

A STUDY TO DETERMINE THE OPTIMUM END SPAN LENGTH
FOR A CIRCULAR HAUNCHED GIRDER INTER-STATE
HIGHWAY GRADE SEPARATION

by 1264

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INTRODUCTION

Today bridges of every type--suspension, arch, truss, plate box girder, etc.--are constructed of steel because of the strength, dependability, and permanence inherent in that material. In the past, for the purpose of obtaining as near a balanced design arrangement as possible, the normal proportion of an end span to an interior span of a steel highway bridge was approximately 1 to 1.25. Now, however, the interior span length will often approach 100 feet and in some cases, primarily due to the use of the current safety criteria, there have been spans of over 135 feet. This extension of the interior span length is particularly necessary if there is a slight skew. Following the extension of the interior span length, in order to meet the balanced design arrangement, the end span length is frequently longer than necessary to take care of the fill slope coming down from the abutment. Thus, there is considerable interest in shortening the end span to the point where uplift at the abutment is eminent.

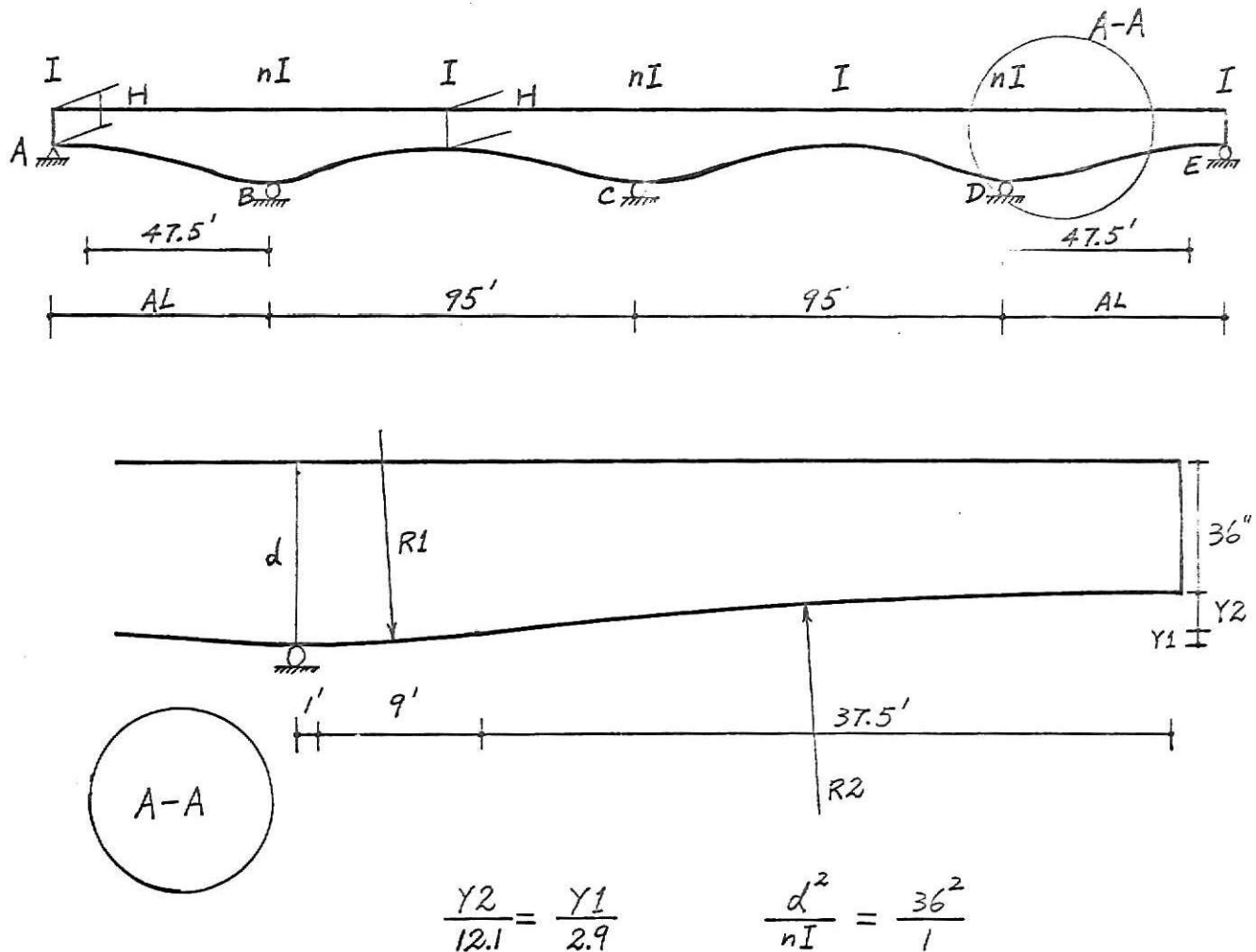
According to the AASHO Specifications, if the end span is shortened severely with respect to the interior span and uplift occurs, adequate attachment of the superstructure to the substructure should be made and a 100 per cent increase in the live-plus-impact load should be taken into account. Unfortunately, the advantage of an attached abutment is not presented in the normal design of a steel structure and the 100 per cent increase in load increases the expense of the design. For these reasons, the design of steel structures with span lengths which do not lead to uplift and still meet the criteria of economy with safety is desirable.

There are several criteria which might be used to determine the optimum span length. One such criteria is total cost of structure including

superstructure and substructure. Since the cost of substructure varies considerably from location to location and since the reinforced concrete cost of superstructure also varies depending on the structures location, it would have been rather difficult to calculate these costs in this study. Therefore, the criterion used in this study was total girder weight. Several simplifying assumptions used in the study are listed in OUTLINE OF THE DESIGN METHOD.

This study used a trial and error method for determining the optimum end span lengths for ratios of the moments of inertia of the girders over the piers to the moments of inertia of the girders at mid-spans of 1.5, 2.0, and 2.5. The trials were made with the end span lengths ranging from 50' to 80'. A total of 12 cases was investigated. The analyses and designs for the cases investigated are summarized in Table 1 and Fig. 10.

OUTLINE OF THE DESIGN METHOD



The Shape of the Haunched Girder

Fig. 1

(I) General Description of the Design Procedure

1. Given the depth of the girder, H, at mid-span or at the abutment.
2. Given the value of nI, where nI is the ratio of the moment of inertia of the girder over the pier to that of the girder at mid-span or at the abutment.

3. Calculate the depth of the girder over the pier from the given values of H and nI . Then compute the radius of the curve describing the girder haunch. The ratio of the moment of inertia of the girder at any section along the bridge to that of the girder at mid-span or at the abutment can then be found immediately.
4. Assume a value of AL , where AL is the length of the end span of the bridge.
5. Use the displacement method to find the ordinates of the influence lines for the moments at supports B and C, and to find the ordinates of the moment diagrams for the bridge under the action of the various loads, such as concentrated live loads or uniform dead loads.
6. Using the values calculated in Step 5, find the minimum girder weight which will prevent uplift at the abutment.
7. Assume a girder weight larger than the minimum required to prevent uplift.
8. Determine the maximum moment and maximum shearing force caused by the dead and live loads, using the data from Step 5. Design the girder section in accordance with the criteria of the current AASHTO Specifications.
9. Calculate the weight of the girder chosen. If it is substantially different from the assumed value, repeat Steps 7 and 8 until a suitable section is obtained.
10. Calculate the total weight of the four girders in Kips.
11. Pick a new value of AL , and repeat Steps 5 through 10 until the pertinent range of AL has been covered.

12. Pick a new value of nI , and repeat Steps 3 through 11 until the prescribed values of nI have been used.
13. Use the length of the end span as the abscissa and the total weight of the four girders as the ordinate, and plot the results obtained from the above steps into curves for the prescribed values of nI . Then, estimate the optimum end span length from the curves.

(II) Simplifying Assumptions Used in the Design

1. The depth of the girder at mid-span and at the abutment as well as the interior span length is held constant. The interior spans are 95 feet each, and the girder depth at mid-span and at the abutment is 36 inches.
2. The continuously varying depth of the girder is to be approximated by a girder which has a prismatic haunch every 5 feet from the interior support to mid-span. The ratios of the moments of inertia of the girders at the interior supports to those of the girders at mid-spans are 1.5, 2.0, and 2.5.
3. The dead load weight of the girder is taken as the average weight of the girder, and the design of the stiffeners and diaphragms is omitted for the purpose of simplifying the computations.
4. There is to be no uplift at the abutments.
5. H20-44 loading is to be used.
6. The current AASHO Standard Specifications for Highway Bridges are to be used.
7. A non-composite reinforced concrete deck is to be used on the welded girders.
8. In order to maintain a symmetric haunch, only lengths of end span,

AL, which are equal to or larger than 47.5 feet were selected.

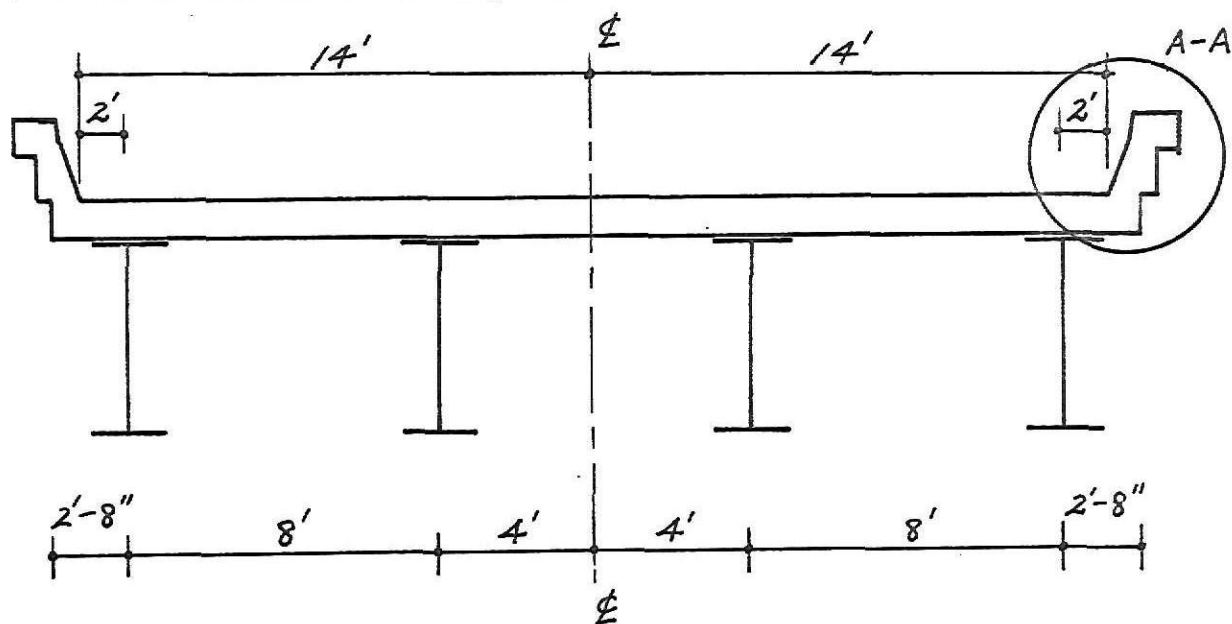
9. For design, use the uplift resulting from the loading which includes the concentrated loads for moment but not for shear.
10. A-36 steel is to be used.

NUMERICAL EXAMPLE AND SUMMARY OF DESIGN RESULTS

A trial and error method was used in this study and all of the calculations were performed on the computer. The method used, in computer program 1, for finding the radius of the curve describing the haunched girder is the simple principle of the arc of a circle in analytical geometry. As for the displacement method, in computer program 2, the author assumes that the readers have had the background of a matrix methods course in structural analysis. Therefore, a detailed explanation of these two preliminary steps in designing the girder section will be omitted here. Only the procedure for the final design using the criteria of the AASHTO Specifications will be covered in detail.

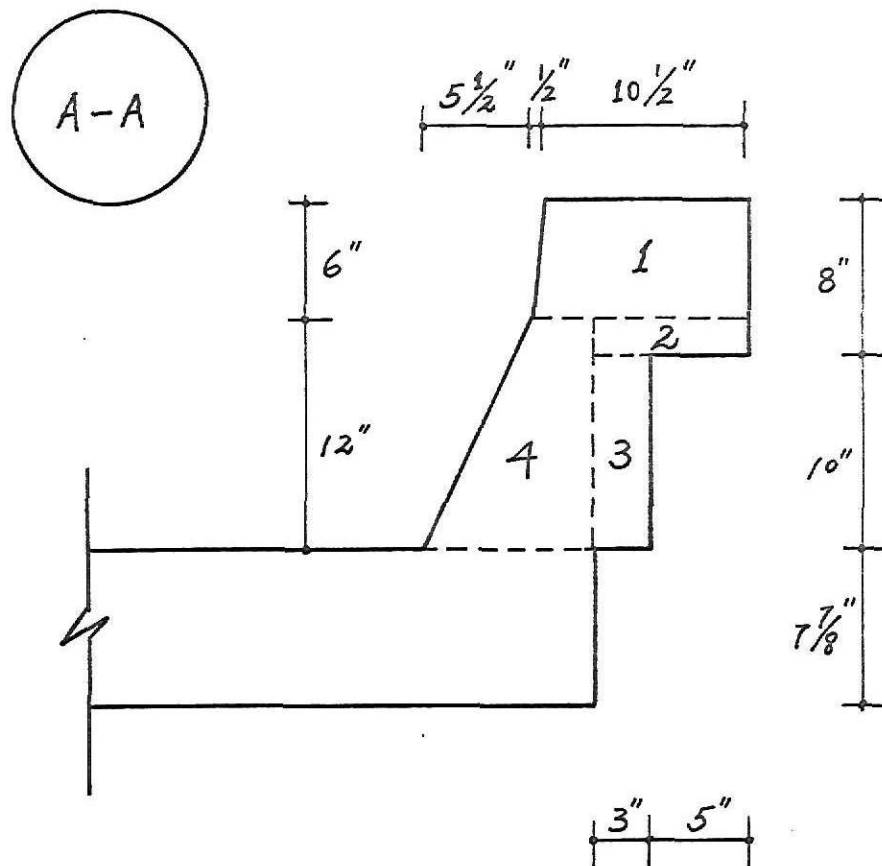
Design of the Girder Section for $nI = 1.5$, $AL = 80'$

(A) Concrete Deck and Girder Layout



Typical Section

Fig. 2-1.



Typical Section

Fig. 2-2.

(I) Dead load of concrete deck for exterior girder

$$\text{Slab: } (4 + 2.667) \left(\frac{7.875}{12} \right) (150) = 656 \text{ lb/ft}$$

$$\text{Parapet: } \text{Area 1} = 67.2 \text{ lb/ft}$$

$$\text{Area 2} = 16.7 \text{ lb/ft}$$

$$\text{Area 3} = 31.2 \text{ lb/ft}$$

$$\text{Area 4} = \underline{72 \text{ lb/ft}}$$

$$\text{Total} = 843.1 \text{ lb/ft}$$

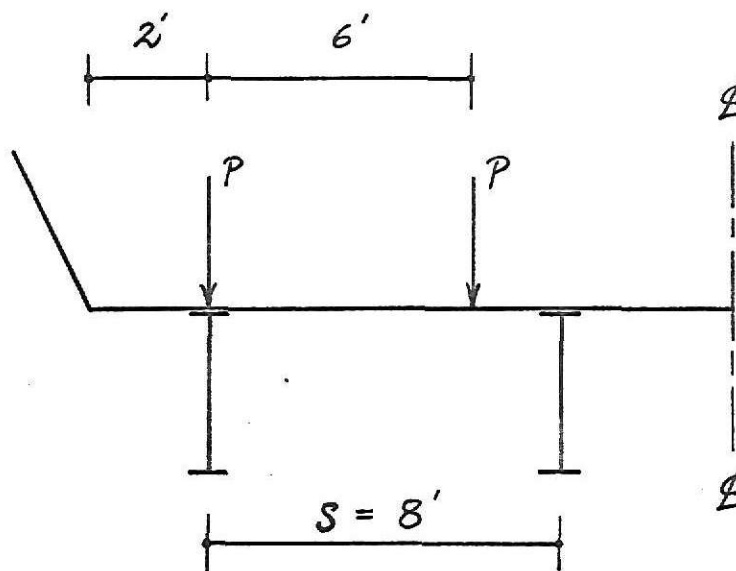
(II) Dead load of concrete deck for interior girder

$$(8)\left(\frac{7.875}{12}\right)(150) = 787.5 \text{ lb/ft}$$

(B) Distribution of Loads¹

(I) For exterior girder

(1) Assume the flooring to act as a simple beam between girders.



Typical Lane Loadings

Fig. 3.

$$\text{D.F.} = 1 + \frac{2}{S} = 1 + \frac{2}{8} = 1.25$$

$$(2) \text{ D.F.} = \frac{S}{4 + 0.25S} = 1.334$$

Therefore, (2) controls. Use D.F. = 1.334

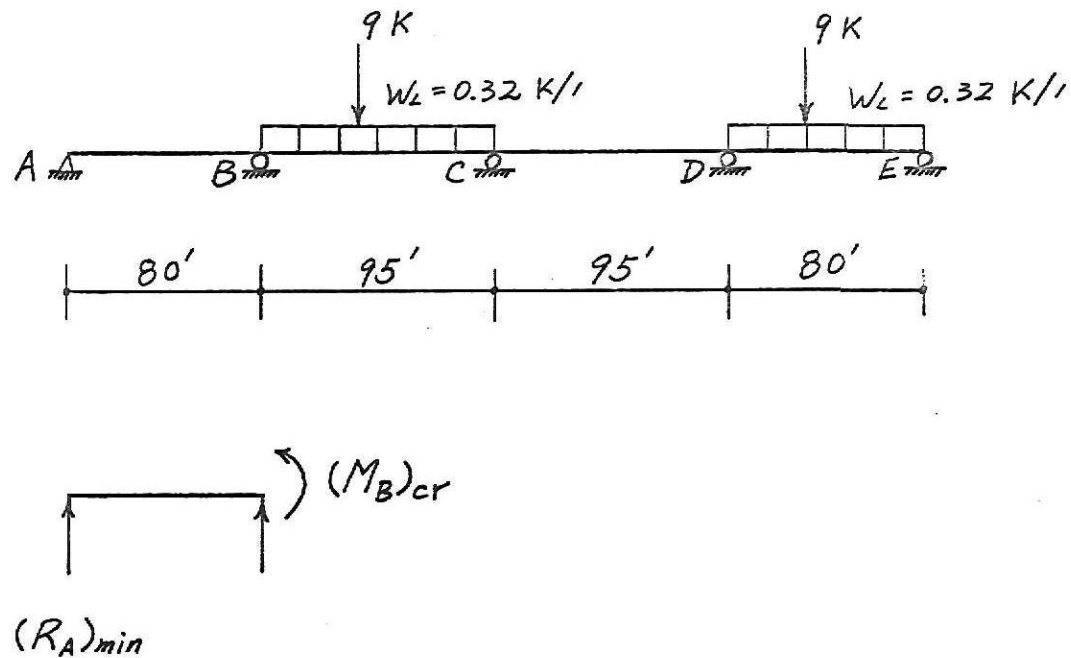
(II) For interior girder

$$\text{D.F.} = \frac{S}{5.5} = 1.455$$

¹Superscripts refer to Reading References.

From Steps (A) and (B), and the live lane loadings, it can be found that the interior girders will control the design.

- (C) Find the Lower Limit of Girder Weight Which Will Prevent Uplift at the Abutment



Live Loadings for Minimum Reaction at Abutment A

Fig. 4.

- (I) Find the critical moment at support B

- (1) Impact formula

$$I = \frac{50}{L + 125} = \frac{50}{80 + 125} = 0.244$$

(2) Due to live loads

(a) Concentrated Loads

$$(M_B)_{\text{conc}} = ((-8.865479)^* + (-0.751801)^*)(9)(1.455)$$

(b) Uniform live load in spans EC and DE

$$(M_B)_{\text{unif}} = (-556.923096)^*(0.32)(1.455)$$

$$\text{Total: } (M_B)_L = (M_B)_{\text{conc}} + (M_B)_{\text{unif}}$$

(3) Due to dead load

$$(M_B)_D = (-844.578613)^*W_D$$

$$(M_B)_{\text{cr}} = (M_B)_D + (1.244)(M_B)_L$$

(II) Find the minimum reaction at support A

$$(R_A)_{\text{min}} = \frac{(M_B)_{\text{cr}}}{80} + \frac{(W_D)(80)}{2} \geq 0$$

Then, we can obtain

$$W_D \geq 0.2034 \text{ k/ft}$$

But the concrete deck wt.

$$= 0.7875 \text{ k/ft}$$

and the estimated wt. of stiffeners and diaphragms = $\frac{0.015 \text{ k/ft}}{0.8025 \text{ k/ft}}$

$$(W_g)_{\text{min}} \geq W_D - 0.8025 < 0$$

Therefore, the minimum girder weight = 0 k/ft

(D) Calculate Maximum Moments

Assume the girder weight = 0.1831 k/ft

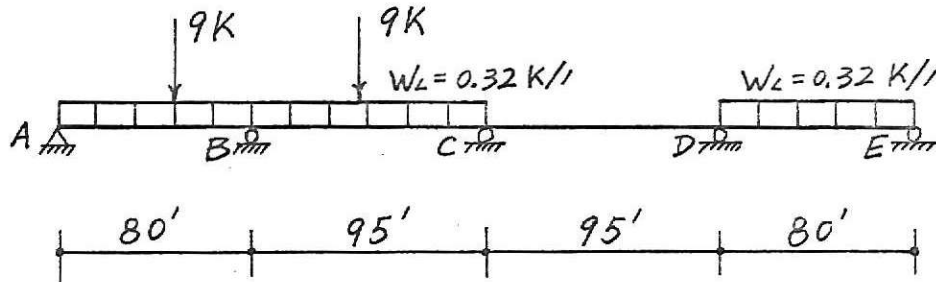
Then, the total dead load = 0.9856 k/ft

(I) For maximum negative moment

Study of Tables A-4, A-5, and A-6 indicates that the negative moment at support B will control the design for the interior girder.

$$I = \frac{50}{1/2 (80+95) + 125} = 0.2353$$

*Computer Output Data in Appendix A.



Live Loadings for Max. Negative Moment at Support B

Fig. 5.

(1) Due to live loads

(a) Concentrated loads

$$(M_B)_{\text{conc}} = ((-8.517578)^* + (-8.865479)^*)(9)(1.455)$$

(b) Uniform load

$$(M_B)_{\text{unif}} = (-997.966309)^*(0.32)(1.455)$$

$$(M_B)_L = (M_B)_{\text{conc}} + (M_B)_{\text{unif}}$$

(2) Due to dead load

$$(M_B)_D = (-844.578613)^*(0.9856)$$

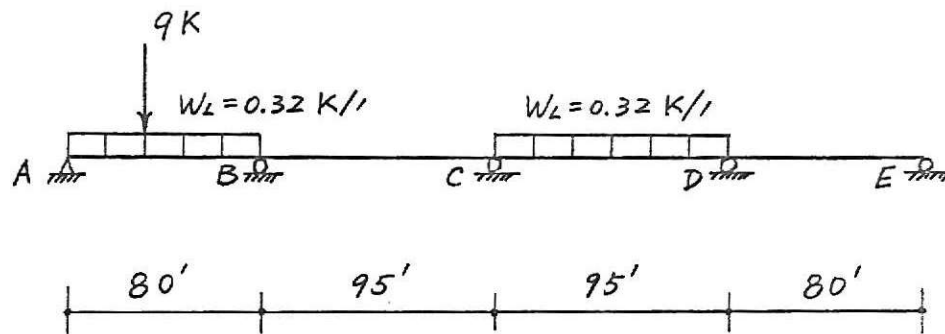
$$(M_B)_{\text{max}} = (M_B)_D + (1.2353)(M_B)_L = -1687.3409^* \text{ k-ft}$$

(II) For maximum positive moment

From the analysis in Tables A-4, A-5, and A-6, Appendix A, it can be seen that the positive moment in the end span is larger than that in the interior span.

$$I = \frac{50}{80 + 125} = 0.244$$

*Computer Output Data in Appendix A.



Live Loadings for Max. Positive Moment in End Span AB

Fig. 6.

(1) Due to live loads

(a) Concentrated load

$$M_{\text{conc}} = (16.003296)^* (9) (1.455)$$

(b) Uniform load

$$M_{\text{unif}} = (641.422119)^* (0.32) (1.455)$$

$$(M)_L = M_{\text{conc}} + M_{\text{unif}}$$

(2) Due to dead load

$$(M)_D = (432.875977)^* (0.9856)$$

$$(M)_{\text{max}} = (M)_D + (1.244)(M)_L = 1058.6164^* \text{ k-ft}$$

Thus, the max. negative moment at support B controls the design.

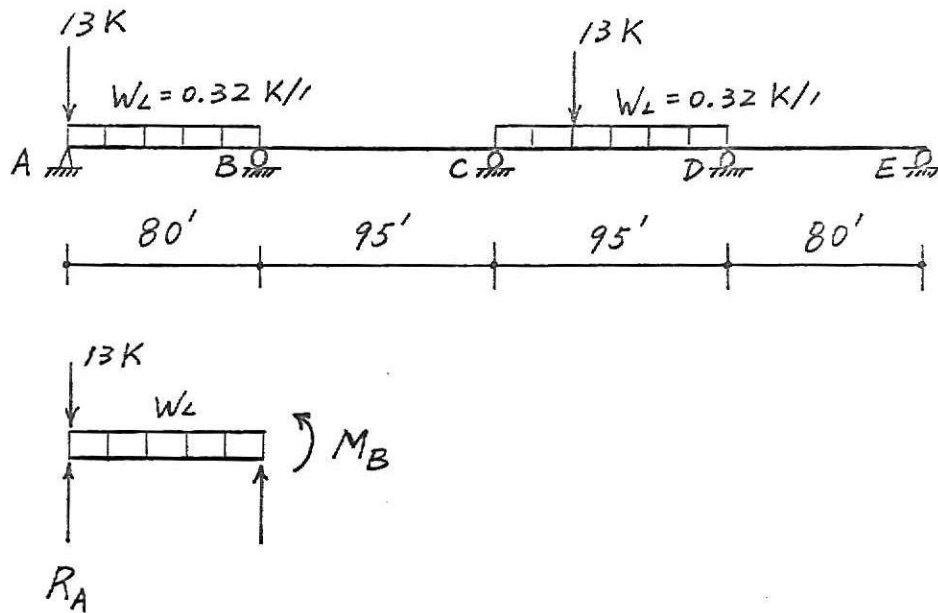
$$M_{\text{des}} = 1687.3409 \text{ k-ft}$$

(E) Calculate Maximum Shearing Forces

(I) For max. shearing force at support A

$$I = \frac{50}{80 + 125} = 0.244$$

*Computer Output Data in Appendix A.



Live Loadings for Max. Shearing Force at Support A

Fig. 7.

(1) Due to live loads

(a) Concentrated loads

$$V_{A1} = (13)(1.455)$$

$$M_B = (2.621933)^*(13)(1.455)$$

$$V_{A2} = \frac{M_B}{80}$$

$$(V_A)_{\text{conc}} = V_{A1} + V_{A2} = 19.529K$$

(b) Uniform load

$$M_B = (-287.114502)^*(0.32)(1.455)$$

$$(V_A)_{\text{unif}} = \frac{M_B}{80} + \frac{(0.32)(1.455)(80)}{2}$$

$$(V_A)_L = (V_A)_{\text{conc}} + (V_A)_{\text{unif}} = 36.477K$$

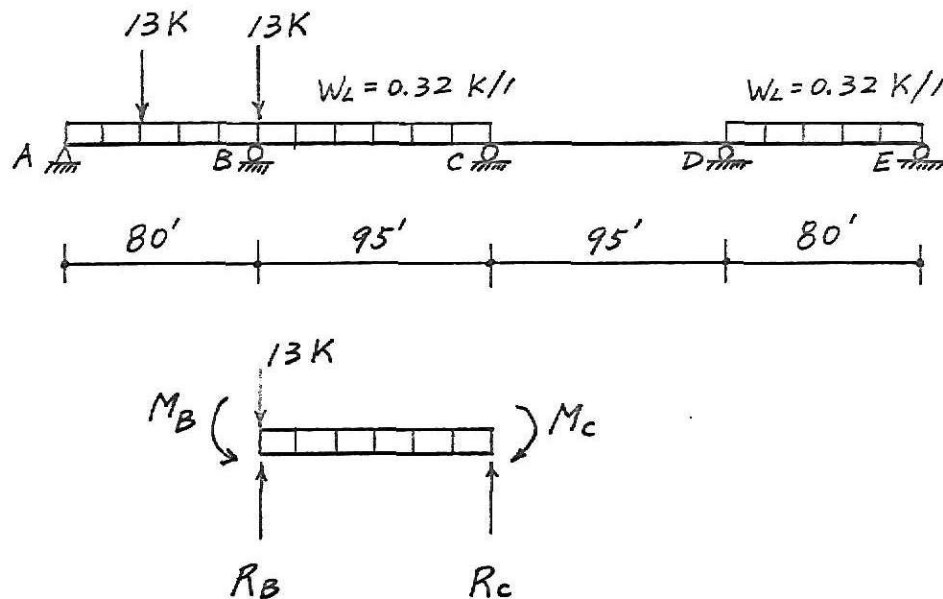
* Computer Output Data in Appendix A.

(2) Due to dead load

$$(V_A)_D = \frac{(-844.578613)^*(0.9856)}{80} + \frac{(0.9856)(80)}{2}$$

$$(V_A)_{\max} = (V_A)_D + (1.244)(V_A)_L = 74.393^* \text{ K}$$

(II) For max. shearing force at support B



Live Loadings for Max. Shearing Force at Support B

Fig. 8.

(1) Due to live loads

(a) Concentrated loads

$$V_{B1} = (13)(1.455)$$

$$M_B = -(-8.517578)^*(13)(1.455)$$

$$M_C = (2.5215)^*(13)(1.455)$$

$$V_{B2} = \frac{M_B + M_C}{95}$$

*Computer Output Data in Appendix A.

$$(V_B)_{conc} = V_{B1} + V_{B2} = 21.106 \text{ K}$$

(b) Uniform load

$$M_B = -(-997.966309) * (0.32)(1.455)$$

$$M_C = (-253.985672) * (0.32)(1.455)$$

$$(V_B)_{unif} = \frac{M_B + M_C}{95} + \frac{(0.32)(1.455)(95)}{2}$$

$$(V_B)_L = (V_B)_{conc} + (V_B)_{unif} = 46.861 \text{ K}$$

(2) Due to dead load

$$M_B = -(-844.578613) * (0.9856)$$

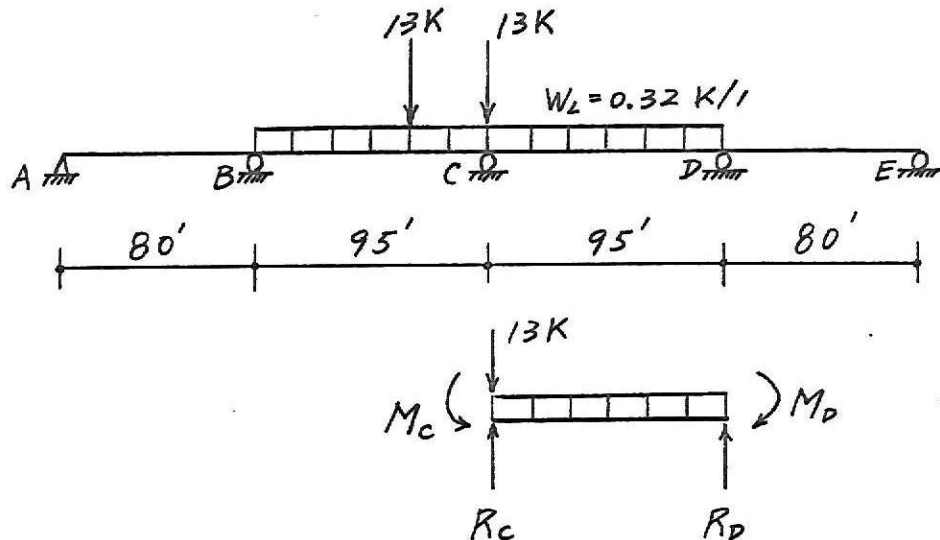
$$M_C = (-769.649658) * (0.9856)$$

$$(V_B)_D = \frac{M_B + M_C}{95} + \frac{(0.9856)(95)}{2}$$

$$I = \frac{50}{95 + 125} = 0.2273$$

$$(V_B)_{max} = (V_B)_D + (1.2273)(V_B)_L = 105.105 \text{ K}$$

(III) For max. shearing force at support C



Live Loadings for Max. Shearing Force at Support C

Fig. 9.

* Computer Output Data in Appendix A.

(1) Due to live loads

(a) Concentrated loads

$$V_{C1} = (13)(1.455)$$

$$M_C = -(-8.804932)^*(13)(1.455)$$

$$M_D = (2.621933)^*(13)(1.455)$$

$$V_{C2} = \frac{M_C + M_D}{95}$$

$$(V_C)_{conc} = V_{C1} + V_{C2} = 21.184 \text{ K}$$

(b) Uniform load

$$M_C = -(-1030.72876)^*(0.32)(1.455)$$

$$M_D = (-365.020752)^*(0.32)(1.455)$$

$$(V_C)_{unif} = \frac{M_C + M_D}{95} + \frac{(0.32)(1.455)(95)}{2}$$

$$(V_C)_L = (V_C)_{conc} + (V_C)_{unif} = 46.554 \text{ K}$$

(2) Due to dead load

$$M_C = -(-769.649658)^*(0.9856)$$

$$M_D = (-845.006592)^*(0.9856)$$

$$(V_C)_D = \frac{M_C + M_D}{95} + \frac{(0.9856)(95)}{2}$$

$$(V_C)_{max} = (V_C)_D + (1.2273)(V_C)_L = 103.17 \text{ K}$$

$$\text{Since } (V_B)_{max} > (V_C)_{max} > (V_A)_{max}$$

$$V_{des} = 105.105 \text{ K}$$

(F) Design of the Girder Section¹

(I) For the girder over the pier

(a) Design web

$$D = 44''^*$$

*Computer Output Data in Appendix A.

$$\text{Assume } t = \frac{5}{16}$$

$$\frac{D}{t} = 140.8 < 165 \text{ (O.K.)}$$

(b) Design flange

$$\text{Assume } t_f = 1", b_f = 20.81"$$

$$\frac{b_f}{t_f} = \frac{20.81}{1} = 20.81 < 23 \text{ (O.K.)}$$

(c) Check bending stress

$$\text{Web: } 44" \times \frac{5}{16} \quad I_x = 2218.33 \text{ in}^4$$

$$\text{Flange: } 2 - 20.81" \times 1" \quad I_x = 21070.13 \text{ in}^4$$

$$\text{Total } I_x = 23288.46 \text{ in}^4$$

It is assumed that the compression flange is partially supported by cross-bracing at no more than 25' intervals. With a length of unsupported flange between lateral supports of 25', the allowable compression stress is defined as follows:

$$F_b = 20000 - 7.5 \left(\frac{L}{b_f} \right)^2 \text{ with } \frac{L}{b_f} \leq 36$$

Continuous girders may be proportioned for negative moment at interior supports for an allowable unit stress 20 per cent higher than that permitted by the above formula, but in no case exceeding the allowable unit stress, 20 ksi for A-36 steel, for the compression flange supported its full length.

$$F_b = [20000 - 7.5 \left(\frac{25 \times 12}{20.81} \right)^2] (1.2) = 22.2 \text{ ksi}$$

Thus $F_b = 20 \text{ ksi}$

$$f_b = \frac{M_{des} \times C}{I_x} = \frac{1687.3409 \times 12 \times 23}{23288.46} = 19.997 \text{ ksi} < 20 \text{ ksi (O.K.)}$$

(d) Check shearing stress

$$f_v = \frac{V_{des}}{A_w} = \frac{105.105}{44 \times \frac{5}{16}} = 7.644 \text{ ksi} < 12 \text{ ksi (O.K.)}$$

(II) For the girder sections in the interior of the spans

Owing to the given ratios of the moments of inertia of the girders over the piers to those of the girders at interior points in the spans and the curve defining the girder haunch, the actual moments of inertia of the girders at interior points in the span can easily be obtained. The design of any girder section in the span can then be performed by routine methods and is not therefore performed here.

It should be noted that the designed girder sections in the spans were based on the influence of the maximum negative moment for the simple reason that the maximum negative moment was larger than the maximum positive moment. However, in order to assure the adequacy of the design, the girder sections in the interior of the spans were checked by using the maximum positive moment as the design moment at each section. In any case where the design was governed by the maximum positive moment, the same procedure outlined previously was used. However the maximum positive moment was used as the design moment. It is obvious that the girder sections over the piers will be over designed anytime the maximum positive moment controls the design.

According to the assumptions described in OUTLINE OF THE DESIGN METHOD, the designed girder sections in the span calculated by the computer for the computations of the weight per ft of the girder and the total girder weight are listed as follows:

Location	Web	2-Flanges	Area
At mid-span	36" x $\frac{5}{16}$ "	20.91" x 1"	53.06" ²
5' from mid-span	36.12" x $\frac{5}{16}$ "	20.98" x 1"	53.25" ²
10' from mid-span	36.46" x $\frac{5}{16}$ "	20.99" x 1"	53.38" ²
15' from mid-span	37.04" x $\frac{5}{16}$ "	20.92" x 1"	53.41" ²
20' from mid-span	37.84" x $\frac{5}{16}$ "	20.77" x 1"	53.37" ²
25' from mid-span	38.87" x $\frac{5}{16}$ "	20.93" x 1"	54.01" ²
30' from mid-span	40.13" x $\frac{5}{16}$ "	20.77" x 1"	54.08" ²
35' from mid-span	41.63" x $\frac{5}{16}$ "	20.83" x 1"	54.67" ²
40' from mid-span	43.19" x $\frac{5}{16}$ "	20.75" x 1"	54.99" ²
45' from mid-span	43.95" x $\frac{5}{16}$ "	20.71" x 1"	55.15" ²

(III) Check girder weight

$$A_1 = (53.25 + 53.58 + 53.41 + 53.37 + 54.01 + 54.08 + 54.67 \\ + 54.99 + 55.15) \times 30 = 14589.216$$

$$A_2 = 53.06 \times (70 + 10) = 4245.07$$

$$A = \frac{A_1 + A_2}{350} = 53.81 \text{ in}^2$$

$$W_g = \frac{0.49 \times 53.81}{144} = 0.1831 \text{ K/ft}$$

Total weight of girders

$$W_T = 0.1831 \times 350 \times 4 = 256.356 \text{ kips}$$

The analyses and designs for the other values of nI and AL are summarized in Table 1 and Fig. 10.

TABLE 1. Summary of Design Results

nI	AL ft	Max. negative moment k-ft	Max. positive moment k-ft	V_{des} kips	Girder section at interior support		Girder section at mid-span		Stresses at interior support		Stresses at mid-span		$(W_g)_{min}$ lb/ft	W_g lb/ft	W_T kips
					web	flange	web	flange	f_b	f_v	f_b	f_v			
1.5	80	1687.341	1058.616	105.105	44x5/16	20.81x1	36x5/16	20.91x1	19.997	7.64	15.55	9.34	0	183.11	256.36
	70	1675.556	933.057	104.596	44x5/16	20.65x1	36x5/16	20.75x1	19.997	7.61	13.80	9.30	0	182.19	240.49
	60	1705.813	933.636	105.686	44x5/16	21.07x1	36x5/16	21.16x1	19.990	7.69	13.56	9.39	0	185.19	229.64
	50	1715.596	924.887	106.136	44x5/16	21.20x1	36x5/16	21.29x1	19.993	7.72	13.36	9.43	123.66	186.27	216.07
2.0	80	1788.964	1027.727	105.651	51x5/16	18.49x1	36x5/16	19.01x1	19.994	6.63	16.47	9.39	0	171.36	239.90
	70	1743.664	872.347	104.327	51x5/16	17.96x1	36x5/16	18.49x1	19.991	6.55	14.34	9.27	0	168.01	221.78
	60	1776.861	869.910	105.482	51x5/16	18.35x1	36x5/16	18.87x1	19.992	6.62	14.04	9.38	0	170.89	211.91
	50	.	.	.	.	.	.	.	.	.	.	.	246.96	246.96	286.47
2.5	80	1873.739	1007.147	106.500	57x3/8	16.28x1	36x3/8	17.25x1	19.997	4.98	17.31	7.89	0	169.77	237.67
	70	1799.460	832.664	104.484	57x3/8	15.50x1	36x3/8	16.49x1	19.995	4.89	14.90	7.74	0	164.92	217.69
	60	1835.434	827.400	105.714	57x3/8	15.88x1	36x3/8	16.86x1	19.994	4.95	14.51	7.83	0	167.91	208.21
	50	.	.	.	.	.	.	.	.	.	.	.	351.03	351.03	407.20

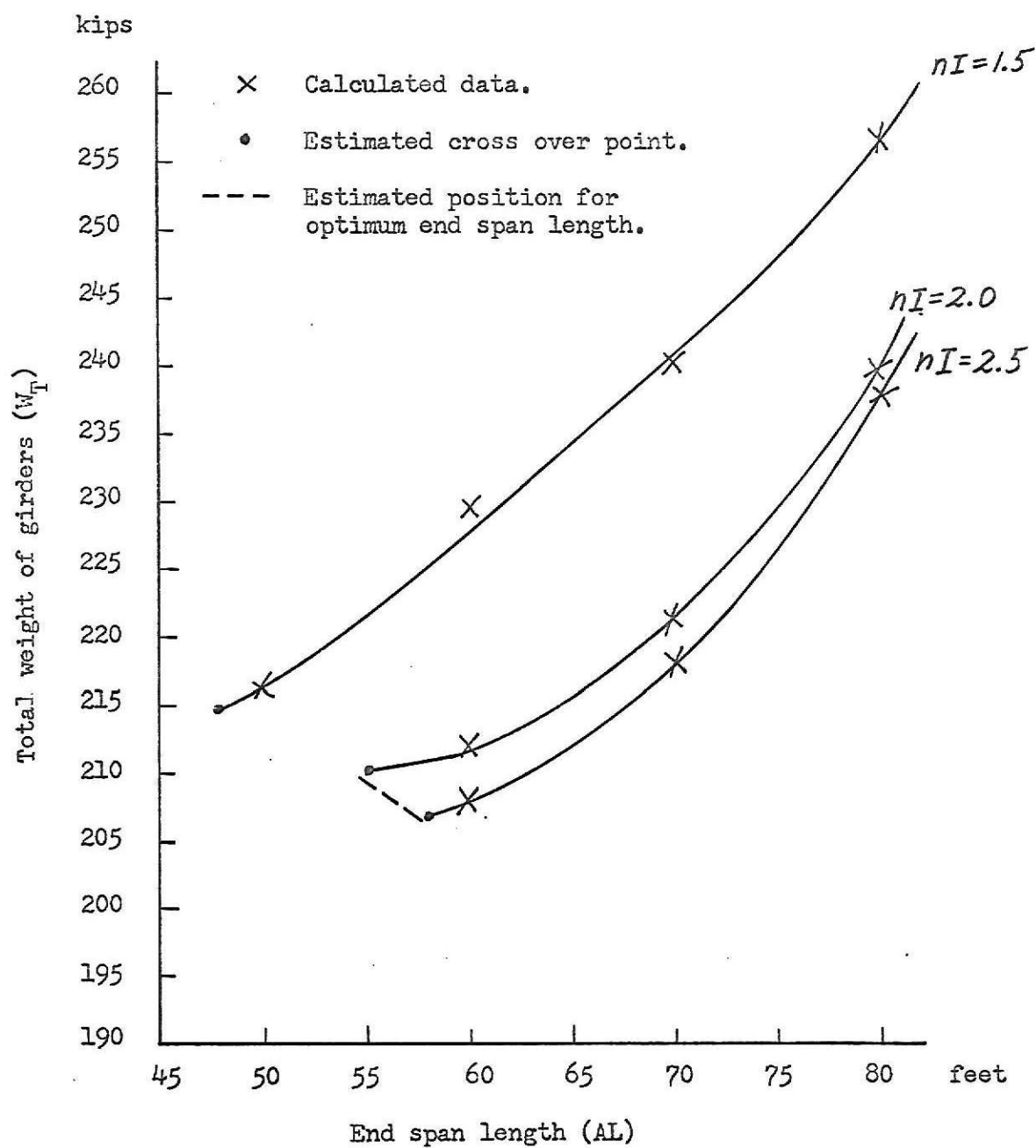
Remarks:

All web and flange dimensions are in inches.

Maximum negative moment was controlled by M_B when $AL = 80'$, otherwise by M_C .

Maximum positive moment was located in the end span when $AL = 80'$, otherwise in the interior span.

The symbol, ., indicates that the design was omitted.



End Span Length vs. Total Weight of Girders
for Girders with Circular Haunches

Fig. 10

DISCUSSION

A trial and error method to determine the optimum end span lengths for girders with circular haunches was used in this study. The digital computer was used to perform routine, tedious calculations. Owing to the truncation and rounding inherent in electronic calculations, a small error in any one operation can easily become a large error in the final result due to the repeated execution of a large number of operations. Fortunately, a stiffness matrix with dominant diagonal terms is generally obtained by the use of the displacement method. The effects of truncating and rounding errors upon the results of calculated values, such as the moment ordinates of the moment diagrams from Computer Program 2, were therefore rather small. These results, with satisfactory accuracy for practical use, can be found in Appendix A.

Study of the tabulated data in Appendix A shows that the negative moment at point B, due to both dead load and live load, increases as the end span length increases. The data also show that the negative moment at point C, due to dead load, decreases as the end span length increases. However, the negative moment at point C, due to live load, increases as the end span length increases. Therefore, these two effects, dead load and live load, tend to offset each other for the negative moment at point C. Table 1 indicates that the maximum negative moment, due to both dead load and live load including impact, will be governed by the moment at point B when the end span length reaches 80 feet. This implies that the maximum negative moment will increase as the end span length increases beyond 80 feet. This is due to the fact that the moment at point B increases as the end span length increases as stated above. On the other hand, when the maximum negative moment occurs at

point C, it will decrease as the end span length increases because the rate of decrement of moment due to dead load is larger than that of increment of moment due to live load including impact. Table 1 also indicates that the maximum positive moment increases rather rapidly when the end span length reaches 80 feet, in the meantime the maximum positive moment will be controlled by the end span instead of the interior span. Furthermore, the slopes of the curves in Fig. 10 will increase after the end span length reaches 80 feet. This implies that the design may be governed by the maximum positive moment rather than the maximum negative moment as the end span length reaches some value beyond 80 feet.

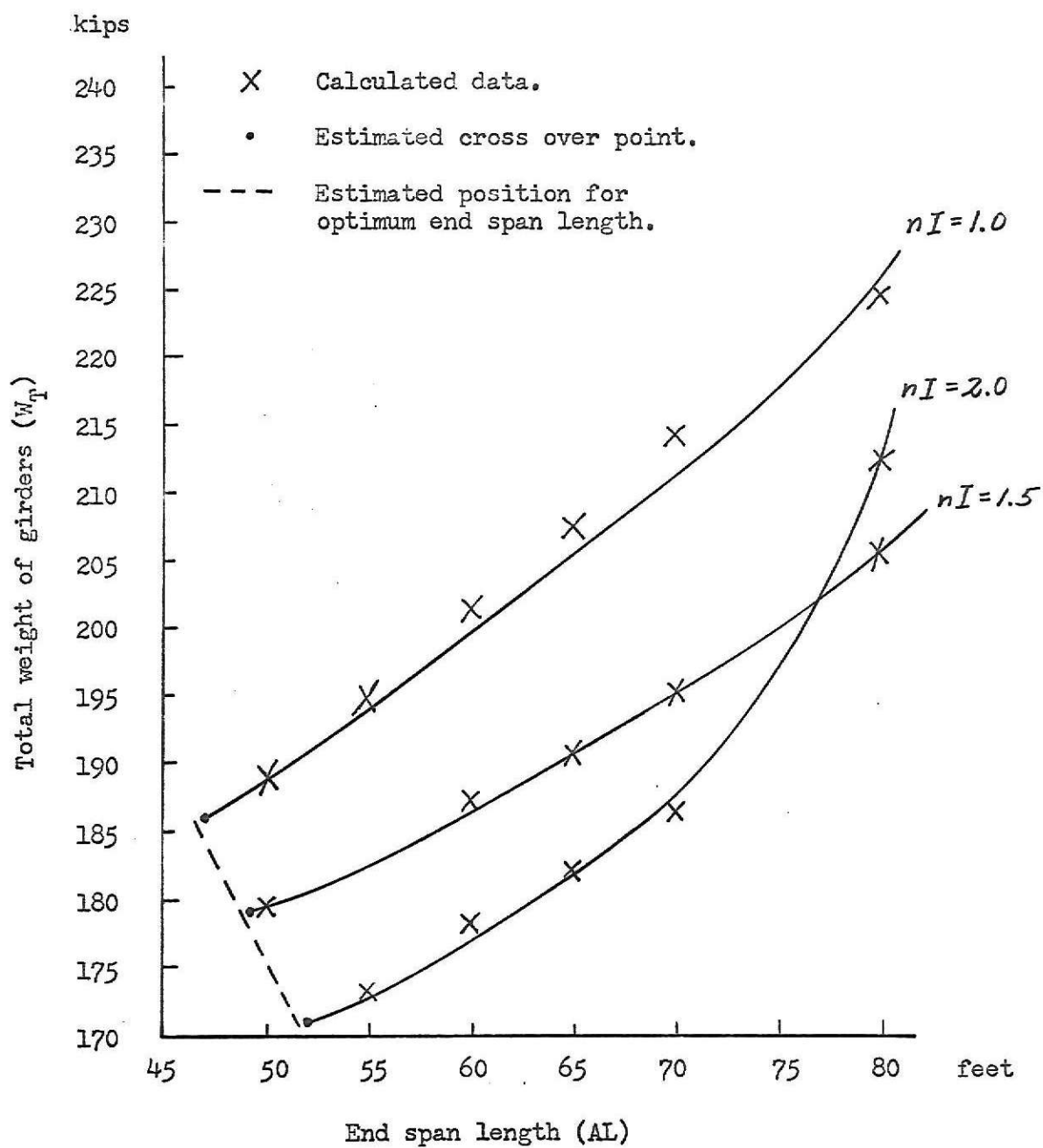
When $nI = 2.0$, $AL = 50'$, a girder with web section $51" \times 5/16"$ and flange section $18.45" \times 1"$ at the interior support was tried and it met the requirements of the AASHO Specifications. However, the weight of this girder section was 171.854 lb/ft which was considerably less than the minimum girder weight, 246.96 lb/ft , for preventing uplift at the abutments and the design was therefore omitted from Table 1. For the same reason, the design for $nI = 2.5$, $AL = 50'$ was omitted.

In order to maintain the symmetric haunch, end span lengths shorter than $50'$ were not tried. In the case of $nI = 1.5$ and $AL = 50'$, $(W_g)_{\min} = 123.66 \text{ lb/ft}$ and the average design weight, W_g , was 186.27 lb/ft . The exact location of the point at which $(W_g)_{\min} = W_g$ was not found, however it can be seen that we are approaching the cross over point where weight rather than stress is the controlling factor. For $nI = 2.0$ and $nI = 2.5$, the design points chosen straddled the cross over points. Thus, the cross over points shown in Fig. 10 were based on the general shapes of the curves.

The optimum end span length was therefore estimated within the range of

55' to 58' as shown by the dashed line in Fig. 10.

Making a study of Reference 2, it can be seen that the optimum end span length, under the action of its constraints, was within the range of 47' to 52'. The average design weight of the girders was around 200 lb/ft as the end span lengths varied from 50' to 80'. However, for the same range of the end span lengths in this study, the average design weight of the girders was about 230 lb/ft. From the point of view of economy, it is obvious that the continuously variable girder section used in this study under the constraints listed in OUTLINE OF THE DESIGN METHOD is not quite as desirable a design as those listed in Reference 2 and shown in Fig. 11. When $nI = 2.0$, $AL = 80'$, the maximum positive moment controlled the design and the girder section over the pier was over designed as stated in Reference 2. However, when $nI = 2.5$, $AL = 80'$ in this study, the design was still controlled by the maximum negative moment. On closer study of the slopes of the curves for $nI = 2.0$, $AL = 80'$ in Fig. 10 and Fig. 11, it seems reasonable that the curve slope in Fig. 11 will become sharper than that in Fig. 10 as the end span length increases beyond 80 feet. Therefore, an advantage in weight might well be gained by using the continuously variable girder section for long span continuous bridges.



End Span Length vs. Total Weight of Girders
for Prismatically Haunched Girders²

Fig. 11

CONCLUSIONS

In order to determine the most economical total structural length, the cost of the structural steel and the reinforced concrete for the superstructure as well as for the substructure would have to be considered. Since this report was confined to working only with the superstructure, the true most economical length of structure was not necessarily found. Study of Fig. 10 does indicate that the range of lengths for which minimum weight girders with no uplift at the abutments were the controlling factor is rather narrow. This range appears to be from approximately 55' to 58'. However, if the quantity of reinforced concrete on the welded girders is taken into consideration, the optimum length may well be somewhat shorter than that indicated above.

In general, bridge girders of continuously variable depth enhance the appearance of the structure, while placing the metal where needed and taking it away where shallower section depth is permissible--thereby saving tons of steel. This is especially true if a long span bridge is used. However, the results obtained under the constraints in this study do not indicate these savings in comparison with the constant depth structures of Reference 2. This probably reflects the fact that the depth to span ratios used for the continuously haunched girders were not as large as they might have been. The 36 inch depth at mid-span was arbitrarily chosen as a reasonable value. However, it appears that a somewhat greater depth at mid-span would have resulted in a more economical girder design. It is doubtful if the minimum total structural length without uplift would change very much if the girder depth were increased slightly. Any change which did occur would be in the direction of increasing the minimum length.

ACKNOWLEDGMENT

The author wishes to express his sincere gratitude and deep appreciation to his major professor, Dr. Robert R. Snell, for his aid, advice, suggestions, and encouragement during the preparation of this report.

NOTATION

A	Total cross sectional area of the plate girder
AL	Length of the end span of the bridge
A_w	Cross sectional area of the web
b_f	Width of the flange
C	Distance from neutral axis to extreme fiber of girder
D	Depth of the web at the interior support
$D.F.$	Lateral load distribution factor
F_b	Allowable bending stress
f_b	Actual bending stress
F_v	Allowable shearing stress
f_v	Actual shearing stress
I	Impact fraction
I_x	Moment of inertia of the girder with respect to x axis
M_B, M_C, M_D	Moments at supports B, C, and D
M_{des}	Moment used for designing the girder section
$(M)_D, (M)_L$	Moments in the span due to dead load and live load
$(M)_{max}$	Maximum moment in the span
$(M)_B^{cr}$	Critical moment at B for minimum reaction at A
$(M)_B^D, (M)_C^D$	Moments at supports B and C, due to dead load
$(M)_B^L, (M)_C^L$	Moments at supports B and C, due to live load
$(M)_B^{max}, (M)_C^{max}$	Maximum moments at supports B and C
nI	Ratio of the moment of inertia of the girder over the piers to that of the girder at mid-span
$(R)_A^{min}$	Minimum reaction at abutment A

t	Thickness of the web
t_f	Thickness of the flange
V_{des}	Shearing force used for designing the girder section
$(V_A)_D, (V_B)_D, (V_C)_D$	Shearing forces at supports A, B, and C, due to dead load
$(V_A)_L, (V_B)_L, (V_C)_L$	Shearing forces at supports A, B, and C, due to live load
$(V_A)_{max}, (V_B)_{max}, (V_C)_{max}$	Maximum shearing forces at supports A, B, and C
W_D	Average dead load in kips/ft
W_g	Weight of girder in kips/ft
$(W_g)_{min}$	Minimum girder weight which will prevent uplift at the abutments
W_L	Uniform live load in kips/ft
W_T	Total girder weight of the bridge

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APPENDIX

Appendix A

Tabular Data

TABLE A-I and TABLE A-II shown below are made for the purpose of explaining the use of the tabulated data. In TABLE A-I, the curve ordinates at the indicated sections for determining the shape of the haunched girder from the interior support to mid-span as well as the ratios of the moments of inertia at the same indicated sections are shown. Also, the moment ordinates for the loading indicated or the ordinates of the influence lines for the moments at the indicated sections are shown in TABLE A-II.

TABLE A-I. POSITION OF CURVE ORDINATES

$\begin{matrix} j \\ i \end{matrix}$	1	2	3	4	5
1	0'	2.5'	5.0'	7.5'	10.0'
2	12.5'	15.0'	17.5'	20.0'	22.5'
3	25.0'	27.5'	30.0'	32.5'	35.0'
4	37.5'	40.0'	42.5'	45.0'	47.5'

Origin at interior support

i : number of row

j : number of column

TABLE A-II. POSITION OF MOMENT ORDINATES

$i \backslash j$	1	2	3	4	5
1	0'	5'	10'	15'	20'
2	25'	30'	35'	40'	45'
3	50'	55'	60'	65'	70'
4	75'	80'	85'	90'	95'
5	100'	105'	110'	115'	120'
6	125'	130'	135'	140'	145'
7	150'	155'	160'	165'	170'
8	175'	180'	185'	190'	195'
9	200'	205'	210'	215'	220'
10	225'	230'	235'	240'	245'
11	250'	255'	260'	265'	270'
12	275'	280'	285'	290'	295'
13	300'	305'	310'	315'	320'
14	325'	330'	335'	340'	345'
15	350'				

Origin at abutment A

i : number of row

j : number of column

For example:

With $nI = 1.5$ find the curve ordinate at the section 30' from the interior support.

From TABLE A-I, it is found that the position of 30' from the interior support is $i = 3$ and $j = 3$. Thus, the result, 37.41", can easily be found in TABLE A-1.

TABLE A-II also can be used by the technique indicated above.

TABLE A-1 (nI = 1.5)

A. RADIUS OF THE CURVES FOR DETERMINING THE SHAPE OF THE HAUNCHED GIRDER

R1 (FT)	R2 (FT)
314.2885	1307.7322

B. CURVE ORDINATES IN INCHES FROM INTERIOR SUPPORT TO MID-SPAN

44.00	43.95	43.69	43.19	42.45
41.63	40.85	40.13	39.47	38.87
38.33	37.84	37.41	37.04	36.72
36.46	36.27	36.12	36.04	36.01

C. MOMENTS OF INERTIA OF THE SECTIONS FROM INTERIOR SUPPORT TO MID-SPAN

1.50	1.49	1.47	1.44	1.39
1.34	1.29	1.24	1.20	1.17
1.13	1.10	1.08	1.06	1.04
1.03	1.01	1.01	1.00	1.00

TABLE A-2 (nI = 2.0)

A. RADII OF THE CURVES FOR DETERMINING THE SHAPE OF THE HAUNCHED GIRDER

R1 (FT)	R2 (FT)
167.7070	697.8180

B. CURVE ORDINATES IN INCHES FROM INTERIOR SUPPORT TO MID-SPAN

51.00	50.91	50.42	49.48	48.09
46.54	45.08	43.74	42.50	41.37
40.35	39.44	38.63	37.93	37.34
36.86	36.48	36.21	36.05	36.00

C. MOMENTS OF INERTIA OF THE SECTIONS FROM INTERIOR SUPPORT TO MID-SPAN

2.00	1.99	1.95	1.88	1.77
1.66	1.56	1.47	1.38	1.31
1.25	1.19	1.14	1.10	1.07
1.04	1.02	1.00	.99	.99

TABLE A-3 (nI = 2.5)

A. RADII OF THE CURVES FOR DETERMINING THE SHAPE OF THE HAUNCHED GIRDER

R1 (FT)	R2 (FT)
119.8735	498.7870

B. CURVE ORDINATES IN INCHES FROM INTERIOR SUPPORT TO MID-SPAN

57.00	56.88	56.19	54.88	52.93
50.75	48.72	46.83	45.10	43.52
42.09	40.81	39.69	38.71	37.88
37.20	36.68	36.30	36.07	36.00

C. MOMENTS OF INERTIA OF THE SECTIONS FROM INTERIOR SUPPORT TO MID-SPAN

2.50	2.49	2.43	2.31	2.15
1.98	1.82	1.68	1.56	1.45
1.36	1.28	1.21	1.15	1.10
1.06	1.03	1.01	1.00	.99

TABLE A-4 (nI = 1.5, AL = 80')

A. INFLUENCE LINE ORDINATES FOR MB

0.0	-1.423477	-2.811279	-4.127243	-5.335556
-6.400391	-7.286133	-7.956787	-8.377441	-8.517578
-8.348877	-7.847900	-7.000000	-5.794281	-4.226730
-2.297211	0.0	-2.325348	-4.285217	-5.888016
-7.136856	-8.039307	-8.609131	-8.865479	-8.836182
-8.551514	-8.047607	-7.363037	-6.538620	-5.615173
-4.632629	-3.627914	-2.634750	-1.682617	-0.796570
0.0	0.688019	1.267807	1.741928	2.111206
2.378036	2.546326	2.621933	2.612885	2.528503
2.379074	2.176331	1.932281	1.659149	1.368484
1.071396	0.777832	0.496521	0.234942	0.0
-0.202621	-0.372864	-0.511215	-0.617676	-0.692581
-0.736847	-0.751801	-0.739517	-0.702377	-0.643188
-0.565033	-0.471024	-0.364345	-0.248170	-0.125668
0.0				

B. INFLUENCE LINE ORDINATES FOR MC

0.0	0.421387	0.832153	1.221710	1.579483
1.894745	2.156967	2.355499	2.480087	2.521500
2.471527	2.323257	2.072159	1.715256	1.251190
0.680054	0.0	-0.788773	-1.667160	-2.611832
-3.597748	-4.595535	-5.571487	-6.489014	-7.308105
-7.989014	-8.490967	-8.774414	-8.804932	-8.551514
-7.986572	-7.090820	-5.850830	-4.258682	-2.311264
0.0	-2.313446	-4.262955	-5.857208	-7.098877
-7.996338	-8.562500	-8.816650	-8.786133	-8.502197
-8.000000	-7.318359	-6.497650	-5.578979	-4.601517
-3.602509	-2.615463	-1.669632	-0.790024	0.0
0.681320	1.253769	1.719025	2.076920	2.328796
2.477631	2.527878	2.486557	2.361740	2.162735
1.899857	1.583786	1.225128	0.834473	0.422555
0.0				

TABLE A-5 (nI = 1.5, AL = 80')

A. MOMENT AT POINT J DUE TO A UNIT LOAD AT J			
0.0	4.598048	8.396700	11.409507
15.176716	16.003296	16.188446	15.791504
13.508789	11.770020	9.732178	7.469727
2.532440	0.0	2.491760	4.933838
9.382324	11.262207	12.842773	14.072754
15.349121	15.343994	14.933838	14.081543
11.279053	9.395996	7.275391	4.952148
0.0	2.502487	4.952881	7.276367
11.288086	12.866943	14.093018	14.937988
15.346680	14.927979	14.068848	12.840576
9.376465	7.252197	4.934326	2.492935
2.531403	5.047852	7.475830	9.745117
13.530273	14.893311	15.811279	16.205917
15.187123	13.665958	11.413614	8.398585
0.0			
			13.658970
			14.872314
			5.046387
			7.252441
			14.923096
			12.857178
			2.503387
			9.407715
			15.357422
			11.258545
			0.0
			11.781982
			16.017273
			4.598525

B. MOMENT ORDINATES DUE TO A UNIT UNIFORM DEAD LOAD			
0.0	134.645996	244.291992	328.937988
423.229980	432.875977	417.521973	377.311035
221.588531	106.490875	-33.977859	-199.052078
-604.510742	-844.578613	-615.688477	-411.880127
-79.192703	49.600250	153.194000	232.268219
314.994629	318.854004	297.908691	251.709625
84.736969	-36.110672	-181.911453	-352.962158
-769.649658	-548.661865	-352.766846	-181.774734
84.920563	180.951813	251.850250	297.998535
314.811035	286.100098	231.912750	152.944000
-79.657547	-233.438797	-412.415283	-616.166992
-604.540039	-389.223877	-198.860672	-33.532547
222.158844	312.436035	377.752441	418.008301
423.577148	388.861816	329.146240	244.430939
0.0			
			388.583984
			312.029785
			-389.403564
			-233.063797
			286.221191
			180.924469
			-548.821777
			-35.845047
			318.975098
			49.205719
			-845.005592
			106.639313
			433.292725
			134.715576

TABLE A-6 (nI = 1.5, AL = 80')

A. MOMENT ORDINATES DUE TO A UNIT UNIFORM LIVE LOAD IN SPANS AB AND CD					
0.0	169.403687	313.807373	433.210938	527.614746	
597.018311	641.422119	660.825684	655.229004	624.604004	
569.104004	488.729004	383.166504	253.170563	98.283844	
-82.208328	-287.114502	-291.988281	-296.714844	-301.500000	
-306.355469	-311.062500	-316.062500	-320.937500	-326.437500	
-331.312500	-336.062500	-341.875000	-346.312500	-351.937500	
-357.062500	-362.386719	-368.492188	-374.015625	-379.503906	
-385.296875	-169.680984	20.955719	186.416656	327.104004	
442.541504	533.166504	598.791504	639.916504	655.729004	
645.979004	612.729004	552.979004	469.416504	360.354004	
226.479156	68.416656	-115.165359	-323.622314	-556.923096	
-522.085938	-487.429688	-452.660156	-417.765625	-382.832031	
-348.210938	-313.406250	-278.714844	-243.828857	-208.996170	
-174.163483	-139.330795	-104.498093	-69.665405	-34.832718	
-0.000015					

B. MAX. MOMENT FOR MB DUE TO UNIT UNIFORM LIVE LOAD

MB	MC	MD
-997.966309	-253.985672	-326.871094

C. MAX. MOMENT FOR MC DUE TO UNIT UNIFORM LIVE LOAD

MB	MC	MD
-365.367188	-1030.728760	-365.020752

TABLE A-7 (nI = 1.5, AL = 70')

A. INFLUENCE LINE ORDINATES FOR MB

0.0	-1.316864	-2.589783	-3.774292	-4.826492
-5.702133	-6.358398	-6.755127	-6.856445	-6.631104
-6.055603	-5.113602	-3.794296	-2.093353	0.0
-2.500854	-4.608154	-6.331024	-7.672852	-8.642090
-9.252930	-9.526611	-9.493164	-9.185791	-8.642090
-7.904602	-7.017288	-6.024399	-4.968185	-3.888885
-2.822754	-1.801544	-0.852264	0.0	0.734619
1.352158	1.855469	2.245605	2.525497	2.699585
2.774200	2.758453	2.662598	2.498215	2.278015
2.015198	1.723129	1.414444	1.101257	0.794373
0.503292	0.235983	0.0	-0.198523	-0.359881
-0.485075	-0.574524	-0.629227	-0.650696	-0.641113
-0.603485	-0.541229	-0.458130	-0.358264	-0.245820
-0.125009	0.0			

B. INFLUENCE LINE ORDINATES FOR MC

0.0	0.392186	0.771255	1.124039	1.437408
1.698288	1.893738	2.011902	2.042114	1.974976
1.803513	1.522919	1.130020	0.623428	0.0
-0.741302	-1.581131	-2.495804	-3.459991	-4.444000
-5.413681	-6.331055	-7.156738	-7.848877	-8.365479
-8.666748	-8.716309	-8.481934	-7.935303	-7.056396
-5.830734	-4.249374	-2.308838	0.0	-2.310852
-4.253448	-5.836655	-7.064194	-7.944824	-8.492188
-8.727295	-8.677734	-8.376465	-7.859131	-7.166290
-6.339417	-5.420502	-4.449417	-3.464264	-2.498947
-1.583252	-0.742371	0.0	0.624496	1.132141
1.525955	1.807343	1.979340	2.046844	2.016769
1.898453	1.702606	1.441177	1.127045	0.773300
0.393241	0.0			

TABLE A-8 (nI = 1.5, AL = 70')

A. MOMENT AT POINT J DUE TO A UNIT LOAD AT J			
0.0	4.548056	8.198565	10.970703
14.020020	14.398926	14.103760	13.205078
9.946045	7.760742	5.315186	2.697983
2.327881	4.654297	6.898438	8.988770
12.452637	13.713867	14.606445	15.082764
14.769043	13.961182	12.776855	11.229248
7.263428	4.947998	2.502777	0.0
4.948730	7.263916	9.380615	11.238525
13.973633	14.772217	15.142334	15.079834
13.709473	12.450195	10.854736	8.981934
4.654053	2.328674	0.0	2.697327
7.766357	9.957031	11.802246	13.224365
14.414551	14.032959	12.905210	10.976059
4.548685	0.0		
			12.896250
			11.791748
			0.0
			10.859131
			15.129883
			9.367920
			2.501877
			12.785400
			14.611572
			6.896484
			5.315918
			14.120361
			8.201035

B. MOMENT ORDINATES DUE TO A UNIT UNIFORM DEAD LOAD			
0.0	109.855804	194.711609	254.567383
299.278809	284.080566	244.049469	178.975250
-26.110672	-166.173172	-331.198486	-521.156494
-516.144287	-321.153564	-151.138016	-6.141927
208.694000	278.666504	323.908691	343.807129
309.432129	254.256516	174.486969	69.772125
-214.462234	-394.473877	-599.083984	-828.696777
-394.208252	-214.442703	-59.641922	70.002594
254.498703	309.350098	339.252441	343.709473
278.455566	208.565094	113.471344	-6.606771
-321.583252	-516.476563	-736.356445	-521.167236
-165.989578	-25.860672	89.147125	179.358063
284.447754	299.543701	289.634766	254.726227
109.908752	0.0		
			289.423096
			88.944000
			-736.170654
			113.619781
			338.885254
			-60.200516
			-598.904053
			174.529938
			323.979004
			-151.470047
			-331.131836
			244.404938
			194.817490

TABLE A-9 (nI = 1.5, AL = 70')

A. MOMENT COORDINATES DUE TO A UNIT UNIFORM LIVE LOAD IN SPANS AB AND CD

0.0	151.644897	278.289795	379.934570	456.579590
508.224365	534.830566	536.689941	513.576660	465.225098
392.346191	294.494629	171.217438	23.326813	-149.532547
-163.246094	-176.941406	-190.652344	-204.207031	-217.781250
-231.605469	-245.324219	-259.500000	-273.187500	-286.875000
-301.250000	-314.812500	-329.000000	-343.019531	-356.808594
-372.031250	-385.832031	-400.277344	-414.738281	-199.134109
-8.454427	157.104156	297.729004	413.416504	503.916504
569.666504	610.729004	626.416504	616.791504	583.729004
523.854004	440.291504	331.416504	197.416656	39.342438
-144.430984	-352.852783	-586.114502	-544.238281	-502.457031
-460.761719	-418.757813	-376.777344	-335.125000	-293.152344
-251.234375	-209.404297	-167.523453	-125.642593	-83.761734
-41.880875	-0.000031			

B. MAX. MOMENT FOR MB DUE TO UNIT UNIFORM LIVE LOAD

MB	MC	MD
-897.469971	-321.360596	-179.710938

C. MAX. MOMENT FOR MC DUE TO UNIT UNIFORM LIVE LOAD

MB	MC	MD
-395.867188	-1014.102783	-395.583252

TABLE A-10 (nI = 1.5, AL = 60')

A. INFLUENCE LINE ORDINATES FOR MB

0.0	-1.189331	-2.323074	-3.345505	-4.201889
-4.839890	-5.211746	-5.274323	-4.993347	-4.342422
-3.302246	-1.860504	0.0	-2.701309	-4.976959
-6.836899	-8.284760	-9.329712	-9.987534	-10.281464
-10.242676	-9.908432	-9.319550	-8.521469	-7.562332
-6.489655	-5.349426	-4.185059	-3.035965	-1.936218
-0.915146	0.0	0.787033	1.446671	1.982285
2.395279	2.688812	2.868179	2.940598	2.916275
2.806580	2.624359	2.383743	2.099380	1.785858
1.457275	1.126755	0.806168	0.505778	0.234329
0.0	-0.190547	-0.338220	-0.444805	-0.511547
-0.540377	-0.534019	-0.495950	-0.430589	-0.342854
-0.238084	-0.121902	0.0		

B. INFLUENCE LINE ORDINATES FOR MC

0.0	0.356654	0.696609	1.003220	1.260010
1.451385	1.562912	1.581726	1.497421	1.302200
0.990295	0.557983	0.0	-0.686325	-1.481461
-2.361450	-3.300522	-4.268646	-5.230942	-6.149185
-6.981689	-7.687012	-8.220215	-8.542236	-8.613281
-8.401367	-7.876465	-7.016846	-5.807205	-4.238541
-2.306030	0.0	-2.307968	-4.242432	-5.813019
-7.024200	-7.885010	-8.411133	-8.623535	-8.552246
-8.230713	-7.696289	-6.990616	-6.156494	-5.237076
-4.273453	-3.304169	-2.364090	-1.483246	-0.687195
0.0	0.558792	0.991882	1.304459	1.500153
1.584717	1.566055	1.454453	1.262772	1.005493
0.698212	0.357472	0.0		

TABLE A-11 (nI = 1.5, AL = 60')

A. MOMENT AT POINT J DUE TO A UNIT LOAD AT J			
0.0	4.483048	7.941686	10.404312
12.549316	12.376465	11.491211	9.991455
5.578262	2.876877	0.0	2.140915
6.494385	8.540283	10.399658	12.009521
14.247314	14.781738	14.887939	14.581055
12.685059	11.173828	9.338379	7.249268
2.502197	0.0	2.501389	4.944580
9.350342	11.183350	12.694824	13.840088
14.900146	14.775879	14.254639	13.305420
10.395264	8.531738	6.492676	4.333984
0.0	2.876419	5.578918	7.990967
11.499023	12.388916	12.559570	11.929443
7.944839	4.483877	0.0	10.410965
			11.919434
			7.985840
			4.334717
			13.307861
			13.828125
			4.943848
			7.250244
			14.586182
			12.004395
			2.141251
			10.000000
			10.410965
B. MOMENT COORDINATES DUE TO A UNIT UNIFORM DEAD LOAD			
0.0	82.625427	140.250854	172.876221
163.162750	120.822906	53.486969	-38.824539
-298.441895	-465.715332	-658.034668	-444.395752
-92.087234	46.467438	159.865875	248.580719
351.088379	364.967285	353.318848	317.443848
169.920563	58.811188	-77.391922	-238.020828
-635.309570	-871.295898	-635.112305	-424.071533
-76.841141	59.194000	170.108063	256.342285
353.740723	364.639160	351.256348	312.318848
159.819000	46.111969	-92.356766	-256.106689
-658.094971	-465.683594	-298.411865	-156.076981
53.580719	120.951813	163.279938	180.622688
140.306656	82.653336	0.000015	172.959961
			180.533844
			-156.111160
			-255.766922
			311.924316
			256.201660
			-424.438721
			-237.981766
			317.576660
			248.358063
			-444.614502
			-38.708328
			172.959961

TABLE A-12 (nI = 1.5, AI = 60°)

A. MOMENT ORDINATES DUE TO A UNIT UNIFORM LIVE LOAD IN SPANS AB AND CD

O.O	134.299927	243.599854	327.899658	387.275879
421.627441	431.111816	415.662598	375.143066	309.857910
219.514313	104.225250	-36.032547	-56.878906	-77.718750
-98.562500	-119.359375	-140.140625	-160.890625	-181.835938
-202.824219	-223.898438	-244.523438	-266.054688	-286.679688
-307.875000	-329.007813	-350.105469	-371.984375	-393.011719
-414.507813	-436.000000	-221.040359	-31.106766	133.717438
273.541504	388.416504	478.479004	543.354004	583.604004
598.604004	588.354004	554.479004	494.166504	409.229004
299.791504	165.041656	6.225261	-178.329422	-387.536377
-621.673096	-569.789063	-518.000000	-466.285156	-414.347656
-362.457031	-310.718750	-258.820313	-207.152344	-155.335205
-103.556808	-51.778412	-0.000015		

B. MAX. MOMENT FOR MB DUE TO UNIT UNIFORM LIVE LOAD

MB	MC	MD
-827.766846	-373.630127	-57.500000

C. MAX. MOMENT FOR MC DUE TO UNIT UNIFORM LIVE LOAD

MB	MC	MD
-431.195313	-994.863770	-431.032471

TABLE A-13 (nI = 1.5, AL = 50')

A. INFLUENCE LINE ORDINATES FOR MB

0.0	-1.037582	-2.003052	-2.826202	-3.440872
-3.786545	-3.812347	-3.476181	-2.745422	-1.596100
0.0	-2.929382	-5.396423	-7.412140	-8.980362
-10.111328	-10.822235	-11.138107	-11.093536	-10.721755
-10.087585	-9.220642	-8.179459	-7.015900	-5.747212
-4.519226	-3.276001	-2.087570	-0.985703	0.0
0.845398	1.551529	2.122284	2.559494	2.826898
3.050659	3.119095	3.083481	2.956833	2.743479
2.489197	2.180237	1.842850	1.492554	1.142860
0.809781	0.501517	0.228605	0.0	-0.177100
-0.304631	-0.385723	-0.423036	-0.420195	-0.381838
-0.313629	-0.222291	-0.115156	0.0	

B. INFLUENCE LINE ORDINATES FOR MC

0.0	0.313698	0.605545	0.854385	1.040207
1.144730	1.152527	1.050903	0.830017	0.48259
0.0	-0.622955	-1.366638	-2.206696	-3.116909
-4.067001	-5.021088	-5.939957	-6.781250	-7.501221
-8.054932	-8.399658	-8.496338	-8.310059	-7.809570
-6.972168	-5.781509	-4.226837	-2.303223	0.0
-2.304169	-4.228714	-5.784225	-6.975983	-7.813721
-8.314697	-8.501221	-8.404297	-8.059082	-7.504883
-6.784363	-5.942123	-5.022598	-4.067871	-3.117538
-2.207031	-1.366928	-0.623077	0.0	0.482681
0.830292	1.051300	1.153015	1.145248	1.040741
0.854828	0.605865	0.313848	0.0	

TABLE A-14 (nI = 1.5, AL = 50')

A. MOMENT AT POINT J DUE TO A UNIT LOAD AT J			
0.0	4.396042	7.597748	9.649170
10.601807	9.707031	8.063721	5.802063
0.0	1.928314	3.971680	6.034424
9.879150	11.508057	12.845703	13.845459
14.616455	14.373535	13.680176	12.582031
9.305176	7.233398	4.938477	2.501312
2.501236	4.940430	7.235840	9.316162
12.591553	13.686768	14.373047	14.623291
13.843262	12.838623	11.500000	9.870605
6.032715	3.970612	1.928329	0.0
5.802155	8.065186	9.710693	10.604248
9.649658	7.598419	4.396408	0.0
			10.613652
			3.062058
			8.030018
			14.441000
			11.111072
			0.0
			11.111029
			14.434014
			8.020096
			3.062053
			10.671582

B. MOMENT ORDINATES DUE TO A UNIT UNIFORM DEAD LOAD			
0.0	51.426651	77.857819	79.301483
7.153728	-66.415848	-164.993484	-288.563721
-610.774658	-400.954346	-216.184891	-56.360672
187.854156	272.686035	332.479004	367.842285
362.018066	322.549316	257.396973	167.178375
-87.700516	-252.298172	-442.497314	-657.237061
-657.027344	-442.180908	-252.239578	-87.290359
167.361969	257.354004	322.479004	362.385254
367.572754	332.400879	272.514160	187.924469
-56.583328	-216.411453	-400.977783	-610.626221
-288.458252	-164.907547	-66.307205	7.221599
79.334915	77.905670	51.451324	0.000015
			55.714996
			-437.118164
			78.233063
			377.525879
			52.264313
			-897.035400
			52.565094
			377.330566
			77.986969
			-436.978027
			55.798737

TABLE A-15 (nI = 1.5, AL = 50')

A. MOMENT ORDINATES DUE TO A UNIT UNIFORM LIVE LOAD IN SPANS AB AND CD

0.0	117.815094	210.623688	278.424316	321.240723
339.100098	331.865723	299.861816	242.733063	160.670563
53.654938	27.375000	1.125000	-25.156250	-51.410156
-77.601563	-103.894531	-130.105469	-156.628906	-182.875000
-209.195313	-235.843750	-261.984375	-288.515625	-314.972656
-341.527344	-368.496094	-395.011719	-421.832031	-448.652344
-235.294266	-46.934891	116.283844	254.416672	367.854004
456.229004	519.604004	558.354004	571.729004	559.979004
524.229004	462.479004	376.291504	264.979004	128.904938
-31.430984	-217.692703	-428.317627	-664.122314	-597.601563
-531.175781	-464.796875	-398.308594	-331.957031	-265.511719
-199.097656	-132.761719	-66.417969	-0.000015	

B. MAX. MOMENT FOR MB DUE TO UNIT UNIFORM LIVE LOAD

MB	MC	MD
-789.212158	-410.684814	39.632813

C. MAX. MOMENT FOR MC DUE TO UNIT UNIFORM LIVE LOAD

MB	MC	MD
-472.097656	-972.532715	-471.899658

TABLE A-16 (nI = 2.0, AL = 80')

A. INFLUENCE LINE ORDINATES FOR MB

0.0	-1.579300	-3.117157	-4.572006	-5.902100
-7.066406	-8.022949	-8.730469	-9.148926	-9.243652
-8.988525	-8.371338	-7.388184	-6.045654	-4.357300
-2.339615	0.0	-2.333801	-4.347977	-6.038086
-7.391846	-8.400146	-9.060547	-9.382813	-9.385498
-9.100342	-8.566650	-7.830566	-6.940918	-5.946701
-4.895523	-3.828796	-2.781326	-1.780716	-0.847504
0.0	0.745865	1.389572	1.929733	2.362167
2.684204	2.895340	2.998108	2.998962	2.907745
2.737228	2.502014	2.217819	1.900314	1.564484
1.223663	0.888947	0.569138	0.270884	0.0
-0.238413	-0.444000	-0.616013	-0.752747	-0.852844
-0.915695	-0.941589	-0.931915	-0.889267	-0.817154
-0.719727	-0.601151	-0.465637	-0.317467	-0.160843
0.0				

B. INFLUENCE LINE ORDINATES FOR MC

0.0	0.504715	0.996170	1.461090	1.886246
2.258377	2.564117	2.790268	2.924026	2.954208
2.872864	2.675522	2.361252	1.932190	1.392593
0.747772	0.0	-0.849594	-1.784973	-2.787903
-3.837555	-4.906464	-5.959473	-6.955322	-7.846436
-8.584229	-9.118896	-9.404541	-9.401611	-9.078857
-8.416748	-7.406738	-6.050293	-4.356461	-2.338287
0.0	-2.335281	-4.350723	-6.042023	-7.396484
-8.405029	-9.065674	-9.387939	-9.390625	-9.104980
-8.571045	-7.834473	-6.944580	-5.950317	-4.898682
-3.831543	-2.783585	-1.782211	-0.848236	0.0
0.746536	1.390244	1.928818	2.356934	2.670425
2.867203	2.948273	2.918015	2.784393	2.558701
2.253540	1.882294	1.458038	0.994080	0.503647
0.0				

TABLE A-17 (nI = 2.0, AL = 80')

A. MOMENT AT POINT J DUE TO A UNIT LOAD AT J				
0.0	4.588540	8.359375	11.328111	13.520822
14.973911	15.734325	15.859403	15.418701	14.480469
13.125732	11.428711	9.457764	7.273438	4.936035
2.493530	0.0	2.480881	4.869873	7.107666
9.145752	10.946777	12.449951	13.625000	14.430908
14.841553	14.842529	14.430908	13.626221	12.442871
10.938721	9.139404	7.098389	4.861816	2.476379
0.0	2.479874	4.867676	7.104004	9.141602
10.943848	12.444092	13.618408	14.424805	14.833496
14.835938	14.425537	13.623291	12.442627	10.943115
9.143555	7.103271	4.865723	2.478745	0.0
2.495712	4.939697	7.277832	9.458252	11.428955
13.121826	14.470703	15.405518	15.849609	15.726307
14.967898	13.516744	11.325707	8.358276	4.588261
0.0				

B. MOMENT ORDINATES DUE TO A UNIT UNIFORM DEAD LOAD				
0.0	131.473236	237.946289	319.419678	375.892822
407.365967	413.839355	395.312500	351.967285	283.311035
190.268219	71.447906	-71.825516	-240.282547	-433.981689
-652.372314	-895.796387	-665.052490	-459.390869	-278.716064
-123.091141	7.643229	113.147125	193.877594	249.490875
280.186035	285.740723	266.408691	222.229156	152.467438
58.361969	-61.075516	-205.575516	-375.016846	-569.416016
-788.765869	-569.292236	-374.923096	-205.532547	-61.161453
58.330719	152.389313	222.033844	266.221191	285.654785
280.225098	249.389313	193.912750	113.272125	7.651042
-122.899734	-278.598877	-459.312012	-664.899658	-895.550049
-652.055908	-433.622314	-240.239578	-71.845047	71.526031
189.807281	283.127441	351.580566	395.091553	413.649902
407.208252	375.766602	319.324951	237.883301	131.441650
0.0				

TABLE A-18 (nI = 2.0, AL = 80')

A. MOMENT ORDINATES DUE TO A UNIT UNIFORM LIVE LOAD IN SPANS AB AND CD

0.0	168.574600	312.149170	430.723633	524.298340
592.872803	636.447510	655.021973	648.854004	617.229004
561.166504	479.854004	373.729004	242.229156	85.936188
-95.641922	-301.778564	-306.484375	-311.621094	-316.312500
-320.812500	-326.375000	-331.062500	-335.937500	-341.062500
-345.937500	-350.750000	-355.687500	-360.750000	-365.000000
-370.187500	-374.750000	-379.593750	-384.199219	-388.687500
-393.816406	-179.266922	10.346354	174.541656	313.604004
428.916504	517.791504	582.354004	621.729004	636.166504
625.791504	590.104004	529.729004	443.791504	333.666504
197.854156	37.166656	-148.430984	-359.227783	-594.692627
-557.312500	-520.093750	-482.828125	-445.480469	-408.210938
-370.898438	-333.527344	-296.578125	-259.374756	-222.321228
-185.267700	-148.214172	-111.160629	-74.107101	-37.053574
-0.000244				

B. MAX. MOMENT FOR MB DUE TO UNIT UNIFORM LIVE LOAD

MB	MC	MD
-1070.187744	-242.778641	-349.484375

C. MAX. MOMENT FOR MC DUE TO UNIT UNIFORM LIVE LOAD

MB	MC	MD
-371.335938	-1092.788818	-371.555908

TABLE A-19 (nI = 2.0, AL = 70')

A. INFLUENCE LINE ORDINATES FOR MB

0.0	-1.456360	-2.861359	-4.163101	-5.310226
-6.251221	-6.935791	-7.318848	-7.364746	-7.050293
-6.364746	-5.307678	-3.887466	-2.116837	0.0
-2.529114	-4.711349	-6.541946	-8.007324	-9.097412
-9.811279	-10.157227	-10.157715	-9.845947	-9.265625
-8.466309	-7.501221	-6.423752	-5.285461	-4.131332
-2.999084	-1.918732	-0.912369	0.0	0.801178
1.490753	2.067398	2.526688	2.866104	3.085251
3.187531	3.180176	3.074371	2.884415	2.626556
2.318359	1.976883	1.618729	1.258423	0.907974
0.576828	0.272074	0.0	-0.233857	-0.429449
-0.586380	-0.703125	-0.778870	-0.813553	-0.808456
-0.766174	-0.690521	-0.586594	-0.459839	-0.316051
-0.160869	0.0			

B. INFLUENCE LINE ORDINATES FOR MC

0.0	0.469055	0.921539	1.340836	1.710327
2.013458	2.233948	2.357300	2.372131	2.270905
2.050018	1.709503	1.252075	0.681839	0.0
-0.793243	-1.681778	-2.647324	-3.669144	-4.719803
-5.763916	-6.759521	-7.658691	-8.410156	-8.964111
-9.272461	-9.293701	-8.995117	-8.356201	-7.366455
-6.026855	-4.345718	-2.335449	0.0	-2.332642
-4.340378	-6.019226	-7.356934	-8.345459	-8.983154
-9.281006	-9.259766	-8.951660	-8.398926	-7.647949
-6.750244	-5.755981	-4.713120	-3.664001	-2.643707
-1.679581	-0.792221	0.0	0.680939	1.250473
1.707291	2.047287	2.267746	2.368774	2.354004
2.230728	2.010574	1.707901	1.338959	0.920273
0.468414	0.0			

TABLE A-21 ($nI = 2.0$, $AL = 70'$)

A. MOMENT ORDINATES DUE TO A UNIT UNIFORM LIVE LOAD IN SPANS AB AND CD			
0.0	151.811066	278.622070	380.433105
509.055176	535.928223	537.736816	514.615723
393.650879	295.350098	171.838531	23.627594
-164.085938	-179.019531	-193.679688	-208.195313
-237.847656	-252.562500	-267.437500	-281.937500
-311.625000	-326.250000	-340.812500	-355.546875
-384.753906	-399.101563	-413.597656	-428.488281
-24.095047	140.041656	279.604004	394.604004
548.291504	587.979004	602.416504	591.979004
496.354004	410.416504	300.479004	164.541656
-181.427078	-392.036377	-627.309814	-582.464844
-492.925781	-448.039063	-403.250000	-358.296875
-268.574219	-223.883301	-179.106644	-134.329987
-44.776672	-0.000015		
B. MAX. MOMENT FOR MB DUE TO UNIT UNIFORM LIVE LOAD			
MB	MC	MD	
-960.634033	-321.927002	-186.042969	
C. MAX. MOMENT FOR MC DUE TO UNIT UNIFORM LIVE LOAD			
MB	MC	MD	
-406.285156	-1072.552002	-406.337158	

457.244141
466.357910
-149.403641
-223.265625
-297.125000
-370.011719
-213.864578
483.854004
556.541504
4.256511
-537.750000
-313.390625
-89.553329

TABLE A-22 (nI = 2.0, AL = 60')

A. INFLUENCE LINE ORDINATES FOR MB

0.0	-1.303574	-2.541641	-3.648514	-4.559586
-5.214951	-5.563965	-5.569580	-5.207901	-4.468140
-3.350601	-1.861633	0.0	-2.752975	-5.127548
-7.118698	-8.711441	-9.895264	-10.669189	-11.042969
-11.040039	-10.697266	-10.062744	-9.190674	-8.139099
-6.966354	-5.728363	-4.474487	-3.245743	-2.074646
-0.985535	0.0	0.863174	1.603745	2.220413
2.708801	3.066132	3.292709	3.392593	3.374115
3.250229	3.037048	2.752731	2.416824	2.048477
1.665878	1.284988	0.918900	0.577789	0.269229
0.0	-0.223866	-0.402897	-0.537276	-0.626236
-0.669739	-0.669052	-0.627045	-0.548229	-0.438686
-0.305593	-0.156745	0.0		

B. INFLUENCE LINE ORDINATES FOR MC

0.0	0.423492	0.825684	1.185272	1.481277
1.694229	1.807648	1.809479	1.691940	1.451599
1.088547	0.604858	0.0	-0.727463	-1.561203
-2.483032	-3.472305	-4.501648	-5.535599	-6.531006
-7.438965	-8.207031	-8.783203	-9.118164	-9.167480
-8.897461	-8.285400	-7.319092	-5.999512	-4.332977
-2.332031	0.0	-2.329529	-4.328110	-5.992523
-7.310791	-8.275635	-8.886963	-9.156250	-9.106934
-8.772461	-8.197021	-7.429688	-6.522949	-5.528702
-4.496017	-3.468170	-2.480148	-1.559525	-0.726669
0.0	0.604233	1.087463	1.450165	1.690216
1.807648	1.805817	1.692459	1.479752	1.184036
0.824829	0.423050	0.0		

TABLE A-23 ($nI = 2.0$, $AL = 60'$)

A. MOMENT AT POINT J DUE TO A UNIT LOAD AT J				
0.0	4.474525	7.909103	10.336685	11.812988
12.407959	12.218994	11.333740	9.861328	7.897949
5.540390	2.876205	0.0	2.090378	4.195801
6.246582	8.180664	9.951416	11.483887	12.732666
13.644287	14.178711	14.309570	14.022949	13.330566
12.244629	10.815918	9.072266	7.067871	4.852051
2.475082	0.0	2.477982	4.857178	7.072754
9.073975	10.820557	12.246094	13.324951	14.017822
14.302734	14.174805	13.640625	12.734619	11.477295
9.949463	8.181152	6.243896	4.193604	2.089417
0.0	2.877380	5.543213	7.901367	9.864014
11.336426	12.215576	12.406982	11.811768	10.336777
7.909134	4.474536	0.0		

B. MOMENT ORDINATES DUE TO A UNIT UNIFORM DEAD LOAD				
0.0	79.904861	134.809723	164.714355	169.639313
149.526031	104.444000	34.368561	-60.727371	-180.833328
-325.842041	-495.987305	-691.058105	-477.430908	-288.657471
-124.997391	13.526042	127.123688	215.772125	279.428223
318.021973	331.674316	320.424316	284.010254	222.760406
136.123688	24.686188	-111.610672	-273.110596	-459.598877
-671.056885	-907.424316	-670.905029	-459.512939	-273.130127
-111.751297	24.779938	136.053375	222.338531	283.713379
320.178223	331.650879	317.947754	279.521973	215.713531
127.307281	13.576823	-125.145828	-288.809814	-477.438721
-690.989502	-495.830566	-325.794189	-180.698318	-60.620682
34.451813	104.479156	149.565094	169.647125	164.734131
134.822769	79.911392	0.000015		

TABLE A-24 (nI = 2.0, AL = 60')

A. MOMENT ORDINATES DUE TO A UNIT UNIFORM LIVE LOAD IN SPANS AB AND CD

0.0	135.507660	246.015137	331.522949	392.100098
427.557129	438.225098	423.658691	384.209473	319.689941
230.166656	115.686188	-23.606766	-46.242188	-69.027344
-91.683594	-114.203125	-137.101563	-159.582031	-182.210938
-204.902344	-227.609375	-250.289063	-272.929688	-295.570313
-317.839844	-340.683594	-363.242188	-385.621094	-408.050781
-430.593750	-453.367188	-239.516922	-50.595047	112.916656
251.416656	365.729004	454.166504	517.854004	556.604004
570.354004	559.041504	522.854004	461.854004	374.979004
264.166504	127.729156	-33.473953	-220.052078	-431.321533
-667.512939	-611.792969	-556.238281	-500.648438	-444.964844
-389.359375	-333.566406	-277.925781	-222.406250	-166.802734
-111.201828	-55.600922	-0.000015		

B. MAX. MOMENT FOR MB DUE TO UNIT UNIFORM LIVE LOAD

MB	MC	MD
-885.270752	-383.266846	-49.695313

C. MAX. MOMENT FOR MC DUE TO UNIT UNIFORM LIVE LOAD

MB	MC	MD
-447.058594	-1048.916504	-447.079346

TABLE A-25 (nI = 2.0, AL = 50')

A. INFLUENCE LINE ORDINATES FOR MB

0.0	-1.115234	-2.144852	-3.006821	-3.627609
-3.947830	-3.923508	-3.527191	-2.744934	-1.572815
0.0	-3.006500	-5.598816	-7.771454	-9.508316
-10.797989	-11.638962	-12.042725	-12.035400	-11.657242
-10.961090	-10.006088	-8.855988	-7.575195	-6.224594
-4.858215	-3.521011	-2.248291	-1.066772	0.0
0.931549	1.727722	2.387543	2.906403	3.281708
3.514175	3.608948	3.575897	3.429764	3.188812
2.873932	2.506622	2.108490	1.699738	1.297897
0.917252	0.568751	0.260563	0.0	-0.206415
-0.360229	-0.462864	-0.514864	-0.518039	-0.476018
-0.394554	-0.281460	-0.146350	0.0	

B. INFLUENCE LINE ORDINATES FOR MC

0.0	0.365845	0.703613	0.986343	1.190002
1.295029	1.287079	1.157089	0.900513	0.516022
0.0	-0.651382	-1.421844	-2.293060	-3.244781
-4.249435	-5.271332	-6.266602	-7.184814	-7.971680
-8.573730	-8.939453	-9.021729	-8.784668	-8.203369
-7.264893	-5.967773	-4.318451	-2.328232	0.0
-2.325790	-4.313797	-5.961151	-7.256592	-8.193848
-8.774414	-9.010986	-8.928955	-8.563965	-7.962158
-7.175781	-6.258636	-5.264557	-4.244049	-3.240677
-2.290253	-1.420197	-0.650589	0.0	0.515411
0.899475	1.155746	1.285629	1.293533	1.188583
0.985214	0.702789	0.365419	0.0	

TABLE A-26 (nI = 2.0, AL = 50')

A. MOMENT AT POINT J DUE TO A UNIT LOAD AT J				
0.0	4.388718	7.571198	9.597168	10.549072
10.525879	9.645752	8.030029	5.803421	3.083954
0.0	1.854279	3.789307	5.726318	7.600098
9.353027	10.903809	12.196533	13.173584	13.782471
13.990967	13.780518	13.156494	12.128418	10.744873
9.034180	7.051270	4.846924	2.474503	0.0
2.477280	4.851074	7.055908	9.035889	10.749023
12.130127	13.152100	13.777100	13.985596	13.779297
13.170898	12.197266	10.895752	9.349854	7.599609
5.723877	3.786835	1.853378	0.0	3.084976
5.805084	8.031982	9.645508	10.526611	10.547363
9.596924	7.570084	4.388611	0.0	
B. MOMENT ORDINATES DUE TO A UNIT UNIFORM DEAD LOAD				
0.0	48.448517	71.912750	70.379623	43.827545
-7.733479	-84.246658	-185.809891	-312.274658	-463.852783
-640.442627	-431.009032	-246.403641	-86.997391	47.326813
156.705719	241.178375	300.416504	334.904785	344.455566
328.838379	288.529785	222.713531	132.072906	16.420563
-124.106766	-289.790283	-480.555908	-696.141846	-936.735596
-695.986816	-480.427002	-289.825439	-124.247391	16.510406
131.994781	222.440094	288.131348	328.732910	344.350098
334.908691	300.635254	241.014313	156.979156	47.272125
-87.180984	-246.622391	-431.020752	-640.368408	-463.759033
-312.255127	-185.727859	-84.169266	-7.642659	43.885406
70.419098	71.947250	48.481232	0.000015	

TABLE A-27 (nI = 2.0, AL = 50')

A. MOMENT ORDINATES DUE TO A UNIT UNIFORM LIVE LOAD IN SPANS AB AND CD

0.0	120.026016	215.049469	285.037598	330.080566
350.076660	345.053223	315.041504	260.064941	180.049469
75.209625	46.589844	17.832031	-10.761719	-39.328125
-68.089844	-96.640625	-125.214844	-153.730469	-182.437500
-211.191406	-239.636719	-268.246094	-296.773438	-325.371094
-353.917969	-382.304688	-410.839844	-439.308594	-468.085938
-255.989578	-68.942703	93.002594	229.541656	342.229004
428.791504	490.791504	527.729004	539.729004	526.729004
488.666504	425.916504	337.291504	224.916656	86.510406
-76.446609	-264.704346	-477.692627	-715.677002	-644.011719
-572.453125	-500.882813	-429.230469	-357.742188	-286.074219
-214.574219	-143.027344	-71.550781	-0.000015	

B. MAX. MOMENT FOR MB DUE TO UNIT UNIFORM LIVE LOAD

MB	MC	MD
-844.876221	-426.270752	58.320313

C. MAX. MOMENT FOR MC DUE TO UNIT UNIFORM LIVE LOAD

MB	MC	MD
-494.230469	-1021.493896	-494.219971

TABLE A-28 (nI = 2.5, AL = 80')

A. INFLUENCE LINE ORDINATES FOR MB

0.0	-1.705093	-3.363922	-4.929886	-6.356689
-7.597656	-8.606689	-9.337402	-9.745361	-9.794678
-9.465576	-8.754150	-7.667480	-6.224121	-4.449158
-2.369614	0.0	-2.338791	-4.389740	-6.141602
-7.571533	-8.658203	-9.390869	-9.768311	-9.802246
-9.520996	-8.965576	-8.189209	-7.247803	-6.199463
-5.096481	-3.983551	-2.895630	-1.857986	-0.887802
0.0	0.791733	1.486160	2.079422	2.563797
2.932083	3.180557	3.308884	3.321014	3.226273
3.038864	2.776367	2.458054	2.103165	1.729660
1.352478	0.983521	0.631332	0.301804	0.0
-0.269445	-0.505905	-0.707764	-0.871933	-0.995514
-1.076462	-1.113907	-1.108322	-1.061996	-0.978897
-0.864136	-0.722961	-0.560715	-0.382584	-0.193932
0.0				

B. INFLUENCE LINE ORDINATES FOR MC

0.0	0.576324	1.136932	1.666245	2.148575
2.568146	2.909164	3.156189	3.294022	3.310593
3.199402	2.959030	2.591858	2.103790	1.503830
0.800995	0.0	-0.897232	-1.876907	-2.924072
-4.021072	-5.142578	-6.253418	-7.308105	-8.255127
-9.035400	-9.592773	-9.874512	-9.837891	-9.456787
-8.718506	-7.623291	-6.183350	-4.419052	-2.354141
0.0	-2.353256	-4.417084	-6.180664	-7.620605
-8.715576	-9.454102	-9.835449	-9.871826	-9.590088
-9.033203	-8.253174	-7.306641	-6.251465	-5.141174
-4.020172	-2.923431	-1.876633	-0.897125	0.0
0.800919	1.503769	2.103806	2.591766	2.959030
3.199615	3.310867	3.294342	3.156631	2.909622
2.568481	2.148956	1.666641	1.137268	0.576447
0.0				

TABLE A-29 (nI = 2.5, AL = 80')

A. MOMENT AT POINT J DUE TO A UNIT LOAD AT J				
0.0	4.580716	8.328683	11.261362	13.407798
14.808803	15.516678	15.595529	15.121826	14.173828
12.833008	11.168701	9.252930	7.132080	4.859863
2.466446	0.0	2.475830	4.831299	7.015625
8.995117	10.728027	12.187500	13.312988	14.085205
14.477051	14.475586	14.068604	13.292236	12.150146
10.696289	8.963135	6.985596	4.807129	2.461639
0.0	2.462982	4.809082	6.987061	8.965576
10.697510	12.163086	13.294189	14.074707	14.474365
14.481445	14.086182	13.314697	12.180420	10.728027
8.996826	7.014893	4.829590	2.474625	0.0
2.468063	4.863037	7.135010	9.258057	11.171875
12.841309	14.181152	15.129150	15.602356	15.522249
14.813005	13.410645	11.263043	8.329458	4.580913
0.0				
B. MOMENT ORDINATES DUE TO A UNIT UNIFORM DEAD LOAD				
0.0	129.027863	233.055664	312.083496	366.111328
395.139160	399.166992	378.194824	332.084473	261.611816
165.729156	44.537750	-101.138016	-272.079346	-468.079346
-689.028564	-934.919189	-702.546631	-495.283203	-313.009033
-155.755203	-23.536453	83.768219	165.861969	222.955719
255.194016	262.361816	244.358063	201.369781	133.330719
40.455719	-77.602859	-220.704422	-388.782471	-581.874268
-799.875488	-581.726318	-388.653564	-220.638016	-77.528641
40.404938	123.412750	201.358063	244.299469	262.260254
255.236984	222.947906	165.873688	83.518219	-23.618484
-155.739578	-313.188721	-495.492676	-702.791504	-935.041504
-688.934814	-467.903564	-272.110596	-101.055984	44.701813
165.729156	261.584473	332.436035	378.374023	399.320557
395.267090	366.213623	312.160156	233.106857	129.053436
0.0				

TABLE A-30 (nI - 2.5, AL = 80')

A. MOMENT ORDINATES DUE TO A UNIT UNIFORM LIVE LOAD IN SPANS AB AND CD

0.0	167.966537	310.932861	428.899414	521.865967
589.832520	632.799072	650.765625	643.666504	611.979004
555.166504	473.104004	366.541504	234.354156	77.869781
-104.813797	-311.876221	-317.179688	-322.773438	-327.812500
-332.750000	-337.937500	-343.375000	-348.000000	-353.000000
-357.812500	-362.437500	-367.000000	-371.500000	-375.375000
-379.750000	-384.312500	-388.312500	-392.257813	-395.812500
-399.839844	-185.462234	3.854167	167.416656	306.479004
420.229004	509.604004	573.104004	611.354004	624.854004
613.166504	576.041504	514.229004	426.541504	314.229004
177.354156	14.666667	-172.845047	-385.997314	-623.512939
-584.738281	-546.015625	-506.742188	-467.968750	-428.621094
-389.816406	-350.800781	-311.769531	-272.786377	-233.816910
-194.847427	-155.877945	-116.908463	-77.938995	-38.969513
-0.000244				

B. MAX. MOMENT FOR MB DUE TO UNIT UNIFORM LIVE LOAD

MB	MC	MD
-1125.731689	-229.778641	-368.855469

C. MAX. MOMENT FOR MC DUE TO UNIT UNIFORM LIVE LOAD

MB	MC	MD
-374.179688	-1140.326904	-374.344971

TABLE A-31 (nI = 2.5, AL = 70')

A. INFLUENCE LINE ORDINATES FOR MB

0.0	-1.568329	-3.078720	-4.473160	-5.693115
-6.681152	-7.380859	-7.743652	-7.739746	-7.353027
-6.583252	-5.441650	-3.949707	-2.131851	0.0
-2.549973	-4.785294	-6.694092	-8.250732	-9.432861
-10.228271	-10.636475	-10.669678	-10.359619	-9.751709
-8.902832	-7.875244	-6.732178	-5.530823	-4.320007
-3.137726	-2.011581	-0.960266	0.0	0.854279
1.601425	2.237411	2.753906	3.143326	3.402100
3.530182	3.532806	3.420593	3.209686	2.920013
2.572815	2.189667	1.790115	1.390656	1.004074
0.639435	0.302952	0.0	-0.264373	-0.489807
-0.674866	-0.816498	-0.912048	-0.960037	-0.960602
-0.915588	-0.828827	-0.706268	-0.554901	-0.381937
-0.194566	0.0			

B. INFLUENCE LINE ORDINATES FOR MC

0.0	0.535095	1.050385	1.526047	1.942398
2.279495	2.518234	2.642136	2.640579	2.508774
2.246017	1.856476	1.347504	0.727356	0.0
-0.833572	-1.759430	-2.762924	-3.826843	-4.926102
-6.025635	-7.080078	-8.035645	-8.833008	-9.413574
-9.722412	-9.715088	-9.362549	-8.651123	-7.578613
-6.157715	-4.407333	-2.351135	0.0	-2.350281
-4.405655	-6.155273	-7.576416	-8.648193	-9.359863
-9.713135	-9.719727	-9.411133	-8.831299	-8.033936
-7.078369	-6.024170	-4.924988	-3.826035	-2.762405
-1.759293	-0.833527	0.0	0.727386	1.347641
1.856766	2.246429	2.509277	2.641342	2.642883
2.519028	2.280396	1.943192	1.526749	1.050873
0.535309	0.0			

TABLE A-32 (nI - 2.5, AL = 70')

A. MOMENT AT POINT J DUE TO A UNIT LOAD AT J				
0.0	4.530996	8.132275	10.828662	12.661562
13.688965	13.984131	13.636719	12.727051	11.350098
9.591064	7.513428	5.190430	2.663849	0.0
2.279404	4.489258	6.574707	8.498535	10.213379
11.682861	12.846436	13.671387	14.127930	14.194580
13.853516	13.135986	12.045410	10.629883	8.927490
6.968750	4.801025	2.460770	0.0	2.461823
4.802734	6.969971	8.928223	10.633057	12.056152
13.138672	13.859375	14.194092	14.134033	13.670410
12.851074	11.677490	10.212158	8.500732	6.574707
4.488281	2.278366	0.0	2.664886	5.191406
7.517822	9.596191	11.357666	12.737061	13.644287
13.992676	13.695892	12.666367	10.831534	8.133605
4.531340	0.0			

B. MOMENT COORDINATES DUE TO A UNIT UNIFORM DEAD LOAD				
0.0	104.869995	184.739990	239.609863	269.479980
274.349854	254.225266	209.029938	139.033844	43.928375
-76.309891	-221.458328	-391.548340	-586.711182	-806.850342
-585.281494	-388.751221	-217.247391	-70.798172	50.615875
146.998688	218.276031	264.787598	285.967285	282.459473
253.393219	199.936188	120.647125	17.045563	-111.735672
-265.856689	-444.778564	-648.762451	-877.632324	-648.574951
-444.661377	-265.708252	-111.825516	17.061188	121.049469
199.705719	253.510406	282.330566	286.135254	264.537598
218.569000	146.889313	50.471344	-70.755203	-217.430984
-388.973877	-585.551025	-806.986816	-586.712646	-391.540283
-221.368484	-76.192703	43.986969	139.151031	209.287750
254.334641	274.464600	269.571533	239.678772	184.785843
104.892929	0.000244			

TABLE A-33 (nI = 2.5, AL = 70')

A. MOMENT ORDINATES DUE TO A UNIT UNIFORM LIVE LOAD IN SPANS AB AND CD

0.0	151.999359	278.998535	380.998047	457.997314
509.996582	536.963379	539.049316	516.131348	467.982910
395.357910	296.928223	173.881500	25.510406	-147.696609
-163.687500	-179.773438	-195.406250	-211.246094	-226.625000
-242.750000	-258.250000	-273.687500	-289.062500	-304.687500
-319.625000	-334.875000	-349.812500	-364.562500	-380.058594
-394.886719	-409.554688	-424.074219	-438.773438	-224.360672
-34.919266	128.854156	268.166504	381.666504	471.291504
534.729004	573.354004	586.979004	575.541504	538.229004
476.979004	389.479004	277.229004	140.666656	-21.778641
-209.364578	-421.985596	-659.384033	-612.484375	-565.707031
-518.511719	-471.628906	-424.433594	-377.433594	-330.277344
-283.101563	-235.945068	-188.756058	-141.567047	-94.378036
-47.189026	-0.000015			

B. MAX. MOMENT FOR MB DUE TO UNIT UNIFORM LIVE LOAD

MB	MC	MD
-1009.841064	-319.196533	-191.140625

C. MAX. MOMENT FOR MC DUE TO UNIT UNIFORM LIVE LOAD

MB	MC	MD
-412.757813	-1116.977051	-412.856689

TABLE A-34 (nI = 2.5, AL = 60')

A. INFLUENCE LINE ORDINATES FOR MB

0.0	-1.393250	-2.712189	-3.882507	-4.831070
-5.492432	-5.818115	-5.776123	-5.353027	-4.549042
-3.377945	-1.859177	0.0	-2.792160	-5.238892
-7.327011	-9.029053	-10.320068	-11.187012	-11.629150
-11.661621	-11.317139	-10.647949	-9.716064	-8.589111
-7.337326	-6.023392	-4.700836	-3.411316	-2.184753
-1.041733	0.0	0.924149	1.729599	2.412170
2.962982	3.374252	3.642059	3.767593	3.756851
3.622665	3.383530	3.061783	2.681458	2.266632
1.838959	1.416473	1.013000	0.638275	0.298692
0.0	-0.252302	-0.458383	-0.617294	-0.726440
-0.783859	-0.789536	-0.745361	-0.655624	-0.526901
-0.368089	-0.189091	0.0		

B. INFLUENCE LINE ORDINATES FOR MC

0.0	0.480331	0.934982	1.338425	1.665405
1.893478	2.005692	1.991348	1.845444	1.568253
1.164551	0.640991	0.0	-0.758835	-1.621521
-2.573639	-3.598724	-4.671921	-5.758545	-6.812256
-7.778076	-8.595459	-9.203369	-9.544189	-9.571045
-9.251953	-8.572021	-7.527344	-6.128174	-4.393921
-2.347702	0.0	-2.346649	-4.391708	-6.125000
-7.523682	-8.568115	-9.248291	-9.567383	-9.540039
-9.199219	-8.591797	-7.774902	-6.808838	-5.755371
-4.669601	-3.596832	-2.572388	-1.620819	-0.758484
0.0	0.640701	1.164047	1.567566	1.844696
1.990555	2.004929	1.892792	1.664871	1.338043
0.934723	0.480164	0.0		

TABLE A-35 (nI = 2.5, AL = 60')

A. MOMENT AT POINT J DUE TO A UNIT LOAD AT J				
0.0	4.467465	7.882227	10.281418	11.724365
12.299805	12.096924	11.220459	9.770752	7.842773
5.521973	2.879654	0.0	2.053467	4.097168
6.070557	7.930176	9.623779	11.106689	12.313721
13.202148	13.732422	13.876709	13.612305	12.960449
11.927734	10.557617	8.886475	6.949463	4.794922
2.459671	0.0	2.461014	4.796631	6.951172
8.887939	10.561523	11.937500	12.963135	13.616455
13.875000	13.736328	13.202148	12.314453	11.100830
9.621826	7.929199	6.069092	4.094971	2.051926
0.0	2.880859	5.523438	7.843994	9.772705
11.220459	12.099365	12.300781	11.728516	10.283218
7.883081	4.467692	0.0		
B. MOMENT ORDINATES DUE TO A UNIT UNIFORM DEAD LOAD				
0.0	77.882156	130.764313	158.646240	161.510406
139.420563	92.279938	20.171051	-76.920975	-199.065262
-346.145996	-518.260986	-715.354004	-501.536377	-312.594971
-148.798172	-10.087239	103.522125	192.182281	255.912766
294.580566	308.045410	296.537598	260.154785	198.619781
111.901031	0.233073	-136.266922	-298.098877	-484.813721
-696.541992	-933.222900	-696.355234	-484.673096	-297.938721
-136.274734	0.358073	112.127594	198.592438	260.080566
296.682129	308.193848	294.545410	255.955734	192.287750
103.592438	-10.165364	-148.970047	-312.821533	-501.696533
-715.458252	-518.262695	-346.221924	-199.056717	-76.936356
20.186920	92.311188	139.420563	161.557281	158.660156
130.773453	77.886734	0.000015		

TABLE A-36 (nI = 2.5, AL = 60')

A. MOMENT ORDINATES DUE TO A UNIT UNIFORM LIVE LOAD IN SPANS AB AND CD

0.0	136.542358	248.084717	334.626953	396.088379
432.748535	444.229004	430.768066	392.279785	328.670410
240.174469	126.451813	-12.130208	-36.562500	-61.078125
-85.351563	-109.644531	-133.792969	-158.078125	-182.171875
-206.171875	-230.328125	-254.296875	-277.925781	-301.914063
-325.449219	-349.031250	-372.968750	-396.281250	-419.855469
-443.082031	-466.527344	-253.040359	-64.548172	98.416656
236.479156	349.604004	437.854004	500.541504	538.291504
550.979004	538.541504	500.729004	438.291504	350.104004
237.166656	99.416656	-63.559891	-252.001297	-465.407471
-703.591064	-645.042969	-586.648438	-527.867188	-469.355469
-410.601563	-352.042969	-293.343750	-234.742188	-176.074463
-117.382980	-58.691498	-0.000015		

B. MAX. MOMENT FOR MB DUE TO UNIT UNIFORM LIVE LOAD

MB	MC	MD
-929.844971	-388.594971	-42.675781

C. MAX. MOMENT FOR MC DUE TO UNIT UNIFORM LIVE LOAD

MB	MC	MD
-457.996094	-1089.463379	-458.208252

TABLE A-37 (nI = 2.5, AL = 50')

A. INFLUENCE LINE ORDINATES FOR MB

0.0	-1.172775	-2.247971	-3.134171	-3.754425
-4.051743	-3.989563	-3.550354	-2.734344	-1.551163
0.0	-3.066025	-5.751617	-8.042694	-9.908646
-11.322510	-12.269775	-12.750244	-12.780273	-12.397217
-11.657471	-10.630371	-9.391159	-8.016190	-6.575073
-5.126526	-3.716354	-2.377350	-1.132111	0.0
1.001038	1.870041	2.602661	3.189438	3.622238
3.897491	4.016968	3.988617	3.827164	3.554230
3.195206	2.777328	2.327576	1.869995	1.424377
1.005737	0.624481	0.287191	0.0	-0.231161
-0.407452	-0.529028	-0.594480	-0.603750	-0.559433
-0.467021	-0.334978	-0.174765	0.0	

B. INFLUENCE LINE ORDINATES FOR MC

0.0	0.409195	0.784332	1.093475	1.309891
1.413681	1.391953	1.238724	0.954071	0.541260
0.0	-0.672455	-1.462219	-2.354965	-3.335129
-4.378540	-5.449951	-6.502686	-7.480713	-8.320801
-8.960205	-9.338135	-9.404541	-9.124756	-8.480225
-7.467285	-6.093506	-4.378159	-2.343643	0.0
-2.342590	-4.375977	-6.090576	-7.463623	-8.476074
-9.120850	-9.400301	-9.334229	-8.956299	-8.317139
-7.477295	-6.499512	-5.446945	-4.376083	-3.333313
-2.353760	-1.461487	-0.672089	0.0	0.540955
0.953552	1.238098	1.391266	1.412949	1.309250
1.092987	0.783936	0.408981	0.0	

TABLE A-38 (nI = 2.5, AL = 50')

A. MOMENT AT POINT J DUE TO A UNIT LOAD AT J				
0.0	4.383148	7.551208	9.561523	10.499756
10.477783	9.609375	8.017578	5.814377	3.104263
0.0	1.798431	3.655029	5.502441	7.291260
8.962646	10.465332	11.721436	12.681396	13.293945
13.525391	13.345215	12.769531	11.800537	10.477783
8.844727	6.930176	4.788330	2.458786	0.0
2.460007	4.790283	6.932129	8.845215	10.481201
11.809814	12.771484	13.348633	13.523438	13.297363
12.679443	11.719971	10.457275	8.959961	7.289795
5.499756	3.653076	1.797363	0.0	3.105301
5.815903	8.018066	9.610107	10.477783	10.500732
9.562500	7.550934	4.383301	0.0	
B. MOMENT COORDINATES DUE TO A UNIT UNIFORM DEAD LOAD				
0.0	46.255737	67.522400	63.797272	35.047272
-18.684158	-97.399734	-201.141922	-329.852783	-483.540283
-662.278564	-452.895752	-268.348877	-109.055984	25.236969
134.315094	218.643219	277.877441	311.896973	320.908691
305.096191	263.881348	197.854156	106.647125	-9.606771
-150.384109	-316.868408	-508.134033	-724.359131	-965.572021
-724.220215	-507.973877	-316.766846	-150.509109	-9.411458
106.901031	197.951813	263.908691	304.963379	321.029785
311.896973	277.912598	218.576813	134.381500	25.104156
-109.251297	-268.583252	-453.024658	-662.364502	-483.579346
-329.880127	-201.192703	-97.411453	-18.683426	35.070709
63.800690	67.524979	46.266083	0.000015	

TABLE A-39 (nI = 2.5, AL = 50°)

A. MOMENT ORDINATES DUE TO A UNIT UNIFORM LIVE LOAD IN SPANS AB AND CD

0.0	121.928329	218.854156	290.768066	337.619629
359.615723	356.439941	328.307129	275.186035	196.971344
93.830719	63.085938	32.199219	1.523438	-29.144531
-59.707031	-90.472656	-120.933594	-151.324219	-181.707031
-212.210938	-242.257813	-272.675781	-302.660156	-332.867188
-363.050781	-392.953125	-423.003906	-452.785156	-482.703125
-271.259033	-84.735672	76.354156	212.291656	323.416504
409.791504	470.666504	506.416504	517.166504	502.979004
463.291504	398.729004	308.729004	193.854156	54.252594
-110.845047	-300.966064	-516.239502	-756.442627	-680.792969
-605.230469	-529.597656	-453.925781	-378.265625	-302.589844
-227.003906	-151.304688	-75.695313	-0.000015	

B. MAX. MOMENT FOR MB DUE TO UNIT UNIFORM LIVE LOAD

MB	MC	MD
-888.239502	-436.798096	74.339844

C. MAX. MOMENT FOR MC DUE TO UNIT UNIFORM LIVE LOAD

MB	MC	MD
-510.472656	-1057.762451	-510.657471

TABLE A-40 (nI = 1.5, AL = 80')

A. MINIMUM, REQUIRED, AND TOTAL WEIGHTS OF THE GIRDER				
WGMIN (LB/FT)	WG (LB/FT)	WT (KIPS)		
0.000	183.111	256.356		
B. MAX. NEGATIVE AND POSITIVE MOMENTS				
MNEGA (KIP-FT)	MPCSI (KIP-FT)	MDES (KIP-FT)		
-1687.341	1058.616	1687.341		
C. MAX. SHEARING FORCE AT SUPPORTS A, B, AND C				
VA (KIPS)	VB (KIPS)	VC (KIPS)	VDES (KIPS)	
74.393	105.105	103.170	105.105	
D. WIDTH OF FLANGES AT INTERIOR SUPPORT AND AT MID-SPAN				
BF1 (IN)	BF2 (IN)			
20.81	20.91			
E. BENDING AND SHEARING STRESSES AT INTERIOR SUPPORT AND AT MID-SPAN				
FB1 (KSI)	FV1 (KSI)	FB2 (KSI)	FV2 (KSI)	
19.997	7.644	15.546	9.343	

TABLE A-41 (nI = 1.5, AL = 70')

A. MINIMUM, REQUIRED, AND TOTAL WEIGHTS OF THE GIRDER			
WGMIN (LB/FT)	WG (LB/FT)	WT (KIPS)	
0.000	182.187	240.487	
B. MAX. NEGATIVE AND POSITIVE MOMENTS			
MNEGA (KIP-FT)	MPCSI (KIP-FT)	MDES (KIP-FT)	
-1675.556	933.057	1675.556	
C. MAX. SHEARING FORCE AT SUPPORTS A, B, AND C			
VA (KIPS)	VB (KIPS)	VC (KIPS)	VDES (KIPS)
68.026	100.399	104.596	104.596
D. WIDTH OF FLANGES AT INTERIOR SUPPORT AND AT MID-SPAN			
BF1 (IN)	BF2 (IN)		
20.65	20.75		
E. BENDING AND SHEARING STRESSES AT INTERIOR SUPPORT AND AT MID-SPAN			
FB1 (KSI)	FV1 (KSI)	FB2 (KSI)	FV2 (KSI)
19.997	7.607	13.798	9.297

TABLE A-42 (nI = 1.5, AL = 60')

A. MINIMUM, REQUIRED, AND TOTAL WEIGHTS OF THE GIRDER			
WGMIN (LB/FT)	WG (LB/FT)	WT (KIPS)	
0.000	185.193	229.639	
B. MAX. NEGATIVE AND POSITIVE MOMENTS			
MNEGA (KIP-FT)	MPCSI (KIP-FT)	MDES (KIP-FT)	
-1705.813	933.636	1705.813	
C. MAX. SHEARING FORCE AT SUPPORTS A, B, AND C			
VA (KIPS)	VB (KIPS)	VC (KIPS)	VDES (KIPS)
61.378	98.779	105.686	105.686
D. WIDTH OF FLANGES AT INTERIOR SUPPORT AND AT MID-SPAN			
BF1 (IN)	BF2 (IN)		
21.07	21.16		
E. BENDING AND SHEARING STRESSES AT INTERIOR SUPPORT AND AT MID-SPAN			
FB1 (KSI)	FV1 (KSI)	FB2 (KSI)	FV2 (KSI)
19.990	7.686	13.558	9.394

TABLE A-43 (nI = 1.5, AL = 50')

A. MINIMUM, REQUIRED, AND TOTAL WEIGHTS OF THE GIRDER				
WGMIN (LB/FT)	WG (LB/FT)	WT (KIPS)		
123.661	186.269	216.072		
B. MAX. NEGATIVE AND POSITIVE MOMENTS				
MNEGA (KIP-FT)	MPCSI (KIP-FT)	MDES (KIP-FT)		
-1715.596	924.887	1715.596		
C. MAX. SHEARING FORCE AT SUPPORTS A, B, AND C				
VA (KIPS)	VB (KIPS)	VC (KIPS)	VDES (KIPS)	
54.072	97.874	106.136	106.136	
D. WIDTH OF FLANGES AT INTERIOR SUPPORT AND AT MID-SPAN				
BF1 (IN)	BF2 (IN)			
21.20	21.29			
E. BENDING AND SHEARING STRESSES AT INTERIOR SUPPORT AND AT MID-SPAN				
FB1 (KSI)	FV1 (KSI)	FB2 (KSI)	FV2 (KSI)	
19.993	7.719	13.356	9.434	

TABLE A-44 ($nI = 2.0$, $AL = 80^\circ$)

A. MINIMUM, REQUIRED, AND TOTAL WEIGHTS OF THE GIRDER	WGMIN	WG	WT
	(LB/FT)	(LB/FT)	(KIPS)
	0.000	171.355	239.898
B. MAX. NEGATIVE AND POSITIVE MOMENTS	MNEGA	MPCSI	MDES
	(KIP-FT)	(KIP-FT)	(KIP-FT)
	-1788.964	1027.727	1788.964
C. MAX. SHEARING FORCE AT SUPPORTS A, B, AND C	VA	VB	VC
	(KIPS)	(KIPS)	(KIPS)
	73.428	105.651	102.871
			105.651
D. WIDTH OF FLANGES AT INTERIOR SUPPORT AND AT MID-SPAN	BF1	BF2	
	(IN)	(IN)	
	18.49	19.01	
E. BENDING AND SHEARING STRESSES AT INTERIOR SUPPORT AND AT MID-SPAN	FB1	FV1	FV2
	(KSI)	(KSI)	(KSI)
	19.994	6.629	9.391
		16.471	

TABLE A-45 (nI = 2.0, AL = 70')

A. MINIMUM, REQUIRED, AND TOTAL WEIGHTS OF THE GIRDER

WGMIN (LB/FT)	WG (LB/FT)	WT (KIPS)
0.000	168.014	221.779

B. MAX. NEGATIVE AND POSITIVE MOMENTS

MNEGA (KIP-FT)	MPCSI (KIP-FT)	MDES (KIP-FT)
-1743.664	872.347	1743.664

C. MAX. SHEARING FORCE AT SUPPORTS A, B, AND C

VA (KIPS)	VB (KIPS)	VC (KIPS)	VDES (KIPS)
67.261	100.061	104.327	104.327

D. WIDTH OF FLANGES AT INTERIOR SUPPORT AND AT MID-SPAN

BF1 (IN)	BF2 (IN)
17.96	18.49

E. BENDING AND SHEARING STRESSES AT INTERIOR SUPPORT AND AT MID-SPAN

FB1 (KSI)	FV1 (KSI)	FB2 (KSI)	FV2 (KSI)
19.991	6.546	14.342	9.273

TABLE A-46 ($nI = 2.0$, $AL = 60^\circ$)

A. MINIMUM, REQUIRED, AND TOTAL WEIGHTS OF THE GIRDER

WGMIN (LB/FT)	WG (LB/FT)	WT (KIPS)
0.000	170.892	211.906

B. MAX. NEGATIVE AND POSITIVE MOMENTS

MNEGA (KIP-FT)	MPCSI (KIP-FT)	MDES (KIP-FT)
-1776.861	869.910	1776.861

C. MAX. SHEARING FORCE AT SUPPORTS A, B, AND C

VA (KIPS)	VB (KIPS)	VC (KIPS)	VDES (KIPS)
60.873	98.481	105.482	105.482

D. WIDTH OF FLANGES AT INTERIOR SUPPORT AND AT MID-SPAN

BF1 (IN)	BF2 (IN)
18.35	18.87

E. BENDING AND SHEARING STRESSES AT INTERIOR SUPPORT AND AT MID-SPAN

FB1 (KSI)	FV1 (KSI)	FB2 (KSI)	FV2 (KSI)
19.992	6.618	14.035	9.376

TABLE A-47 (nI = 2.5, AL = 80')

A. MINIMUM, REQUIRED, AND TOTAL WEIGHTS OF THE GIRDER			
WGMIN (LB/FT)	WG (LB/FT)	WT (KIPS)	
0.000	169.767	237.674	
B. MAX. NEGATIVE AND POSITIVE MOMENTS			
MNEGA (KIP-FT)	MPCSI (KIP-FT)	MDES (KIP-FT)	
-1873.739	1007.147	1873.739	
C. MAX. SHEARING FORCE AT SUPPORTS A, B, AND C			
VA (KIPS)	VB (KIPS)	VC (KIPS)	VDES (KIPS)
72.928	106.500	102.969	106.500
D. WIDTH OF FLANGES AT INTERIOR SUPPORT AND AT MID-SPAN			
BF1 (IN)	BF2 (IN)		
16.28	17.25		
E. BENDING AND SHEARING STRESSES AT INTERIOR SUPPORT AND AT MID-SPAN			
FB1 (KSI)	FV1 (KSI)	FB2 (KSI)	FV2 (KSI)
19.997	4.982	17.307	7.889

TABLE A-48 (nI = 2.5, AL = 70')

A. MINIMUM, REQUIRED, AND TOTAL WEIGHTS OF THE GIRDER

WGMIN (LB/FT)	WG (LB/FT)	WT (KIPS)
0.000	164.920	217.694

B. MAX. NEGATIVE AND POSITIVE MOMENTS

MNEGA (KIP-FT)	MPCSI (KIP-FT)	MDES (KIP-FT)
-1799.460	832.664	1799.460

C. MAX. SHEARING FORCE AT SUPPORTS A, B, AND C

VA (KIPS)	VB (KIPS)	VC (KIPS)	VDES (KIPS)
66.900	100.368	104.484	104.484

D. WIDTH OF FLANGES AT INTERIOR SUPPORT AND AT MID-SPAN

BF1 (IN)	BF2 (IN)
15.50	16.49

E. BENDING AND SHEARING STRESSES AT INTERIOR SUPPORT AND AT MID-SPAN

FB1 (KSI)	FV1 (KSI)	FB2 (KSI)	FV2 (KSI)
19.995	4.888	14.898	7.740

TABLE A-49 (nI = 2.5, AL = 60')

A. MINIMUM, REQUIRED, AND TOTAL WEIGHTS OF THE GIRDER

WGMIN (LB/FT)	WG (LB/FT)	WT (KIPS)
0.000	167.908	208.206

B. MAX. NEGATIVE AND POSITIVE MOMENTS

MNEGA (KIP-FT)	MPCSI (KIP-FT)	MDES (KIP-FT)
-1835.434	827.400	1835.434

C. MAX. SHEARING FORCE AT SUPPORTS A, B, AND C

VA (KIPS)	VB (KIPS)	VC (KIPS)	VDES (KIPS)
60.689	98.413	105.714	105.714

D. WIDTH OF FLANGES AT INTERIOR SUPPORT AND AT MID-SPAN

BF1 (IN)	BF2 (IN)
15.88	16.86

E. BENDING AND SHEARING STRESSES AT INTERIOR SUPPORT AND AT MID-SPAN

FB1 (KSI)	FV1 (KSI)	FB2 (KSI)	FV2 (KSI)
19.994	4.946	14.512	7.831

TABLE A-50 (nI = 2.0, AL = 50')

A. MINIMUM, REQUIRED, AND TOTAL WEIGHTS OF THE GIRDER		
WGMIN	WG	WT
(LB/FT)	(LB/FT)	(KIPS)
246.955	246.955	286.468

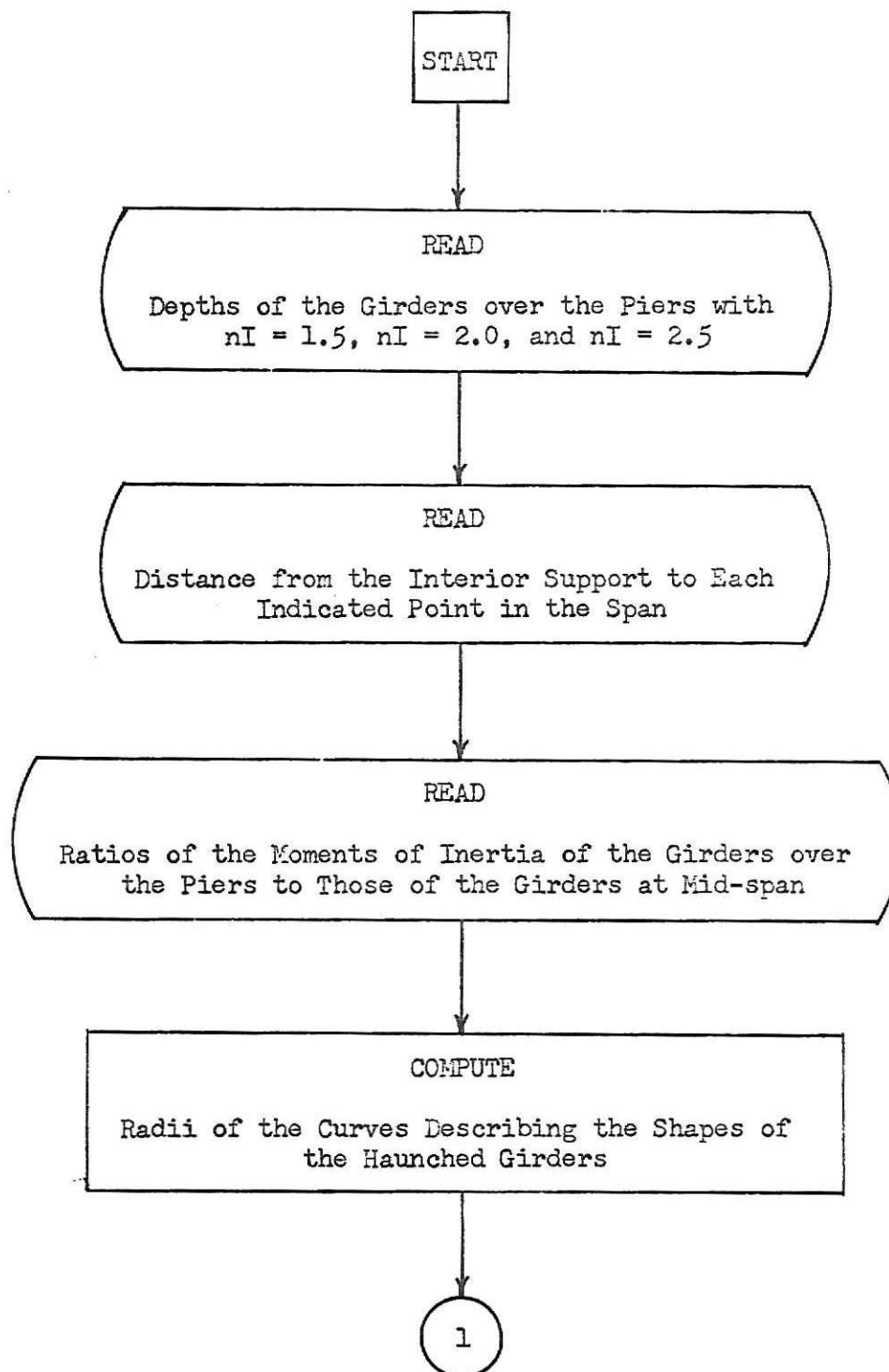
TABLE A-51 (nI = 2.5, AL = 50')

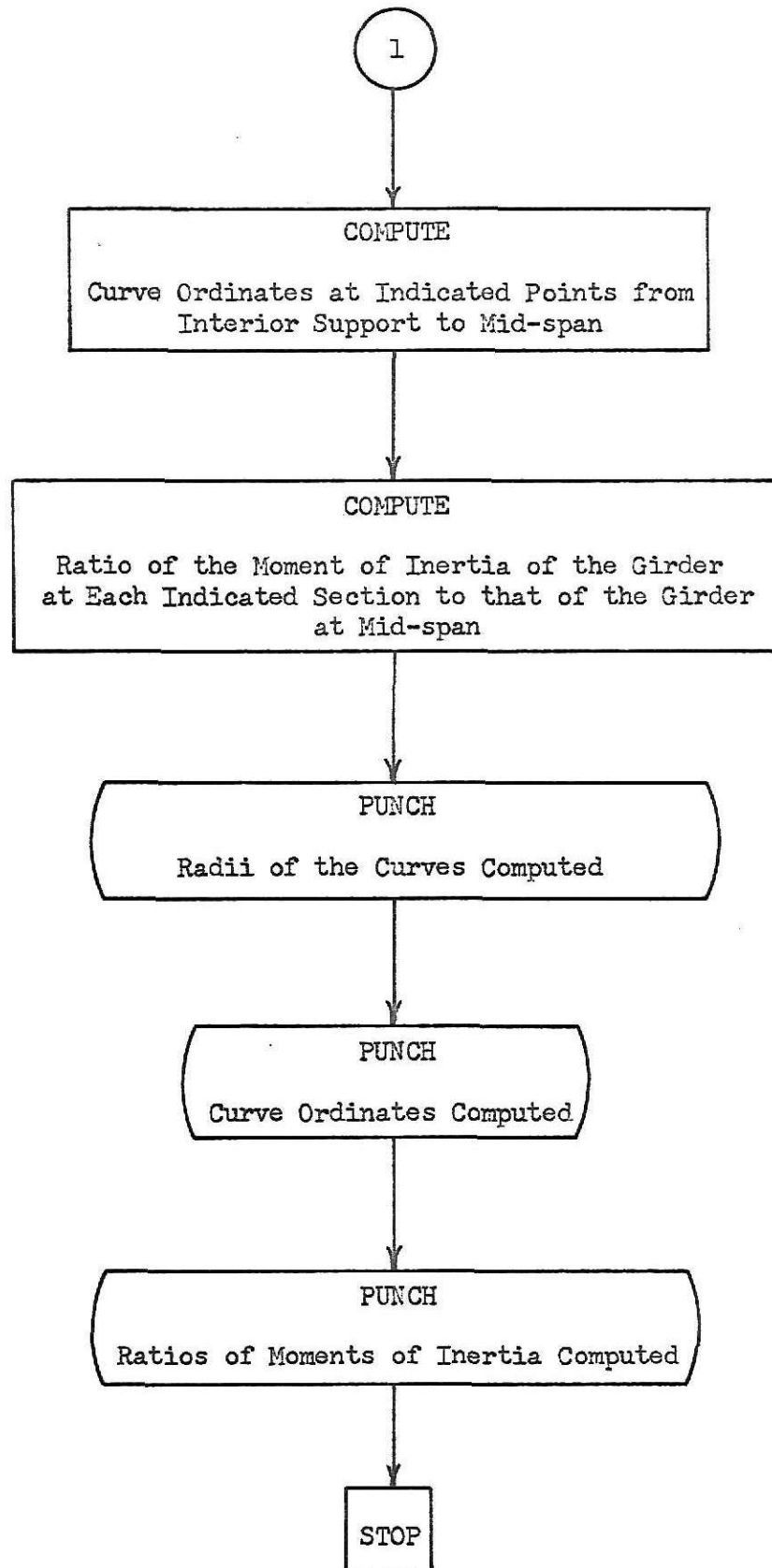
A. MINIMUM, REQUIRED, AND TOTAL WEIGHTS OF THE GIRDER		
WGMIN	WG	WT
(LB/FT)	(LB/FT)	(KIPS)
351.032	351.032	407.197

Appendix B

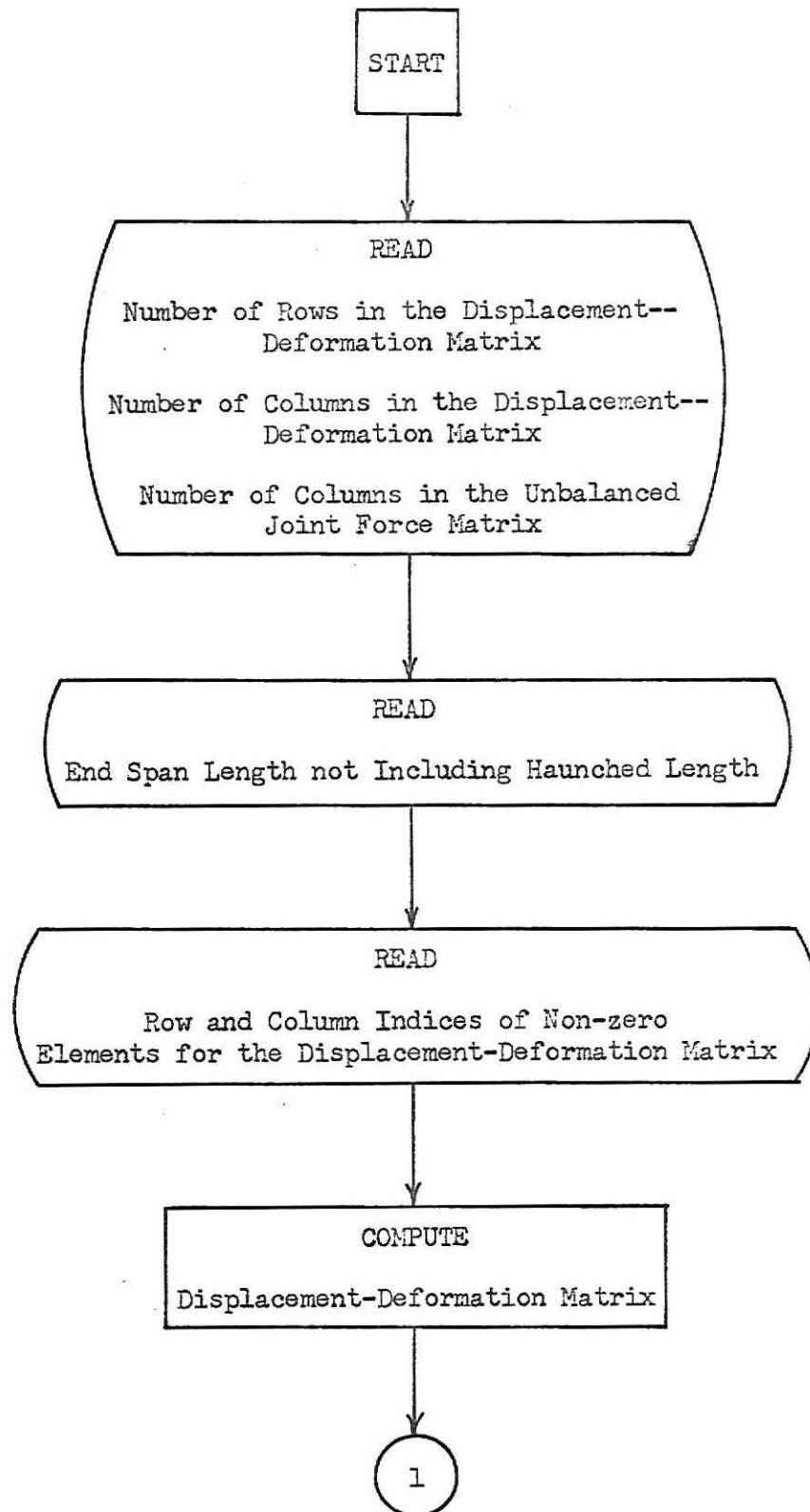
Flow Charts and Computer Programs

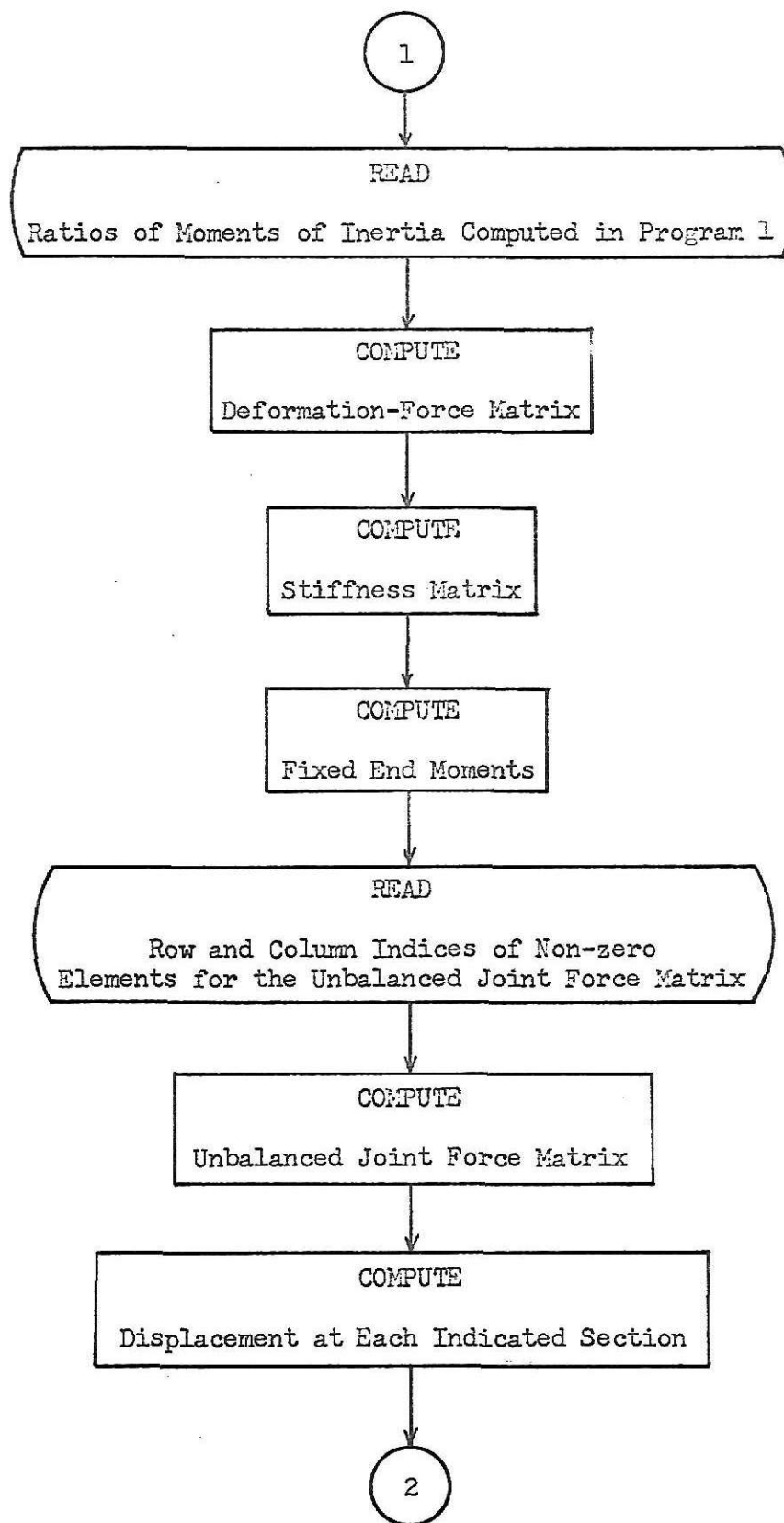
Flow Chart for Program 1

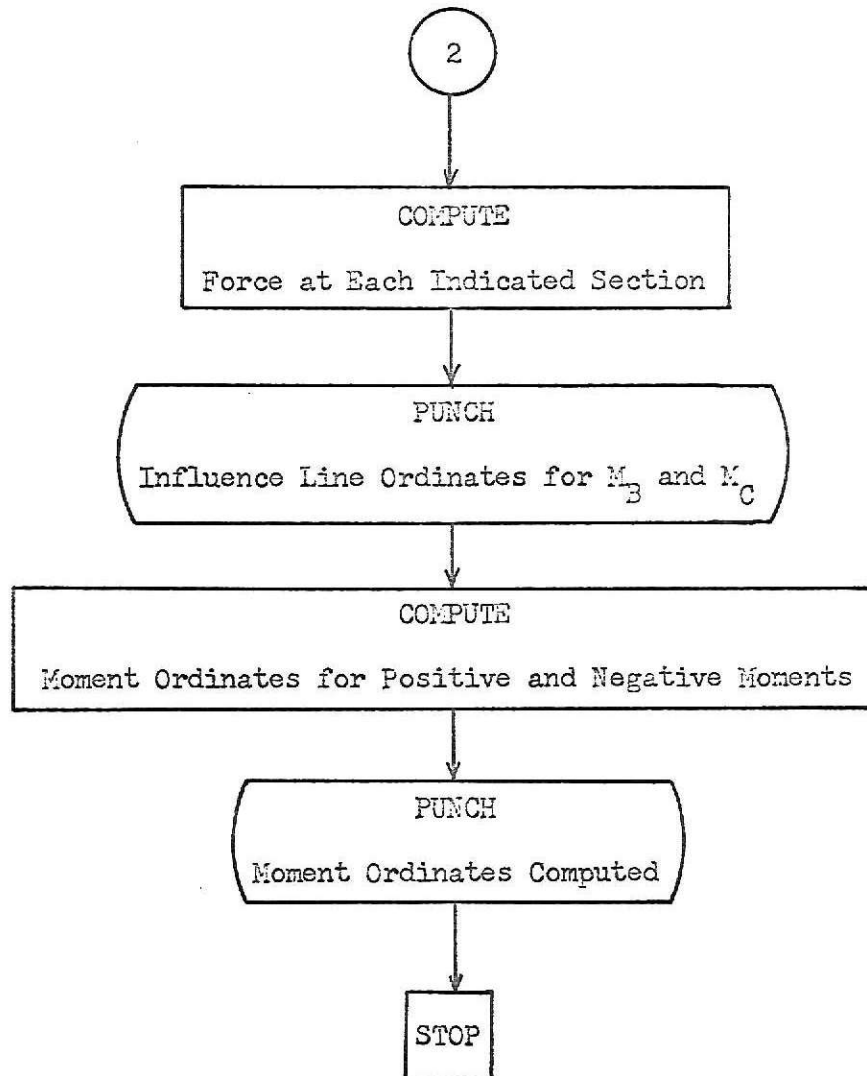




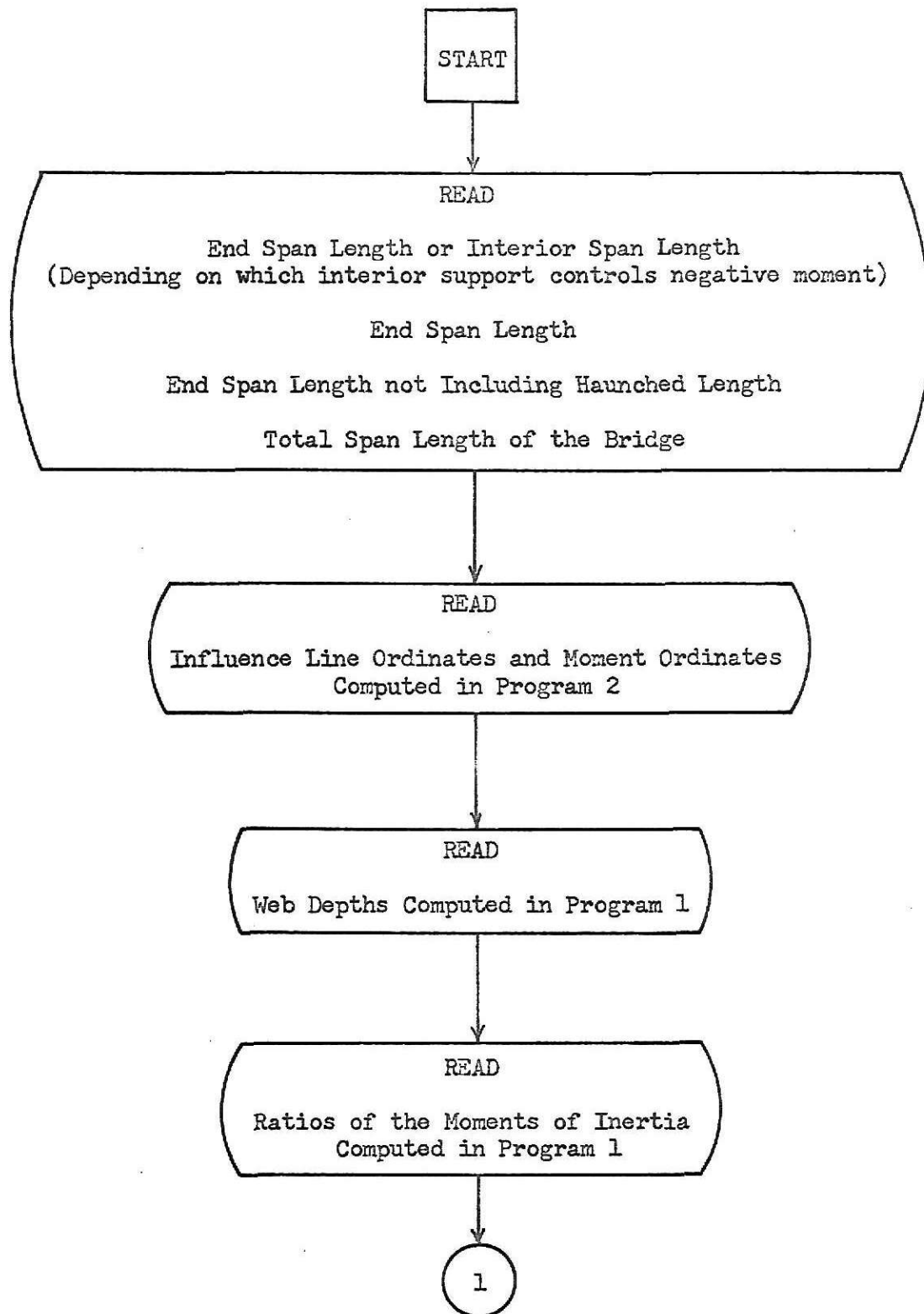
Flow Chart for Program 2

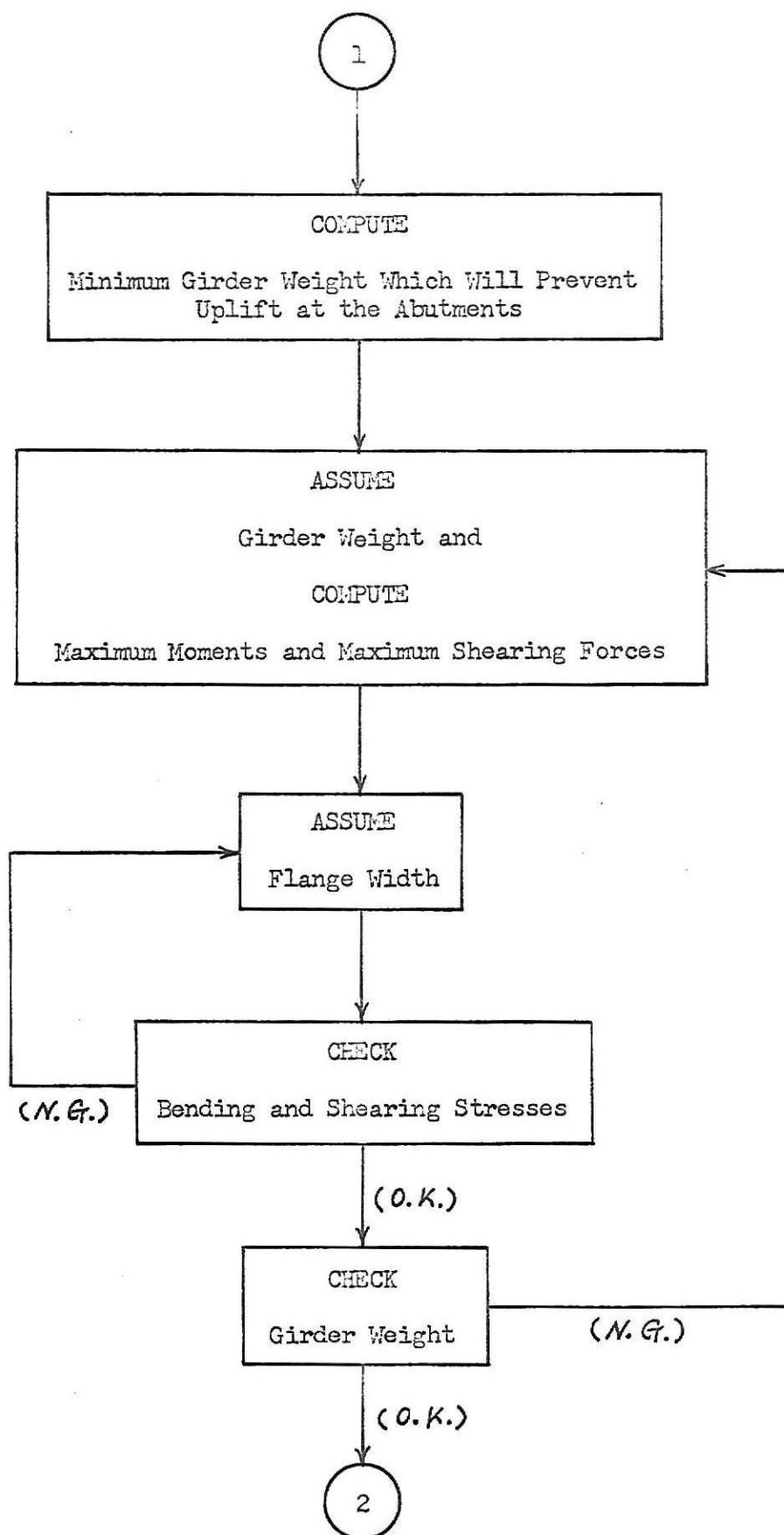


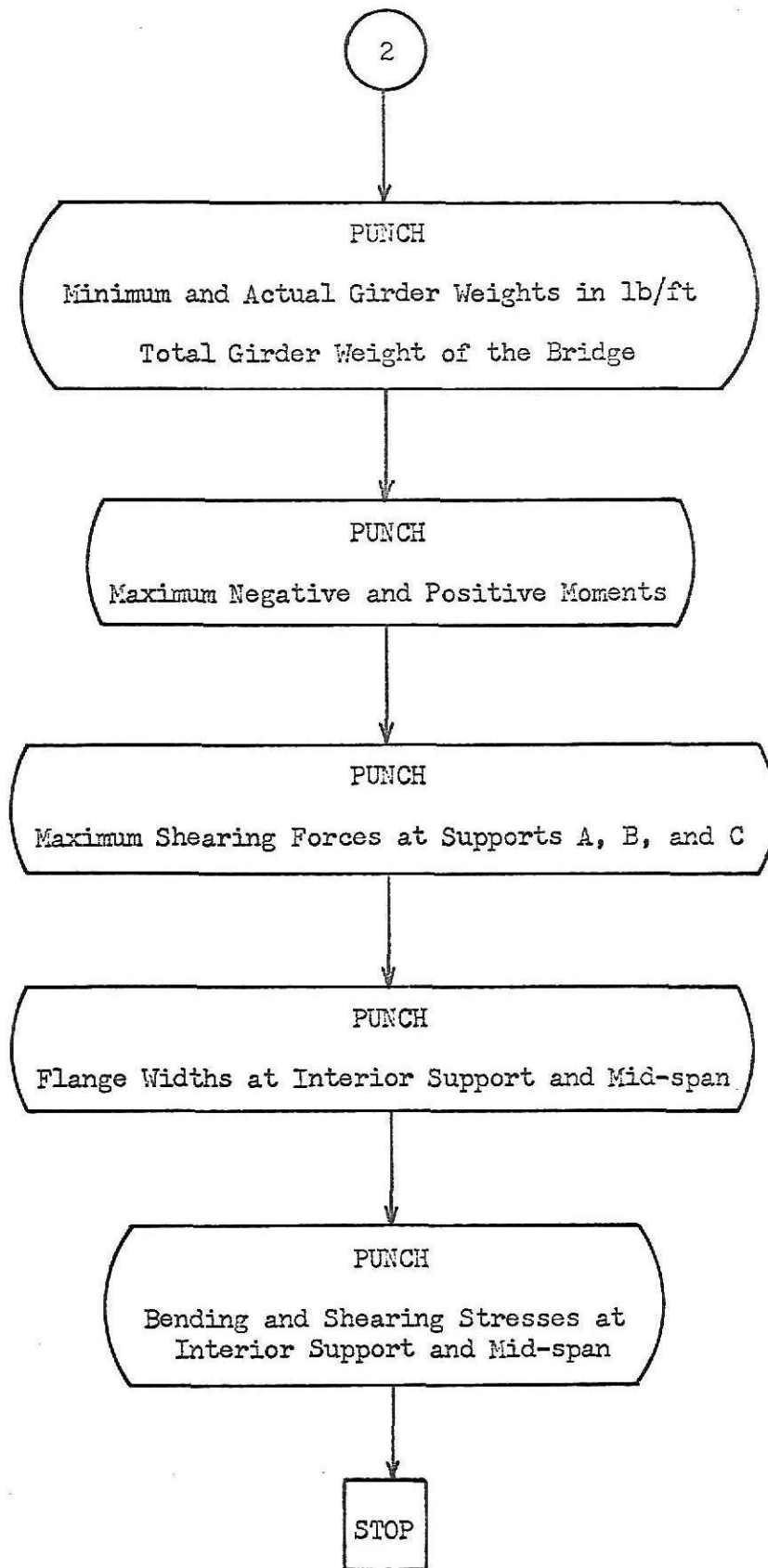




Flow Chart for Program 3







Variable Definitions for Program 1

DS(I)	Depths of the girders over the piers
X(J)	Distances from the interior support to the indicated points in the span
AN(I)	Ratios of the moments of inertia of the girders over the piers to those of the girders at mid-span
RL(I), R2(I)	Radii of curves describing the shape of the haunched girder
D(I, J)	Curve ordinates
RI(I, J)	Ratios of the moments of inertia of the girders with respect to that of the girder at mid-span

Variable Definitions for Program 2

NRA	Number of rows in A matrix
NCA	Number of columns in A matrix
NCQ	Number of columns in Q matrix
A(I, J)	Displacement-deformation matrix or internal stresses
AK(I, J)	Deformation-force matrix or stiffness matrix
AM(I, J)	Fixed end moments or internal stresses
Q(I, J)	Unbalanced joint forces or nodal displacements
PM(I, J)	Moment ordinates
LARRY	Subroutine for matrix multiplication
JIMMY	Subroutine for transpose multiplication
FRED	Subroutine for matrix inversion with accompanying solution of linear equations

Variable Definitions for Program 3

SPAN(I)	End span length or interior span length
AM(I)	Influence line ordinates or moment ordinates
DWEB(I)	Depths of the webs
RI(I)	Ratios of the moments of inertia of the girders
TWEB	Thickness of the web of the girder at the interior support
AMIW(I)	Moments of inertia of webs with respect to X axis
SPAW(I)	Cross sectional areas of the webs
WOC	Weight of reinforced concrete on the welded girder
WGMIN	Minimum girder weight which will prevent uplift at the abutments
WOG	Assumed girder weight
ANMAX, PMAX	Maximum negative and positive moments
DESM	Design moment
VAMAX, VEMAX, VCMAX	Maximum shearing forces at supports A, B, and C
DESV	Design shearing force
BFLAN	Flange width of the girder at interior support
AMIFL	Moment of inertia of flange at interior support with respect to X axis
FBS	Actual bending stress at interior support
FVS	Actual shearing stress at interior support
WG	Actual girder weight in lb/ft
WT	Total girder weight of the bridge

```

C      A SERIES OF PROGRAMS FOR DESIGNING HIGHWAY BRIDGE
C      PROGRAM 1  COMPUTE THE RADII OF THE CURVES, CURVE ORDINATES AND
C      MOMENTS OF INERTIA OF THE SECTIONS
      DIMENSION DS(5),X(80),AN(5),Y1(5),R1(5),Y2(5),AK(5),R2(5),YA(5,20)
      DIMENSION YB(5,80),D(5,100),RI(5,100)
100  FORMAT (5F14.2)
110  FORMAT (2F25.4)
120  FORMAT (20X,27HR1                                R2)
130  FORMAT (19X,29H(FT)                                (FT))
140  FORMAT (7X,72HA.  RADII OF THE CURVES FOR DETERMINING THE SHAPE OF
      1 THE HAUNCHED GIRDER)
150  FORMAT (7X,63HB.  CURVE ORDINATES IN INCHES FROM INTERIOR SUPPORT
      1 TO MID-SPAN)
160  FORMAT (7X,72HC.  MOMENTS OF INERTIA OF THE SECTIONS FROM INTERIOR
      1 SUPPORT TO MID-SPAN)
      READ 100, (DS(I),I=1,3)
      READ 100, (X(J),J=1,76)
      READ 100, (AN(I),I=1,3)
      DO 10 I=1,3
        Y1(I)=(DS(I)-36.)*(2.9/15.)
        R1(I)=(108.**2+Y1(I)**2)/(24.*Y1(I))
        Y2(I)=DS(I)-36.-Y1(I)
        AK(I)=(450.**2-Y2(I)**2)/(2.*Y2(I))
10  R2(I)=((450.**2+AK(I)**2)**0.5)/12.
      DO 11 I=1,3
        DO 11 J=1,19
11  YA(I,J)=(R1(I)-(R1(I)**2-X(J)**2)**0.5)*12.
      DO 12 I=1,3
        DO 12 J=1,76
12  YB(I,J)=(-(AK(I)/12.)+(R2(I)**2-(X(J)-37.5)**2)**0.5)*12.
      DO 13 I=1,3
        DO 13 J=1,19
13  D(I,J)=DS(I)-YA(I,J)
      DO 14 I=1,3
        DO 14 J=2,76
14  D(I,J+18)=DS(I)-Y1(I)-YB(I,J)
      DO 15 I=1,3
        DO 15 J=1,94
15  RI(I,J)=AN(I)*(D(I,J)/D(I,1))**2
      DO 16 I=1,3
        PUNCH 140
        PUNCH 120
        PUNCH 130
        PUNCH 110, R1(I),R2(I)
        PUNCH 150
        PUNCH 100, DS(I),(D(I,J),J=4,94,5)
        PUNCH 160
16  PUNCH 100, AN(I),(RI(I,J),J=4,94,5)
      STOP
      END

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C   A SERIES OF PROGRAMS FOR DESIGNING HIGHWAY BRIDGE
C   PROGRAM 2 USING DISPLACEMENT METHOD TO COMPUTE INFLUENCE LINE
C   ORDINATES, POSITIVE AND NEGATIVE MOMENTS
      DIMENSION A(120,120),AK(120,120),AI(60),B(120,120),Q(120,80),PM(80
1,2),AM(120,80)
100 FORMAT (3I10)
110 FORMAT (F14.6)
120 FORMAT (5F14.6)
130 FORMAT (5X,35HA. INFLUENCE LINE ORDINATES FOR MB)
140 FORMAT (5X,35HB. INFLUENCE LINE ORDINATES FOR MC)
150 FORMAT (5X,45HA. MOMENT AT POINT J DUE TO A UNIT LOAD AT J)
160 FORMAT (5X,52HB. MOMENT ORDINATES DUE TO A UNIT UNIFORM DEAD LOAD
1)
170 FORMAT (5X,71HA. MOMENT ORDINATES DUE TO A UNIT UNIFORM LIVE LOAD
1 IN SPANS AB AND CD)
180 FORMAT (5X,52HB. MAX. MOMENT FOR MB DUE TO UNIT UNIFORM LIVE LOAD
1)
190 FORMAT (8X,30HMB MC MD)
200 FORMAT (5X,52HC. MAX. MOMENT FOR MC DUE TO UNIT UNIFORM LIVE LOAD
1)
      READ (1,100) NRA,NCA,NCQ
      DO 10 J=1,NCA
      DO 10 I=1,NRA
10  A(I,J)=0.
      N=NRA/2
      A(1,1)=1.
      A(NRA,N+1)=1.
      I=1
      DO 12 J=2,N
      K=0
11  I=I+1
      A(I,J)=1.
      K=K+1
      IF(K-1) 11,11,12
12  CONTINUE
      READ (1,110) SPAN
      N1=NRA-2
      N2=NRA-6
      DO 13 I=1,2
      A(I,N+2)=1./SPAN
      J=N1+I
13  A(J,NCA)=-A(I,N+2)
      DO 14 I=3,4
      A(I,N+2)=-0.2
      J=N2+I
14  A(J,NCA)=-A(I,N+2)
      NC=0
15  NC=NC+1
      READ (1,100) JMIN,JMAX,I
      DO 17 J=JMIN,JMAX

```

```

      K=0
16  I=I+1
      A(I,J)=0.2
      A(I+2,J)=-0.2
      K=K+1
      IF(K-1) 16,16,17
17  CONTINUE
      IF(NC-4) 15,18,18
18  DO 19 J=1,NRA
      DO 19 I=1,NRA
19  AK(I,J)=0.
      READ (1,120) (AI(K),K=1,N)
      J=0
      DO 20 I=1,2
      J=J+1
      AK(I,J)=10.*AI(1)/SPAN
      NI=N1+I
      NII=N1+J
20  AK(NI,NII)=AK(I,J)
      AK(2,1)=AK(1,1)/2.
      AK(1,2)=AK(2,1)
      AK(NRA,NRA-1)=AK(2,1)
      AK(NRA-1,NRA)=AK(2,1)
      N3=N-1
      I=3
      J=3
      DO 22 K=2,N3
      NC=0
21  AK(I,J)=2.*AI(K)
      NC=NC+1
      I=I+1
      J=J+1
      IF(NC-2) 21,22,22
22  CONTINUE
      J=3
      K=2
      DO 23 I=4,N1,2
      AK(I,J)=AI(K)
      AK(J,I)=AK(I,J)
      J=J+2
23  K=K+1
      CALL LARRY (AK,A,B,NRA,NRA,NCA)
      CALL JIMMY (A,B,AK,NRA,NCA,NCA)
      DO 24 J=1,NCQ
      DO 24 I=1,NRA
24  AM(I,J)=0.
      DO 25 J=1,NCQ
      DO 25 I=1,NCA
25  Q(I,J)=0.
      K=SPAN/5.+1.

```



```

X=0.
DO 26 J=1,K
AM(1,J)=X*(SPAN-X)**2/SPAN**2
AM(2,J)=-(X**2*(SPAN-X)/SPAN**2)
NI=NCQ-K+J
AM(NRA-1,NI)=AM(1,J)
AM(NRA,NI)=AM(2,J)
Q(1,J)=-AM(1,J)
Q(2,J)=-AM(2,J)
Q(N,NI)=Q(1,J)
Q(N+1,NI)=Q(2,J)
Q(N+2,J)=(X+Q(1,J)+Q(2,J))/SPAN
Q(NCA,NI)=(SPAN-X-Q(1,J)-Q(2,J))/SPAN
26 X=X+5.
NC=0
27 NC=NC+1
READ (1,100) IMIN,IMAX,J
DO 28 I=IMIN,IMAX
Q(I,J)=1.
28 J=J+1
IF(NC-4) 27,29,29
29 CALL FRED (AK,NCA,Q,NCQ,DET)
CALL LARRY (B,Q,A,NRA,NCA,NCQ)
DO 30 J=1,NCQ
DO 30 I=1,NRA
30 AM(I,J)=A(I,J)+AM(I,J)
WRITE (2,130)
WRITE (2,120) (AM(20,J),J=1,NCQ)
WRITE (2,140)
WRITE (2,120) (AM(58,J),J=1,NCQ)
X=0.
DO 31 J=1,K
PM(J,1)=(SPAN-X+AM(2,J))*X/SPAN
NI=NCQ-K+J
PM(NI,1)=(SPAN-X+AM(NRA-1,NI))*X/SPAN-AM(NRA-1,NI)
31 X=X+5.
J=K
N4=NRA-4
DO 32 I=4,N4,2
J=J+1
32 PM(J,1)=AM(I,J)
WRITE (2,150)
WRITE (2,120) (PM(J,1),J=1,NCQ)
DO 33 J=1,4
DO 33 I=1,NRA,N1
AM(I,J)=SPAN**2/12.
33 AM(I+1,J)=-AM(I,J)
DO 34 J=1,4
DO 34 I=3,N1,2
AM(I,J)=5.**2/12.

```

```

34 AM(I+1,J)=-AM(I,J)
   DC 35 I=59,96
35 AM(I,3)=0.
   DC 36 I=1,20
36 AM(I,4)=0.
   DC 37 I=21,58
37 AM(I,2)=0.
   DC 38 J=2,4,2
   DC 38 I=97,116
38 AM(I,J)=0.
   DC 39 J=1,4
   Q(1,J)=-AM(1,J)
39 Q(N+1,J)=-AM(NRA,J)
   K=0
40 K=K+1
   J=0
   DC 41 I=2,N
   J=J+2
41 Q(I,K)=-AM(J,K)-AM(J+1,K)
   IF(K-4) 40,42,42
42 DC 43 J=1,4
   Q(N+2,J)=SPAN/2.+5./2.
43 Q(NCA,J)=Q(N+2,J)
   N5=N+3
   N6=NCA-1
   DC 44 J=1,4
   DC 44 I=N5,N6
44 Q(I,J)=5.
   DC 45 I=87,104
45 Q(I,3)=0.
   DC 46 I=60,68
46 Q(I,4)=0.
   DC 47 I=69,86
47 Q(I,2)=0.
   DC 48 J=2,4,2
   DC 48 I=105,113
48 Q(I,J)=0.
   CALL LARRY (AK,Q,A,NCA,NCA,4)
   CALL LARRY (B,A,Q,NRA,NCA,4)
   DC 49 J=1,4
   DC 49 I=1,NRA
49 AM(I,J)=Q(I,J)+AM(I,J)
   K=SPAN/5.+1.
   DC 50 J=1,2
   X=0.
   DC 50 I=1,K
   NI=NCQ-K+I
   PM(I,J)=(SPAN/2.+AM(2,J)/SPAN)*X-X**2/2.
   PM(NI,1)=(SPAN/2.+AM(NRA-1,1)/SPAN)*X-X**2/2.-AM(NRA-1,1)
   PM(NI,2)=(AM(NRA-1,2)/SPAN)*X-AM(NRA-1,2)

```

```

50 X=X+5.
   DO 51 J=1,2
     KI=K
     DO 51 I=4,N4,2
       KI=KI+1
51 PM(KI,J)=AM(I,J)
   WRITE (2,160)
   WRITE (2,120) (PM(I,1),I=1,NCQ)
   WRITE (2,170)
   WRITE (2,120) (PM(I,2),I=1,NCQ)
   WRITE (2,180)
   WRITE (2,190)
   WRITE (2,120) (AM(I,3),I=20,96,38)
   WRITE (2,200)
   WRITE (2,190)
   WRITE (2,120) (AM(I,4),I=20,96,38)
   STOP
   END

```

```

C      SUBROUTINE LARRY (A,B,R,L,M,N)
      MATRIX MULTIPLICATION
      DIMENSION A(120,120),B(120,120),R(120,120)
      DO 10 J=1,N
        DO 10 I=1,L
          R(I,J)=0.
          DO 10 K=1,M
10    R(I,J)=R(I,J)+A(I,K)*B(K,J)
          RETURN
        END

```

```

C      SUBROUTINE JIMMY (A,B,R,L,M,N)
      TRANSPOSE MULTIPLICATION
      DIMENSION A(120,120),B(120,120),R(120,120)
      DO 10 J=1,N
        DO 10 I=1,M
          R(I,J)=0.
          DO 10 K=1,L
10    R(I,J)=R(I,J)+A(K,I)*B(K,J)
          RETURN
        END

```

```

SUBROUTINE FRED (A,N,B,M,DET)
C  MATRIX INVERSION WITH ACCOMPANYING SOLUTION OF LINEAR EQUATIONS
EQUIVALENCE (IROW,JROW),(ICOLU,JCOLU),(AMAX,T,SWAP)
DIMENSION IPIVCT(120),A(120,120),B(120,80),INDEX(120,2),PIVCT(120)
DET=1.
DO 10 J=1,N
10 IPIVCT(J)=0
DO 29 I=1,N
AMAX=0.
DO 15 J=1,N
IF(IPIVCT(J)-1) 11,15,11
11 DO 14 K=1,N
IF(IPIVCT(K)-1) 12,14,33
12 IF(ABS(AMAX)-ABS(A(J,K))) 13,14,14
13 IROW=J
ICOLU=K
AMAX=A(J,K)
14 CONTINUE
15 CONTINUE
IPIVCT(ICOLU)=IPIVCT(ICOLU)+1
IF(IROW-ICOLU) 16,20,16
16 DET=-DET
DO 17 L=1,N
SWAP=A(IROW,L)
A(IROW,L)=A(ICOLU,L)
17 A(ICOLU,L)=SWAP
IF(M) 20,20,18
18 DO 19 L=1,M
SWAP=B(IROW,L)
B(IROW,L)=B(ICOLU,L)
19 B(ICOLU,L)=SWAP
20 INDEX(I,1)=IROW
INDEX(I,2)=ICOLU
PIVCT(I)=A(ICOLU,ICOLU)
DET=DET*PIVCT(I)
A(ICOLU,ICOLU)=1.
DO 21 L=1,N
21 A(ICOLU,L)=A(ICOLU,L)/PIVCT(I)
IF(M) 24,24,22
22 DO 23 L=1,M
23 B(ICOLU,L)=B(ICOLU,L)/PIVCT(I)
24 DO 29 L1=1,N
IF(L1-ICOLU) 25,29,25
25 T=A(L1,ICOLU)
A(L1,ICOLU)=0.
DO 26 L=1,N
26 A(L1,L)=A(L1,L)-A(ICOLU,L)*T
IF(M) 29,29,27
27 DO 28 L=1,M
28 B(L1,L)=B(L1,L)-B(ICOLU,L)*T

```

```
29 CONTINUE
   DO 32 I=1,N
     L=N+1-I
     IF (INDEX(L,1)-INDEX(L,2)) 30,32,30
30  JROW=INDEX(L,1)
     JCOLUM=INDEX(L,2)
     DO 31 K=1,N
       SWAP=A(K,JROW)
       A(K,JROW)=A(K,JCOLUM)
       A(K,JCOLUM)=SWAP
31  CONTINUE
32  CONTINUE
33  RETURN
    END
```

```

C   A SERIES OF PROGRAMS FOR DESIGNING HIGHWAY BRIDGE
C   PROGRAM 3  DESIGN THE GIRDER SECTION WITH THE ACTUAL SHEARING
C   STRESS AND ACTUAL BENDING STRESS TO MEET THE REQUIREMENTS OF THE
C   AASHO SPECIFICATION AFTER GETTING THE MAX. SHEARING FORCE AND MAX.
C   MOMENT
      DIMENSION SPAN(5),AM(25),SPANI(15),DWEB(15),RI(15),AMIW(15),AMIF(1
15),SPFLA(15),SPAW(15),A(15),FB(15)
100 FORMAT (5F14.6)
110 FORMAT (3F20.3)
120 FORMAT (2F25.2)
130 FORMAT (4F15.3)
140 FORMAT (5X,54HA.  MINIMUM, REQUIRED, AND TOTAL WEIGHTS OF THE GIRD
IER)
150 FORMAT (5X,38HB.  MAX. NEGATIVE AND POSITIVE MOMENTS)
160 FORMAT (5X,47HC.  MAX. SHEARING FORCE AT SUPPORTS A, B, AND C)
170 FORMAT (5X,56HD.  WIDTH OF FLANGES AT INTERIOR SUPPORT AND AT MID-
SPAN)
180 FORMAT (5X,69HE.  BENDING AND SHEARING STRESSES AT INTERIOR SUPPOR
IT AND AT MID-SPAN)
190 FORMAT (13X,45HMNEGA                                MPOSI                                MDES)
200 FORMAT (12X,48H(KIP-FT)                                (KIP-FT)                                (KIP-FT))
210 FORMAT (11X,48HVA                                VB                                VC                                VDES)
220 FORMAT (9X,51H(KIPS)                                (KIPS)                                (KIPS)                                (KIPS))
230 FORMAT (21X,28HBF1                                BF2)
240 FORMAT (21X,29H(IN)                                (IN))
250 FORMAT (11X,48HFB1                                FV1                                FB2                                FV2)
260 FORMAT (10X,50H(KSI)                                (KSI)                                (KSI)                                (KSI))
270 FORMAT (15X,43HWGMIN                                WG                                WT)
280 FORMAT (14X,46H(LB/FT)                                (LB/FT)                                (KIPS))

      READ 100, (SPAN(I),I=1,4)
      READ 100, (AM(I),I=1,25)
      READ 100, (DWEB(I),I=1,12)
      READ 100, (RI(I),I=1,11)
      AI1=50./(.5*(SPAN(1)+95.)+125.)+1.
      AI2=50./((SPAN(1)+125.)+1.
      AI3=50./((SPAN(2)+125.)+1.
      AI4=50./((95.)+125.)+1.
      DF=8./5.5
      VAC=(AM(8)/SPAN(2)+1.)*13.*DF
      VALD=(AM(9)*0.32/SPAN(2)+0.32*SPAN(2)/2.)*DF+VAC
      VBC=(1.+(AM(11)+AM(12))/95.)*13.*DF
      VBLD=((AM(13)+AM(14))*0.32/95.+0.32*95./2.)*DF+VBC
      VCC=(1.+(AM(17)+AM(18))/95.)*13.*DF
      VCLD=((AM(19)+AM(20))*0.32/95.+0.32*95./2.)*DF+VCC
      IF(DWEB(11)-51.) 10,10,11
10  TWEB=0.3125
      GO TO 12
11  TWEB=0.375
12  DO 13 I=1,11
      AMIW(I)=TWEB*DWEB(I)**3/12.

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      AMIF(I)=2.*((DWEB(I)+1.)/2.)*2
13 SPAW(I)=DWEB(I)*TWEB
      WCC=63.*0.15/12.+0.015
      CRMBL=((AM(23)+AM(24))*9.+AM(25)*0.32)*DF)*AI3
      WD=(-(CRMBL/SPAN(2)))/(AM(10)/SPAN(2)+SPAN(2)/2.)
      DWD=WD-WCC
      IF(DWD) 14,14,15
14 WGMIN=0.
      GO TO 16
15 WGMIN=DWD*1000.
16 WCG=0.2
17 WCG=WCG-0.00001
      W=WCC+WCG
      ANMAX=((AM(1)+AM(2))*9.+AM(3)*0.32)*DF)*AI1+AM(4)*W
      PMAX=((AM(5)*9.+AM(6)*0.32)*DF)*AI2+AM(7)*W
      IF(ABS(ANMAX)-ABS(PMAX)) 18,18,19
18 DESM=ABS(PMAX)
      GO TO 20
19 DESM=ABS(ANMAX)
20 VAMAX=(AM(10)/SPAN(2)+SPAN(2)/2.)*W+VALD*AI3
      VBMAX=((AM(15)+AM(16))/95.+95./2.)*W+VBLD*AI4
      VCMAX=((AM(21)+AM(22))/95.+95./2.)*W+VCLD*AI4
      IF(ABS(VAMAX)-ABS(VBMAX)) 21,21,22
21 DESV=ABS(VBMAX)
      GO TO 23
22 DESV=ABS(VAMAX)
      GO TO 26
23 IF(ABS(VCMAX)-DESV) 24,24,25
24 DESV=DESV
      GO TO 28
25 DESV=ABS(VCMAX)
      GO TO 28
26 IF(ABS(VCMAX)-DESV) 27,27,25
27 DESV=DESV
28 BFLAN=22.
      NC=0
29 BFLAN=BFLAN-0.01
      GO TO 31
30 NC=NC+1
      BFLAN=BFLAN+0.01
31 AMIFL=AMIF(11)*BFLAN
      AMI=AMIW(11)+AMIFL
      FBS=DESM*12.*DWEB(12)/AMI
      PRINT 100, FBS
      IF(NC) 32,32,33
32 DFB=20.-FBS
      IF(DFB-0.01) 33,33,29
33 FVS=DESV/SPAW(11)
      FVM=DESV/SPAW(1)
      DO 35 I=1,10
      SPANI(I)=AMI*RI(I)/RI(11)

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      FB(I)=PMAX*6.*(DWEB(I)+2.)/SPANI(I)
      IF(FB(I)-20.) 34,34,30
34  SPFLA(I)=(SPANI(I)-AMIW(I))/AMIF(I)
35  A(I)=SPAW(I)+2.*SPFLA(I)
      A1=(A(2)+A(3)+A(4)+A(5)+A(6)+A(7)+A(8)+A(9)+A(10))*30.
      A2=A(1)*(SPAN(3)+10.)
      AREA=(A1+A2)/SPAN(4)
      WG=0.49*AREA/144.
      DWG=WCG-WG
      IF(DWG-0.00001) 36,36,17
36  WCG=WG*1000.
      IF(WGMIN-WCG) 37,37,41
37  WT=WG*SPAN(4)*4.
      IF(NC) 38,38,39
38  DESM=ABS(ANMAX)
      GO TO 40
39  DESM=PMAX
40  PUNCH 140
      PUNCH 270
      PUNCH 280
      PUNCH 110, WGMIN,WCG,WT
      PUNCH 150
      PUNCH 190
      PUNCH 200
      PUNCH 110, ANMAX,PMAX,DESM
      PUNCH 160
      PUNCH 210
      PUNCH 220
      PUNCH 130, VAMAX,VBMAX,VCMAX,DESV
      PUNCH 170
      PUNCH 230
      PUNCH 240
      PUNCH 120, BFLAN,SPFLA(1)
      PUNCH 180
      PUNCH 250
      PUNCH 260
      PUNCH 130, FBS,FVS,FB(1),FVM
      GO TO 42
41  WT=WGMIN*SPAN(4)*4./1000.
      PUNCH 140
      PUNCH 270
      PUNCH 280
      PUNCH 110, WGMIN,WGMIN,WT
42  CONTINUE
      STOP
      END

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A STUDY TO DETERMINE THE OPTIMUM END SPAN LENGTH
FOR A CIRCULAR HAUNCHED GIRDER INTER-STATE
HIGHWAY GRADE SEPARATION

by

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Diploma, Taipei Institute of Technology, 1963

AN ABSTRACT OF A MASTER'S REPORT

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The objective of this study was to find the end span lengths, for girders with circular haunches, resulting in the minimum girder weight for a four span symmetric four girder bridge under the following constraints:

1. The depth of the girder at mid-span and at the abutment as well as the interior span length is held constant. The interior spans are 95 feet each, and the girder depth at mid-span and at the abutment is 36 inches.
2. The continuously varying depth of the girder is to be approximated by a girder which has a prismatic haunch every 5 feet from the interior support to mid-span. The ratios of the moments of inertia of the girders at the interior supports to those of the girders at mid-spans are 1.5, 2.0, and 2.5.
3. The dead load weight of the girder is taken as the average weight of the girder, and the design of the stiffeners and diaphragms is omitted for the purpose of simplifying the computations.
4. There is to be no uplift at the abutments.
5. H20-44 loading is to be used.
6. The current AASHTO Standard Specifications for Highway Bridges are to be used.
7. A non-composite reinforced concrete deck is to be used on the welded girders.
8. In order to maintain a symmetric haunch, only lengths of end span, AL , which are equal to or larger than 47.5 feet were selected.
9. For design, use the uplift resulting from the loading which includes the concentrated loads for moment but not for shear.
10. A-36 steel is to be used.

A trial and error method was used in this study and all of the calculations were performed on the computer. The trials were made with the end span lengths ranging from 50' to 80'. A total of 12 cases was investigated. Since this study was confined to working only with the superstructure, the true most economical length of structure was not necessarily found. The study indicates that the range of lengths for which minimum weight girders with no uplift at the abutments were the controlling factor is rather narrow. This range appears to be from approximately 55' to 58'. However, if the quantity of reinforced concrete on the welded girders is taken into consideration, the optimum length may well be somewhat shorter than that indicated above.