

3-0
A MICROCOMPUTER PROGRAM FOR THE DESIGN OF
MINIMUM WEIGHT BRIDGE PLATE GIRDERS

by

DONALD K. ALLISON

B. S., Kansas State University, 1982

A MASTER'S REPORT

submitted in partial fulfillment of the

requirements for the degree

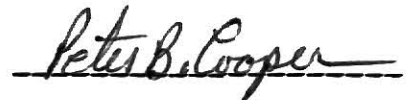
MASTER OF SCIENCE

Department of Civil Engineering

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1984

Approved by:



Major Professor

LD
2008
R4
1984
A46
c.2

TABLE OF CONTENTS

ALL202 663148

	Page
INTRODUCTION	1
DESIGN CRITERIA	2
INPUT	5
DESIGN COMPUTATIONS	7
OUTPUT	10
FLOW DIAGRAM	11
DESIGN EXAMPLE	16
DISCUSSION OF RESULTS	27
SUMMARY	31
RECOMMENDATIONS FOR FURTHER WORK	32
APPENDIX I - NOTATION	33
APPENDIX II - PROGRAM LISTING	34

LIST OF FIGURES

	Page
1. Flow Diagram	13
2. Girder Weight vs. Web Thickness	28
3. Girder Weight vs. Span Length	30

LIST OF TABLES

1. Minimum Weld Size	2
2. Sizing of Web and Flange Plates	3
3. Unstiffened Girder Design, $F_y = 36$ ksi	19
4. Transversely Stiffened Girder Design, $F_y = 36$ ksi	20
5. Longitudinally Stiffened Girder Design, $F_y = 36$ ksi	22
6. Unstiffened Girder Design, $F_y = 50$ ksi	23
7. Transversely Stiffened Girder Design, $F_y = 50$ ksi	24
8. Longitudinally Stiffened Girder Design, $F_y = 50$ ksi	26

ACKNOWLEDGEMENTS

I would like to express my appreciation to all those who have helped me throughout my graduate studies at Kansas State University. I would like to extend a special thanks to my faculty advisor, Dr. Peter B. Cooper, for his guidance and help with this report; to Dr. Kuo K. Hu for providing me with the necessary background in computer programming; and to my fiancée, Susan Mostaffa, for her understanding and patience throughout this past year.

INTRODUCTION

The objective of the work described in this report was to develop a microcomputer program to aid in the design of minimum weight bridge plate girders according to the Twelfth Edition of the Standard Specifications for Highway Bridges published by the American Association of State Highway and Transportation Officials (AASHTO) in 1977.*

The plate girders designed by this program have a constant cross section and simply supported spans. They are designed assuming that sufficient lateral support will be provided along the compressive flange such that the maximum applied bending stress is equal to the maximum allowable bending stress, F_b , where F_b equals $0.55 F_y$, and F_y is the steel yield stress. Yield stresses of 36 and 50 ksi can be used in the design. The program does not include the lateral load distribution procedures specified in the AASHTO Specifications, nor does it provide for the design of stiffeners.

The program listing presented in Appendix II has been written in the Z-Basic language for use with the Zenith Z-100 Desktop Microcomputer. Minor editing is needed for use with other computer systems.

The text of this report has been written on the Radio Shack TRS-80 Model II Microcomputer using Scripsit Word Processing Version 2.1.

* Since this is the only reference used in this report, a separate listing of references is not provided.

DESIGN CRITERIA

Plate girders bridges must be designed to absorb impact loads as well as dead and live loads. In accordance with the AASHTO Specifications, the maximum live load shear and moment shall be increased by

$$I = 50/(L+125) \quad (1)$$

where I is the impact fraction, not greater than 0.3, and L is the length of the girder span in feet.

The specifications suggest that the ratio of the web depth, D , to the span length be not less than $1/25$. Although this ratio may be exceeded, it has not been in this program.

Welds connecting the web plate to the flanges must meet the specifications for maximum and minimum weld sizes. A summary of the minimum fillet weld size for plate thicknesses of $5/16"$ to $6"$ is presented in Table 1. The maximum weld size may not exceed the thickness of the thinner plate less $1/16"$.

Thickness (T) of Thicker Part (inches)	Min. Size of Fillet Weld (inches)
$T \leq 1/2$	$3/16$
$1/2 < T \leq 3/4$	$1/4$
$3/4 < T \leq 1-1/2$	$5/16$
$1-1/2 < T \leq 2-1/4$	$3/8$
$2-1/4 < T \leq 6$	$1/2$

Table 1. Minimum weld size.

For the purpose of this program, the dimensions of the web and flange plates are set in increments shown in Table 2.

Section	Dimension	Increment (in)
Web	Thickness	1/16
	Depth	1
Flange	Thickness	1/4
	Width	1

Table 2. Sizing of Web and Flange Plates.

The minimum plate thickness permitted by the AASHTO Specifications is 5/16".

For the design of unstiffened girders, the minimum web thickness shall be not less than $D/150$, and the average unit shearing stress, f_v , on the gross section of the web may not exceed

$$F_v = (5.625 * 10^7) / (D/t_w)^2 \quad (2)$$

where F_v is the allowable shearing stress in ksi and t_w is the web thickness in inches. The maximum value of F_v is $F_y/3$.

Equation (2) may be solved for t_w , resulting in Equation (3) where V_d is the design shear in pounds.

$$t_w = ((D * V_d) / (7500)^2)^{1/3} \quad (3)$$

For transversely stiffened girders, the web plate thickness shall be not less than

$$t_w = D*(F_b)^{1/2}/23000. \quad (4)$$

This thickness shall in no case be less than $D/170$. Where the maximum compressive bending stress, f_b , is equal to F_b , the ratios of D/t_w for 36 and 50 ksi steels are 165 and 140, respectively.

For plate girders stiffened both transversely and longitudinally, the web plate thickness shall be not less than

$$t_w = D*(f_b)^{1/2}/46000. \quad (5)$$

Where the maximum compressive bending stress is equal to F_b , the ratios of D/t_w for 36 and 50 ksi steels are 330 and 280, respectively.

The ratio of the flange width, b_f , to the thickness, t_f , shall not exceed

$$b_f/t_f = 3250/(F_b)^{1/2}. \quad (6)$$

This ratio shall in no case exceed 24. Where the maximum compressive bending stress is equal to F_b , the ratios of b_f/t_f for 36 and 50 ksi steels are 23 and 20, respectively.

INPUT

There are seven parameters upon which the plate girder designs are based: span length, maximum live load shear, maximum live load moment, maximum dead load shear, maximum dead load moment, assumed girder weight per foot, and the steel yield strength.

SPAN LENGTH. The span length is the longitudinal distance in feet between the two simply supported ends.

MAXIMUM LIVE LOAD SHEAR. The maximum live load shear in kips is calculated in accordance with Article 1.2.5 of the AASHTO Specifications. This must be done prior to starting the girder design using the computer program.

MAXIMUM LIVE LOAD MOMENT. The maximum live load moment in kip-feet is computed in the same manner as the maximum live load shear.

MAXIMUM DEAD LOAD SHEAR. The maximum dead load shear is the shear expressed in kips found at each end of the girder due to the weight of the slab, curb, railing, and any other dead load other than that of the girder's self weight.

MAXIMUM DEAD LOAD MOMENT. The maximum dead load moment is the moment expressed in kip-feet found at the center of the span due to weight of the slab, curb, railing, and any other dead load other than that of the girder's self weight.

ASSUMED UNIT GIRDER WEIGHT. The assumed girder weight in pounds per linear foot is an approximate value of the weight of the girder with the minimum allowable web thickness. Although this input need not be exact, the closer the approximation to the actual girder weight,

the more accurate this first design will represent the loading conditions upon the span.

YIELD STRENGTH OF STEEL. The yield strength of steel is the minimum allowable yield strength of the steel being used in the fabrication of the girder. This program allows for yield strengths of 36 and 50 ksi only.

DESIGN COMPUTATIONS

The design of the plate girder is executed in the following manner:

1. CALCULATE DESIGN SHEAR AND MOMENT. The design shear and moment values are calculated in the same manner. The live load plus impact shear and moment values are obtained by multiplying their live load input values by an impact factor. The dead load shear and moment values are obtained by adding their respective input values to the maximum shear and moment values due to the girder dead load. The design shear and moment is the sum of the respective dead, live and impact load values.

2. CALCULATE REQUIRED SECTION MODULUS. The section modulus is obtained by dividing the design moment by F_b .

3. DETERMINE MINIMUM WEB THICKNESS. For the design of an unstiffened plate girder, the minimum web thickness is equal to the largest of the three values obtained by Equation (3) and

$$t_w = D / (D/t_w \text{ Ratio}) \quad (7)$$

$$t_w = 5/16". \quad (8)$$

For the design of a plate girder with stiffeners, whether transverse or longitudinal, the minimum web thickness is the larger of the two values obtained by Equations (7) and (8). In all three cases, the values from Equations (3) and (7) are rounded to the next largest 1/16th inch increment.

4. DETERMINE MAXIMUM WEB DEPTH. The maximum web depth for unstiffened girders is the smaller of the two values obtained by solving Equations (3) and (7) for D. For stiffened girders, this dimension is the value obtained by solving Equation (7) for D. In all three designs, D must be equal to or greater than

$$D = L/25 \quad (9)$$

where L is the span length in inches.

5. CALCULATE REQUIRED FLANGE MOMENT OF INERTIA. The required moment of inertia of the flange is

$$I_f = (D/2 + t_f) * S - (1/12) * t_w * D^3 \quad (10)$$

where I_f is the flange moment of inertia in in^4 , t_f is the flange thickness in inches, and S is the required section modulus in in^3 .

6. CALCULATE REQUIRED FLANGE AREA. The required flange area is

$$A_f = I_f / (2 * (D/2 + t_f/2)^2) \quad (11)$$

where A_f is the cross sectional area of the flange in in^2 .

7. CALCULATE MINIMUM FLANGE THICKNESS. The minimum required flange thickness is

$$t_f = A_f / (b_f / t_f \text{ Ratio}) \quad (12)$$

where t_f is rounded to the next largest 1/4 inch increment.

8. CALCULATE FLANGE WIDTH. The flange width is calculated by dividing the required flange area by the minimum flange thickness. This value is rounded to the next larger one inch increment.

9. CALCULATE GIRDER WEIGHT PER FOOT. The girder weight per foot is the product of the cross sectional area of the girder and the unit weight of steel (490 pcf).

10. INCREMENT WEB THICKNESS AND REPEAT PROCEDURE. Once the girder weight per foot has been calculated, the above procedure is repeated beginning with Step 4 and incrementing the web thickness by 1/16". Comparisons between the girder weights begin upon the completion of the second acceptable design alternative.

OUTPUT

There is an output for all trial sections. Should all specifications be met by a design, then it may be considered as an acceptable alternative. The section with the lowest girder weight is considered the most economical section and is highlighted with such an explanation as shown in Table 3. Two alternative flange designs are also presented along with the most economical section.

Each trial section meeting all specifications set forth by AASHTO will have output for each of the following:

1. Web Thickness
2. Web Depth
3. Flange Thickness
4. Flange Width
5. Weld Size and
6. Weight Per Foot.

An explanation will be given for each trial section not meeting an AASHTO specification. A trial section will be rejected for the following reasons:

1. Section Fails To Meet Minimum Depth Specifications
2. Section Fails To Meet Maximum Compressive Bending Stress Specifications
3. Section Fails To Meet Maximum Shearing Stress Specifications
4. Section Fails To Meet Maximum/Minimum Weld Size Specifications or
5. Section Fails To Meet Flange Requirements.

FLOW DIAGRAM

Portions of the flow diagram presented in Figure 1 should be self explanatory for the computations previously discussed. Other aspects of the flow diagram are discussed here.

A trial section is run through five cycles in order to zero in on the least girder weight for a particular web thickness. On each cycle, a trial design is developed based on the loading conditions corresponding to a girder weight of a previous cycle or the assumed girder weight in the case of an initial design.

After the dimensions of this section have been determined, it is then checked for compliance with the specifications. Should a design not meet any one of the specifications, it is rejected as an alternative and all data on that section is then stored in memory.

Comparisons between girder weights are made upon the completion of the second successful girder design. If the challenging girder has a lesser weight than the previous design, the program continues. Once the challenging girder weight becomes greater, the process of designing sections terminates with the least weight girder being considered the most economical.

With the web dimensions remaining the same, two alternative flange designs are developed in the same manner as was the original with the exception that the flange thickness of each is chosen to be $1/4$ " and $1/2$ " thicker than

the original thickness. These designs are then checked for compliance with the specifications.

All results are the presented on the video monitor and/or printed for inspection.

FLOW DIAGRAM

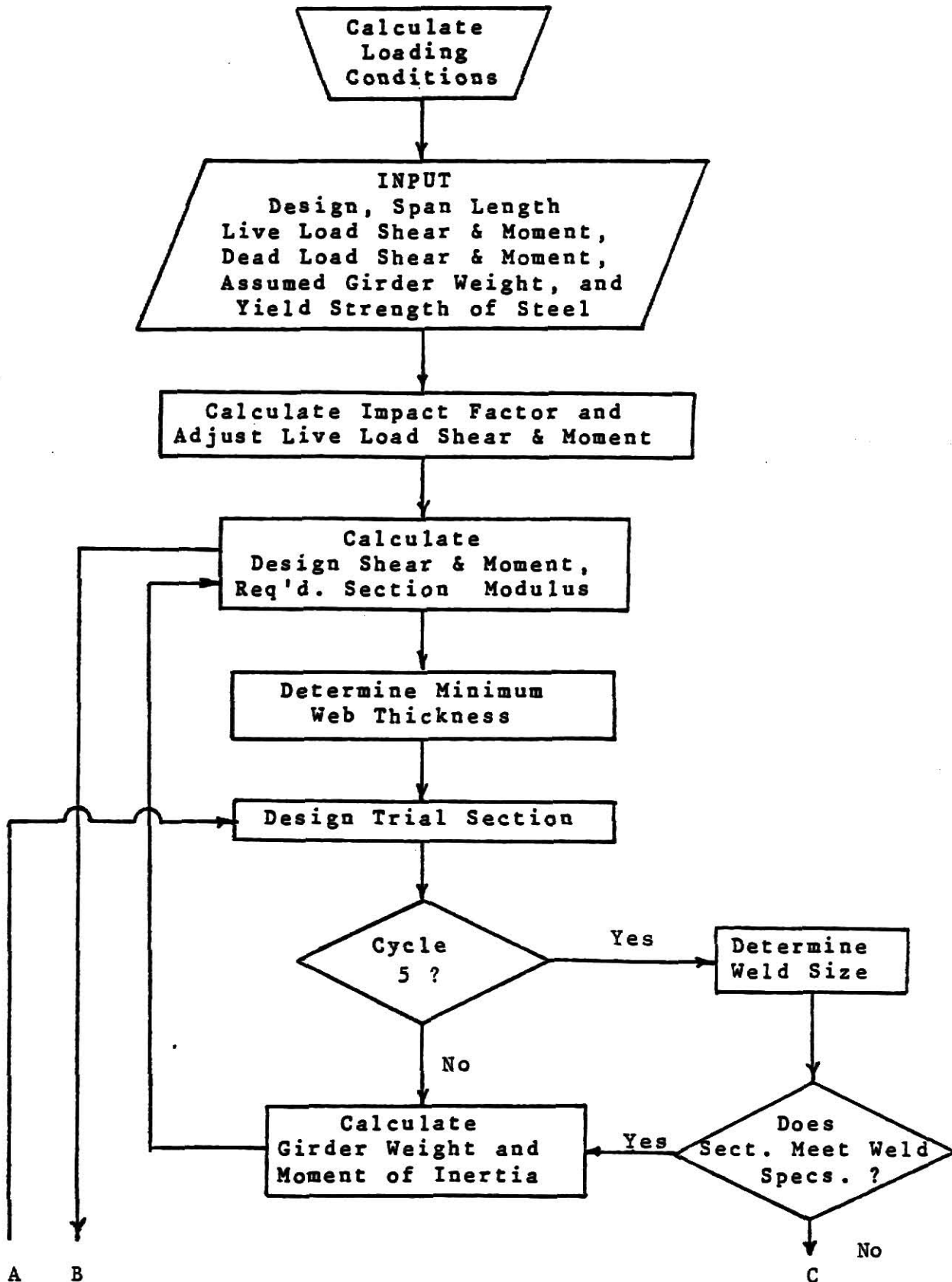


Figure 1. Flow Diagram.

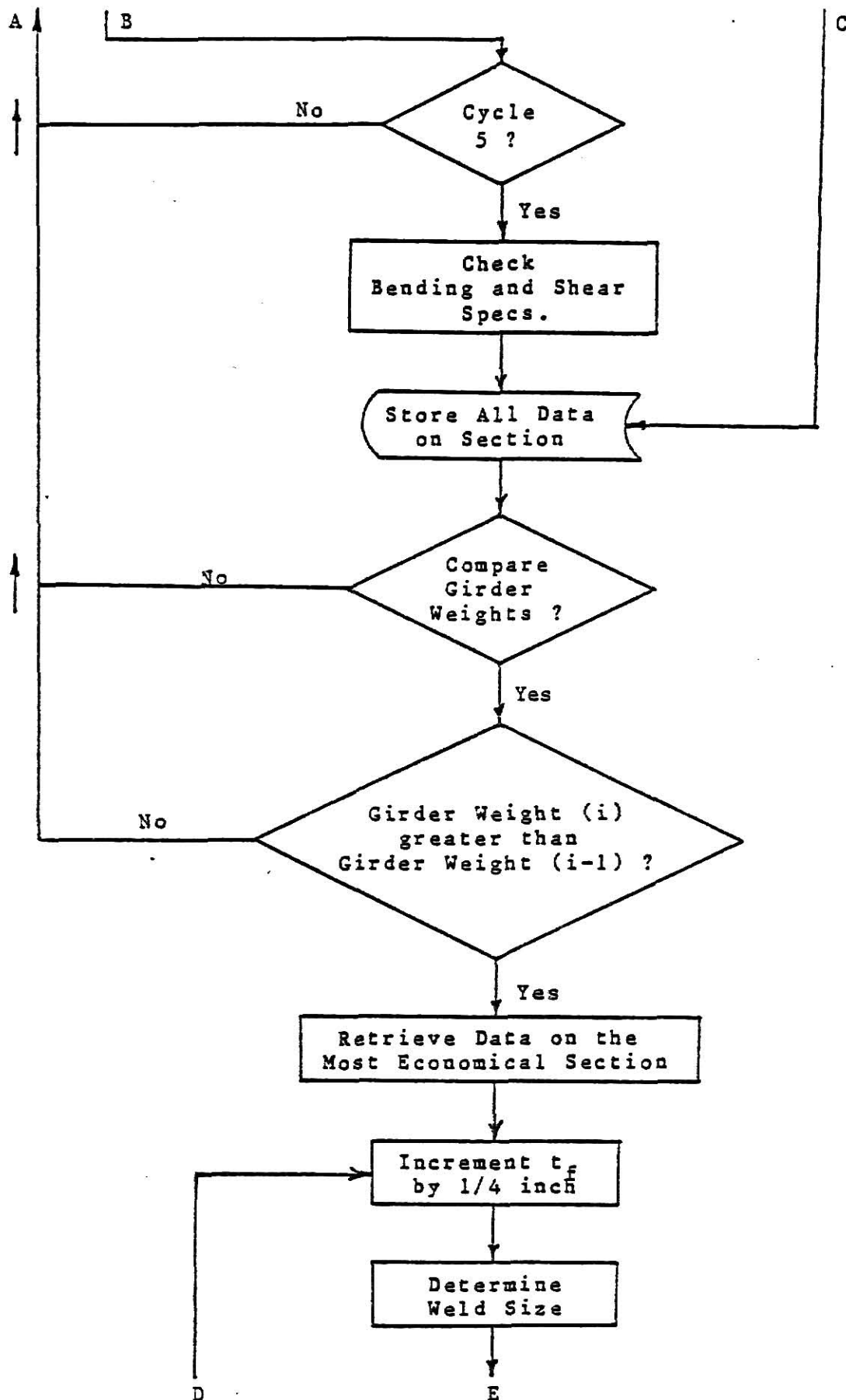


Figure 1. Flow Diagram (cont.)

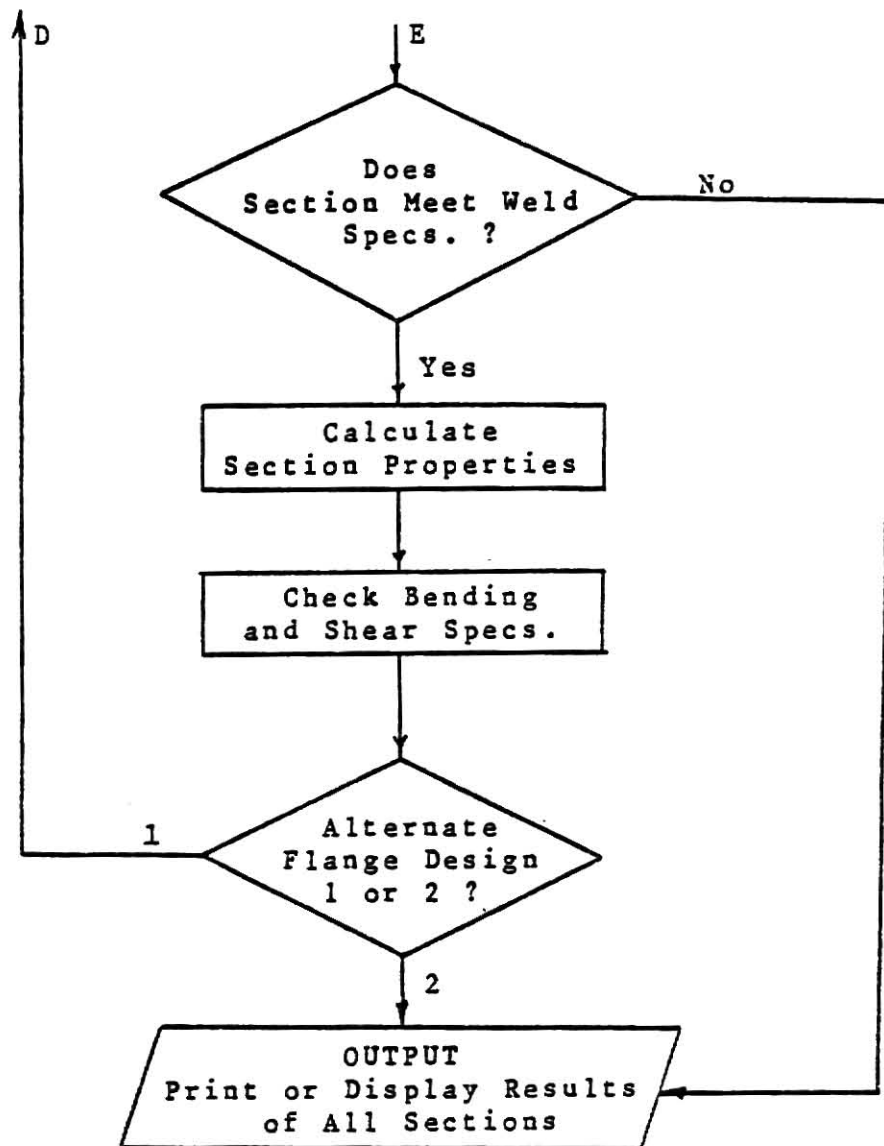


Figure 1. Flow Diagram (cont.)

DESIGN EXAMPLE

PROBLEM STATEMENT:

Select the unstiffened, transversely stiffened, and longitudinally stiffened plate girders of the lightest weight for both 36 and 50 ksi steel for the simply supported bridge shown. Design the girders, each supporting one lane of traffic, for H 20 loading conditions given the following:

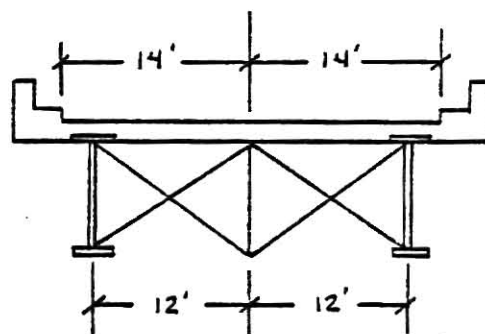
Span Length = 100'

Curb and Railing Wt. = 200 plf

Slab thickness = 8"

Lane Width = 14'

Concrete Unit Weight = 150 pcf

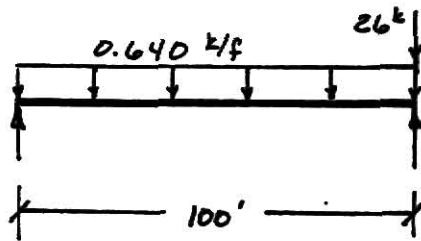


SOLUTION:

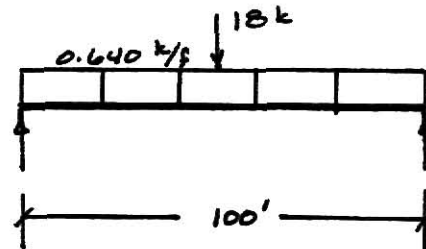
It is assumed that sufficient lateral support is provided along the compressive flange such that the applied bending stress is equal to the maximum allowable bending stress ($f_b = 0.55 F_y$).

Live Loads. For this example, it is assumed that the AASHTO lane loading controls. Under H 20 loading conditions, Article 1.2.5 of the AASHTO Specifications requires that each lane of road carry a uniform load of 640 plf in addition to an 18 kip concentrated load when determining the maximum live load moment and a 26 kip concentrated load when determining the maximum live load shear. The free body diagram and the resultant maximum live load shear and moment are shown.

For Maximum Shear



For Maximum Moment



$$\text{Max. } V_{LL} = \frac{(0.640 \text{ klf})(100')}{2} + 26 \text{ k} = 58 \text{ k}$$

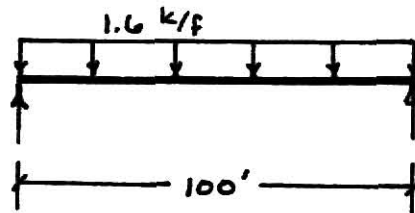
$$\text{Max. } M_{LL} = \frac{(0.640 \text{ klf})(100')^2}{8} + \frac{(18 \text{ k})(100')}{4} = 1250 \text{ k'}$$

Dead Loads. The dead loads applied to the girder are those due to the weight of the slab, curb and railing. The tabulation of the maximum dead load shear and moment along with the free body diagram are shown below.

$$\text{Slab Wt.} = (8/12')(0.150 \text{ kcf})(14') = 0.2 \text{ klf}$$

$$\text{Curb and Railing Wt.} = 1.4$$

$$\text{Total Dead Load} = 1.6 \text{ klf}$$



$$\text{Max. } V_{DL} = \frac{(1.6 \text{ k/f})(100')}{2} = 80 \text{ k}$$

$$\text{Max. } M_{DL} = \frac{(1.6 \text{ k/f})(100')^2}{8} = 2000 \text{ k'}$$

Input Summary.

Span Length = 100'
Max. Live Load Shear = 58 k
Max. Live Load Moment = 1250 k'
Max. Dead Load Shear = 80 k
Max. Dead Load Moment = 2000 k'
Yield Strength of Steel = 36 and 50 ksi
Assumed Girder Dead Load = 300 plf

Output. The output for unstiffened, transversely stiffened, and longitudinally stiffened plate girders of both 36 and 50 ksi steel are presented in Tables 3 through 8. The lightest section for each design is that presented as the "MOST ECONOMICAL SECTION".

UNSTIFFENED GIRDER DESIGN ---

FOR WEB THICKNESS		=	9/16 IN(S)
WEB DEPTH		=	59
FLANGE THICKNESS		=	1-1/4
FLANGE WIDTH		=	28
WELD SIZE		=	5/16
WEIGHT PER FOOT		=	351.1 PLF

UNSTIFFENED GIRDER DESIGN ---

*** MOST ECONOMICAL SECTION ***

FOR WEB THICKNESS		=	5/8 IN(S)
WEB DEPTH		=	82
FLANGE THICKNESS		=	1
FLANGE WIDTH		=	21
WELD SIZE		=	5/16
WEIGHT PER FOOT		=	317.3 PLF

ALTERNATIVE FLANGE DESIGNS

FLANGE THICKNESS		=	1-1/4 IN(S)
FLANGE WIDTH		=	17
WELD SIZE		=	5/16
WEIGHT PER FOOT		=	319 PLF

FLANGE THICKNESS		=	1-1/2 IN(S)
FLANGE WIDTH		=	14
WELD SIZE		=	5/16
WEIGHT PER FOOT		=	317.3 PLF

UNSTIFFENED GIRDER DESIGN ---

FOR WEB THICKNESS		=	11/16 IN(S)
WEB DEPTH		=	103
FLANGE THICKNESS		=	3/4
FLANGE WIDTH		=	15
WELD SIZE		=	1/4
WEIGHT PER FOOT		=	317.5 PLF

Table 3. Unstiffened Girder Design, $F_y = 36$ ksi.

TRANSVERSELY STIFFENED GIRDER DESIGN

FOR WEB THICKNESS = 5/16 IN(S)
 WEB DEPTH = 51
 FLANGE THICKNESS = 1-1/2
 SECTION FAILS TO MEET MAX./MIN. WELD SIZE SPECIFICATIONS.

TRANSVERSELY STIFFENED GIRDER DESIGN

FOR WEB THICKNESS = 3/8 IN(S)
 WEB DEPTH = 61
 FLANGE THICKNESS = 1-1/4
 FLANGE WIDTH = 28
 WELD SIZE = 5/16
 WEIGHT PER FOOT = 316 PLF

TRANSVERSELY STIFFENED GIRDER DESIGN

FOR WEB THICKNESS = 7/16 IN(S)
 WEB DEPTH = 72
 FLANGE THICKNESS = 1-1/4
 FLANGE WIDTH = 22
 WELD SIZE = 5/16
 WEIGHT PER FOOT = 294.3 PLF

Table 4. Transversely Stiffened Girder Design, $F_y = 36$ ksi.

TRANSVERSELY STIFFENED GIRDER DESIGN

*** MOST ECONOMICAL SECTION ***

FOR WEB THICKNESS	=	1/2 IN(S)
WEB DEPTH	=	82
FLANGE THICKNESS	=	1
FLANGE WIDTH	=	22
WELD SIZE	=	5/16
WEIGHT PER FOOT	=	289.2 PLF

ALTERNATIVE FLANGE DESIGNS

FLANGE THICKNESS	=	1-1/4 IN(S)
FLANGE WIDTH	=	18
WELD SIZE	=	5/16
WEIGHT PER FOOT	=	292.6 PLF

FLANGE THICKNESS	=	1-1/2 IN(S)
FLANGE WIDTH	=	15
WELD SIZE	=	5/16
WEIGHT PER FOOT	=	292.6 PLF

TRANSVERSELY STIFFENED GIRDER DESIGN

FOR WEB THICKNESS	=	9/16 IN(S)
WEB DEPTH	=	92
FLANGE THICKNESS	=	1
FLANGE WIDTH	=	17
WELD SIZE	=	5/16
WEIGHT PER FOOT	=	291.7 PLF

Table 4 (cont.). Transversely Stiffened Girder Design,
F_y = 36 ksi.

LONGITUDINALLY STIFFENED GIRDER DESIGN ---

FOR WEB THICKNESS = 5/16 IN(S)
 WEB DEPTH = 103
 FLANGE THICKNESS = 1
 SECTION FAILS TO MEET MAX./MIN. WELD SIZE SPECIFICATIONS.

LONGITUDINALLY STIFFENED GIRDER DESIGN ---

*** MOST ECONOMICAL SECTION ***

FOR WEB THICKNESS = 3/8 IN(S)
 WEB DEPTH = 123
 FLANGE THICKNESS = 3/4
 FLANGE WIDTH = 15
 WELD SIZE = 1/4
 WEIGHT PER FOOT = 233.5 PLF

ALTERNATIVE FLANGE DESIGNS

FLANGE THICKNESS = 1 IN(S)
 FLANGE WIDTH = 12
 WELD SIZE = 5/16
 WEIGHT PER FOOT = 238.6 PLF

FLANGE THICKNESS = 1-1/4 IN(S)
 FLANGE WIDTH = 9
 WELD SIZE = 5/16
 WEIGHT PER FOOT = 233.5 PLF

LONGITUDINALLY STIFFENED GIRDER DESIGN ---

FOR WEB THICKNESS = 7/16 IN(S)
 WEB DEPTH = 144
 FLANGE THICKNESS = 3/4
 FLANGE WIDTH = 8
 WELD SIZE = 1/4
 WEIGHT PER FOOT = 255.2 PLF

Table 5. Longitudinally Stiffened Girder Design, $F_y = 36$ ksi.

UNSTIFFENED GIRDER DESIGN -----

FOR WEB THICKNESS	=	9/16 IN(S)
WEB DEPTH	=	60
FLANGE THICKNESS	=	1-1/4
FLANGE WIDTH	=	19
WELD SIZE	=	5/16
WEIGHT PER FOOT	=	276.4 PLF

UNSTIFFENED GIRDER DESIGN -----

*** MOST ECONOMICAL SECTION ***

FOR WEB THICKNESS	=	5/8 IN(S)
WEB DEPTH	=	83
FLANGE THICKNESS	=	1
FLANGE WIDTH	=	12
WELD SIZE	=	5/16
WEIGHT PER FOOT	=	258.1 PLF

ALTERNATIVE FLANGE DESIGNS

FLANGE THICKNESS	=	1-1/4 IN(S)
FLANGE WIDTH	=	10
WELD SIZE	=	5/16
WEIGHT PER FOOT	=	261.5 PLF

FLANGE THICKNESS	=	1-1/2 IN(S)
FLANGE WIDTH	=	8
WELD SIZE	=	5/16
WEIGHT PER FOOT	=	258.1 PLF

UNSTIFFENED GIRDER DESIGN -----

FOR WEB THICKNESS	=	11/16 IN(S)
WEB DEPTH	=	103
FLANGE THICKNESS	=	3/4
FLANGE WIDTH	=	7
WELD SIZE	=	1/4
WEIGHT PER FOOT	=	276.6 PLF

Table 6. Unstiffened Girder Design, $F_y = 50$ ksi.

TRANSVERSELY STIFFENED GIRDER DESIGN

FOR WEB THICKNESS = 3/8 IN(S)
 WEB DEPTH = 32
 FLANGE THICKNESS = 1-1/4
 FLANGE WIDTH = 24
 WELD SIZE = 5/16
 WEIGHT PER FOOT = 270.5 PLF

TRANSVERSELY STIFFENED GIRDER DESIGN

FOR WEB THICKNESS = 7/16 IN(S)
 WEB DEPTH = 61
 FLANGE THICKNESS = 1-1/4
 FLANGE WIDTH = 19
 WELD SIZE = 5/16
 WEIGHT PER FOOT = 252.4 PLF

TRANSVERSELY STIFFENED GIRDER DESIGN

*** MOST ECONOMICAL SECTION ***

FOR WEB THICKNESS = 1/2 IN(S)
 WEB DEPTH = 70
 FLANGE THICKNESS = 1
 FLANGE WIDTH = 19
 WELD SIZE = 5/16
 WEIGHT PER FOOT = 248.4 PLF

ALTERNATIVE FLANGE DESIGNS

FLANGE THICKNESS = 1-1/4 IN(S)
 FLANGE WIDTH = 15
 WELD SIZE = 5/16
 WEIGHT PER FOOT = 246.7 PLF

 FLANGE THICKNESS = 1-1/2 IN(S)
 FLANGE WIDTH = 13
 WELD SIZE = 5/16
 WEIGHT PER FOOT = 251.8 PLF

Table 7. Transversely Stiffened Girder Design, $F_y = 50$ ksi.

TRANSVERSELY STIFFENED GIRDER DESIGN ---

FOR WEB THICKNESS	=	9/16 IN(S)
WEB DEPTH	=	78
FLANGE THICKNESS	=	1
FLANGE WIDTH	=	15
WELD SIZE	=	5/16
WEIGHT PER FOOT	=	251.3 PLF

Table 7 (cont.). Transversely Stiffened Girder Design,
Fy = 50 ksi.

LONGITUDINALLY STIFFENED GIRDER DESIGN ---

FOR WEB THICKNESS = 5/16 IN(S)
 WEB DEPTH = 87
 FLANGE THICKNESS = 1
 SECTION FAILS TO MEET MAX./MIN. WELD SIZE SPECIFICATIONS.

LONGITUDINALLY STIFFENED GIRDER DESIGN ---

*** MOST ECONOMICAL SECTION ***

FOR WEB THICKNESS = 3/8 IN(S)
 WEB DEPTH = 105
 FLANGE THICKNESS = 3/4
 FLANGE WIDTH = 13
 WELD SIZE = 1/4
 WEIGHT PER FOOT = 200.3 PLF

ALTERNATIVE FLANGE DESIGNS

FLANGE THICKNESS = 1 IN(S)
 FLANGE WIDTH = 10
 WELD SIZE = 5/16
 WEIGHT PER FOOT = 202 PLF

FLANGE THICKNESS = 1-1/4 IN(S)
 FLANGE WIDTH = 8
 WELD SIZE = 5/16
 WEIGHT PER FOOT = 202 PLF

LONGITUDINALLY STIFFENED GIRDER DESIGN ---

FOR WEB THICKNESS = 7/16 IN(S)
 WEB DEPTH = 122
 FLANGE THICKNESS = 3/4
 FLANGE WIDTH = 7
 WELD SIZE = 1/4
 WEIGHT PER FOOT = 217.3 PLF

Table 8. Longitudinally Stiffened Girder Design, $F_y = 50$ ksi.

DISCUSSION OF RESULTS

GIRDER WEIGHT vs. WEB THICKNESS. The relationship between the girder weight and the web thickness for the example is summarized in Figure 2.

It can be seen for the unstiffened and transversely stiffened girders that initially as the web thickness increases, the girder weight decreases. This is due to the fact that as the web increases in thickness and depth, the girder's required flange area (translated from the required flange moment of inertia) becomes smaller, the difference in flange areas being greater than the increase in web area.

At a particular web thickness (the thickness corresponding to the last point plotted on each curve), the increase in web area begins to exceed the decrease in flange area. It is at this point the program terminates the incrementing process and develops alternative flange designs for the most economical section.

The above also holds true for longitudinally stiffened girders but the initial decrease in girder weight cannot be seen since there has been no girder weight output for the two sections with a 5/16" web thicknesses.

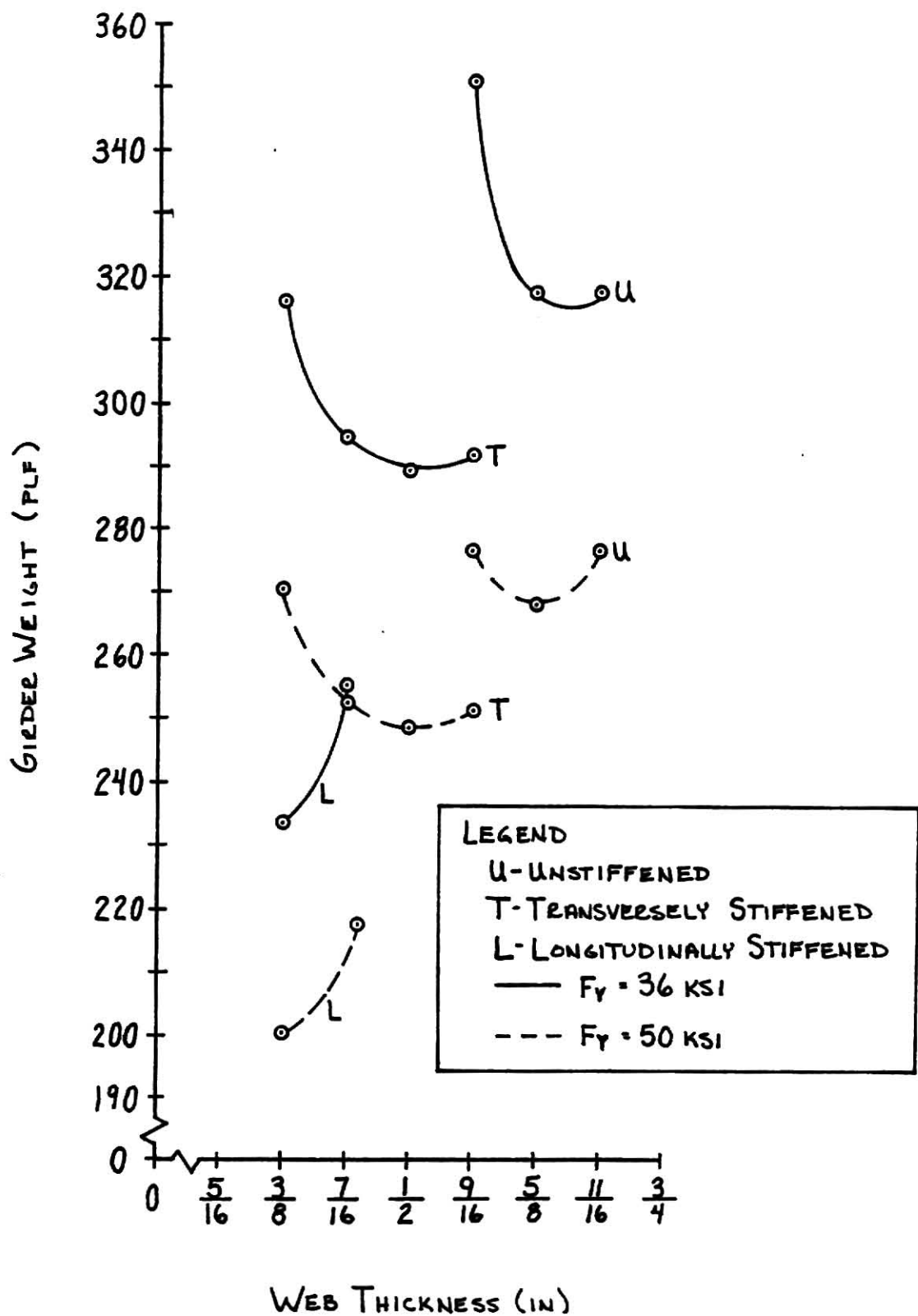


Figure 2. Girder Weight vs. Web Thickness.

GIRDER WEIGHT vs. SPAN LENGTH. Figure 3 shows how the girder weight of the most economical section varies with the span length for the type of bridge considered in the example designed for the same loading conditions. The computer print out of these values has not been presented with this report.

It can be seen in this figure how the weight varies with the design. Transversely stiffened girders are roughly 10 percent lighter than unstiffened girders of the same span length initially, decreasing in percentage as the span length increases. Girders with longitudinal stiffeners are roughly 15 percent lighter than those which are unstiffened initially, increasing in percentage as the span length increases.

Girders with a yield strength of 50 ksi are roughly 15 to 20 percent lighter than those with a yield strength of 36 ksi.

Figure 3 can be of aid to the user to assume the initial girder dead load when designing a girder.

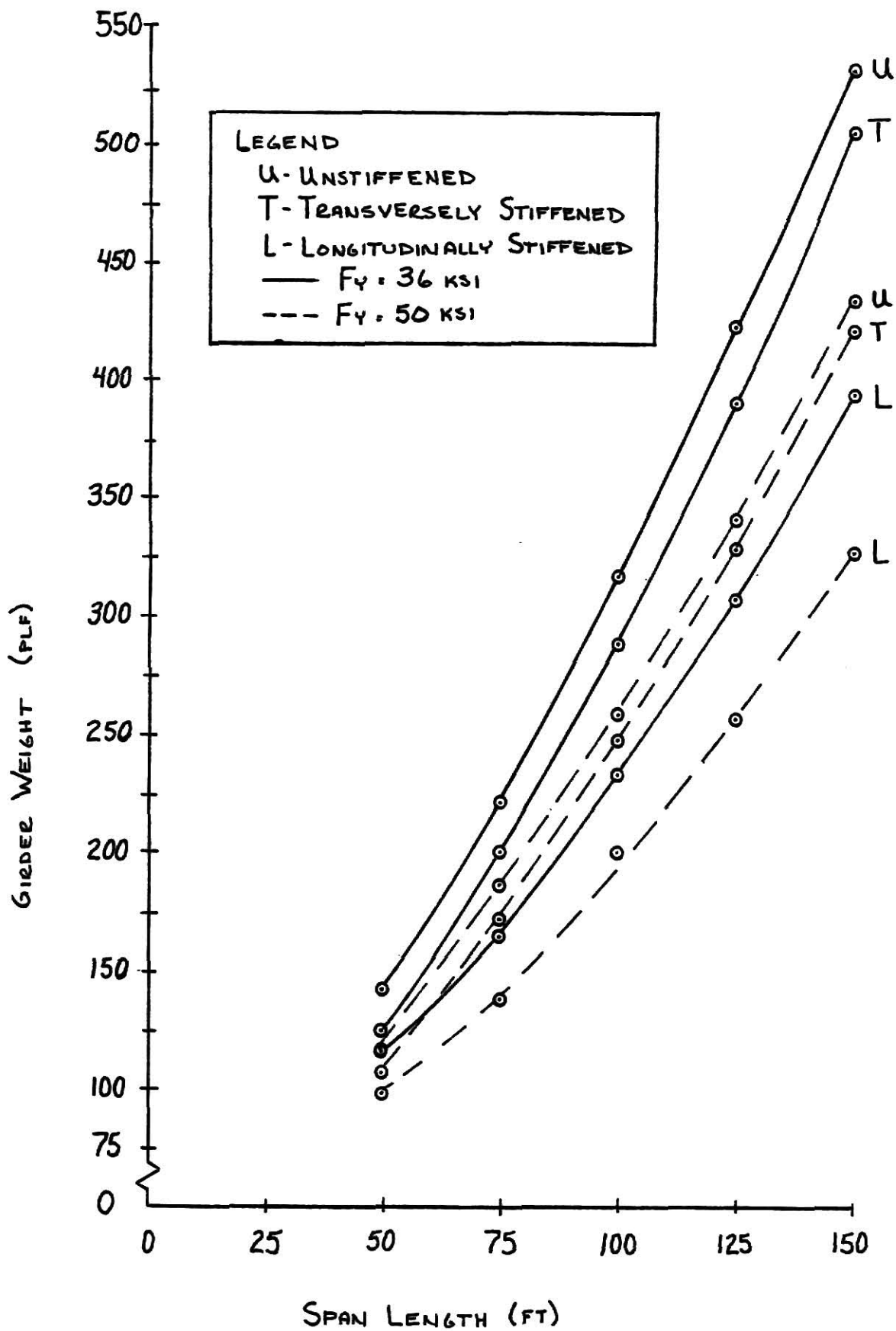


Figure 3. Girder Weight vs. Span Length.

SUMMARY

A microcomputer program for the design of minimum weight bridge plate girders has been developed to aid in the design of such structures according to the specifications set forth by the American Association of State Highway and Transportation Officials. The program designs plate girders of constant cross section for simply supported spans for steel yield strengths of 36 and 50 ksi. It is assumed that sufficient lateral support shall be provided along the compressive flange such that the maximum applied bending stress is equal to that which is allowed. The program does not include the lateral load distribution procedures specified in the specifications, nor does it provide for the design of stiffeners.

An example design for unstiffened, transversely stiffened, and longitudinally stiffened girders with steel yield strengths of 36 and 50 ksi has been presented to illustrate the use of the program. Along with other information presented, it has been found that transversely stiffened girders are roughly 10 percent lighter than unstiffened girders of the same span length initially, decreasing in percentage as the span length increases. Girders with longitudinal stiffeners are roughly 15 percent lighter than those which are unstiffened initially, increasing in percentage as the span length increases. Girders with a yield strength of 50 ksi are roughly 15 to 20 percent lighter than those with a yield strength of 36 ksi.

RECOMMENDATIONS FOR FURTHER WORK

It is the author's opinion that a computer program is never finished; it can always be improved with minor editing and added functions.

Minor editing can improve this program's efficiency. As an example, by combining the monitor and hard copy print commands, the number of programming steps (or lines) may be decreased, resulting in a larger bank of memory for added functions and also additional disk storage space.

Additional functions which would generalize this program are:

1. The calculation of maximum shears and moments
2. The design of bearing, tranverse, and longitudinal stiffeners
3. The design of plate girders of varying cross section
4. The design of hybrid plate girders
5. The design of composite plate girders
6. The design of multi-span continuous plate girders

APPENDIX I - NOTATION

A_F	= Required area of flange plate
b_f	= Base length of flange plate
D	= Depth of web plate
f_b	= Maximum applied bending stress
F_b	= Maximum allowable bending stress
f_v	= Average unit shearing stress
F_v	= Maximum allowable unit shearing stress
F_y	= Yield strength of steel
I	= Impact factor
I_f	= Required moment of inertia of the flange plate
L	= Length of girder span
S	= Required section modulus
T	= Thickness of plate
t_f	= Thickness of flange plate
t_w	= Thickness of web plate
V_d	= Design shear

APPENDIX II - PROGRAM LISTING

```

10 REM THIS IS A BRIDGE PLATE GIRDER DESIGN PROGRAM BASED ON ASSHTO
    SPECIFICATIONS.
20 REM
30 REM A = LETTER CORRESPONDING TO UNSTIFFENED GIRDER DESIGN
40 REM ABF = ALTERNATIVE FLANGE DESIGN BASE LENGTH
50 REM ACH = IDENTIFIES IF ALTERNATIVE FLANGE DESIGN IS ACCEPTABLE
60 REM AF = AREA OF FLANGE PLATE
70 REM AGL = ALTERNATIVE FLANGE DESIGN GIRDER LOAD
80 REM AIN = MOMENT OF INERTIA FOR ALTERNATIVE FLANGE DESIGN GIRDER
90 REM AL = ASSUMED GIRDER LOAD
100 REM AS = MAXIMUM BENDING STRESS OF ALTERNATIVE FLANGE DESIGN GIRDER
110 REM AV = MAXIMUM SHEARING STRESS OF ALTERNATIVE FLANGE DESIGN GIRDER
120 REM AWS = WELD SIZE FOR ALTERNATIVE FLANGE DESIGN SECTION
130 REM A$ = IDENTIFIES USER COMMAND TO CONTINUE
140 REM B = LETTER CORRESPONDING TO TRANSVERSELY STIFFENED GIRDER DESIGN
150 REM BF = BASE LENGTH OF FLANGE PLATE
160 REM BT = BF/TF RATIO
170 REM B$ = IDENTIFIES HARD COPY COMMAND
180 REM C = LETTER CORRESPONDING TO LONGITUDINALLY STIFFENED GIRDER DESIGN
190 REM CH = IDENTIFIES IF TRIAL DESIGN IS ACCEPTABLE
200 REM CK = IDENTIFIES MOST ECONOMICAL SECTION FOR LATER REFERENCE
210 REM C1 = IDENTIFIES FIRST OR SECOND CYCLE OF A TRIAL DESIGN
220 REM C2 = IDENTIFIES THAT THE MOST ECONOMICAL SECTION HAS BEEN FOUND
    AND THAT ALTERNATIVE FLANGES ARE BEING DESIGNED
230 REM C4 = COUNTS NUMBER OF ACCEPTABLE DESIGNS
240 REM C5 = IDENTIFIES OUTPUT OF ALTERNATIVE FLANGE DESIGNS
250 REM C6 = COUNTS TOTAL NUMBER OF TRIAL DESIGNS
260 REM D = DEPTH OF WEB PLATE
270 REM D$ = IDENTIFIES USERS CHOICE OF DESIGN
280 REM DM = DEAD LOAD MOMENT NOT DUE TO WEIGHT OF GIRDER
290 REM DV = DEAD LOAD SHEAR NOT DUE TO WEIGHT OF GIRDER
300 REM DT = D/TW RATIO
310 REM FB = MAXIMUM ALLOWABLE BENDING STRESS
320 REM FI = MOMENT OF INERTIA OF FLANGE PLATE
330 REM FR = DECIMAL VALUE USED TO IDENTIFY FRACTION
340 REM FV = MAXIMUM ALLOWABLE SHEARING STRESS
350 REM FY = YIELD STRENGTH OF STEEL (36 OR 50 KSI)
360 REM F$ = FRACTION EQUAL TO DECIMAL VALUE
370 REM GL = UNIT WEIGHT OF GIRDER
380 REM G$ = IDENTIFIES USER COMMAND TO CONTINUE WITH PROGRAM
390 REM H$ = IDENTIFIES COMMAND TO CHANGE INPUT
400 REM I = LOOP VARIABLE
410 REM I$ = IDENTIFIES COMMAND TO PRINT HARD COPY
420 REM IM = IMPACT FACTOR
430 REM IN = MOMENT OF INERTIA OF SECTION
440 REM J = LOOP VARIABLE
450 REM K = LOOP VARIABLE
460 REM LM = MAXIMUM LIVE LOAD MOMENT
470 REM LV = MAXIMUM LIVE LOAD SHEAR
480 REM MD = DEAD LOAD MOMENT INCLUDING GIRDER WEIGHT
490 REM ML = LIVE LOAD MOMENT PLUS IMPACT LOAD
500 REM MT = DESIGN MOMENT
510 REM N = LOOP VARIABLE; NO
520 REM S = SECTION MODULUS
530 REM SH = SHEARING STRESS
540 REM SIG = BENDING STRESS
550 REM SP = SPAN LENGTH
560 REM T = IDENTIFIES MINIMUM WEB THICKNESS
570 REM TF = THICKNESS OF FLANGE PLATE
580 REM TM = TEMPORARY MEMORY
590 REM TW = THICKNESS OF WEB PLATE
600 REM VD = DEAD LOAD SHEAR INCLUDING GIRDER WEIGHT
610 REM VL = LIVE LOAD SHEAR PLUS IMPACT LOAD

```

```

620 REM VT = DESIGN SHEAR
630 REM WLD = AASHTO WELD SIZES FOR VARIOUS THICKNESSES OF PLATES
640 REM WS = WELD SIZE
650 REM Y = YES
660 CLS
670 PRINT "
680 PRINT "
690 PRINT "THIS PROGRAM HAS BEEN DEVELOPED TO AID IN THE DESIGN OF BRIDGE PLATE
GIRDERS."
700 PRINT
710 PRINT "THE DESIGNS RESULTING FROM THE USE OF THIS PROGRAM CONFORM WITH THE "
720 PRINT
730 PRINT "SPECIFICATIONS SET FORTH IN THE TWELFTH EDITION (1977) OF THE 'STANDA
RD "
740 PRINT
750 PRINT "SPECIFICATIONS FOR HIGHWAY BRIDGES' PUBLISHED BY THE AMERICAN ASSOCIA
TION"
760 PRINT
770 PRINT "OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)."
```

USER REQUIREMENTS"

```

790 PRINT "
800 PRINT "
810 PRINT "THE USER IS TO CALCULATE THE MAXIMUM SHEARS AND MOMENTS THE GIRDER WI
LL BE "
820 PRINT
830 PRINT "SUBJECTED TO FOR BOTH DEAD AND LIVE LOADS. THE DEAD LOAD SHEAR AND M
OMENT IS "
840 PRINT
850 PRINT "NOT TO INCLUDE THAT PART DUE TO THE ASSUMED GIRDER DEAD LOAD."
```

PRESS THE 'RETURN' KEY TO CONTINUE. ";A*

```

860 PRINT:PRINT
870 INPUT "
880 IF A$="" THEN 900
890 GOTO 870
900 CLS
910 PRINT "
920 PRINT:PRINT
930 PRINT "A. UNSTIFFENED GIRDER DESIGN."
940 PRINT
950 PRINT "B. TRANSVERSELY STIFFENED GIRDER DESIGN."
960 PRINT
970 PRINT "C. LONGITUDINALLY STIFFENED GIRDER DESIGN."
980 PRINT:PRINT
990 INPUT "
1000 IF D$="A" OR D$="B" OR D$="C" THEN 1020
1010 CLS:GOTO 900
1020 IF H$="Y" THEN 1040
1030 IF H$="N" THEN 1470
1040 CLS
1050 PRINT "
1060 PRINT "
1070 PRINT:PRINT
1080 PRINT "
1090 PRINT
1100 INPUT "
1110 PRINT
1120 INPUT "
1130 PRINT
1140 INPUT "
1150 PRINT
1160 INPUT "
1170 PRINT
1180 INPUT "
1190 PRINT
```

DESIGN PARAMETERS"

PLEASE INPUT THE FOLLOWING:"

```

SPAN LENGTH (FT) . . . . . = ";SP
MAXIMUM LIVE LOAD SHEAR (K) . . . . . = ";LV
MAXIMUM LIVE LOAD MOMENT (K-FT) . . . = ";LM
MAXIMUM DEAD LOAD SHEAR (K) . . . . . = ";DV
MAXIMUM DEAD LOAD MOMENT (K-FT) . . . = ";DM
```

```

1200 INPUT "          ASSUMED GIRDER DEAD LOAD (PLF) . . . . = ";AL
1210 PRINT
1220 INPUT "          YIELD STRENGTH OF STEEL (KSI) . . . . = ";FY
1230 IF FY=36 OR FY=50 THEN 1250
1240 GOTO 1220
1250 PRINT:PRINT
1260 INPUT "          DO YOU WISH TO HAVE A COPY OF THIS (Y/N)";IS
1270 IF IS="Y" THEN 1300
1280 IF IS="N" THEN 1470
1290 GOTO 1260
1300 LPRINT "          DESIGN PARAMETERS"
1310 LPRINT "          -----"
1320 LPRINT
1330 LPRINT "          SPAN LENGTH . . . . . = ";SP;"FT"
1340 LPRINT
1350 LPRINT "          MAXIMUM LIVE LOAD SHEAR . . . . . = ";LV;"K"
1360 LPRINT
1370 LPRINT "          MAXIMUM LIVE LOAD MOMENT . . . . . = ";LM;"K-FT"
1380 LPRINT
1390 LPRINT "          MAXIMUM DEAD LOAD SHEAR . . . . . = ";DV;"K"
1400 LPRINT
1410 LPRINT "          MAXIMUM DEAD LOAD MOMENT . . . . . = ";DM;"K-FT"
1420 LPRINT
1430 LPRINT "          ASSUMED GIRDER DEAD LOAD . . . . . = ";AL;"PLF"
1440 LPRINT
1450 LPRINT "          YIELD STRENGTH OF STEEL . . . . . = ";FY;"KSI"
1460 LPRINT:LPRINT:LPRINT
1470 GL=AL
1480 IF FY=36 THEN FB=20
1490 IF FY=36 THEN FV=12
1500 IF FY=36 THEN BT=23
1510 IF FY=50 THEN FB=27.5
1520 IF FY=50 THEN FV=16.67
1530 IF FY=50 THEN BT=20
1540 IF IS="Y" THEN 1580
1550 DIM TM(3),TW(15),D(15),TF(15),BF(15),GL(15),WS(15),IN(15)
1560 DIM S(15),CH(15),SH(15),SIG(15)
1570 DIM ABF(2),AGL(2),AWS(2),AIN(2),AS(2),AV(2),ACH(2)
1580 GOTO 2180
1590 REM: THIS IS SUB 1.  THIS SUB ADJUSTS THE DEAD LOADS, THE DESIGN LOADS,
      AND THE REQ'D SECTION MODULUS.
1600 GL=(2*BF*TF+D*TW)*490/144
1610 IF K=0 THEN GL(I)=GL
1620 IF K=1 THEN AGL(N)=GL
1630 IN=BF*(D+2*TF)^3/12-(BF-TW)*D^3/12
1640 IF K=0 THEN IN(I)=IN
1650 IF K=1 THEN AIN(N)=IN
1660 VD=DV+GL*SP/2000
1670 MD=DM+GL*SP^2/8000
1680 REM: DESIGN LOADS
1690 VT=VL+VD
1700 MT=ML+MD
1710 S=MT*12/FB
1720 RETURN
1730 REM: THIS IS SUB 2.  THIS SUB DETERMINES WELD SIZES.
1740 TM(1)=TW
1750 TM(2)=TF
1760 FOR J=1 TO 2
1770 IF TM(J)<=.5 THEN WLD(J,1)=.1875
1780 IF TM(J)>.5 AND TM(J)<=.75 THEN WLD(J,1)=.25
1790 IF TM(J)>.75 AND TM(J)<=1.5 THEN WLD(J,1)=.3125
1800 IF TM(J)>1.5 AND TM(J)<=2.25 THEN WLD(J,1)=.375
1810 IF TM(J)>2.25 AND TM(J)<=6 THEN WLD(J,1)=.5

```

```

1820 IF TM(J)>6 THEN WLD(J,1)=.625
1830 WLD(J,2)=TM(J)-1/16
1840 NEXT J
1850 IF WLD(1,2)<WLD(2,1) OR WLD(2,2)<WLD(1,1) THEN 1890
1860 IF TF>TW AND WLD(2,1)<WLD(1,2) THEN WS=WLD(2,1)
1870 IF TF<TW AND WLD(1,1)<WLD(2,2) THEN WS=WLD(1,1)
1880 GOTO 1920
1890 WS=0
1900 IF K=0 THEN CH(I)=1
1910 IF K=1 THEN ACH(N)=1
1920 RETURN
1930 REM: THIS IS SUB 3. THIS SUB STORES SECTION DIMENSIONS AND COMPARES
      THEM WITH OTHER SECTIONS.
1940 IF WS>0 THEN 1970
1950 BF(I)=0:GL(I)=0:TW(I)=TW:D(I)=D:WS(I)=WS:TF(I)=TF
1960 GOTO 2030
1970 TW(I)=TW:D(I)=D:TF(I)=TF:BF(I)=BF:GL(I)=GL:WS(I)=WS:S(I)=S
1980 IF CH(I)=1 THEN 2030
1990 C4=C4+1
2000 IF C4=1 THEN 2020
2010 IF GL(I)>GL(CK) THEN 2030
2020 CK=I
2030 RETURN
2040 REM: THIS IS SUB 4. THIS SUB CHECKS BENDING AND SHEAR REQUIREMENTS.
2050 SIG=MT*12*(D/2+TF)/IN
2060 SH=VT/(TW*D)
2070 IF SIG>FB THEN CH=1
2080 IF SH>FV THEN CH=1
2090 IF K=1 THEN 2140
2100 IF CH=1 THEN CH(I)=1
2110 SIG(I)=SIG
2120 SH(I)=SH
2130 GOTO 2170
2140 IF CH=1 THEN ACH(N)=1
2150 AS(N)=SIG
2160 AV(N)=SH
2170 RETURN
2180 C2=0:CH=0:CK=0:C4=0
2190 REM: ADJUST LIVE LOADS FOR IMPACT.
2200 IM=INT(50/(SP+125)*100)/100
2210 IF IM>.3 THEN IM=.3
2220 VL=(1+IM)*LV
2230 ML=(1+IM)*LM
2240 GOSUB 1660
2250 IF D$="B" OR D$="C" THEN 2460
2260 REM: CALCULATION OF TW FOR DESIGN A.
2270 D=INT(SP*12/25)
2280 TM(1)=D/150
2290 TM(2)=(D+VT*1000/7500^2)^(1/3)
2300 TM(3)=5/16
2310 REM: THIS LOOP ROUNDS TO THE NEXT LARGEST 1/16th INCH.
2320 FOR I=1 TO 2
2330 FOR J=5 TO 500
2340 IF J/16>TM(I) THEN 2360
2350 NEXT J
2360 TM(I)=J/16
2370 NEXT I
2380 REM: THIS LOOP DETERMINES WHICH OF THREE THICKNESSES CONTROLS. (TW MIN.)
2390 T=TM(1)
2400 FOR I=2 TO 3
2410 IF TM(I)<T THEN 2430
2420 T=TM(I)
2430 NEXT I

```

```

2440 GOTO 2620
2450 REM: CALCULATION OF TW FOR DESIGNS B AND C.
2460 IF FY=50 THEN 2500
2470 IF D*="B" THEN DT=165
2480 IF D*="C" THEN DT=330
2490 GOTO 2520
2500 IF D*="B" THEN DT=140
2510 IF D*="C" THEN DT=280
2520 D=INT(SP*12/25)
2530 TM(1)=D/DT
2540 TM(2)=5/16
2550 REM: LOOP ROUNDS TO NEXT LARGEST 1/16th INCH.
2560 FOR J=5 TO 500
2570 IF J/16=TM(1) THEN 2590
2580 NEXT J
2590 TM(1)=J/16
2600 IF TM(1)>TM(2) THEN T=TM(1)
2610 IF TM(1)<=TM(2) THEN T=5/16
2620 REM: THIS LOOP DETERMINES SECTION SIZES.
2630 I=1
2640 C1=0:C6=I:CH=0
2650 TF=1
2660 TW=T+(I-1)/16
2670 IF D*="B" OR D*="C" THEN 2780
2680 REM: CHOOSES CONTROLLING WEB DEPTH FOR DESIGN A.
2690 TM(1)=150*TW
2700 TM(2)=TW^3*7500^2/(VT*1000)
2710 IF TM(1)>TM(2) THEN 2740
2720 D=INT(TM(1))
2730 GOTO 2750
2740 D=INT(TM(2))
2750 IF D>INT(SP*12/25) THEN 2830
2760 D(I)=0:CH(I)=1:TW(I)=TW
2770 GOTO 3150
2780 REM: CHOOSES CONTROLLING WEB DEPTH FOR DESIGNS B AND C.
2790 D=INT(DT*TW)
2800 IF D>INT(SP*12/25) THEN 2830
2810 D(I)=0:CH(I)=1
2820 GOTO 3150
2830 FI=(D/2+TF)*S-TW*D^3/12
2840 IF FI>0 THEN 2880
2850 TF=0:WS=-1
2860 GOSUB 1930
2870 GOTO 3440
2880 AF=FI/(2*(D/2+TF/2)^2)
2890 TF=INT(SQR(AF/BT)*100)/100
2900 REM: ADJUSTS FLANGE TO 1/4th INCH INCREMENTS.
2910 FOR J=2 TO 50
2920 IF TF<=J/4 THEN 2940
2930 NEXT J
2940 TF=J/4
2950 BF=AF/TF
2960 IF (BF-INT(BF))<=0 THEN 3030
2970 BF=INT(BF)+1
2980 GOTO 3000
2990 BF=INT(BF)
3000 IF BF/TF<BT THEN 3030
3010 TF=TF+.25
3020 GOTO 2950
3030 IF C1<5 THEN 3070
3040 GOSUB 1730
3050 IF CH(I)=0 THEN 3070
3060 GOTO 3130

```

```

3070 GOSUB 1590
3080 IF C1=5 THEN 3120
3090 C1=C1+1
3100 IF D$="A" THEN 2680
3110 IF D$="B" OR D$="C" THEN 2830
3120 GOSUB 2040
3130 GOSUB 1930
3140 IF C4>1 AND GL(I)>GL(CK) THEN 3160
3150 I=I+1 : IF I<=15 THEN 2640
3160 REM: THE MOST ECONOMICAL SECTION HAS BEEN FOUND AND THIS PART OF THE
      PROGRAM TAKES THIS SECTION AND MODIFIES THE FLANGES FOR AN
      ALTERNATIVE DESIGN.

3170 K=1
3180 TW=TW(CK):D=D(CK):S=S(CK):TF=TF(CK)
3190 C2=1
3200 FOR N=1 TO 2
3210 TF=TF+1/4
3220 GOSUB 1730
3230 IF ACH(N)=0 THEN 3290
3240 IF N=1 THEN 3270
3250 AWS(2)=0
3260 GOTO 3430
3270 AWS(1)=0:AWS(2)=0:ACH(2)=1:N=2
3280 GOTO 3430
3290 AWS(N)=WS
3300 FI=(D/2+TF)*S-TW*D^3/12
3310 IF FI>0 THEN 3340
3320 AWS(N)=-1
3330 GOTO 3430
3340 AF=FI/(2*(D/2+TF/2)^2)
3350 BF=AF/TF
3360 IF (BF-INT(BF))<=0 THEN 3390
3370 BF=INT(BF)+1
3380 GOTO 3400
3390 BF=INT(BF)
3400 ABF(N)=BF
3410 GOSUB 1590
3420 GOSUB 2040
3430 NEXT N
3440 REM: DISPLAY OF RESULTS
3450 FOR J=1 TO C6
3460 CLS
3470 IF D$="B" THEN 3520
3480 IF D$="C" THEN 3550
3490 PRINT "
3500 PRINT "
3510 GOTO 3570
3520 PRINT "
3530 PRINT "
3540 GOTO 3570
3550 PRINT "
3560 PRINT "
3570 PRINT "
3580 IF J=CK THEN PRINT "
3590 PRINT "
3600 GOSUB 4170
3610 PRINT "          FOR WEB THICKNESS . . . . . = "F$;" IN(S)"
3620 IF D(J)=0 THEN 3920
3630 PRINT "          WEB DEPTH . . . . . = "D(J)
3640 IF WS(J)=-1 THEN 3920
3650 GOSUB 4180
3660 PRINT "          FLANGE THICKNESS . . . . . = "F$
3670 IF WS(J)=0 THEN 3920

```

```

3680 PRINT "                FLANGE WIDTH . . . . . = ";BF(J)
3690 GOSUB 4190
3700 PRINT "                WELD SIZE . . . . . = ";F$
3710 PRINT "                WEIGHT PER FOOT . . . . . = ";INT(GL(J)*10)
/10;" PLF"
3720 IF CH(J)=1 THEN 3920
3730 IF J=CK THEN 3750
3740 GOTO 4080
3750 C5=1
3760 PRINT
3770 PRINT "                ALTERNATIVE FLANGE DESIGNS"
3780 FOR K=1 TO 2
3790 GOSUB 4200
3800 PRINT "                FLANGE THICKNESS . . . . . = ";F$;" IN(S)"
3810 IF AWS(K)=0 OR AWS(K)=-1 THEN 3970
3820 PRINT "                FLANGE WIDTH . . . . . = ";ABF(K)
3830 GOSUB 4210
3840 PRINT "                WELD SIZE . . . . . = ";F$
3850 PRINT "                WEIGHT PER FOOT . . . . . = ";INT(AGL(K)*10)
/10;" PLF"
3860 IF ACH(K)=1 THEN 3970
3870 IF K=2 THEN 3890
3880 PRINT
3890 NEXT K
3900 C5=0
3910 GOTO 4080
3920 D=D(J)
3930 SIG=SIG(J)
3940 SH=SH(J)
3950 WS=WS(J)
3960 GOTO 4000
3970 SIG=AS(K)
3980 SH=AV(K)
3990 AW=AWS(K)
4000 IF D=0 THEN PRINT "                SECTION FAILS TO MEET MINIMUM DEPTH SPECIFIC
ATIONS."
4010 IF D=0 THEN 4080
4020 IF SIG>FB THEN PRINT "                SECTION FAILS TO MEET MAX. COMPRESSIVE BE
NDING STRESS SPECS."
4030 IF SH>FV THEN PRINT "                SECTION FAILS TO MEET MAX. SHEAR SPECIFICA
TIONS."
4040 IF WS=0 THEN PRINT "                SECTION FAILS TO MEET MAX./MIN. WELD SIZE S
PECIFICATIONS."
4050 IF WS=-1 THEN PRINT "                SECTION FAILS TO MEET FLANGE REQUIREMENTS."
"
4060 PRINT
4070 IF C5=1 THEN 3890
4080 PRINT
4090 INPUT "                DO YOU WISH TO HAVE A COPY OF THIS (Y/N)"; B$
4100 IF B$="Y" THEN GOSUB 4560
4110 IF B$="Y" THEN 4140 : REM: THIS LINE EXISTS SO WHEN SUB IS FINISHED IT WILL
CONTINUE ON.
4120 IF B$="N" THEN 4140
4130 GOTO 4090
4140 NEXT J
4150 GOTO 5190
4160 REM: THIS IS SUB 5. THIS SUB WILL ALLOW THE OUTPUT TO BE PRINTED IN EQUIV.
FRACTIONS.
4170 FR=TW(J):GOTO 4220
4180 FR=TF(J):GOTO 4220
4190 FR=WS(J):GOTO 4220
4200 FR=TF(J)+K/4:GOTO 4220
4210 FR=AWS(K)

```

4220 IF FR=1/16 THEN F\$="1/16"
 4230 IF FR=1/8 THEN F\$="1/8"
 4240 IF FR=3/16 THEN F\$="3/16"
 4250 IF FR=1/4 THEN F\$="1/4"
 4260 IF FR=5/16 THEN F\$="5/16"
 4270 IF FR=3/8 THEN F\$="3/8"
 4280 IF FR=7/16 THEN F\$="7/16"
 4290 IF FR=1/2 THEN F\$="1/2"
 4300 IF FR=9/16 THEN F\$="9/16"
 4310 IF FR=5/8 THEN F\$="5/8"
 4320 IF FR=11/16 THEN F\$="11/16"
 4330 IF FR=3/4 THEN F\$="3/4"
 4340 IF FR=13/16 THEN F\$="13/16"
 4350 IF FR=7/8 THEN F\$="7/8"
 4360 IF FR=15/16 THEN F\$="15/16"
 4370 IF FR=1 THEN F\$="1"
 4380 IF FR=1+1/16 THEN F\$="1-1/16"
 4390 IF FR=1+1/8 THEN F\$="1-1/8"
 4400 IF FR=1+3/16 THEN F\$="1-3/16"
 4410 IF FR=1+1/4 THEN F\$="1-1/4"
 4420 IF FR=1+5/16 THEN F\$="1-5/16"
 4430 IF FR=1+3/8 THEN F\$="1-3/8"
 4440 IF FR=1+7/16 THEN F\$="1-7/16"
 4450 IF FR=1+1/2 THEN F\$="1-1/2"
 4460 IF FR=1+9/16 THEN F\$="1-9/16"
 4470 IF FR=1+5/8 THEN F\$="1-5/8"
 4480 IF FR=1+11/16 THEN F\$="1-11/16"
 4490 IF FR=1+3/4 THEN F\$="1-3/4"
 4500 IF FR=1+13/16 THEN F\$="1-13/16"
 4510 IF FR=1+7/8 THEN F\$="1-7/8"
 4520 IF FR=1+15/16 THEN F\$="1-15/16"
 4530 IF FR=2 THEN F\$="2"
 4540 IF FR=2+1/16 THEN F\$="2-1/16"
 4550 IF FR=2+1/8 THEN F\$="2-1/8"
 4560 IF FR=2+3/16 THEN F\$="2-3/16"
 4570 IF FR=2+1/4 THEN F\$="2-1/4"
 4580 IF FR=2+5/16 THEN F\$="2-5/16"
 4590 IF FR=2+3/8 THEN F\$="2-3/8"
 4600 IF FR=2+7/16 THEN F\$="2-7/16"
 4610 IF FR=2+1/2 THEN F\$="2-1/2"
 4620 IF FR=2+9/16 THEN F\$="2-9/16"
 4630 IF FR=2+5/8 THEN F\$="2-5/8"
 4640 IF FR=2+11/16 THEN F\$="2-11/16"
 4650 IF FR=2+3/4 THEN F\$="2-3/4"
 4660 IF FR=2+13/16 THEN F\$="2-13/16"
 4670 IF FR=2+7/8 THEN F\$="2-7/8"
 4680 IF FR=2+15/16 THEN F\$="2-15/16"
 4690 IF FR=3 THEN F\$="3"
 4700 IF FR=3+1/16 THEN F\$="3-1/16"
 4710 IF FR=3+1/8 THEN F\$="3-1/8"
 4720 IF FR=3+3/16 THEN F\$="3-3/16"
 4730 IF FR=3+1/4 THEN F\$="3-1/4"
 4740 IF FR=3+5/16 THEN F\$="3-5/16"
 4750 IF FR=3+3/8 THEN F\$="3-3/8"
 4760 IF FR=3+7/16 THEN F\$="3-7/16"
 4770 IF FR=3+1/2 THEN F\$="3-1/2"
 4780 IF FR=3+9/16 THEN F\$="3-9/16"
 4790 IF FR=3+5/8 THEN F\$="3-5/8"
 4800 IF FR=3+11/16 THEN F\$="3-11/16"
 4810 IF FR=3+3/4 THEN F\$="3-3/4"
 4820 IF FR=3+13/16 THEN F\$="3-13/16"
 4830 IF FR=3+7/8 THEN F\$="3-7/8"
 4840 IF FR=3+15/16 THEN F\$="3-15/16"

```

4860 IF FR=4+1/16 THEN F$="4-1/16"
4870 IF FR=4+1/8 THEN F$="4-1/8"
4880 IF FR=4+3/16 THEN F$="4-3/16"
4890 IF FR=4+1/4 THEN F$="4-1/4"
4900 IF FR=4+5/16 THEN F$="4-5/16"
4910 IF FR=4+3/8 THEN F$="4-3/8"
4920 IF FR=4+7/16 THEN F$="4-7/16"
4930 IF FR=4+1/2 THEN F$="4-1/2"
4940 IF FR=4+9/16 THEN F$="4-9/16"
4950 IF FR=4+5/8 THEN F$="4-5/8"
4960 IF FR=4+11/16 THEN F$="4-11/16"
4970 IF FR=4+3/4 THEN F$="4-3/4"
4980 IF FR=4+13/16 THEN F$="4-13/16"
4990 IF FR=4+7/8 THEN F$="4-7/8"
5000 IF FR=4+15/16 THEN F$="4-15/16"
5010 IF FR=5 THEN F$="5"
5020 IF FR>5 THEN F$="BEYOND OUTPUT LIMITATIONS"
5030 RETURN
5040 IF D$="B" THEN 5090
5050 IF D$="C" THEN 5120
5060 LPRINT "
5070 LPRINT "
5080 GOTO 5140
5090 LPRINT "
5100 LPRINT "
5110 GOTO 5140
5120 LPRINT "
5130 LPRINT "
5140 LPRINT "
5150 IF J=CK THEN LPRINT "
5160 LPRINT "
5170 GOSUB 4170
5180 LPRINT "
5190 IF D(J)=0 THEN 5490
5200 LPRINT "
5210 IF WS(J)=-1 THEN 5490
5220 GOSUB 4180
5230 LPRINT "
5240 IF WS(J)=0 THEN 5490
5250 LPRINT "
5260 GOSUB 4190
5270 LPRINT "
5280 LPRINT "
5290 IF CH(J)= 1 THEN 5490
5300 IF J=CK THEN 5320
5310 GOTO 5650
5320 CS=1
5330 LPRINT "
5340 LPRINT "
5350 FOR K=1 TO 2
5360 GOSUB 4200
5370 LPRINT "
5380 IF AWS(K)=0 OR AWS(K)=-1 THEN 5540
5390 LPRINT "
5400 GOSUB 4210
5410 LPRINT "
5420 LPRINT "
5430 IF ACH(K)=1 THEN 5540
5440 IF K=2 THEN 5460
5450 LPRINT "

```

UNSTIFFENED GIRDER DESIGN"

TRANSVERSELY STIFFENED GIRDER DESIGN"

LONGITUDINALLY STIFFENED GIRDER DESIGN"

*** MOST ECONOMICAL SECTION ***"

FOR WEB THICKNESS = "F\$;" IN(S)"

WEB DEPTH = "D(J)"

FLANGE THICKNESS = "F\$"

FLANGE WIDTH = "BF(J)"

WELD SIZE = "F\$"

WEIGHT PER FOOT = "INT(GL(J)*100)/10;" PLF"

ALTERNATIVE FLANGE DESIGNS"

FLANGE THICKNESS = "F\$;" IN(S)"

FLANGE WIDTH = "ABF(K)"

WELD SIZE = "F\$"

WEIGHT PER FOOT = "INT(AGL(K)*100)/10;" PLF"

```

5460 NEXT K
5470 C5=0
5480 GOTO 5650
5490 D=D(J)
5500 SIG=SIG(J)
5510 SH=SH(J)
5520 WS=WS(J)
5530 GOTO 5570
5540 SIG=AS(K)
5550 SH=AV(K)
5560 WS=AWS(K)
5570 IF D=0 THEN LPRINT "          SECTION FAILS TO MEET MINIMUM DEPTH SPECIFI
CATIONS."
5580 IF D=0 THEN 5650
5590 IF SIG>FB THEN LPRINT "          SECTION FAILS TO MEET MAX. COMPRESSIVE B
ENDING STRESS SPECS."
5600 IF SH>FV THEN LPRINT "          SECTION FAILS TO MEET MAX. SHEAR SPECIFIC
ATIONS."
5610 IF WS=0 THEN LPRINT "          SECTION FAILS TO MEET MAX./MIN. WELD SIZE
SPECIFICATIONS."
5620 IF WS=-1 THEN LPRINT "          SECTION FAILS TO MEET FLANGE REQUIREMENTS
."
5630 LPRINT
5640 IF C5=1 THEN 5460
5650 LPRINT:LPRINT:LPRINT:LPRINT:LPRINT
5660 RETURN
5670 PRINT:PRINT:PRINT
5680 INPUT "          DO YOU WISH TO CONTINUE WITH THIS PROGRAM (Y/N)";G$
5690 IF G$="Y" THEN 5720
5700 IF G$="N" THEN 5850
5710 GOTO 5680
5720 PRINT
5730 FOR I=1 TO 15
5740 TW(I)=0:D(I)=0:TF(I)=0:BF(I)=0:GL(I)=0:WS(I)=0:IN(I)=0
5750 SIG(I)=0:SH(I)=0:CH(I)=0:S(I)=0
5760 NEXT I
5770 FOR I=1 TO 2
5780 ABF(I)=0:AGL(I)=0:AWS(I)=0:AIN(I)=0:AS(I)=0:AV(I)=0:ACH(I)=0
5790 NEXT I
5800 TM(1)=0:TM(2)=0:TM(3)=0:S=0:WS=0:C1=0:C2=0:C4=0:C5=0:C6=0
5810 CK=0:CH=0:I=0:J=0:K=0:N=0:T=0:TF=0
5820 INPUT "          DO YOU WISH TO CHANGE THE INPUT (Y/N)";H$
5830 IF H$="Y" OR H$="N" THEN 900
5840 GOTO 5820
5850 END

```

A MICROCOMPUTER PROGRAM FOR THE DESIGN OF
MINIMUM WEIGHT BRIDGE PLATE GIRDERS

by

DONALD K. ALLISON

B. S., Kansas State University, 1982

AN ABSTRACT OF A MASTER'S REPORT

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Civil Engineering

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1984

ABSTRACT

Engineers have long sought to find quick and accurate methods to analyze and design minimum weight bridge plate girders. A microcomputer program has been developed to aid in the design of such structures according to the specifications set forth by the American Association of State Highway and Transportation Officials. The program designs plate girders of constant cross section for simply supported spans for steel yield strengths of 36 and 50 ksi. It is assumed that sufficient lateral support shall be provided along the compressive flange such that the maximum applied bending stress is equal to that which is allowed. The program does not include the lateral load distribution procedures specified in the specifications, nor does it provide for the design of stiffeners.

An example design for unstiffened, transversely stiffened, and longitudinally stiffened girders with steel yield strengths of 36 and 50 ksi has been presented to illustrate the use of the program. Along with other information presented, it has been found that transversely stiffened girders are roughly 10 percent lighter than unstiffened girders of the same span length initially, decreasing in percentage as the span length increases. Girders with longitudinal stiffeners are roughly 15 percent lighter than those which are unstiffened initially, increasing in percentage as the span length increases. Girders with a yield strength of 50 ksi are roughly 15 to 20 percent lighter than those with a yield strength of 36 ksi.