
RBFPU =	.70	RTFPU =	.70
BFPU =	270.0 ksi	TFPU =	270.0 ksi
IBLOSS =	10.0 %	ITLOSS =	10.0 %
FBLOSS =	14.5 %	FTLOSS =	14.5 %

Ploads:





PRESTRESSED BEAM DESIGN

IDENTIFICATION

	PROG.	PROB. NO.	PROJECT NO., COUNTY, NAME, DATE, REMARKS, ETC.
*	B05	EX 1	EXAMPLE PROBLEM NO. 1, DRAPE DESIGN

SPAN DATA

	D/A	℄ CLASS	SKIP T	SKIP L	SKIP M	L (FT)	DFM	DFV	DFD	$W_{DL_{NC}}$	W_{DL_C}	WSW	f'_c	f'_{ci}		NPL	SIT	SFB	SFT_E
1	D	HS20				83.583	1.418	1.418	1.000	.739	.271	.	5.000	4.000	XXXXX	2	-.200	-.464	-.001

ENTER 1 TO SKIP ℄

BEAM DATA

	BEAM DIMENSIONS (INCHES)								COMPOSITE SLAB (INCHES)			EX10[3]	
	WTC	HT	FT	WS	HB	WB	FB	DB	WF	TF	DF	EBM	E SLAB
2	.	.	.	.	.	.	.	.	88.50	7.375	.750	4.30	3.50

STRAND DATA

BEAM TYPE

	T	NST	XDIST (FT)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	AS_B	AS_T	DIAM	TCL	BCL	SPAC
3		2	.001	12	12	12	10	8	6	4	2	2												.	.	.	.	.	.

(Columns 1–20: ACT. NO. OR MAX. NO. STRANDS PER ROW)

ENTER 1 FOR LOW LAX STRANDS

	RB_{FPU}	B_{FPU} (KSI)	IB LOSS	FB LOSS	RT_{FPU}	T_{FPU} (KSI)	IT LOSS	FT LOSS	WT_C	LL	IT LENGTH	FT LENGTH	D LENGTH
4	.70	270.00	10.00	24.50	.70	270.00	10.00	24.50	.		.	.	.

DEBONDED DATA

ENTER 1 TO DEBOND

ACT. NO. AND LENGTH OR MAX. NO. AND LENGTH DEBONDED PER ROW (1ST CHOICE)

	D	N1	L1	N2	L2	N3	L3	N4	L4	N5	L5	N6	L6	N7	L7	N8	L8	N9	L9	N10	L10	N11	L11	N12	L12	N13	L13	N14	L14
5			.		.		.		.		.		.		.		.		.		.		.		.		.		.

ACT. NO. AND LENGTH OR MAX. NO. AND LENGTH DEBONDED PER ROW (2ND CHOICE)

	N1	L1	N2	L2	N3	L3	N4	L4	N5	L5	N6	L6	N7	L7	N8	L8	N9	L9	N10	L10	N11	L11	N12	L12	N13	L13	N14	L14
6		.		.		.		.		.		.		.		.		.		.		.		.		.		.

NOTE: LENGTHS ARE A MULTIPLE OF .05

DRAPED DATA

ENTER 1 FOR DRAPED

ACT. NO. OR MAX. NO. STRANDS DRAPED PER ROW

	D	RAISED END HEIGHT	HOLD PT.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
7	1	.	.	2	2	2	2	2	2	2	2								

P - LOADS

	XP_1	P_1	XP_2	P_2	XP_3	P_3	XP_4	P_4	XP_5	P_5
8	27.867	2.350	55.722	2.350	.	.	.	.	.	.

EXAMPLE PROBLEM NO.1, DRAPE DESIGN

SPAN DATA

D/A	LL CLASS	LL SK.	LENGTH	DFM	DFV	DFD	WDINC	WDLC	WSWK	F'C	F'CI	NPL	SIT	SFB	SFTE
D	HS20	0 0 0	83.583	1.418	1.418	1.000	0.739	0.271	0.000	5.000	4.000	2	-0.200	-0.464	0.001

BEAM DATA

BEAM DIMENSIONS								* COMPOSITE SLAB			* (E X 1,000,000)		* STIRRUP	DECK	
WT	HT	FT	WS	HB	WB	FB	DB	* WF	TF	DF	* E BEAM	E SLAB	* SIZE	PANEL	FSY
20.00	8.00	6.00	8.00	8.00	26.00	9.00	54.00	88.50	7.375	0.750	4.30	3.50	5	0	40.

STRAND DATA

TYPE	NST	XDIST	ACTUAL NO. OR MAX. NO. OF STRANDS PER ROW	ASB	AST	DIAM	TCL	BCL	SPAC.
4	2	0.0010	12 12 12 10 8 6 2 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0.1530	0.1530	0.500	2.50	3.00	2.00

RBFPU	BFPU	IBLOSS	FBLOSS	RTFPU	TFPU	ITLOSS	FTLOSS	WTC	LOW LAX	ITLENGTH	FTLENGTH	DLENGTH
.70	270.00	10.00	24.50	.70	270.00	10.00	24.50	.150	0	0.00	0.00	0.00

DEBONDING DATA

DEBOND ACT. # AND LENGTH OR MAX. # AND LENGTH OF STRANDS DEBONDED PER ROW

0 0 .00

0 .00 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00

DRAPE DATA

DRAPED	MAX RAISE	HOLD DOWN PT.	ACT. # OR MAX. # OF STRANDS DRAPED PER ROW
1	0.00	.00	2 2 2 2 2 2 2 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0

P-LOADS

XP1	P1	XP2	P2	XP3	P3	XP4	P4	XP5	P5
27.867	2.350	55.722	2.350						

PRESTRESSED BEAM DESIGN - OUTPUT DATA FOR PROBLEM NO. EX 1 EXAMPLE PROBLEM NO.1, DRAPE DESIGN

MOMENTS AT SPAN TWENTIETH POINTS - KIP-FEET

LOADS	BRNG	0.05 L	0.10 L	0.15 L	0.20 L	0.25 L	0.30 L	0.35 L	0.40 L	0.45 L	0.50 L
UNIFORM D.L. BEAM	0.000	136.366	258.377	366.034	459.337	538.286	602.880	653.120	689.006	710.537	717.714
UNIFORM D.L. NON-C.	0.000	122.615	232.323	329.125	413.019	484.007	542.088	587.262	619.529	638.889	645.343
CONCENTRATED P-LOADS	0.000	9.820	19.641	29.461	39.281	49.101	58.922	65.483	65.482	65.481	65.480
UNIFORM D.L. COMP.	0.000	44.964	85.196	120.694	151.459	177.491	198.790	215.356	227.189	234.288	236.655
LIVE LOAD + IMPACT	0.000	221.720	416.993	585.817	728.194	844.124	933.605	1001.562	1052.914	1077.819	1076.277
TOTAL D.L. + L.L.	0.000	535.486	1012.529	1431.131	1791.291	2093.009	2336.285	2522.782	2654.120	2727.015	2741.469

STRESSES AT SPAN TWENTIETH POINTS - KIPS PER SQ.IN.

LOADS		BRNG	0.05 L	0.10 L	0.15 L	0.20 L	0.25 L	0.30 L	0.35 L	0.40 L	0.45 L	0.50 L
UNIFORM D.L. BEAM	TOP	0.000	0.184	0.348	0.493	0.619	0.725	0.812	0.880	0.928	0.957	0.967
	BOT	0.000	-0.155	-0.294	-0.417	-0.523	-0.613	-0.686	-0.743	-0.784	-0.809	-0.817
TOTAL NONCOMP. D.L.	TOP	0.000	0.362	0.687	0.976	1.228	1.443	1.622	1.759	1.851	1.906	1.924
	BOT	0.000	-0.306	-0.581	-0.825	-1.038	-1.220	-1.370	-1.486	-1.564	-1.611	-1.626
TOTAL COMP.D.L.+L.L.	TOP	0.000	0.081	0.152	0.213	0.266	0.309	0.342	0.368	0.387	0.396	0.397
	BOT	0.000	-0.196	-0.370	-0.520	-0.648	-0.753	-0.834	-0.897	-0.943	-0.967	-0.967
TOTAL COMP.+NONCOMP.	TOP	0.000	0.443	0.839	1.189	1.494	1.752	1.964	2.127	2.237	2.302	2.321
	BOT	0.000	-0.502	-0.951	-1.345	-1.686	-1.972	-2.205	-2.383	-2.507	-2.577	-2.593

SHEARS AT SPAN TWENTIETH POINTS - KIPS

LOADS	BRNG	0.05 L	0.10 L	0.15 L	0.20 L	0.25 L	0.30 L	0.35 L	0.40 L	0.45 L	0.50 L
UNIFORM D.L. BEAM	34.347	30.913	27.478	24.043	20.608	17.174	13.739	10.304	6.869	3.435	0.000
UNIFORM D.L. NON-C.	30.884	27.796	24.707	21.619	18.530	15.442	12.354	9.265	6.177	3.088	0.000
CONCENTRATED P-LOADS	2.350	2.350	2.350	2.350	2.350	2.350	2.350	0.000	0.000	0.000	0.000
UNIFORM D.L. COMP.	11.325	10.193	9.060	7.928	6.795	5.663	4.530	3.398	2.265	1.133	0.000
LIVE LOAD + IMPACT	56.218	53.264	50.292	47.303	44.295	41.267	38.216	35.143	32.045	28.920	25.766
TOTAL D.L. + L.L.	135.125	124.515	113.888	103.243	92.579	81.895	71.189	58.110	47.356	36.575	25.766

BEAM PROPERTIES

* * * * * NON-COMPOSITE BEAM PROPERTIES							*	* * * * COMPOSITE BEAM PROPERTIES						
I	YT	YB	ST	SB	A	W	*	I	YT	YB	ST	SB	A	QS
260740.6	29.266	24.734	8909.3	10541.9	789.00	0.822	*	623792.3	15.704	38.296	39721.4	16288.8	1320.26	10700.42

STRAND AND MISC. DATA

MAX # STRDS	ACT # STRDS	MIN # STRDS	E @ C.L.	E @ END	PS	ASE	NS(FACT-EEND)	BPI	BPF	TPI	TPF
46	34	26	17.234	14.763	0.66%	1.77	83.998	832.810	698.635	52.051	43.665

MOMENTS(K-FT.) AND SHEARS(KIPS), STIRRUP SPACING, STRESSES(KSI) AT SPAN TWENTIETH POINTS

LOADS	BRNG	0.05 L	0.10 L	0.15 L	0.20 L	0.25 L	0.30 L	0.35 L	0.40 L	0.45 L	0.50 L
ULT. MOMENT REQD.	0.000	888.296	1677.696	2368.198	2959.805	3452.514	3846.327	4147.670	4362.917	4479.266	4496.719
ULT. MOMENT FURN.	0.887	3543.376	5680.088	5708.914	5737.738	5766.566	5795.393	5824.221	5853.051	5881.881	5910.711
1.2*CRACKING MOMENT	865.471	3942.097	3812.422	3700.581	3606.573	3530.399	3472.059	3433.685	3417.438	3419.024	3438.443
DIST. TO N.A.(IN.)	0.001	2.723	4.418	4.419	4.419	4.420	4.421	4.422	4.423	4.423	4.424
MAX STEEL RATIO	0.000	0.044	0.071	0.071	0.071	0.070	0.070	0.070	0.069	0.069	0.069
ULT. COMP. SHEAR	136.531	128.657	120.747	112.798	104.808	96.774	88.693	80.561	72.376	64.133	55.828
ULT. TOTAL SHEAR	224.386	208.033	191.642	175.213	158.743	142.229	125.668	106.001	89.336	72.613	55.828
BEAM SHEAR CAPACITY	103.286	177.469	199.306	218.805	162.775	122.567	95.178	71.827	56.263	52.293	52.531
MIN. STIRRUP AREA	0.840	0.307	0.120	0.120	0.120	0.199	0.249	0.256	0.238	0.157	0.120
STRP.(#5) SPAC.(IN.)	8.857*	24.000	24.000	24.000	24.000	24.000	24.000	24.000	24.000	24.000	24.000
PRESTRESS STRESS TOP	0.000	-0.369	-0.394	-0.418	-0.443	-0.467	-0.492	-0.517	-0.541	-0.566	-0.590
BOT	0.001	2.381	2.402	2.423	2.444	2.464	2.485	2.506	2.527	2.547	2.568
INITIAL STRESSES TOP	0.000	-0.186	-0.046	0.075	0.176	0.258	0.320	0.363	0.387	0.391	0.377
BOT	0.001	2.226	2.108	2.006	1.921	1.852	1.799	1.762	1.742	1.739	1.751
FINAL STRESSES TOP	0.000	0.133	0.509	0.838	1.122	1.360	1.551	1.693	1.784	1.828	1.826
BOT	0.001	1.495	1.064	0.687	0.364	0.095	-0.120	-0.281	-0.388	-0.440	-0.439
FINAL # TOP STRANDS	0.001	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000
FINAL # BOT STRANDS	0.016	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000
DEVELOP. # TOP STRDS	0.000	1.214	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000
DEVELOP. # BOT STRDS	0.005	19.429	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000

* - FOR "ASE" REQUIREMENTS WITHIN A MAXIMUM DISTANCE OF 11.007" (D/4) FROM THE END OF BEAM USE EITHER
3 LOCATIONS OF 2-#5 STIRRUPS AT A MAXIMUM SPACING OF 4.504" OR
3 LOCATIONS OF 2-#6 STIRRUPS AT A MAXIMUM SPACING OF 4.504" USING 2" CL. FROM END OF BEAM

DEFLECTIONS(INCHES) AT CENTER LINE OF SPAN

BEAM	WDINC	P-LOADS	WDLC	INITIAL	FINAL	SIDEWALK	TRUCK	LANE	MILITARY	RAILROAD	PRESTR.	CAMBER
0.805	0.724	0.075	0.111	-0.824	0.349	0.000	0.326	0.250	0.232	0.000	-1.629	-1.385

MAXIMUM, ACTUAL AND MINIMUM ECCENTRICITIES(INCHES)AT SPAN TWENTIETH POINTS

ITEM	BRNG	0.05 L	0.10 L	0.15 L	0.20 L	0.25 L	0.30 L	0.35 L	0.40 L	0.45 L	0.50 L
MAX ECC, SIT= -200	999.900	15.155	16.810	18.270	19.535	20.606	21.482	22.163	22.649	22.941	23.039
MAX ECC, SIB= 2400	67538.711	17.081	18.736	20.196	21.461	22.532	23.408	24.089	24.576	24.868	24.965
INITIAL ECCENTRICITY	14.763	15.010	15.257	15.504	15.751	15.999	16.246	16.493	16.740	16.987	17.234
FINAL ECCENTRICITY	14.763	15.010	15.257	15.504	15.751	15.999	16.246	16.493	16.740	16.987	17.234
MIN ECC, SFT= 2000	-47563.086	-7.400	-2.642	1.563	5.214	8.312	10.855	12.810	14.141	14.918	15.142
MIN ECC, SFB= -464	-13073.157	-12.815	-6.446	-0.845	3.990	8.058	11.359	13.892	15.655	16.651	16.880

```
* SPAN * * * * * * * * * * * * * * ECCENTRICITY PLOT (INCHES) * * * * * * * * * * * * * * * * *
                                                            1    1    1    1    1    1    1    1    1    1    2    2    2    2    2
* POINTS *0....1....2....3....4....5....6....7....8....9....0....1....2....3....4....5....6....7....8....9....0....1....2....3....4
* 0.00 L *                                                                          +
* 0.05 L *                                                                           +*
* 0.10 L *                                                                            +       *
* 0.15 L *        *                                                                     +            *
* 0.20 L *                          *                                                    +                  *
* 0.25 L *                                          *                                     +                      *
* 0.30 L *                                                         *                       +                         *
* 0.35 L *                                                                     *            +                            *
* 0.40 L *                                                                              *     +                            *
* 0.45 L *                                                                                   * +                             *
* 0.50 L *                                                                                    * +                            *
* * * *    * = MAX. AND MIN. ECCENTRICITY, + = ACTUAL ECCENTRICITY, HOLD-DOWN POINT IS  0.00 FEET FROM CENTER LINE OF SPAN
```

STRAND ARRANGEMENT (TOP STRANDS NOT SHOWN)= 2

```
    + + + R R + + +
+ + + + + R R + + + + +
+ + + + + R R + + + + +
```

```
* SPAN * * * * * * * * * * * * * * *STRAND ARRANGEMENT (INCHES) * * * * * * * * * * * * * * * * * *
                              1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 3 3 3 3 3 3 3 3 3 3 4 4 4 4 4 4 4 4 4 4 5 5 5 5 5 5 5 5 5 5 6
* POINTS *0.1.2.3.4.5.6.7.8.9.0.1.2.3.4.5.6.7.8.9.0.1.2.3.4.5.6.7.8.9.0.1.2.3.4.5.6.7.8.9.0.1.2.3.4.5.6.7.8.9.0.1.2.3.4.5.6.7.8.9.0

* END    *      +   +   +                   R   R   R

* BRNG   *      +   +   +                   R   R   R


* 0.05 L *      +   +   +                R   R   R


* 0.10 L *      +   +   +             R   R   R


* 0.15 L *      +   +   +           R   R   R


* 0.20 L *      +   +   +        R   R   R


* 0.25 L *      +   +   +     R   R   R


* 0.30 L *      +   +   +  R   R   R


* 0.35 L *      +   +   R   R   R


* 0.40 L *      +   + R + R   R


* 0.45 L *      +  R+  R+  R


* 0.50 L *      R   R   R
```

FINAL STRAND ARRANGEMENT AT END

ROW	TOTAL #STRDS	*	VER DIST-STRAIGHT STRDS	*	#RAISED STRDS	VER DIST-RAISED STRDS	*	#DEB 1	DEB LENGTH 1	*	#DEB 2	DEB LENGTH 2
		*		*			*			*		
1	12	*	3.000	*	2	17.000	*	0	0.00L	*	0	0.00L
		*		*			*			*		
2	12	*	5.000	*	2	19.000	*	0	0.00L	*	0	0.00L
		*		*			*			*		
3	8	*	7.000	*	2	21.000	*	0	0.00L	*	0	0.00L
TOP	2		51.500									

INITIAL TRANSFER LENGTH = 2.362 FT

FINAL TRANSFER LENGTH = 1.982 FT

DEVELOPMENT LENGTH = 6.885 FT

LOSSES (KSI)

TOP STRANDS INITIAL LOSSES= 18.900 TOP STRANDS ADDITIONAL LOSSES= 27.405 TOP STRANDS FINAL LOSSES= 46.305

BOT STRANDS INITIAL LOSSES= 18.900 BOT STRANDS ADDITIONAL LOSSES= 27.405 BOT STRANDS FINAL LOSSES= 46.305

TOTAL LOSSES FOR ALL STRANDS= 46.305

Example Number Two: Debonded Design

Given Data:

Live Load: HS20 and/or military, no sidewalk

Dead Load: Non-composite = .739 kips/ft.
Composite = .271 kips/ft.

AASHTO Type IV interior beam of two lane bridge with four beams.

Span length = 83′- 7"

Beam spacing = 7′ - 9 5/8"

Distribution factors: DFM = 7.8/5.5 = 1.418
DFV = 1.418
DFD = 1.000

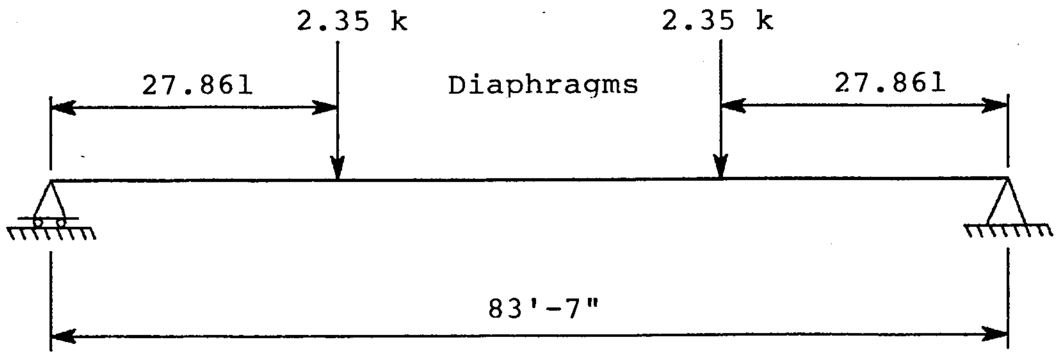
Beam concrete : f′c = 5.0 ksi EBM = 4,300 ksi
f′ci = 4.0 ksi

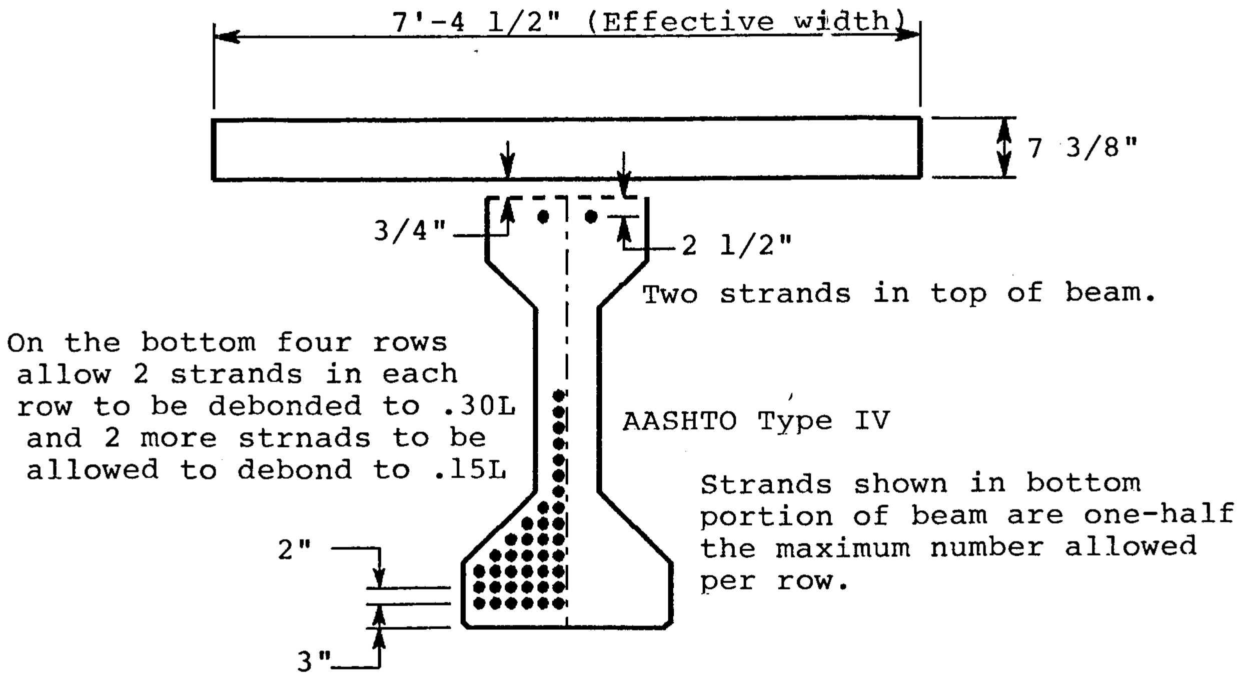
Modulus of elasticity of slab concrete = 3,500 ksi

Strand information:

ASB .153 in2	AST = .153 in2
RBFPU = .70	RTFPU = .70
BFPU = 270.0 ksi	TFPU = 270.0 ksi
IBLOSS = 10.0 %	ITLOSS = 10.0 %
FBLOSS = 14.5 %	FTLOSS = 14.5 %

Ploads:





PRESTRESSED BEAM DESIGN

IDENTIFICATION

	PROG.	PROB. NO.	PROJECT NO., COUNTY, NAME, DATE, REMARKS, ETC.
*	B05	EX 2	EXAMPLE PROBLEM NO. 2, DEBONDED DESIGN

SPAN DATA

Card	D/A	℄ CLASS	SKIP T	SKIP L	SKIP M	L (FT)	DFM	DFV	DFD	$W_{DL_{NC}}$	W_{DL_C}	WSW	f'_c	f'_{ci}		NPL	SIT	SFB	SFT_E
1	D	HS20				83.583	1.418	1.418	1.000	.739	.271	.	5000	4000	XXXXX	2	-.200	-.464	-.001

ENTER 1 TO SKIP ℄

BEAM DATA

Card	BEAM DIMENSIONS (INCHES)								COMPOSITE SLAB (INCHES)			EX10 ^{3}	
	WTC	HT	FT	WS	HB	WB	FB	DB	WF	TF	DF	EBM	E SLAB
2	.	.	.	.	.	.	.	.	88.50	7.375	.750	4.30	3.50

STRAND DATA

BEAM TYPE

Card	T	NST	XDIST (FT)	ACT. NO. OR MAX. NO. STRANDS PER ROW 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	AS_B	AS_T	DIAM	T_{CL}	B_{CL}	SPAC
3	4	2	.001	12	12	12	10	8	6	2	2													.	.	.	.	.	.

ENTER 1 FOR LOW LAX STRANDS

Card	RB_{FPU}	B_{FPU} (KSI)	IB LOSS	FB LOSS	RT_{FPU}	T_{FPU} (KSI)	IT LOSS	FT LOSS	WT_C	LL	IT LENGTH	FT LENGTH	D LENGTH
4	.70	270.00	10.00	24.50	.70	270.00	10.00	24.50	.		.	.	.

DEBONDED DATA

ENTER 1 TO DEBOND

ACT. NO. AND LENGTH OR MAX. NO. AND LENGTH DEBONDED PER ROW (1ST CHOICE)

Card	D	N1	L1	N2	L2	N3	L3	N4	L4	N5	L5	N6	L6	N7	L7	N8	L8	N9	L9	N10	L10	N11	L11	N12	L12	N13	L13	N14	L14
5	1	2	3.0	2	3.0	2	3.0	2	3.0	2	3.0	2	3.0	2	3.0		.		.		.		.		.		.		.

ACT. NO. AND LENGTH OR MAX. NO. AND LENGTH DEBONDED PER ROW (2ND CHOICE)

Card	N1	L1	N2	L2	N3	L3	N4	L4	N5	L5	N6	L6	N7	L7	N8	L8	N9	L9	N10	L10	N11	L11	N12	L12	N13	L13	N14	L14
6	2	1.5	2	1.5	2	1.5	2	1.5		.		.		.		.		.		.		.		.		.		.

NOTE: LENGTHS ARE A MULTIPLE OF .05

DRAPED DATA

ENTER 1 FOR DRAPED

Card	D	RAISED END HEIGHT	HOLD PT.	ACT. NO. OR MAX. NO. STRANDS DRAPED PER ROW 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
7		.	.																

P - LOADS

Card	XP_1	P_1	XP_2	P_2	XP_3	P_3	XP_4	P_4	XP_5	P_5
8	27.867	2.350	55.722	2.350	.	.	.	.	.	.

EXAMPLE PROBLEM NO.2, DEBONDED DESIGN

SPAN DATA

D/A	LL CLASS	LL SK.	LENGTH	DFM	DFV	DFD	WDINC	WDLC	WSWK	F'C	F'CI	NPL	SIT	SFB	SFTE
D	HS20	0 0 0	83.583	1.418	1.418	1.000	0.739	0.271	0.000	5.000	4.000	2	-0.200	-0.464	0.001

BEAM DATA

BEAM DIMENSIONS								* COMPOSITE SLAB			* (E X 1,000,000)		* STIRRUP	DECK	
WT	HT	FT	WS	HB	WB	FB	DB *	WF	TF	DF *	E BEAM	E SLAB *	SIZE	PANEL	FSY
20.00	8.00	6.00	8.00	8.00	26.00	9.00	54.00	88.50	7.375	0.750	4.30	3.50	5	0	40.

STRAND DATA

TYPE	NST	XDIST	ACTUAL NO. OR MAX. NO. OF STRANDS PER ROW	ASB	AST	DIAM	TCL	BCL	SPAC.
4	2	0.0010	12 12 12 10 8 6 2 2 0 0 0 0 0 0 0 0 0 0 0 0	0.1530	0.1530	0.500	2.50	3.00	2.00

RBFPU	BFPU	IBLOSS	FBLOSS	RTFPU	TFPU	ITLOSS	FTLOSS	WTC	LOW LAX	ITLENGTH	FTLENGTH	DLENGTH
.70	270.00	10.00	24.50	.70	270.00	10.00	24.50	.150	0	0.00	0.00	0.00

DEBONDING DATA

DEBOND ACT. # AND LENGTH OR MAX. # AND LENGTH OF STRANDS DEBONDED PER ROW

1 2 .30 2 .30 2 .30 2 .30 2 .30 2 .30 2 .30 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00

2 .15 2 .15 2 .15 2 .15 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00

DRAPE DATA

DRAPED	MAX RAISE	HOLD DOWN PT.	ACT. # OR MAX. # OF STRANDS DRAPED PER ROW
0	0.00	.00	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

P-LOADS

XP1	P1	XP2	P2	XP3	P3	XP4	P4	XP5	P5
27.867	2.350	55.722	2.350						

PRESTRESSED BEAM DESIGN - OUTPUT DATA FOR PROBLEM NO. EX 2 EXAMPLE PROBLEM NO.2, DEBONDED DESIGN

MOMENTS AT SPAN TWENTIETH POINTS - KIP-FEET

LOADS	BRNG	0.05 L	0.10 L	0.15 L	0.20 L	0.25 L	0.30 L	0.35 L	0.40 L	0.45 L	0.50 L
UNIFORM D.L. BEAM	0.000	136.366	258.377	366.034	459.337	538.286	602.880	653.120	689.006	710.537	717.714
UNIFORM D.L. NON-C.	0.000	122.615	232.323	329.125	413.019	484.007	542.088	587.262	619.529	638.889	645.343
CONCENTRATED P-LOADS	0.000	9.820	19.641	29.461	39.281	49.101	58.922	65.483	65.482	65.481	65.480
UNIFORM D.L. COMP.	0.000	44.964	85.196	120.694	151.459	177.491	198.790	215.356	227.189	234.288	236.655
LIVE LOAD + IMPACT	0.000	221.720	416.993	585.817	728.194	844.124	933.605	1001.562	1052.914	1077.819	1076.277
TOTAL D.L. + L.L.	0.000	535.486	1012.529	1431.131	1791.291	2093.009	2336.285	2522.782	2654.120	2727.015	2741.469

STRESSES AT SPAN TWENTIETH POINTS - KIPS PER SQ.IN.

LOADS		BRNG	0.05 L	0.10 L	0.15 L	0.20 L	0.25 L	0.30 L	0.35 L	0.40 L	0.45 L	0.50 L
UNIFORM D.L. BEAM	TOP	0.000	0.184	0.348	0.493	0.619	0.725	0.812	0.880	0.928	0.957	0.967
	BOT	0.000	-0.155	-0.294	-0.417	-0.523	-0.613	-0.686	-0.743	-0.784	-0.809	-0.817
TOTAL NONCOMP. D.L.	TOP	0.000	0.362	0.687	0.976	1.228	1.443	1.622	1.759	1.851	1.906	1.924
	BOT	0.000	-0.306	-0.581	-0.825	-1.038	-1.220	-1.370	-1.486	-1.564	-1.611	-1.626
TOTAL COMP.D.L.+L.L.	TOP	0.000	0.081	0.152	0.213	0.266	0.309	0.342	0.368	0.387	0.396	0.397
	BOT	0.000	-0.196	-0.370	-0.520	-0.648	-0.753	-0.834	-0.897	-0.943	-0.967	-0.967
TOTAL COMP.+NONCOMP.	TOP	0.000	0.443	0.839	1.189	1.494	1.752	1.964	2.127	2.237	2.302	2.321
	BOT	0.000	-0.502	-0.951	-1.345	-1.686	-1.972	-2.205	-2.383	-2.507	-2.577	-2.593

SHEARS AT SPAN TWENTIETH POINTS - KIPS

LOADS	BRNG	0.05 L	0.10 L	0.15 L	0.20 L	0.25 L	0.30 L	0.35 L	0.40 L	0.45 L	0.50 L
UNIFORM D.L. BEAM	34.347	30.913	27.478	24.043	20.608	17.174	13.739	10.304	6.869	3.435	0.000
UNIFORM D.L. NON-C.	30.884	27.796	24.707	21.619	18.530	15.442	12.354	9.265	6.177	3.088	0.000
CONCENTRATED P-LOADS	2.350	2.350	2.350	2.350	2.350	2.350	2.350	0.000	0.000	0.000	0.000
UNIFORM D.L. COMP.	11.325	10.193	9.060	7.928	6.795	5.663	4.530	3.398	2.265	1.133	0.000
LIVE LOAD + IMPACT	56.218	53.264	50.292	47.303	44.295	41.267	38.216	35.143	32.045	28.920	25.766
TOTAL D.L. + L.L.	135.125	124.515	113.888	103.243	92.579	81.895	71.189	58.110	47.356	36.575	25.766

BEAM PROPERTIES

* * * * * NON-COMPOSITE BEAM PROPERTIES * * * *							*	* * * * * * * COMPOSITE BEAM PROPERTIES * * * * * * *						
I	YT	YB	ST	SB	A	W	*	I	YT	YB	ST	SB	A	QS
260740.6	29.266	24.734	8909.3	10541.9	789.00	0.822	*	623792.3	15.704	38.296	39721.4	16288.8	1320.26	10700.42

STRAND AND MISC. DATA

MAX # STRDS	ACT # STRDS	MIN # STRDS	E @ C.L.	E @ END	PS	ASE	NS(FACT-EEND)	BPI	BPF	TPI	TPF
46	34	26	17.234	16.311	0.66%	1.77	0.000	832.810	698.635	52.051	43.665

MOMENTS(K-FT.) AND SHEARS(KIPS), STIRRUP SPACING, STRESSES(KSI) AT SPAN TWENTIETH POINTS

LOADS	BRNG	0.05 L	0.10 L	0.15 L	0.20 L	0.25 L	0.30 L	0.35 L	0.40 L	0.45 L	0.50 L
ULT. MOMENT REQD.	0.000	888.296	1677.696	2368.198	2959.805	3452.514	3846.327	4147.670	4362.917	4479.266	4496.719
ULT. MOMENT FURN.	0.698	2812.138	4632.048	5057.760	5478.830	5820.000	5910.711	5910.711	5910.711	5910.711	5910.711
1.2*CRACKING MOMENT	865.157	3290.484	3369.252	3898.933	3776.590	3672.080	3585.404	3518.693	3474.109	3447.360	3438.443
DIST. TO N.A.(IN.)	0.001	2.094	3.488	3.797	4.105	4.357	4.424	4.424	4.424	4.424	4.424
MAX STEEL RATIO	0.000	0.033	0.055	0.060	0.064	0.068	0.069	0.069	0.069	0.069	0.069
ULT. COMP. SHEAR	136.531	128.657	120.747	112.798	104.808	96.774	88.693	80.561	72.376	64.133	55.828
ULT. TOTAL SHEAR	224.386	208.033	191.642	175.213	158.743	142.229	125.668	106.001	89.336	72.613	55.828
BEAM SHEAR CAPACITY	106.340	162.223	187.000	210.081	159.175	125.948	98.599	73.889	57.397	52.531	52.531
MIN. STIRRUP AREA	0.799	0.385	0.144	0.120	0.120	0.176	0.225	0.241	0.230	0.155	0.120
STRP.(#5) SPAC.(IN.)	9.315*	19.323	24.000	24.000	24.000	24.000	24.000	24.000	24.000	24.000	24.000
PRESTRESS STRESS TOP	0.000	-0.381	-0.442	-0.590	-0.590	-0.590	-0.590	-0.590	-0.590	-0.590	-0.590
BOT	0.001	1.905	2.078	2.568	2.568	2.568	2.568	2.568	2.568	2.568	2.568
INITIAL STRESSES TOP	0.000	-0.198	-0.094	-0.097	0.029	0.135	0.222	0.290	0.338	0.367	0.377
BOT	0.001	1.749	1.784	2.151	2.045	1.955	1.882	1.825	1.784	1.759	1.751
FINAL STRESSES TOP	0.000	0.123	0.468	0.694	0.999	1.257	1.469	1.631	1.742	1.807	1.826
BOT	0.001	1.095	0.792	0.809	0.469	0.182	-0.050	-0.229	-0.353	-0.423	-0.439
FINAL # TOP STRANDS	0.001	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000
FINAL # BOT STRANDS	0.012	24.000	26.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000
DEVELOP. # TOP STRDS	0.000	1.214	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000
DEVELOP. # BOT STRDS	0.003	14.572	24.607	27.035	29.463	31.463	32.000	32.000	32.000	32.000	32.000

* - FOR "ASE" REQUIREMENTS WITHIN A MAXIMUM DISTANCE OF 11.394" (D/4) FROM THE END OF BEAM USE EITHER
3 LOCATIONS OF 2-#5 STIRRUPS AT A MAXIMUM SPACING OF 4.697" OR
3 LOCATIONS OF 2-#6 STIRRUPS AT A MAXIMUM SPACING OF 4.697" USING 2" CL. FROM END OF BEAM

DEFLECTIONS(INCHES) AT CENTER LINE OF SPAN

BEAM	WDINC	P-LOADS	WDLC	INITIAL	FINAL	SIDEWALK	TRUCK	LANE	MILITARY	RAILROAD	PRESTR.	CAMBER
0.805	0.724	0.075	0.111	-0.905	0.280	0.000	0.326	0.250	0.232	0.000	-1.710	-1.535

MAXIMUM, ACTUAL AND MINIMUM ECCENTRICITIES(INCHES)AT SPAN TWENTIETH POINTS

ITEM	BRNG	0.05 L	0.10 L	0.15 L	0.20 L	0.25 L	0.30 L	0.35 L	0.40 L	0.45 L	0.50 L
MAX ECC, SIT= -200	999.900	16.344	17.992	18.270	19.535	20.606	21.482	22.163	22.649	22.941	23.039
MAX ECC, SIB= 2400	88326.781	26.448	25.613	20.196	21.461	22.532	23.408	24.089	24.576	24.868	24.965
INITIAL ECCENTRICITY	16.310	16.311	16.698	17.234	17.234	17.234	17.234	17.234	17.234	17.234	17.234
FINAL ECCENTRICITY	16.311	16.311	16.698	17.234	17.234	17.234	17.234	17.234	17.234	17.234	17.234
MIN ECC, SFT= 2000	-62200.793	-13.152	-5.627	1.563	5.214	8.312	10.855	12.810	14.141	14.918	15.142
MIN ECC, SFB= -464	-17091.400	-12.647	-4.965	-0.845	3.990	8.058	11.359	13.892	15.655	16.651	16.880

```
* SPAN * * * * * * * * * * * * * * ECCENTRICITY PLOT (INCHES) * * * * * * * * * * * * * * * * *
                                                  1   1   1   1   1   1   1   1   1   1   2   2   2   2   2
* POINTS *0...1...2...3...4...5...6...7...8...9...0...1...2...3...4...5...6...7...8...9...0...1...2...3...4
* 0.00 L *                                                                 +
* 0.05 L *                                                                 +
* 0.10 L *                                                                   +    *
* 0.15 L *      *                                                              +   *
* 0.20 L *                     *                                               +        *
* 0.25 L *                                 *                                   +            *
* 0.30 L *                                           *                         +                *
* 0.35 L *                                                   *                 +                   *
* 0.40 L *                                                         *           +                     *
* 0.45 L *                                                            *        +                      *
* 0.50 L *                                                             *       +                      *
* * * *     * = MAX. AND MIN. ECCENTRICITY, + = ACTUAL ECCENTRICITY, HOLD-DOWN POINT IS  0.00 FEET FROM CENTER LINE OF SPAN
```

STRAND ARRANGEMENT (TOP STRANDS NOT SHOWN)= 2

```
  + + + D D + + +
+ + + + + D D + + + + +
+ + + + D D D D + + + +
```

```
* SPAN   * * * * * * * * * * * * * * *STRAND ARRANGEMENT (INCHES) * * * * * * * * * * * * * * * * **
                              1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 3 3 3 3 3 3 3 3 3 3 4 4 4 4 4 4 4 4 4 4 5 5 5 5 5 5 5 5 5 5 6
* POINTS *0.1.2.3.4.5.6.7.8.9.0.1.2.3.4.5.6.7.8.9.0.1.2.3.4.5.6.7.8.9.0.1.2.3.4.5.6.7.8.9.0.1.2.3.4.5.6.7.8.9.0.1.2.3.4.5.6.7.8.9.0

* END    *      D   D   D

* BRNG   *      D   D   D


* 0.05 L *      D   D   D


* 0.10 L *      D   D   D


* 0.15 L *      +   +   +


* 0.20 L *      +   +   +


* 0.25 L *      +   +   +


* 0.30 L *      +   +   +


* 0.35 L *      +   +   +


* 0.40 L *      +   +   +


* 0.45 L *      +   +   +


* 0.50 L *      +   +   +
```

FINAL STRAND ARRANGEMENT AT END

ROW	TOTAL #STRDS	*	VER DIST-STRAIGHT STRDS	*	#RAISED STRDS	VER DIST-RAISED STRDS	*	#DEB 1	DEB LENGTH 1	*	#DEB 2	DEB LENGTH 2
		*		*			*			*		
1	12	*	3.000	*	0	0.000	*	2	0.10L	*	2	0.05L
		*		*			*			*		
2	12	*	5.000	*	0	0.000	*	2	0.10L	*	0	0.00L
		*		*			*			*		
3	8	*	7.000	*	0	0.000	*	2	0.10L	*	0	0.00L
TOP	2		51.500									

INITIAL TRANSFER LENGTH = 2.362 FT

FINAL TRANSFER LENGTH = 1.982 FT

DEVELOPMENT LENGTH = 6.885 FT

LOSSES (KSI)

TOP STRANDS INITIAL LOSSES= 18.900 TOP STRANDS ADDITIONAL LOSSES= 27.405 TOP STRANDS FINAL LOSSES= 46.305

BOT STRANDS INITIAL LOSSES= 18.900 BOT STRANDS ADDITIONAL LOSSES= 27.405 BOT STRANDS FINAL LOSSES= 46.305

TOTAL LOSSES FOR ALL STRANDS= 46.305

Example Number Three: Debonded and Draped Analysis

Given Data:

Live Load: HS20 and/or military, no sidewalk

Dead Load: Non-composite = .739 kips/ft.
Composite = .271 kips/ft.

AASHTO Type IV interior beam of two lane bridge with four beams.

Span length = 83′- 7"

Beam spacing = 7′ - 9 5/8"

Distribution factors: DFM = 7.8/5.5 = 1.418
DFV = 1.418
DFD = 1.000

Beam concrete : f′c = 5.0 ksi EBM = 4,300 ksi
f′ci = 4.0 ksi

Modulus of elasticity of slab concrete = 3,500 ksi

Strand information:

ASB .153 in2	AST = .153 in2
RBFPU = .75	RTFPU = .75
BFPU = 270.0 ksi	TFPU = 270.0 ksi

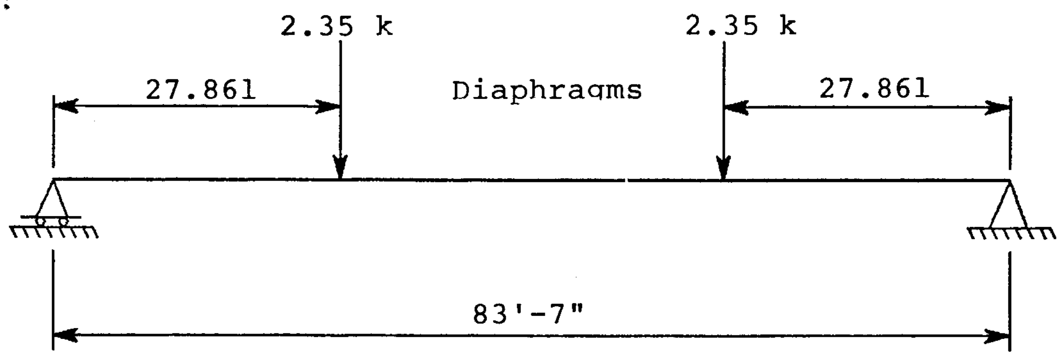
All strands are low relaxation, losses are to be calculated

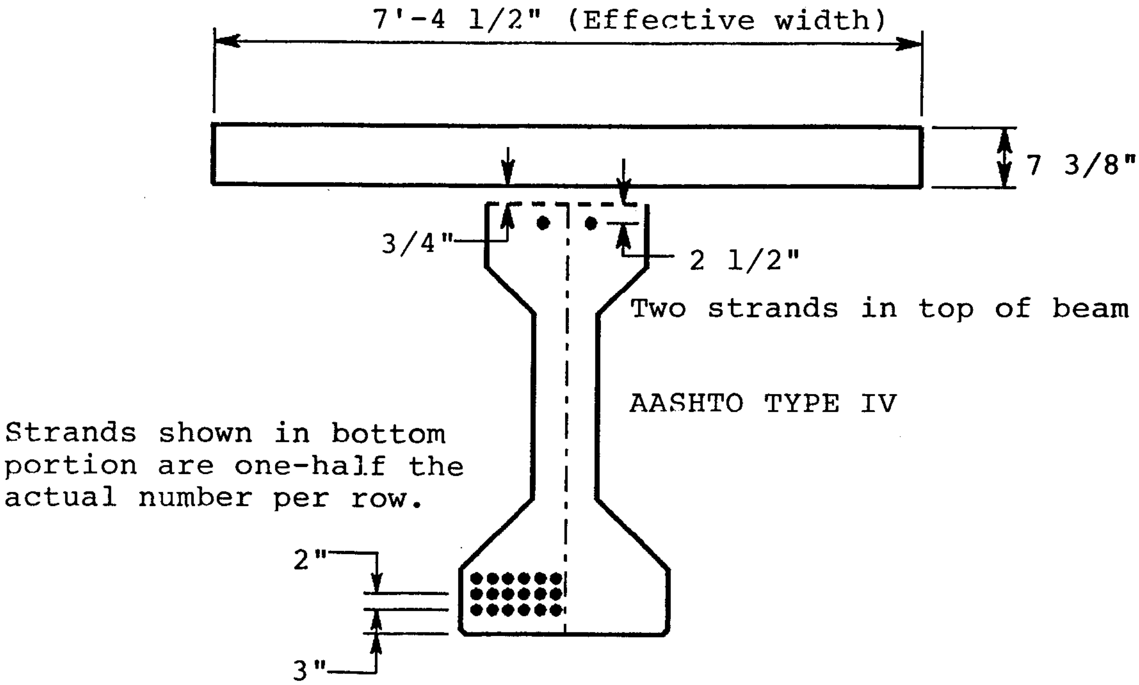
Strand arrangement:

A. Draped Strands - Hold pt. @ .45
- Row 1 - drape 2 strands
- Row 2 - drape 2 strands
- Row 3 - drape 2 strands

B. Debonded Strands
- Row 1 - debond 2 to .20L
  and debond 2 to .15L
- Row 2 - debond 2 to .10L
- Row 3 - debond 2 to .05L

Ploads:





PRESTRESSED BEAM DESIGN

IDENTIFICATION

PROG.	PROB. NO.	PROJECT NO., COUNTY, NAME, DATE, REMARKS, ETC.
*B05	EX 3	EXAMPLE PROBLEM NO. 3, DRAPED AND DEBONDED DESIGN

SPAN DATA

	D/A	$\mathcal{L}$ CLASS	SKIP T L M	L (FT)	DFM	DFV	DFD	$W_{DL_{NC}}$	W_{DL_C}	WSW	f'_c	f'_{ci}		NPL	SIT	SFB	SFT_E
1	A	HS20		83.583	1.418	1.418	1.000	.739	.271	.	5.000	4.000	XXXXX	2	-.200	-.464	.001

ENTER 1 TO SKIP $\mathcal{L}$

BEAM DATA

	BEAM DIMENSIONS (INCHES)								COMPOSITE SLAB (INCHES)			Ex10[3]	
	WTC	HT	FT	WS	HB	WB	FB	DB	WF	TF	DF	EBM	E SLAB
2	.	.	.	.	.	.	.	.	88.50	7.375	.750	4.30	3.50

STRAND DATA

BEAM TYPE

ACT. NO. OR MAX. NO. STRANDS PER ROW

	T	NST	XDIST (FT)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	AS_B	AS_T	DIAM	T_{CL}	B_{CL}	SPAC
3	4	2	.001	12	12	12																		.	.	.	.	.	.

ENTER 1 FOR LOW LAX STRANDS

	RB_{FPU}	B_{FPU} (KSI)	IB LOSS	FB LOSS	RT_{FPU}	T_{FPU} (KSI)	IT LOSS	FT LOSS	WT_C	LL	IT LENGTH	FT LENGTH	D LENGTH
4	.75	270.00	.	.	.75	270.00	.	.	.	1	.	.	.

DEBONDED DATA

ENTER 1 TO DEBOND

ACT. NO. AND LENGTH OR MAX. NO. AND LENGTH DEBONDED PER ROW (1ST CHOICE)

	D	N1	L1	N2	L2	N3	L3	N4	L4	N5	L5	N6	L6	N7	L7	N8	L8	N9	L9	N10	L10	N11	L11	N12	L12	N13	L13	N14	L14
5	1	2	.20	2	.10	2	.05		.		.		.		.		.		.		.		.		.		.		.

ACT. NO. AND LENGTH OR MAX. NO. AND LENGTH DEBONDED PER ROW (2ND CHOICE)

	N1	L1	N2	L2	N3	L3	N4	L4	N5	L5	N6	L6	N7	L7	N8	L8	N9	L9	N10	L10	N11	L11	N12	L12	N13	L13	N14	L14
6	2	.15		.		.		.		.		.		.		.		.		.		.		.		.		.

NOTE: LENGTHS ARE A MULTIPLE OF .05

DRAPED DATA

ENTER 1 FOR DRAPED

ACT. NO. OR MAX. NO. STRANDS DRAPED PER ROW

	D	RAISED HEIGHT (IN)	HOLD PT.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
7	1	33.00	.45	2	2	2													

P - LOADS

	XP_1	P_1	XP_2	P_2	XP_3	P_3	XP_4	P_4	XP_5	P_5
8	27.867	2.350	55.722	2.350	.	.	.	.	.	.

21-AUG-92 GEORGIA DEPARTMENT OF TRANSPORTATION 13:29:53
THE ANALYSIS OR DESIGN OF SIMPLE SPAN PRESTRESSED BEAMS PROB. NO. EX 3

EXAMPLE PROBLEM NO.3, DRAPE AND DEBONDED ANALYSIS

SPAN DATA

D/A	LL CLASS	LL SK.	LENGTH	DFM	DFV	DFD	WDINC	WDLC	WSWK	F'C	F'CI	NPL	SIT	SFB	SFTE
A	HS20	0 0 0	83.583	1.418	1.418	1.000	0.739	0.271	0.000	5.000	4.000	2	-0.200	-0.464	0.001

BEAM DATA

BEAM DIMENSIONS								*	COMPOSITE SLAB			* (E X 1,000,000)		*	STIRRUP	DECK	
WT	HT	FT	WS	HB	WB	FB	DB	*	WF	TF	DF	* E BEAM	E SLAB	*	SIZE	PANEL	FSY
20.00	8.00	6.00	8.00	8.00	26.00	9.00	54.00		88.50	7.375	0.750	4.30	3.50		5	0	40.

STRAND DATA

TYPE	NST	XDIST	ACTUAL NO. OR MAX. NO. OF STRANDS PER ROW	ASB	AST	DIAM	TCL	BCL	SPAC.
4	2	0.0010	12 12 12 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0.1530	0.1530	0.500	2.50	3.00	2.00

RBFPU	BFPU	IBLOSS	FBLOSS	RTFPU	TFPU	ITLOSS	FTLOSS	WTC	LOW LAX	ITLENGTH	FTLENGTH	DLENGTH
.75	270.00	0.00	0.00	.75	270.00	0.00	0.00	.150	1	0.00	0.00	0.00

DEBONDING DATA

DEBOND ACT. # AND LENGTH OR MAX. # AND LENGTH OF STRANDS DEBONDED PER ROW

1 2 .20 2 .10 2 .05 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00

2 .15 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00 0 .00

DRAPE DATA

DRAPED	MAX RAISE	HOLD DOWN PT.	ACT. # OR MAX. # OF STRANDS DRAPED PER ROW
1	33.00	.45	2 2 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

P-LOADS

XP1	P1	XP2	P2	XP3	P3	XP4	P4	XP5	P5
27.867	2.350	55.722	2.350						

PRESTRESSED BEAM DESIGN - OUTPUT DATA FOR PROBLEM NO. EX 3 EXAMPLE PROBLEM NO.3, DRAPE AND DEBONDED ANALYSIS

MOMENTS AT SPAN TWENTIETH POINTS - KIP-FEET

LOADS	BRNG	0.05 L	0.10 L	0.15 L	0.20 L	0.25 L	0.30 L	0.35 L	0.40 L	0.45 L	0.50 L
UNIFORM D.L. BEAM	0.000	136.366	258.377	366.034	459.337	538.286	602.880	653.120	689.006	710.537	717.714
UNIFORM D.L. NON-C.	0.000	122.615	232.323	329.125	413.019	484.007	542.088	587.262	619.529	638.889	645.343
CONCENTRATED P-LOADS	0.000	9.820	19.641	29.461	39.281	49.101	58.922	65.483	65.482	65.481	65.480
UNIFORM D.L. COMP.	0.000	44.964	85.196	120.694	151.459	177.491	198.790	215.356	227.189	234.288	236.655
LIVE LOAD + IMPACT	0.000	221.720	416.993	585.817	728.194	844.124	933.605	1001.562	1052.914	1077.819	1076.277
TOTAL D.L. + L.L.	0.000	535.486	1012.529	1431.131	1791.291	2093.009	2336.285	2522.782	2654.120	2727.015	2741.469

STRESSES AT SPAN TWENTIETH POINTS - KIPS PER SQ.IN.

LOADS		BRNG	0.05 L	0.10 L	0.15 L	0.20 L	0.25 L	0.30 L	0.35 L	0.40 L	0.45 L	0.50 L
UNIFORM D.L. BEAM	TOP	0.000	0.184	0.348	0.493	0.619	0.725	0.812	0.880	0.928	0.957	0.967
	BOT	0.000	-0.155	-0.294	-0.417	-0.523	-0.613	-0.686	-0.743	-0.784	-0.809	-0.817
TOTAL NONCOMP. D.L.	TOP	0.000	0.362	0.687	0.976	1.228	1.443	1.622	1.759	1.851	1.906	1.924
	BOT	0.000	-0.306	-0.581	-0.825	-1.038	-1.220	-1.370	-1.486	-1.564	-1.611	-1.626
TOTAL COMP.D.L.+L.L.	TOP	0.000	0.081	0.152	0.213	0.266	0.309	0.342	0.368	0.387	0.396	0.397
	BOT	0.000	-0.196	-0.370	-0.520	-0.648	-0.753	-0.834	-0.897	-0.943	-0.967	-0.967
TOTAL COMP.+NONCOMP.	TOP	0.000	0.443	0.839	1.189	1.494	1.752	1.964	2.127	2.237	2.302	2.321
	BOT	0.000	-0.502	-0.951	-1.345	-1.686	-1.972	-2.205	-2.383	-2.507	-2.577	-2.593

SHEARS AT SPAN TWENTIETH POINTS - KIPS

LOADS	BRNG	0.05 L	0.10 L	0.15 L	0.20 L	0.25 L	0.30 L	0.35 L	0.40 L	0.45 L	0.50 L
UNIFORM D.L. BEAM	34.347	30.913	27.478	24.043	20.608	17.174	13.739	10.304	6.869	3.435	0.000
UNIFORM D.L. NON-C.	30.884	27.796	24.707	21.619	18.530	15.442	12.354	9.265	6.177	3.088	0.000
CONCENTRATED P-LOADS	2.350	2.350	2.350	2.350	2.350	2.350	2.350	0.000	0.000	0.000	0.000
UNIFORM D.L. COMP.	11.325	10.193	9.060	7.928	6.795	5.663	4.530	3.398	2.265	1.133	0.000
LIVE LOAD + IMPACT	56.218	53.264	50.292	47.303	44.295	41.267	38.216	35.143	32.045	28.920	25.766
TOTAL D.L. + L.L.	135.125	124.515	113.888	103.243	92.579	81.895	71.189	58.110	47.356	36.575	25.766

BEAM PROPERTIES

* * * * * NON-COMPOSITE BEAM PROPERTIES * * * * * *								* * * * * * * COMPOSITE BEAM PROPERTIES * * * * * * * *					
I	YT	YB	ST	SB	A	W	*	I	YT	YB	ST	SB	A	QS
260740.6	29.266	24.734	8909.3	10541.9	789.00	0.822	*	623792.3	15.704	38.296	39721.4	16288.8	1320.26	10700.42

STRAND AND MISC. DATA

MAX # STRDS	ACT # STRDS	MIN # STRDS	E @ C.L.	E @ END	PS	ASE	NS(EACT-EEND)	EPI	EPF	TPI	TPF
42	38	24	17.286	11.301	0.74%	2.17	227.462	1029.244	878.413	57.180	48.801

MOMENTS(K-FT.) AND SHEARS(KIPS), STIRRUP SPACING, STRESSES(KSI) AT SPAN TWENTIETH POINTS

LOADS		BRNG	0.05 L	0.10 L	0.15 L	0.20 L	0.25 L	0.30 L	0.35 L	0.40 L	0.45 L	0.50 L
ULT. MOMENT REQD.		0.000	888.296	1677.696	2368.198	2959.805	3452.514	3846.327	4147.670	4362.917	4479.266	4496.719
ULT. MOMENT FURN.		0.773	3132.591	4928.502	5207.457	5600.594	6011.984	6311.971	6497.937	6570.329	6629.840	6629.840
1.2*CRACKING MOMENT		865.103	3542.749	3684.556	3859.278	4066.914	4292.385	4271.057	4269.696	4290.461	4329.060	4320.144
DIST. TO N.A.(IN.)		0.001	2.560	4.033	4.199	4.448	4.705	4.880	4.973	4.983	4.984	4.984
MAX STEEL RATIO		0.000	0.044	0.069	0.070	0.073	0.076	0.078	0.079	0.078	0.077	0.077
ULT. COMP. SHEAR		136.531	128.657	120.747	112.798	104.808	96.774	88.693	80.561	72.376	64.133	55.828
ULT. TOTAL SHEAR		224.386	208.033	191.642	175.213	158.743	142.229	125.668	106.001	89.336	72.613	55.828
BEAM SHEAR CAPACITY		98.431	185.126	207.841	224.990	172.847	140.538	114.452	89.417	71.190	55.626	52.582
MIN. STIRRUP AREA		0.930	0.280	0.120	0.120	0.120	0.120	0.142	0.158	0.155	0.137	0.120
STRP.(#5) SPAC.(IN.)		8.003*	24.000	24.000	24.000	24.000	24.000	24.000	24.000	24.000	24.000	24.000
PRESTRESS STRESS	TOP	0.000	-0.056	-0.153	-0.263	-0.386	-0.509	-0.564	-0.620	-0.675	-0.731	-0.731
	BOT	0.001	2.054	2.269	2.496	2.733	2.970	3.017	3.064	3.111	3.158	3.158
INITIAL STRESSES	TOP	0.000	0.127	0.195	0.230	0.233	0.217	0.248	0.260	0.253	0.226	0.236
	BOT	0.001	1.898	1.975	2.079	2.210	2.358	2.331	2.321	2.327	2.350	2.341
FINAL STRESSES	TOP	0.000	0.394	0.708	0.965	1.164	1.318	1.482	1.598	1.661	1.678	1.697
	BOT	0.001	1.250	0.986	0.785	0.647	0.563	0.371	0.232	0.148	0.118	0.102
FINAL # TOP STRANDS		0.001	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000
FINAL # BOT STRANDS		0.013	28.000	30.000	32.000	34.000	36.000	36.000	36.000	36.000	36.000	36.000
DEVELOP. # TOP STRDS		0.000	1.285	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000
DEVELOP. # BOT STRDS		0.004	17.990	28.642	29.927	31.854	33.854	35.212	35.927	36.000	36.000	36.000

* - FOR "ASE" REQUIREMENTS WITHIN A MAXIMUM DISTANCE OF 10.142" (D/4) FROM THE END OF BEAM USE EITHER
4 LOCATIONS OF 2-#5 STIRRUPS AT A MAXIMUM SPACING OF 2.714" OR
3 LOCATIONS OF 2-#6 STIRRUPS AT A MAXIMUM SPACING OF 4.071" USING 2" CL. FROM END OF BEAM

DEFLECTIONS(INCHES) AT CENTER LINE OF SPAN

BEAM	WDINC	P-LOADS	WDLC	INITIAL	FINAL	SIDEWALK	TRUCK	LANE	MILITARY	RAILROAD	PRESTR.	CAMBER
0.805	0.724	0.075	0.111	-1.166	0.032	0.000	0.326	0.250	0.232	0.000	-1.971	-2.044

MAXIMUM, ACTUAL AND MINIMUM ECCENTRICITIES(INCHES)AT SPAN TWENTIETH POINTS

ITEM	BRNG	0.05 L	0.10 L	0.15 L	0.20 L	0.25 L	0.30 L	0.35 L	0.40 L	0.45 L	0.50 L
MAX ECC, SIT= -200	999.900	15.277	16.628	17.644	18.379	18.878	19.591	20.146	20.542	20.780	20.859
MAX ECC, SIB= 2400	76547.844	18.045	17.682	17.185	16.576	15.872	16.586	17.141	17.537	17.775	17.854
INITIAL ECCENTRICITY	11.300	11.878	12.786	13.704	14.632	15.462	15.918	16.374	16.830	17.286	17.286
FINAL ECCENTRICITY	11.301	11.878	12.786	13.704	14.632	15.462	15.918	16.374	16.830	17.286	17.286
MIN ECC, SFT= 2000	-53906.547	-7.663	-1.954	2.587	6.156	8.906	10.942	12.508	13.573	14.195	14.374
MIN ECC, SFB= -464	-14814.522	-12.807	-6.787	-2.162	1.302	3.786	6.429	8.457	9.868	10.665	10.849

```
* SPAN * * * * * * * * * * * * * * * ECCENTRICITY PLOT (INCHES) * * * * * * * * * * * * * * * * * *
                                                            1    1    1    1    1    1    1    1    1    1    2    2    2    2    2
* POINTS *0....1....2....3....4....5....6....7....8....9....0....1....2....3....4....5....6....7....8....9....0....1....2....3....4
* 0.00 L *                                                         +
* 0.05 L *                                                           +                *
* 0.10 L *                                                                +                  *
* 0.15 L *             *                                                       +                *
* 0.20 L *                               *                                         +         *
* 0.25 L *                                             *                               + *
* 0.30 L *                                                       *                        +  *
* 0.35 L *                                                               *                  +   *
* 0.40 L *                                                                    *               +   *
* 0.45 L *                                                                       *              +  *
* 0.50 L *                                                                        *             +  *
* * * *     * = MAX. AND MIN. ECCENTRICITY, + = ACTUAL ECCENTRICITY, HOLD-DOWN POINT IS  4.25 FEET FROM CENTER LINE OF SPAN
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STRAND ARRANGEMENT (TOP STRANDS NOT SHOWN)= 2

+ + + + D R R D + + + +

+ + + + D R R D + + + +

+ + + D D R R D D + + +

```
* SPAN * * * * * * * * * * * * * * *STRAND ARRANGEMENT (INCHES) * * * * * * * * * * * * * * * * * **
                              1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 3 3 3 3 3 3 3 3 3 3 4 4 4 4 4 4 4 4 4 4 5 5 5 5 5 5 5 5 5 5 6
* POINTS *0.1.2.3.4.5.6.7.8.9.0.1.2.3.4.5.6.7.8.9.0.1.2.3.4.5.6.7.8.9.0.1.2.3.4.5.6.7.8.9.0.1.2.3.4.5.6.7.8.9.0.1.2.3.4.5.6.7.8.9.0

* END    *      D   D   D                                           R   R   R

* BRNG   *      D   D   D                                           R   R   R

* 0.05 L *      D   D   D                                     R   R   R

* 0.10 L *      D   D   +                               R   R   R

* 0.15 L *      D   +   +                         R   R   R

* 0.20 L *      D   +   +                   R   R   R

* 0.25 L *      +   +   +             R   R   R

* 0.30 L *      +   +   +       R   R   R

* 0.35 L *      +   +   +   R   R   R

* 0.40 L *      +   + R + R   R

* 0.45 L *      R   R   R

* 0.50 L *      R   R   R
```

FINAL STRAND ARRANGEMENT AT END

ROW	TOTAL #STRDS	*	VER DIST-STRAIGHT STRDS	*	#RAISED STRDS	VER DIST-RAISED STRDS	*	#DEB 1	DEB LENGTH 1	*	#DEB 2	DEB LENGTH 2
		*		*			*			*		
1	12	*	3.000	*	2	29.000	*	2	0.20L	*	2	0.15L
		*		*			*			*		
2	12	*	5.000	*	2	31.000	*	2	0.10L	*	0	0.00L
		*		*			*			*		
3	12	*	7.000	*	2	33.000	*	2	0.05L	*	0	0.00L
TOP	2		51.500									

INITIAL TRANSFER LENGTH = 2.595 FT

FINAL TRANSFER LENGTH = 2.215 FT

DEVELOPMENT LENGTH = 6.506 FT

LOSSES (KSI)

TOP STRANDS INITIAL LOSSES= 15.637 TOP STRANDS ADDITIONAL LOSSES= 27.384 TOP STRANDS FINAL LOSSES= 43.020

BOT STRANDS INITIAL LOSSES= 15.637 BOT STRANDS ADDITIONAL LOSSES= 27.384 BOT STRANDS FINAL LOSSES= 43.020

TOTAL LOSSES FOR ALL STRANDS= 43.020

7.0 ERROR MESSAGES

The "Prestressed Beam Design/Analysis" computer program checks the validity of the input data as it is processed with regard to procedure and omission of data. The actual data could not, of course be checked. If an error is detected by the program, the program will print an "ERROR MESSAGE" and then continue with the existing problem or will proceed to the next problem depending upon the severity of the error.