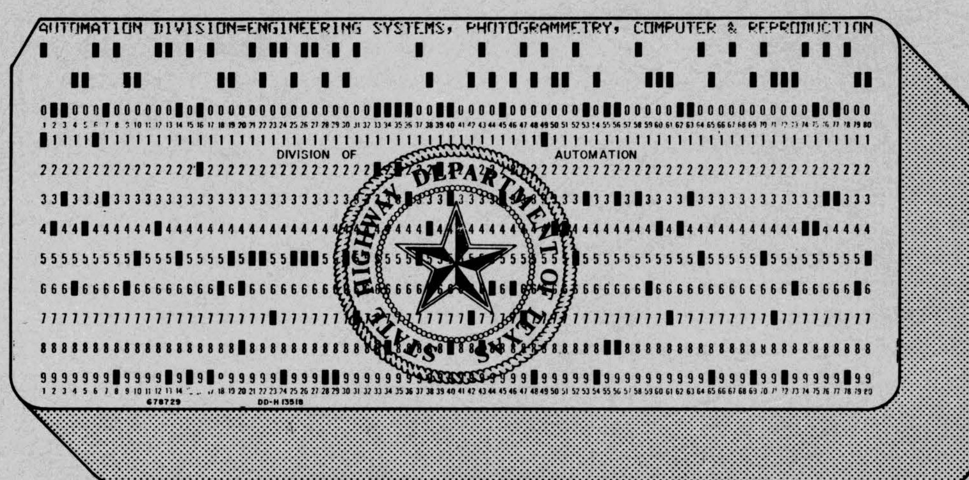
PRESTRESSED CONCRETE GIRDER DESIGN



TEXAS HIGHWAY DEPARTMENT
DIVISION OF AUTOMATION

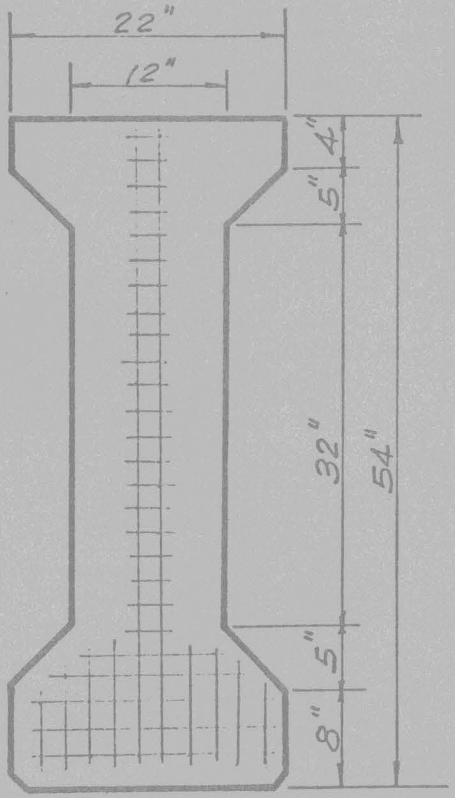
1971

PSTRS 10

REVISIONS TO PRESTRESSED CONCRETE
GIRDER DESIGN PROGRAM
SEPTEMBER, 1975

The Prestressed Concrete Girder Design program has been revised to incorporate those sections of the current AASHTO Specifications for Highway Bridges pertaining to minimum steel percentage, spacing of interior diaphragms, load factors, and prestress loss. These revisions require that the number of diaphragms be input on the Standard Beam input form, and the relative humidity be input on both the Standard and Non-Standard Beam input forms.

A new "standard" beam, Type 5M, has been added to the program. This beam is a modified Type 54 and has the dimensions and properties shown below.



Beam Properties

Area = 817 $in.^2$
Wt. = 850 #/ft.
I. = 243,178 $in.^4$
S_t = 8,719 $in.^3$
S_b = 9,314 $in.^3$
Y_t = 27.89 in.
Y_b = 26.11 in.

54" MOD. PSTR. BM. (TYPE 5M)

The input form numbers for these revisions are as follows:

Standard Beam: Form 1318-1, 2 - Revised 9/75
Non-Standard Beam: Form 1319-1, 2 - Revised 9/75

REVISIONS TO PRESTRESSED CONCRETE

GIRDER DESIGN PROGRAM

SEPTEMBER 1972

The Prestressed Concrete Girder Design program has been revised as indicated below. The non-standard beam input form has been revised to facilitate these changes (Form 1319-1,2 - Revised 9/72).

Output

The output from the program has been revised as follows:

1. All input data is printed out. ? what about effective width?

2. When design is controlled by ultimate moment requirements two designs are output: one based on stress requirements only and one based on ultimate moment requirements.

3. If the required number of strands exceeds the allowable (increased to 90) a summary of moments, shears, and stresses due to external loads is printed out.

4. The stress due to live load in the top fiber of the slab at midspan is output.

Ultimate Moment

The procedure for calculating ultimate moment capacity has been revised to utilize the 28-day strength of both the slab and beam concrete when the section acts as a flanged section. Calculations are based on the assumption that the stress distribution on the compression side of the section is in the form of a rectangular stress block. The depth of the equivalent rectangular stress block "a" is calculated as follows:

$$a = \frac{A_s F_{su}}{.85 F'_{cs} b} \quad \text{or } 0.354\ d \text{ Maximum}$$

where: A_s = area of prestressing steel

F_{su} = average stress in the prestressing steel at ultimate load

F'_{cs} = 28-Day compressive strength of slab concrete

b = effective flange width

d = distance between the C.G. of prestressing steel and the top of the slab.

The section is considered to be rectangular if "a" is less than or equal to the slab thickness and is considered to be flanged if "a" is greater than the slab thickness. If "a" is less than or equal to the maximum value the section is considered to be under reinforced and considered over reinforced if "a" is greater than maximum.

The 28-day strength of the slab concrete is used for calculating the ultimate moment capacity of a rectangular section. When the section is flanged the capacity is calculated using the 28-day strength of the slab concrete for the slab portion of the section and the 28-day strength of the beam concrete for the beam portion.

ADDENDUM TO
THE PRESTRESSED CONCRETE GIRDER DESIGN
AUGUST, 1971

The Prestressed Concrete Girder Design program has been revised to include some of the 1971 AASHO Interim Specifications and to make the standard beam input form more versatile. (The non-standard beam form has also been revised.) The changes include:

1. Revision of the standard input form to better handle railroad loadings.

2. Reinforcing steel for stirrups changed to Grade 60 (60ksi yield strength).

3. Stirrup bar size changed to No. 3.

4. Allowable final tension for highway beams changed to $6 \sqrt{f'c}$.

5. Maximum number of strands allowed is 70. (Input data and a message is printed out if this number is exceeded.)

The input form numbers for these revisions are as follows:

Standard Beam: Form 1318-1,2 - Revised 8/71

Non-Standard Beam: Form 1319-1,2 - Revised 8/71

PRESTRESSED CONCRETE
GIRDER DESIGN

TEXAS HIGHWAY DEPARTMENT
DIVISION OF AUTOMATION
1971

This manual is a reprint of pages 1 through 24 of the following publication:

Ingram, L. L. and H. D. Butler. Prestressed Concrete Bridge Girder Design Program. Research Report Number 149-1 (Final). Research Study Number 2-5-69-149. Texas Transportation Institute. November, 1970.

The complete report is available from the Highway Design Division (File D-8).

NOTE: The maximum length of beams on page 12 has been changed from the original report.

Table of Contents

List of Figures

List of Tables

I. INTRODUCTION

Automated design procedures are very beneficial in the design of structural members which require iterative types of calculations. The prestressed concrete beam, as an element in a structural system, is one member which requires such calculations. The different structural layouts, geometric and material properties of the member, and service requirements make it necessary to make several trial designs before the most desirable one is accepted. The digital computer can be programmed to perform the requisite calculations for the best design of such a structural member.

In this study a computer program has been developed to perform the necessary calculations for the design of simple span beams of pretensioned prestressed concrete for use in highway and railroad bridges. The purpose of this report is to describe that program so that the method will be understood, and to make it readily applicable to problems of design. Definitions of terms, flow diagrams, and a complete listing are included with example problems which illustrate the uses of the program.

II. COMPUTER PROGRAM

The Prestressed Concrete Beam Design Program is written in FORTRAN IV language for IBM 360/50 and 360/65 computers. The program is comprised of one main calling routine, twenty-three subroutines, and one Block Data set. Compile time for a FORTRAN version of the program is approximately three minutes and the required storage is approximately 100,000 bytes.

Two types of data input forms are provided for use with this program which is written so that these forms may be used independently or together. One form is for use when a "standard" beam is to be designed while the other is to be used when a "non-standard" beam is to be designed. A "standard" beam is defined as one having the properties and dimensions shown in Table I and is designed using the design criteria shown in Table II. Any beam not in this category is considered to ba a "non-standard" beam.

All the data in Tables I and II are contained in the Block Data set and Subroutine Indata; therefore additions and/or modifications to the "standard" beams may be made quite easily.

Two types of output are also provided for users of this program. One is a brief, one-page output, which contains input data and details of the designed beam. The other type is a multi-page output which contains all the above information plus summaries of moments, shears, stresses, etc., tabulated at various points along the beam for the different stages of loading.

TABLE I. PROPERTIES AND DIMENSIONS FOR STANDARD BEAMS

Beam Type	Moment of Inertia (in.^{4})	Area in.^{2}	y_b in.	y_t in.	Section Dimensions: Depth in.	B in.	C in.	E in.	WD in.	A in.	H in.
A	22,658	275.44	12.61	15.39	28	16.0	5.0	5.0	6.0	12.0	4.0
B	43,177	360.31	14.93	19.07	34	18.0	6.0	5.75	6.5	12.0	5.5
C	82,602	494.94	17.09	22.91	40	22.0	7.0	7.5	7.0	14.0	6.0
48	101,950	403.44	22.87	25.13	48	14.0	7.0	4.0	6.0	14.0	3.5
54	164,022	493.44	25.53	28.47	54	16.0	8.0	5.0	6.0	16.0	4.0
60	255,319	628.44	28.41	31.59	60	18.0	9.0	5.5	7.0	18.0	4.5
66	374,688	740.94	31.07	34.93	66	20.0	10.0	6.5	7.0	20.0	5.0
72	532,060	863.44	33.73	38.27	72	22.0	11.0	7.5	7.0	22.0	5.5
IV	260,403	788.44	24.75	29.25	54	26.0	8.0	9.0	8.0	20.0	8.0
V	521,180	1013.00	31.96	31.04	63	28.0	8.0	10.0	8.0	42.0	5.0
VI	733,320	1085.00	36.38	35.62	72	28.0	8.0	10.0	8.0	42.0	5.0

Beam Types A - 72 - THD standard beams

Types IV, V, VI - AASHO standard beams

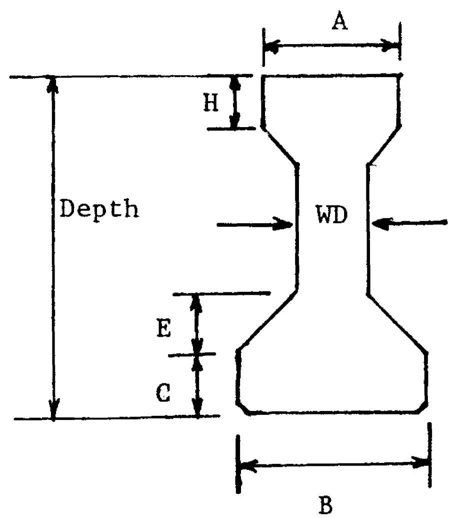


TABLE II. DESIGN CRITERIA FOR STANDARD BEAMS

1. Live load distribution factor = beam spacing ÷ 11
2. Strand diameter = 1/2 in.
3. Strand area = 0.153 sq. in.
4. Unit weight of beam and slab = 150 pcf
5. Compressive strength of slab concrete = 3,600 psi
6. Modulus of elasticity for beam and slab concrete = 5×10^6 psi
7. Modulus of elasticity for steel = 28×10^6 psi
8. Ultimate strength of strand = 270,000 psi
9. Yield point stress for web reinforcement = 40,000 psi
10. Dead load applied to the composite section = zero
11. Number of strands to be draped in the web = 2 (A design for three strands in the web is also provided for AASHO IV beams.)

A section entitled INPUT/OUTPUT is included later in this report which contains instructions for completing both types of input forms, discussion of both types of output, and examples of each.

Use of this program is limited to simply-supported I-shaped beams which are similar in shape to the Texas Highway Department and AASHO standard sections. By use of the appropriate type of output, the following information may be obtained from this program:

1. Vertical shears, moments, and stresses at tenth points and hold-down points in the beam.
2. Maximum ultimate horizontal shear between slab and girders at tenth points.
3. Stirrup spacing, based on ACI Specifications, at tenth points.
4. Stirrup spacing, based on AASHO Specifications, at midspan and quarter points.
5. Ultimate moment required for design loads and provided by the designed section.
6. Dead load deflections at midspan and quarter points due to slab and diaphragms.
7. Predicted maximum camber.
8. Predicted loss of prestress.
9. Arrangement of prestressing strands at ends and center line of beam.
10. Required concrete strengths (release and 28-day).

In outline form, the basic steps of the program are:

1. Read in input data.
2. Determine composite and noncomposite section properties.
3. Calculate moments and shears due to all loads.
4. Calculate dead load deflections.
5. Determine allowable stresses.
6. Calculate stresses due to all loads.
7. Determine number and location of prestressing strands.
8. Calculate required web reinforcement.
9. Calculate ultimate moments (required and provided).
10. Print out results.

III. DESIGN CONSIDERATIONS

Procedures and Specifications

The designs produced by this computer program are based on currently acceptable design procedures as used by the Texas Highway Department and the following specifications:

1. 1969 AASHO Specifications for Highway Bridges (1).*
2. 1968 American Railway Engineering Association Specifications (2).
3. 1963 American Standard Building Code Requirements for Reinforced Concrete, ACI (318-63)(3).

Concrete strengths

The required concrete release strength is determined from the midspan bottom fiber stress conditions at the time of release. The required 28-day concrete strength is determined from the midspan top fiber stress conditions under full working loads.

Number of Strands

The number of prestressing strands is dependent upon the algebraic sum of the allowable tension in the concrete and the bottom fiber stress at midspan due to all loads. A trial design is made assuming the midspan eccentricity equal to the distance from the centroid of the beam to the bottom fiber. The initial trial temporary prestressing force, which is subject to change later, and the corresponding number of strands are found from Equations 1 and 2, respectively.

---

*Numbers in parentheses refer to corresponding items in the list of references.

$$PF = \frac{f_b}{\frac{1}{A} + \frac{e_{c.l.}}{Z_b}} \qquad \text{(Eq. 1)}$$

$$NS = \frac{PF}{P} \qquad \text{(Eq. 2)}$$

where PF = trial prestressing force

f_b = stress in the bottom fiber due to all loads plus allowable tensile stress divided by (1 - prestress loss)

P = prestressing force per strand

NS = number of strands

$e_{c.l.}$ = eccentricity of steel at midspan

A = gross cross-sectional area of the beam

Z_b = section modulus at bottom of beam

The minimum number of strands is given by Equation 3.

$$NS = \frac{0.003 \times A}{A_s} \qquad \text{(Eq. 3)}$$

where NS = minimum number of strands

A = gross cross-sectional area of the beam

A_s = cross-sectional area of one prestressing strand

The larger number of strands calculated by Equation 2 or Equation 3 is selected for the first trial. If the midspan bottom fiber stress produced by prestress is less than f_b, the number of strands is increased in increments of two.

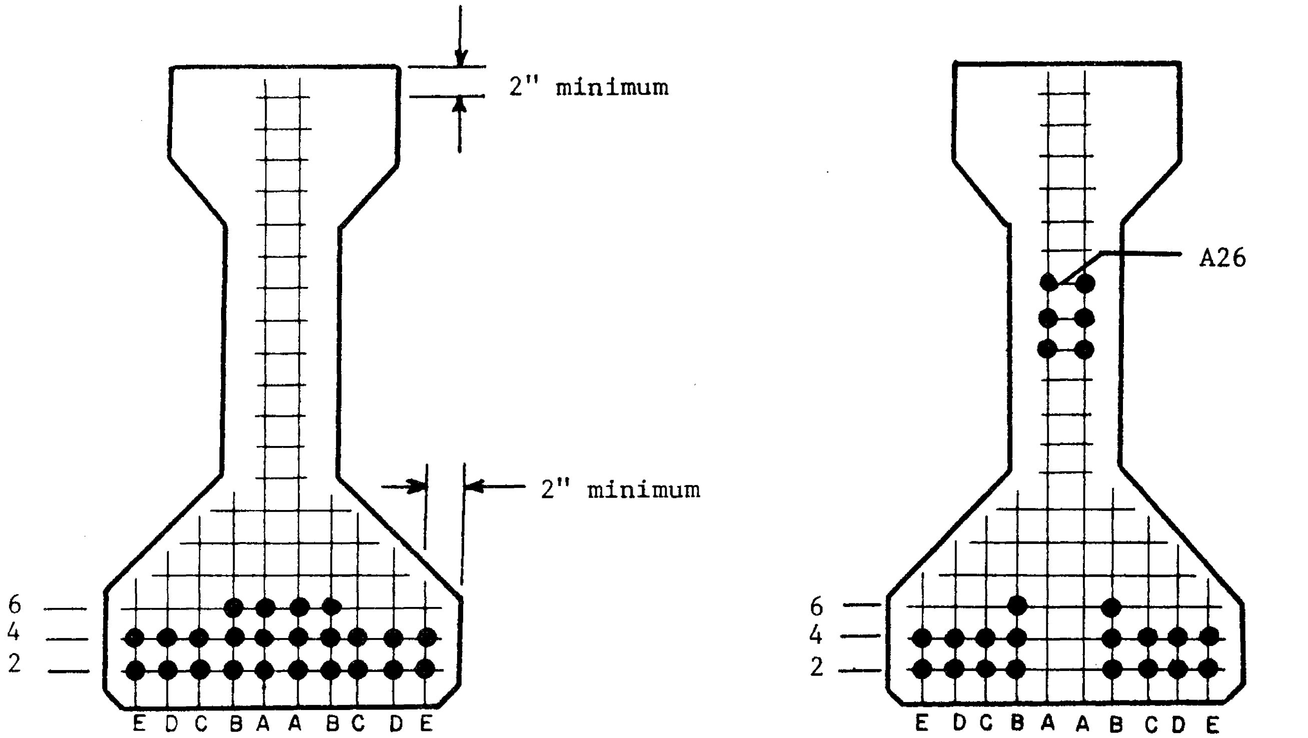
Location and Placement of Strands

Figure 1 shows typical grid systems for placement of the prestressing strands. The strands are placed as low as possible on this grid beginning in row 2, then proceeding to row 4, then to row 6, etc., beginning each row in the "A" position and working outward until the required number of strands is reached.

Strand Pattern Modification

Modifications to the trial pattern are made when required by moments or stresses. Such situation is one in which top fiber tension at midspan exceeds the allowable, although bottom fiber stress is satisfactory. The modification is made by moving strands from a lower level to a higher level, thus reducing the midspan eccentricity and top tensile stress.

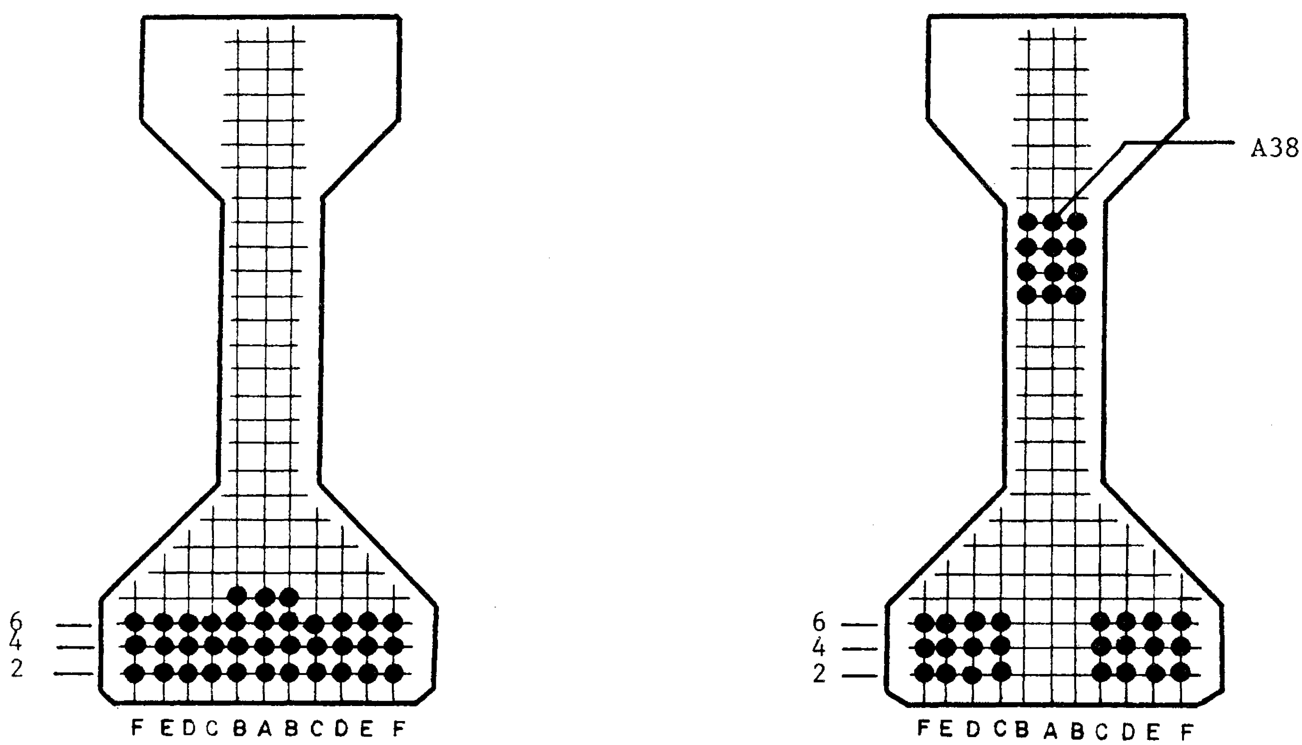
By way of illustration, consider a beam and loading conditions that require ten prestressing strands to satisfy the bottom fiber stress at midspan. The strand arrangement for the illustration uses six strands to fill the bottom layer, and the remaining four strands are positioned in the next, second, layer. The midspan eccentricity for this strand pattern may cause the midspan top fiber stress to exceed the allowable stress for concrete in tension. For this case, two strands from the bottom layer would be moved to form a third layer since the number of strands in the bottom layer is greater than the four used in the second layer. The strand pattern then would be four strands in the first layer, four strands in the second layer, and two



Center Line

End

Typical 2-Strand Drape Pattern



Center Line

End

Typical 3-Strand Drape Pattern

Figure 1. Typical 2-inch Grid Systems.

strands in the third layer. The top fiber stress would be recomputed using the eccentricity of the revised pattern of strands to determine if that stress falls within the allowable limits. If the top fiber stress still exceeds the allowable stress, two strands from the second layer would be moved up to make a fourth layer since it is the next layer below the third layer containing more strands than the third layer. The strand pattern then would be four strands in the first layer and two strands in each of the remaining three layers. The top fiber stress would be recomputed using the revised pattern of strands to determine if that stress falls within the allowable limits.

End Eccentricity

The required end eccentricity is determined from the top and bottom fiber stress conditions in the end of the beam at the time of release. This eccentricity is obtained by draping all of the strands in the two middle columns of strands, or, in the case of a three strand web design, the three central columns of strands in each horizontal row to a position that will furnish the required end eccentricity. The maximum position to which these strands can be raised is one that provides a minimum of two inches of cover to the center of the top strands.

If the end eccentricity required to accommodate the midspan release strength necessitates placement of the strands above the maximum position allowed, the program will place the strands at the maximum position and a beam design with release strength based on this end eccentricity will be printed out.

Ultimate Moment

The ultimate moments, required and provided, are determined in accordance with AASHO specifications for highway beams or in accordance with AREA specifications for railway beams. If the ultimate resisting moment is less than that required, additional prestressed strands are added in increments of two until required resistance is attained.

Camber and Prestress Loss

Maximum camber and prestress loss are predicted by the hyperbolic function method developed by Sinno (4). However, the prestress loss actually used in the program is 20 percent of the initial stress.

Hold-down Locations

Strand hold-down points are located as follows:

1. Five feet on each side of midspan for beam lengths less than 120 feet.
2. Six feet on each side of midspan for beam lengths equal to or greater than 120 feet and less than 140 feet.
3. Seven feet on each side of midspan for beam lengths equal to or greater than 140 feet and less than 160 feet.
4. Eight feet on each side of midspan for beam lengths equal to 160 feet and less than 170 feet.

No provisions are made for beam lengths of 170 feet or longer.

Diaphragm Location

For "standard" beams, interior diaphragms are located as follows:

1. One located at midspan for span lengths less than or equal to 50 feet.
2. Two located at one-third points for span lengths between 50.01 and 90.00 feet.
3. Three located at one-fourth points for span lengths between 90.01 and 130.00 feet.
4. Four located at one-fifth points for span lengths between 130.01 and 170.00 feet.

For "nonstandard" beams interior diaphragms must be entered as concentrated static loads applied to the composite section.

No provisions are made for span lengths greater than 170.00 feet.

IV. INPUT/OUTPUT

Input Form for "Standard" Beams

As previously discussed in the section describing the computer program (Section II), this input form is to be used when a "standard" beam is to be designed. The first three cards of this form are for information purposes and must be filled in one time, and one time only, for each run of the program. These cards are programmed for any alphameric information; therefore, data may be arranged in any form convenient to the user.

The three information cards are followed by one card for each beam to be designed. Data required for this card are: type of beam (any type shown in Table I), span length (between centers of bearing), beam spacing, type of live loading (H-15, H-20, HS-20, or Cooper's E loadings). The two columns headed Span Designation and Beam Designation are for beam identification purposes only and may be left blank if desired.

There is no limit on the number of beams that may be stacked and run at one time. The program continues execution until design of the last beam is completed.

Input Form for "Nonstandard" Beams

As previously discussed, this form is to be used for beams which do not fit in the "standard" beam category. When this form is used all problem data must be input by the user.

This form may be used in lieu of, or in conjunction with, the form for "standard" beams. When used in conjunction with the form for "standard" beams, only one set of identification cards is to be used.

In addition to three identification cards, which may or may not be required, the input data set for the design of a "nonstandard" beam is made up of nine cards, all of which must be included for each problem. The first three cards of this set contain the design requirements, section properties of the beam being designed, and the physical properties of the concrete and prestressing steel being used. Note that Beam Type on this form must be designated NS. If a live loading other than the standard AASHO and Railroad loadings is used, the columns headed AASHO L.L. and R.R. L.L. should be left blank. The live loading must then be entered on card type 5, i.e., cards with the numbers 05 in columns 1 and 2. Note that only concentrated live loads may be entered on these cards.

The next six cards are used to describe concentrated loads which can be applied to the beam being designed. All these cards must be included in the data set with the card types punched in Columns 1 and 2, even if no further data appears on the cards. Card type 03 is used to describe concentrated static loads applied to a noncomposite section, card type 04 is used to describe concentrated static loads applied to a composite section, and card type 05 is used to describe a concentrated live load pattern applied to a composite section which is moved across the beam to determine the maximum stress conditions at the previously discussed locations.

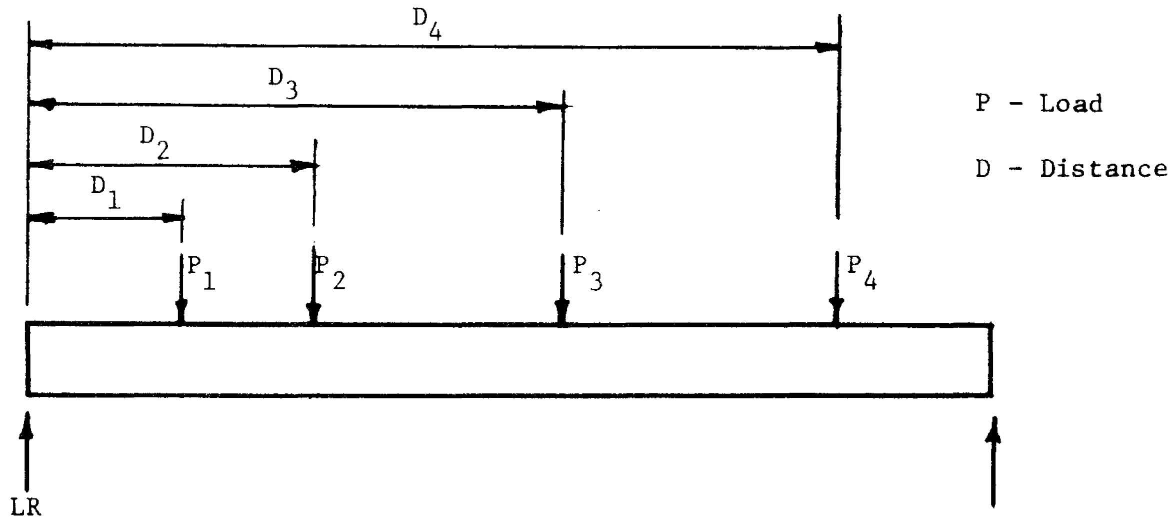
Whenever a load is input on a load card it must be accompanied by a corresponding distance on the distance card of the same card type which immediately follows the load card. For static loads the number of distances is equal to the number of loads, however for live loads, the number of distances is one less than the number of loads. This is illustrated in Figure 2.

If there is an inconsistency between the number of loads and the number of distances input, execution of the problem is stopped, an error message is printed out, and execution of the next problem begins.

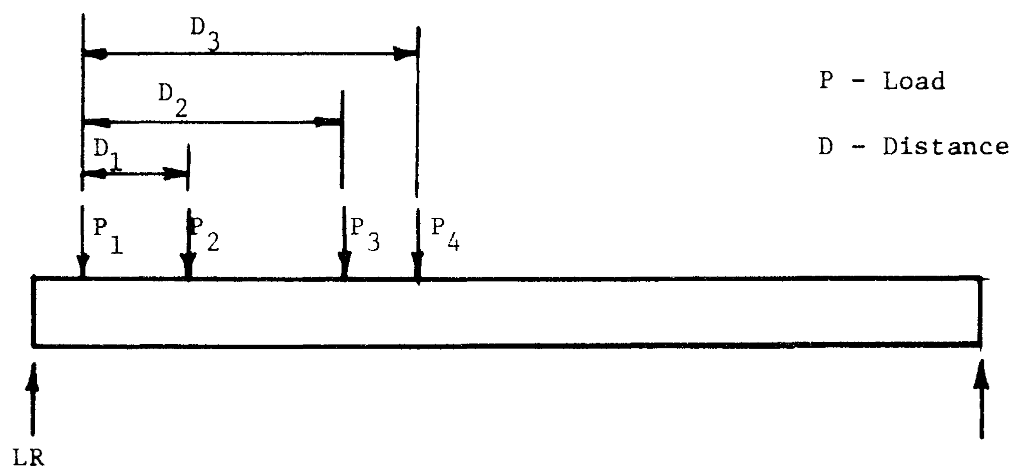
Program Output

Users of this program may choose between a brief one-page output which contains only input data and details of the designed beam and an extended multipage form which contains the above information plus summaries of moments, shears, stresses, etc., tabulated at various points along the beam for the different stages of loading.

There are two informative messages output in conjunction with the ultimate moments. The first tells whether the section used for calculating the ultimate moment provided is flanged or rectangular. The second message tells whether the output beam design is based on stress requirements or ultimate moment requirements.



a. Static Loads



b. Live Loads

Figure 2. Typical Concentrated Loads and Required Distances

When the topmost draped strands are placed in the maximum upper allowable position and the release strength, based on centerline conditions, is not adequate, a message is printed out indicating that the concrete release strength shown was calculated from end eccentricity based on that maximum draped position.

When the beam being designed is an AASHO IV beam, designs for both 2 and 3 strands in the web of the beam will be made and the results printed out.

Examples of the input and output forms are shown in Figures 3, 4, 5, and 6, respectively.

TEXAS HIGHWAY DEPARTMENT
BRIDGE DIVISION

PRESTRESSED CONCRETE BEAM DESIGN PROGRAM

(STANDARD BEAM)

SHEET___ OF___ BY________
DATE________ CONTROL________
DISTRICT________ IPE________
COUNTY________ PROB. NO.________

DISTRICT (1–8) 14 (10–11) TRAVIS (15–27) CØUNTY (29–34) HIGHWAY NØ. (38–48) IH 35 (50–55) SUBMITTED BY (59–70) HDB (72–80)

CØNTRØL NØ. (1–11) 476-219 (13–19) IPE (23–25) 675 (27–29) DATE (33–36) NØVEMBER 1970 (38–55)

GENERAL INFORMATION

DESCRIPTIØN (1–11) SAMPLE INPUT (13–80)

ENTER "1" FOR EXTENDED OUTPUT

BEAM TYPE	SPAN (C-C BRG) (FT)	BEAM SPACING (FT)	SLAB THICKNESS (IN.)	AASHO L.L.	R.R. L.L.	SPAN DESIGNATION	BEAM DESIGNATION	ENTER "1" FOR EXTENDED OUTPUT	REMARKS
A	34.00	6.75	7.50	H-15		14R	10-15	1	
B	64.00	5.50	7.00	HS-20					
C	70.00	8.00	7.25	H-20		12-19	2R-3L		
48	75.41	7.33	7.00	HS-20					
54	64.25	2.67	9.00		72	ALL	ALL	1	Coopers E-72 Loading
60	90.87	6.75	7.33	HS-20					
66	93.42	7.33	7.25						
72	102.50	6.75	6.75						
IV	110.25	7.33	7.25					1	AASHO Beams
V	109.75	7.75	6.75						" "
VI	125.18	7.00	7.00	HS-20		ALL	ALL		" "
3 4	7 11	14 17	20 23	26 30	33 35	40 44	47 51	54	

Figure 3. Input Form for "Standard" Beam

PRESTRESSED CONCRETE BEAM DESIGN PROGRAM (NON-STANDARD BEAMS)

TEXAS HIGHWAY DEPARTMENT
BRIDGE DIVISION

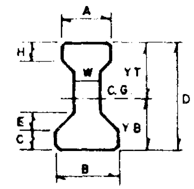
SHEET __ OF __ BY __ DATE __ CONTROL __
DISTRICT __ IPE __ COUNTY __ PROP NO __

DISTRICT 12 HARRIS COUNTY HIGHWAY NO. US 290

CONTROL NO. 214-876 IPE 694 SUBMITTED BY HDB

GENERAL INFORMATION

DESCRIPTION SAMPLE INPUT



BEAM TYPE	SPAN L (FT) C-C BRG	BEAM SPACING (FT)	SLAB THICK (IN)	AASHO L.L.	R.R. L.L.	SPAN DESIGNATION	BEAM DESIGNATION	ENTER "1" FOR EXTENDED OUTPUT
NS	118.75	7.00	7.25	HS-20		120	4	1

	INERTIA (IN⁴)	AREA (IN²)	D (IN)	YB (IN)	YT (IN)	B (IN)	W (IN)	C (IN)	E (IN)	A (IN)	H (IN)	STRANDS IN WEB
01	216836.00	709.00	54.00	25.98	28.02	20.00	10.00	8.00	5.00	20.00	4.00	2

	STRAND SIZE (3/8---9/16)	ULT STGTH OF STRAND (KSI)	UNIT WT (LBS/CU FT) BEAM	UNIT WT SLAB	SLAB CONC 28-DAY ST (PSI)	MODULUS OF ELASTICITY (10^6 PSI) BEAM CONC.	SLAB CONC	STEEL	WIDTH COMP SLAB (FT)	UNIF D.L. ON COMPSEC (K/FT)	L.L. DIST FACTOR
02	1/2	270.00	150.00	150.00	3600.00	5.00	5.00	28.00	7.00		.636

CONCENTRATED STATIC LOAD APPLIED TO NON-COMPOSITE SECTION

03	2.00	2.00	2.00								LOADS (KIPS)
03	29.38	59.38	89.38								DISTANCE FROM LEFT SUPPORT (FT)

CONCENTRATED STATIC LOADS APPLIED TO COMPOSITE SECTION

04											LOADS (KIPS)
04											DISTANCE FROM LEFT SUPPORT (FT)

CONCENTRATED LIVE LOADS APPLIED TO COMPOSITE SECTION

05											LOADS (KIPS)
05											DISTANCE FROM LEFT LOAD (FT)

BEAM TYPE	SPAN L (FT) C-C BRG	BEAM SPACING (FT)	SLAB THICK (IN)	AASHO L.L.	R.R. L.L.	SPAN DESIGNATION	BEAM DESIGNATION	ENTER "1" FOR EXTENDED OUTPUT
NS	126.42	7.00	7.25	-		14-F	2 L-R	

	INERTIA (IN⁴)	AREA (IN²)	D (IN)	YB (IN)	YT (IN)	B (IN)	W (IN)	C (IN)	E (IN)	A (IN)	H (IN)	STRANDS IN WEB
01	243178.00	817.00	54.00	26.11	27.89	22.00	12.00	8.00	5.00	22.00	4.00	3

	STRAND SIZE (3/8---9/16)	ULT STGTH OF STRAND (KSI)	UNIT WT (LBS/CU FT) BEAM	UNIT WT SLAB	SLAB CONC 28-DAY ST (PSI)	MODULUS OF ELASTICITY (10^6 PSI) BEAM CONC.	SLAB CONC	STEEL	WIDTH COMP SLAB (FT)	UNIF D.L. ON COMPSEC (K/FT)	L.L. DIST FACTOR
02	9/16	270.00	150.00	112.00	3600.00	5.00	5.00	28.00	7.00		.636

CONCENTRATED STATIC LOAD APPLIED TO NON-COMPOSITE SECTION

03	2.00	2.00	2.00								LOADS (KIPS)
03	31.60	63.20	94.80								DISTANCE FROM LEFT SUPPORT (FT)

CONCENTRATED STATIC LOADS APPLIED TO COMPOSITE SECTION

04											LOADS (KIPS)
04											DISTANCE FROM LEFT SUPPORT (FT)

CONCENTRATED LIVE LOADS APPLIED TO COMPOSITE SECTION

05	4.00	16.00	16.00								LOADS (KIPS)
05	14.00	28.00									DISTANCE FROM LEFT LOAD (FT)

Figure 4. Input Form for "Non-Standard" Beam

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DISTRICT 14          TRAVIS COUNTY    HIGHWAY NO. LP 275    SUBMITTED BY BR WINN
CONTROL NO. 151-6      IPE 228    DATE NOV 2 1970

                       LOOP 275 OVERPASS US 183    SPANS NO 1-6

                              SPAN      1    BEAM      1


**** INPUT DATA ****

BEAM TYPE          =    54          UNIT WT. BEAM CONC.      =  150.    PCF              L.L. DIST. FACTOR =        0.69
SPAN LENGTH        =  77.25 FT      UNIT WT. SLAB CONC.      =  150.    PCF              COMP. SLAB WIDTH  =          90.48 IN
BEAM SPACING       =   7.54 FT      28-DAY ST.(SLAB CONC.) = 3600.    PSI              COMP. DEAD LOAD   =        0.0  KLF
SLAB THICKNESS     =   7.50 IN      E(BM.CONC.)              =      5.00 E(06)PSI       BEAM INERTIA      = 164023.    IN4
STRAND SIZE        =   1/2  IN      E(SLB.CONC.)             =      5.00 E(06)PSI       BEAM AREA         =      493.44 IN2
STRAND ULT. STR.   =   270K         E(PSRR. STL.)            =     28.00 E(06)PSI       BEAM DEPTH        =       54.00 IN
NO.OF WEB STRNS.   =    2           AASHO L.L.               =    HS-20                 BEAM YB           =       25.53 IN
GRID SIZE          =   2.    IN     RAILROAD L.L.            =      E- 0.               BEAM YT           =       28.47 IN

*** BEAM DESIGN ***


TYPE OF BEAM                 =    54                   D.L. DEFLECTION AT MID-SPAN =  0.058 FT (SLAB)      0.007 FT (DIAF)
NO. OF STRANDS               =    22.                  D.L. DEFLECTION AT 1/4 PT.  =  0.041 FT (SLAB)      0.005 FT (DIAF)
SIZE OF STRANDS              =    1/2
TYPE OF STRANDS              =    270K                 ULTIMATE MOMENT REQUIRED = 3806. FT-KIPS
ECCENTRICITY AT C.L.         =    20.80 IN             ULT. MOMENT PROVIDED =     4161. FT-KIPS  UNDER REINF. RECT. SECT.
ECCENTRICITY AT END          =    13.53 IN
NO. OF DEPRESSED STRANDS     =     8                   STIRRUP SPAC. (MIDDLE 1/2 SPAN) = NO. 4 AT 24.00 IN
DEPRESS TOP 2 STRANDS TO POSITION A-28                 STIRRUP SPAC. (EXT. 1/4 SPAN)   = NO. 4 AT 16.43 IN
CONCRETE RELEASE STRENGTH = 4425.    PSI
CONCRETE 28-DAY STRENGTH  =    5000.    PSI            TOP FIBER DESIGN STRESS (C.L.)     = 2231. PSI
                                                       BOTTOM FIBER DESIGN STRESS (C.L.) = 2869. PSI

                                                       MAXIMUM CAMBER =  1.80 IN
                                                       PRESTRESS LOSS = 17.16 PERCENT

*** STRAND PATTERN ***
    (C.L. OF BEAM)

ROW  1 HAS  6. STRANDS
ROW  2 HAS  6. STRANDS
ROW  3 HAS  6. STRANDS
ROW  4 HAS  4. STRANDS
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Figure 5. Typical Output, One-Page

DISTRICT 14 TRAVIS COUNTY HIGHWAY NO. LP 275 SUBMITTED BY BR WINN
CONTROL NO. 151-6 IPE 228 DATE NOV 2 1970

LOOP 275 OVERPASS US 183 SPANS NO 1-6

SPAN 5 BEAM NO. ALL

INPUT DATA

BEAM TYPE	= 54	UNIT WT. BEAM CONC.	= 150. PCF	L.L. DIST. FACTOR	= 0.58
SPAN LENGTH	= 96.42 FT	UNIT WT. SLAB CONC.	= 150. PCF	COMP. SLAB WIDTH	= 75.96 IN
BEAM SPACING	= 6.33 FT	28-DAY ST.(SLAB CONC.)	= 3600. PSI	COMP. DEAD LOAD	= 0.0 KLF
SLAB THICKNESS	= 7.25 IN	E(BM. CONC.)	= 5.00 E(06)PSI	BEAM INERTIA	= 164023. IN4
STRAND SIZE	= 1/2 IN	E(SLB. CONC.)	= 5.00 E(06)PSI	BEAM AREA	= 493.44 IN2
STRAND ULT. STR.	= 270K	E(PSTR. STL.)	= 28.00 E(06)PSI	BEAM DEPTH	= 54.00 IN
NO. OF WEB STRNS.	= 2	AASHO L.L.	= HS-20	BEAM YB	= 25.53 IN
GRID SIZE	= 2. IN	RAILROAD L.L.	= E- 0.	BEAM YT	= 28.47 IN

SECTION	MOMENT SUMMARY (FT-KIPS) DEAD LOAD	L.L.+I.	TOTAL	SHEAR SUMMARY (KIPS) DEAD LOAD	L.L.+I.	TOTAL
0	0.0	0.0	0.0	55.3	45.9	101.2
1	479.7	393.3	873.1	44.2	40.8	85.0
2	852.9	688.7	1541.6	33.2	35.7	68.9
3	1119.4	886.2	2005.6	22.1	30.6	52.8
4	1279.3	1001.5	2280.8	11.1	25.6	36.6
5	1332.6	1026.8	2359.4	-0.0	20.5	20.5
6	1279.3	1001.5	2280.8	11.1	25.6	36.6
7	1119.4	886.2	2005.6	22.1	30.6	52.8
8	852.9	688.7	1541.6	33.2	35.7	68.9
9	479.7	393.3	873.1	44.2	40.8	85.0
10	0.0	0.0	0.0	55.3	45.9	101.2
HOLD-DOWN	1318.3	1025.9	2344.1	5.7	18.0	23.7

LOOP 275 OVERPASS US 183 SPANS NO 1-6

STRESSES IN EXTREME FIBERS DUE TO EXTERNAL LOADS (LBS PER SQ. IN.)

SECTION	BEAM		SLAB		TOTAL D.L. NON-COMP SEC.		DEAD LOAD COMP SEC.		LIVE LOAD PLUS IMPACT		TOTAL	
	TOP	BOT	TOP	BOT	TOP	BOT	TOP	BOT	TOP	BOT	TOP	BOT
0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1	448.	402.	551.	494.	999.	896.	0.	0.	125.	461.	1125.	1357.
2	796.	714.	980.	879.	1776.	1593.	0.	0.	220.	808.	1996.	2401.
3	1045.	937.	1286.	1154.	2332.	2091.	0.	0.	292.	1039.	2614.	3130.
4	1194.	1071.	1470.	1318.	2665.	2389.	0.	0.	319.	1174.	2984.	3564.
5	1244.	1116.	1532.	1373.	2776.	2489.	0.	0.	327.	1204.	3103.	3693.
6	1194.	1071.	1470.	1318.	2665.	2389.	0.	0.	319.	1174.	2984.	3564.
7	1045.	937.	1286.	1154.	2332.	2091.	0.	0.	282.	1039.	2614.	3130.
8	796.	714.	980.	879.	1776.	1593.	0.	0.	220.	808.	1996.	2401.
9	448.	402.	551.	494.	999.	896.	0.	0.	125.	461.	1125.	1357.
10	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
HOLD-DOWN	1231.	1104.	1515.	1359.	2746.	2462.	0.	0.	327.	1203.	3073.	3665.

STRESSES DUE TO EXTERNAL LOADS PLUS PRESTRESS (LBS PER SQ. IN.)

	INITIAL PREST.		BEAM PLUS INITIAL PREST.		FINAL PREST. PLUS TOT. D.L.(N/C SEC.)		ALL LOADS PLUS FINAL PREST.	
	TOP	BOT	TOP	BOT	TOP	BOT	TOP	BOT
0	164.	3210.	164.	3210.	131.	2568.	131.	2568.
1	-134.	3477.	314.	3075.	892.	1885.	1017.	1424.
2	-432.	3744.	365.	3029.	1431.	1402.	1651.	594.
3	-729.	4010.	316.	3073.	1748.	1118.	2031.	79.
4	-1027.	4277.	167.	3206.	1843.	1032.	2162.	-142.
5	-1170.	4406.	74.	3290.	1839.	1036.	2167.	-168.
6	-1027.	4277.	167.	3206.	1843.	1032.	2162.	-142.
7	-729.	4010.	316.	3073.	1748.	1118.	2031.	79.
8	-432.	3744.	365.	3029.	1431.	1402.	1651.	594.
9	-134.	3477.	314.	3075.	892.	1985.	1017.	1424.
10	164.	3210.	164.	3210.	131.	2568.	131.	2568.
HOLD-DOWN	-1170.	4406.	61.	3302.	1810.	1062.	2137.	-141.

Figure 6. Typical Output, Multi-page

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LOOP 275 OVERPASS US 183    SPANS NO 1-6

STIRRUP SPACING IN EXTERIOR 1/4 SPAN (AASHO SPECS.)     NO. 4 AT  16.8 IN.

STIRRUP SPACING IN MIDDLE 1/2 SPAN (AASHO SPECS.)       NO. 4 AT  24.0 IN.

STIRRUP SPACING BASED ON ACI SPECS.

     SECTION

       0        NO. 4 AT  4.6 IN.
       1        NO. 4 AT 17.4 IN.
       2        NO. 4 AT 16.7 IN.
       3        NO. 4 AT 17.0 IN.
       4        NO. 4 AT 17.4 IN.
       5        NO. 4 AT 17.4 IN.
       6        NO. 4 AT 17.4 IN.
       7        NO. 4 AT 17.0 IN.
       8        NO. 4 AT 16.7 IN.
       9        NO. 4 AT 17.4 IN.
      10        NO. 4 AT  4.6 IN.


MAXIMUM ULTIMATE HORIZONTAL SHEAR BETWEEN SLAB AND GIRDER FLANGE (VQ/I)

     SECTION

       0          223.2 PSI
       1          188.0 PSI
       2          152.8 PSI
       3          117.6 PSI
       4           82.4 PSI
       5           61.5 PSI
       6           82.4 PSI
       7          117.6 PSI
       8          152.8 PSI
       9          138.0 PSI
      10          223.2 PSI




LOOP 275 OVERPASS US 183    SPANS NO 1-6


ULTIMATE MOMENT REQUIRED =  4565.8 FT-KIPS
ULTIMATE MOMENT PROVIDED =  5396.9 FT-KIPS          UNDER REINFORCED RECTANGULAR SECTION
                                                    DESIGN BASED ON STRESSES


DEAD LOAD DEFLECTIONS       SLAB       DIAPHRAM         COMP DEAD LOAD

             MIDSPAN     0.113 FT    0.016 FT            0.0    FT

       QUARTER POINT     0.081 FT    0.011 FT            0.0    FT


MAXIMUM CAMBER =  2.85 IN.
PRESTRESS LOSS = 19.22 PERCENT


TYPE OF BEAM                =      54
NO. OF STRANDS              =     30.
SIZE OF STRANDS             =     1/2
ULT. STRENGTH OF STRANDS    =      270K
ECCENTRICITY AT C.L.        =   19.40 IN.
ECCENTRICITY AT END         =   10.60 IN.
CONCRETE RELEASE STRENGTH   =   5490. PSI
CONCRETE 28-DAY STRENGTH    =   5490. PSI
NUMBER OF DRAPED STRANDS    = 12
DEPRESS TOP STRANDS TO POSITION A-34

STRAND PATTERN AT CENTERLINE OF BEAM

ROW 1 HAS  6 STRANDS

ROW 2 HAS  6 STRANDS

ROW 3 HAS  6 STRANDS

ROW 4 HAS  6 STRANDS

ROW 5 HAS  4 STRANDS

ROW 6 HAS  2 STRANDS
```

Figure 6, cont'd.

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