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Date August, 1980

ANALYSIS AND DESIGN PROGRAMS FOR THE PRACTICING STRUCTURAL ENGINEER USING MICRO COMPUTERS

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

William Edd Mitchell, Jr.

August 1986

DEDICATION

This thesis is dedicated to my loving wife, who selflessly has given support and encouragement through eleven years of scholastic endeavor.

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ABSTRACT

With the technological advances made to date, the availability of computers and packaged programming has become virtually unlimited. Programs are designed to be compatible with a number of hardware systems. However, there remains a gap in this advancement and availability of programming, that being the many non-compatible micro computer systems. This gap becomes wider still when considering Structural Engineering programs specifically written for hardware of limited storage capacity.

This thesis attempts to bridge that gap partially by providing programming for a number of fundamental design and analysis applications specifically prepared for an Epson HX-20 32^{K} byte storage basic language machine.

The programs written were chosen primarily on a frequency-of-use basis for practicing Structural Engineers. Further, the programs are user friendly and provide thorough and understandable documentation of results for inclusion in contract calculations.

The results of all programs were verified by other computing systems, by hand computed solutions, or by both methods.

Examples, user information, flow charts, and copies of the program are included to make adaptation of the programs to other basic language micro computers as easy as possible.

After using the included programs on a regular professional basis, the writer has concluded that, though some perform reasonably simple engineering tasks, they are of enormous value for documentation and time-saving purposes.

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INTRODUCTION

The programming that follows is divided into separate chapters, each presenting documentation of one program.

A brief description of the function of each program is provided followed by definitions of the variables and explanation of the screen displayed prompt statements that will appear through operation of each program.

A flow chart describing the chronological operation of each program is included, as well as a print-out of each program.

The primary tool in understanding the operation of the following programs is a step-by-step example in each chapter showing the correct response to screen prompt statements. Other examples without this detailed documentation are included. It is important to note that examples illustrated do not cover all the possible conditions that can be analyzed by each program, but rather attempt to demonstrate some of its applications.

Through careful examination of the documentation provided, the user should be able to answer any questions that may arise about program operation.

All programming was designed to satisfy the various code requirements that were applicable at the date noted on the title sheet. The user is cautioned to review and revise the programs as required when subsequent code revisions occur.

All the programs have been checked for accuracy and have been used in structural consulting practice.

The programs are specifically written to be user-friendly to the practicing Structural Engineer who is familiar with the operations each performs and to be of a size that will fit into the memory of most micro-computers.

CHAPTER 1

ONE-STORY FRAME ANALYSIS

Description of Program

The one-story frame program is written to analyze frame action using the moment distribution method. Joint translation and axial deformation due to gravity loads is not considered. A maximum of ten spans may be loaded by any combination of a maximum dead load plus live load total of twelve concentrated loads, five uniform loads, five triangular loads, and five concentrated moments. A load duplication option is provided which will allow duplication of the loads of a previously input span.

The user has the option to skip load the frame live loads if, in his judgment, it will result in substantially larger moments. The options for skip loading include live load removal from the odd spans, live load removal from the even spans, and live load removal from the span(s) chosen by the user. Although the skip load option is selected, the program will run only the option desired by the user, as he may see the specific case which produces the worst case moments and not require the other skip option results. The skip load option is also very useful in analysis of structures with complex live and dead load combinations where the live and dead actions are needed for separate evaluation, i.e.,live load deflection, etc. In this event,

all spans can have live load removed and the user has results of total load actions and dead load actions.

Member properties for beams are input by span. Column properties may be input one at a time if they are non-typical or as a group if standard in length and inertia.

The program may also be used for continuous beam analysis. In this case, the user inputs that no columns exist above and below. The program then assigns a column length of 99' and a column inertia of 0.01 $in.^4$, thereby eliminating stiffness so that no moment is attracted.

The results of each frame run include the shear and moment at the tenth points, the column moment above and below each beam joint, the inflection points in each span, and the maximum deflection in each span.

Nomenclature

The following is an explanation of the variable names used in the program. Names were assigned, as much as possible, to describe use.

AJM - At-the-joint moment

D - Deflection

DB - Distance from origin to point where W1 begins

DE - Distance from origin to point where W1 ends

DF - Distribution factor

DW	- Distance from origin to point where the triangular load is equal to W
DM	- Distance from origin to M1
DO	- Distance from origin to point where the triangular load is zero
EM	- End moment
FEM	- Fixed-end moment
I	- Inertia
K	- Column factor
L	- Length
M	- Moment
M1	- Concentrated moment
M1SAVE	- Array to save concentrated live moments
M1SKIP	- Array set equal to the negative of M1SAVE
P	- Concentrated load
PSAVE	- Array to save concentrated live loads
PSKIP	- Array set equal to the negative of PSAVE
RA	- Reaction at End A
RB	- Reaction at End B
TJM	- Total joint moment
V	- Shear
W	- Triangular load maximum value
WSAVE	- Array to save triangular live loads

WSKIP - Array set equal to the negative of WSAVE

W1 - Uniform load

W1SAV - Array to save uniform dead loads

W1SAVE - Array to save uniform live loads

W1SKIP - Array set equal to the negative of W1SAVE

X - Distance from origin (left end) to P

User Prompt Definitions

INPUT FRAME IDENTIFICATON

Request for identity of frame (i.e., TYP INTERIOR @ 5TH FL).

INPUT NUMBER OF SPANS

Request for number of spans excluding cantilevers.

INPUT MODULUS OF ELASTICITY

Request for modulus of elasticity in ksi units.

INPUT L (FT.), I (IN.^ 4) SPAN ___

Request for span length in feet and inertia in $in.^4$ for the span displayed.

COLUMNS ABOVE OR BELOW? 1 = YES 0 = NO

Request to determine if continuous beam or frame analysis.

ALL COLUMNS ABOVE STANDARD? 1 = YES 0 = NO

If all columns above have the same length, inertia, and extremity conditions, the user may avoid individual column input with a "yes" response.

ALL COLUMNS BELOW STANDARD? 1 = YES 0 = NO

Similar to above.

STANDARD COL. ABOVE LENGTH AND INERTIA

Input standard column length in feet and inertia in $in.^4$ for columns above (separate by ",").

STANDARD COL. BELOW LENGTH AND INERTIA

Similar to above.

INPUT COLUMN LENGTH, INERTIA (NEG. IF PIN) COL. ABOVE (L TO R)

Input the column length in feet and inertia in $in.^4$ for the columns above for each joint beginning at the extreme left end and working to the right (separate with ",").

INPUT COLUMN LENGTH, INERTIA (NEG. IF PIN) COL. BELOW (L TO R)

Similar to above.

CHANGE MEMBER DATA 1 = YES 0 = NO

The user has the option to change member data if a review of print-out indicates an error or if a change is desired

DO YOU WANT TO SKIP LOAD? 1 = YES 0 = NO

Request for option to skip load the live load.

CHOOSE LOAD OPTION FOR SPAN ___

Choose a load type from those listed on print-out.

INPUT DESIRED SKIP: 1 = ODD SKIP 2 = EVEN SKIP 3 = CHOICE 4 = END

Request for the desired skip loading option: "1" is removal of live load on odd spans; "2" is removal of live load from even spans; "3" is removal of live load from span(s) of the user's choice; and, "4" is end of skip loading option.

SPAN LIVE LOAD REMOVAL OPTION 1 = REMOVE 0 = FINISHED

Request to input the span the user desires to have the live load removed from or input that removal of live loads is complete.

Examples

Example 1-1

Using the ten span frame illustrated in Figure 1 and the typical loading in Figure 2, the operation of the program will be demonstrated. The program begins with the screen prompt "INPUT FRAME IDENTIFICATION?" The user inputs identification of the frame, which in this case is an interior frame along Column Line 5. Input INTERIOR FRAME ALONG 5 and press RETURN.

The program then provides the screen prompt "INPUT NUMBER OF SPANS?" Input 10 and press RETURN.

The screen then displays "INPUT MODULUS OF ELASTICITY?" Input 3605 and press RETURN. The modulus of elasticity, E, should be in units of kips per square inch.

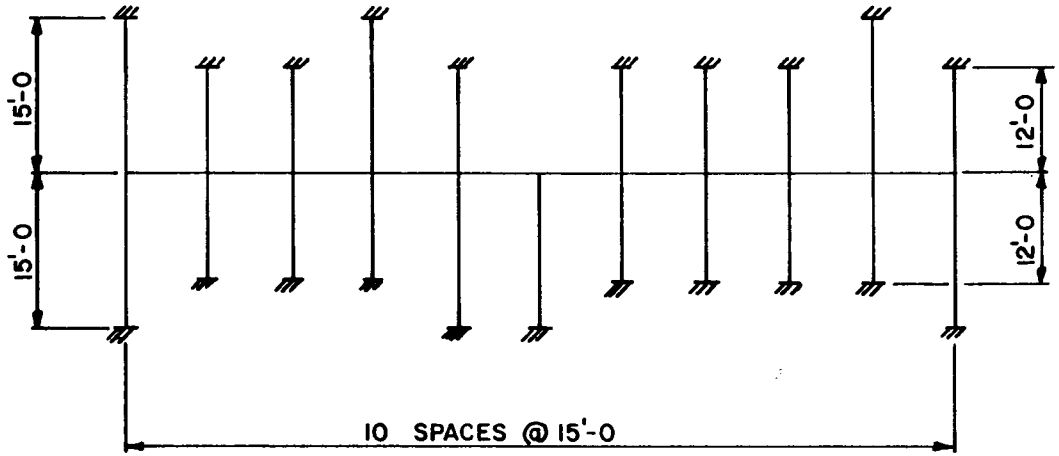


FIGURE 1

EXAMPLE 1-1 FRAME CONFIGURATION

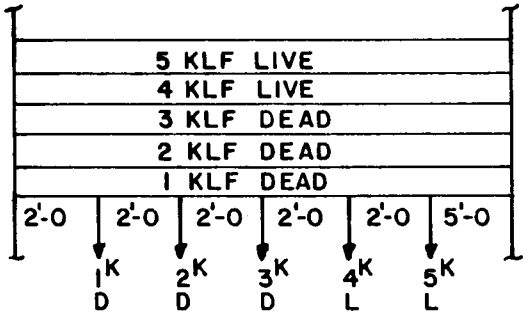


FIGURE 2

TYPICAL BAY LOADING FOR
EXAMPLE 1-1 FRAME

The screen then displays "INPUT L (FT.), I (IN.^ 4) SPAN 1?" Input 15,900 and press RETURN. The screen then displays "SPAN 2?" Input 15,900 and press RETURN. Note that this input is not fifteen thousand nine hundred, but rather fifteen feet and nine hundred inches to the fourth, separated by a comma. This continues until all spans are complete.

The screen then displays "COLUMNS ABOVE OR BELOW 1=YES 0=NO?" Input 1 for a yes response and press RETURN. The screen then displays "ALL COLUMNS ABOVE STANDARD 1=YES 0=NO?" As the example does not have all standard columns, input 0 for a no response and press RETURN. The screen then displays "ALL COLUMNS BELOW STANDARD 1=YES 0=NO?" Input 0 for a no response and press RETURN.

The screen then displays "INPUT COLUMN LENGTH, INERTIA (NEG. IF PIN) COL. ABOVE (L TO R)?" This is a request to input the column length in feet and inertia in inches^4 for the columns above each joint, in order, starting at the left end of the frame and working to the right. If the column is pinned at its extremity, the inertia should be input as a negative. This allows the stiffness to be properly reduced. Input 15,500 and press RETURN. The screen displays "15,500" and "?" which is a request for the next column above. Input 12,500 and press RETURN. The screen displays "12,500" and "?" asking for the next column above. The screen displays the values of the previously input column to aid the user in

keeping proper track of joints completed. This process continues until the last column above has been input. In Fig. 1, it can been seen that there is no column above at one location. The length can be input as 99' and the inertia input as 0.01 to eliminate the model column stiffness.

The screen then dispays "COL. BELOW (L TO R)?" which is a request for the same information just input but for the column below. This process continues until the last column below has been input.

The screen then clears and the printer displays the frame data just entered. The screen then displays "CHANGE MEMBER DATA 1=YES 0=NO?" This gives the user the opportunity to change data if a review of the print-out indicates an input error. Input 0 for a no response and press RETURN.

The screen then displays "DO YOU WANT TO SKIP LOAD? 1 = YES 0 = NO?" Input 1 and press RETURN.

The printer then displays the load options, the maximum number of each, and tells the user that live loads should be designated by selecting the negative of the desired option.

The screen then displays "CHOOSE LOAD OPTION FOR SPAN 1." Referring to Fig. 2 for the typical loading, input 1 for uniform dead load and press RETURN. The screen displays "W,Db,De=?" Input 1,0,15 and press RETURN. The printer displays the same information on the tape. The screen then displays "CHOOSE LOAD OPTION FOR SPAN 1." Input

1 and press RETURN. The screen displays "W,Db,De=?" Input 2,0,15 and press RETURN. The screen displays "CHOOSE LOAD OPTION FOR SPAN 1?" Input 1 and press RETURN. The screen displays W,Db,De=?" Input 3,0,15 and press RETURN. The screen displays "CHOOSE LOAD OPTION FOR SPAN 1." Input -1 for uniform live load and press RETURN. The screen displays "W,Db,De=?" Input 4,0,15 and press RETURN. This process continues for the remainder of the loads on Span 1. After the last load entry of Span 1, input 6 and press RETURN. The printer displays "SPAN 2." The screen displays "CHOOSE LOAD OPTION FOR SPAN 2?"

Because all spans are loaded in exactly the same manner, the span duplication option can be used. Input 5 and press RETURN. The screen displays "DUPLICATE WHICH SPAN?" Input 1 and press RETURN. The printer displays "LOADS SAME AS SPAN 1?" The screen then displays "CHOOSE LOAD OPTION FOR SPAN 3?" This continues until all spans have been entered. The screen then displays "RUNNING."

The program next prints out results for the ten spans in order for all loads on all spans. After the tenth span is completed, the screen displays "INPUT DESIRED SKIP 1 = ODD SKIP 2 = EVEN SKIP 3 = CHOICE 4 = END?" To remove the live loads from the odd spans, input 1 and press RETURN. The screen displays "RUNNING." The printer then displays the heading "LIVE LOAD ON EVEN SPANS" indicating dead loads are on all spans and live loads have been removed from odd

spans. The program then prints out results for the ten spans in order.

After the tenth span is completed, the screen displays "INPUT DESIRED SKIP 1 = ODD SKIP 2 = EVEN SKIP 3 = CHOICE 4 = END?" To remove the live loads from the even spans, input 2 and press RETURN. The screen displays "RUNNING." The printer then displays the heading "LIVE LOAD ON ODD SPANS," indicating dead loads are on all spans and live loads have been removed from even spans. The program then prints out results for the ten spans in order.

After the tenth span is completed, the screen displays "INPUT DESIRED SKIP 1 = ODD SKIP 2 = EVEN SKIP 3 = CHOICE 4 = END?" To demonstrate "CHOICE," input 3 and press RETURN. The screen displays "SPAN LIVE LOAD REMOVAL OPTION 1 = REMOVE 0 = FINISHED?" Input 1 and press RETURN. The printer displays the heading "LIVE LOAD REMOVED FROM THE FOLLOWING SPANS:." The screen displays "INPUT THE SPAN YOU WISH TO SKIP?" Input 1 and press RETURN. The printer displays "1" and the screen displays "1 = REMOVE 0 = FINISHED?" Input 1 and press RETURN. The screen will again display the request for which span is to be skipped. Continuing to skip all the odd spans will result in verification of the first skip option described.

The same frame and loadings were run on an Olivetti 652 machine language computer for verification of results. The

comparison of values attained in these two runs is contained in Tables I, II and III.

Figure 3 is a print-out of the tape resulting from all loads on all spans for this example.

Example 1-2

The use of the program for continuous beam analysis is demonstrated in this example as is the use of the triangular load and concentrated moment options. It is assumed that the user is familiar with the operation of the program after a review of Example 1-1, so detailed documentation of the input has been omitted. Referring to Figure 4, it may be seen that the continuous beam has cantilevers on each end. Loads on these cantilevers are input as concentrated moments at the end support joints. Comparative results as described in Example 1-1 are shown in Tables IV, V and VI.

Example 1-3

Example 1-3 introduces the use of concentrated moments at locations other than joints and the use of standard columns above and below the beam members. Referring to Figure 5, it is seen that 10.0 foot-kip moments are applied at the mid-span of the end bays, as well as at the end joints. Comparative results as described in Example 1-1 are shown in Tables VII, VIII and IX.

Example 1-4

Example 1-4 illustrates the use of the program to analyze a partial triangular load combined with a

TABLE I: FRAME EXAMPLE 1-1 ALL LOADS ON ALL SPANS

	(K-FT) MOMENT AT LEFT END		(K-FT) MOMENT AT RIGHT END		(K) SHEAR AT LEFT END		(K) SHEAR AT RIGHT END		(IN) MAXIMUM DEFLECTION		(FT) INFLECTION POINTS			
	A	B	A	B	A	B	A	B	A	B	A		B	
SPAN 1	-167.08	-165.03	-358.84	-357.06	107.38	107.37	-132.62	-132.63	1.81	1.84	1.81,	11.63	1.75,	11.69
SPAN 2	-327.18	-342.21	-298.39	-296.96	122.09	121.98	-117.91	-118.02	1.06	1.1	3.46,	11.8	3.37,	11.85
SPAN 3	-303.03	-300.22	-307.48	-305.96	119.87	119.78	-120.13	-120.22	1.18	1.21	3.19,	11.77	3.13,	11.82
SPAN 4	-306.69	-303.88	-306.12	-304.64	120.2	120.12	-119.8	-119.88	1.16	1.19	3.23,	11.78	3.17,	11.83
SPAN 5	-306.13	-303.43	-306.31	-304.52	120.15	120.09	-119.85	-119.91	1.16	1.2	3.23,	11.78	3.16,	11.83
SPAN 6	-306.23	-303.72	-306.23	-304.63	120.17	120.11	-119.83	-119.89	1.16	1.19	3.23,	11.78	3.17,	11.83
SPAN 7	-306.02	-303.12	-306.78	-305.32	120.12	120.02	-119.88	-119.98	1.16	1.19	3.23,	11.77	3.16,	11.82
SPAN 8	-307.35	-304.51	-303.21	-301.77	120.44	120.35	-119.56	-119.65	1.18	1.21	3.23,	11.81,	3.17,	11.86
SPAN 9	-298.44	-295.68	-326.84	-325.14	118.24	118.2	-121.73	-121.8	1.07	1.1	3.2,	11.55	3.14,	11.63
SPAN 10	-354.49	-351.26	-176.39	-176.05	132.04	131.85	-107.96	-108.15	1.77	1.8	3.36,	13.08	3.29,	13.13

A - THESIS PROGRAM B- CHECK COMPUTING SYSTEM

TABLE II: FRAME EXAMPLE 1-1 DEAD LOAD ALL SPANS, LIVE LOAD ON EVEN SPANS

	(K-FT) MOMENT AT LEFT END		(K-FT) MOMENT AT RIGHT END		(K) SHEAR AT LEFT END		(K) SHEAR AT RIGHT END		(IN) MAXIMUM DEFLECTION		(FT) INFLECTION POINTS			
	A	B	A	B	A	B	A	B	A	B	A		B	
SPAN 1	-50.0	-50.34	-200.77	-199.55	39.08	39.19	-56.92	-56.81	.45	.41	1.45,	10.29	1.45,	10.34
SPAN 2	-283.62	-280.51	-261.75	-261.47	121.62	121.44	-118.38	-118.56	1.67	1.69	2.85,	12.31	2.8,	18.35
SPAN 3	-158.26	-158.54	-163.53	-162.27	48.78	48.88	-47.22	-47.12	-.203	-.12	4.71,	9.75	4.66,	9.89
SPAN 4	-266.24	-263.17	-262.74	-262.51	120.40	120.21	-119.60	-119.79	1.79	1.81	2.69,	12.33	2.62,	12.38
SPAN 5	-156.75	-157.14	-181.95	-180.34	47.45	47.59	-48.55	-48.41	-.31	-.25	5.08,	9.08	4.95,	9.16
SPAN 6	-240.69	-238.05	-278.47	-278.01	117.65	117.5	-122.35	-122.5	1.86	1.88	2.47,	12.24	2.4,	12.27
SPAN 7	-166.20	-166.4	-157.10	-155.94	49.74	49.83	-46.26	-46.17	-.20	-.13	4.93,	9.84	9.84,	9.99
SPAN 8	-266.70	-263.58	-266.78	-266.50	120.16	119.97	-119.84	-120.03	1.75	1.78	2.71,	12.29	2.64,	12.34
SPAN 9	-156.90	-157.2	-173.07	-171.84	48.06	48.16	-47.94	-47.84	-.25	-.18	4.86,	9.4	4.78,	9.53
SPAN 10	-290.59	-287.55	-196.36	-195.96	126.45	126.27	-113.55	-113.73	2.1	2.13	2.78,	12.96	2.73,	13.02

A - THESIS PROGRAM B- CHECK COMPUTING SYSTEM

TABLE III: FRAME EXAMPLE 1-1 - DEAD LOAD ON ALL SPANS, LIVE LOAD ON ODD SPANS

	(K-FT) MOMENT AT LEFT END		(K-FT) MOMENT AT RIGHT END		(K) SHEAR AT LEFT END		(K) SHEAR AT RIGHT END		(IN) MAXIMUM DEFLECTION		(FT) INFLECTION POINTS			
	A	B	A	B	A	B	A	B	A	B	A		B	
SPAN 1	-184.75	-182.36	-299.56	-299.00	112.51	112.39	-127.49	-127.61	2.12	2.14	1.92,	12.16	1.85,	12.19
SPAN 2	-174.54	-174.68	-154.22	-153.07	50.49	50.57	-45.51	-45.43	-.23	-.17	5.23,	9.77	5.11,	9.93
SPAN 3	-266.17	-263.09	-256.20	-264.93	120.23	120.27	-119.77	-119.96	1.77	1.79	2.7,	12.31	2.63,	12.35
SPAN 4	-163.27	-163.53	-164.05	-162.79	49.08	49.18	-46.92	-46.82	-.23	-.16	4.96,	9.61	4.88,	9.77
SPAN 5	-271.80	-268.72	-245.55	-245.38	121.92	121.72	-118.08	-118.28	1.88	1.9	2.71,	12.49	2.64,	12.54
SPAN 6	-187.78	-187.92	-148.62	-147.48	51.74	51.83	-44.26	-44.17	-.29	-.23	5.61,	9.70	5.51,	9.88
SPAN 7	-262.50	-259.39	-270.56	-270.27	119.63	119.44	-120.37	-120.56	1.76	1.78	2.67,	12.27	2.6,	12.37
SPAN 8	-163.79	-164.07	-155.91	-154.75	49.66	49.75	-46.34	-46.25	-.18	-.11	4.8,	9.95	4.74,	10.09
SPAN 9	-261.1	-258.03	-282.77	-282.30	118.72	118.55	-121.28	-121.45	1.68	1.7	2.68,	12.15	2.61,	12.18
SPAN 10	-205.84	-205.65	-48.8	-48.86	59.6	59.59	-36.4	-36.41	.41	.38	4.57,	13.46	4.56,	13.46

A - THESIS PROGRAM B - CHECK COMPUTING SYSTEM

EXAMPLE 1-1

E= 3605 KSI

SPAN	LENGTH	INERTIA
1	15	900
2	15	900
3	15	900
4	15	900
5	15	900
6	15	900
7	15	900
8	15	900
9	15	900
10	15	900

JOINT NO.	LENGTH ft.	INERTIA in^4
0	15	500
	15	500
1	12	500
	12	500
2	12	500
	12	500
3	15	500
	12	500
4	12	500
	15	500
5	99	.01
	15	500
6	12	500
	12	500
7	12	500
	12	500
8	12	500
	12	500
9	15	500
	12	500
10	12	500
	15	500

+I=FIXED -I=PINNED

LOAD OPTIONS
1=UNIFORM LOAD (5)
2=CONCENTRATED LOAD (12)
3=TRIANGULAR LOAD (5)
4=CONCENTRATED MOMENT(5)
5=DUPLICATE LOADS
6=END LOADING
() INDICATES THE MAX. NO.
OF LOADS(D+L)PER SPAN

INPUT LOAD OPTIONS AS
A NEGATIVE TO INDICATE
LIVE LOAD.

LOAD K,K/FT	BEGIN FT	ENDS FT
SPAN: 1		
W 1.00	0.00	15.00
W 2.00	0.00	15.00
W 3.00	0.00	15.00
WLL 4.00	0.00	15.00
WLL 5.00	0.00	15.00
P 1.00	2.00	
P 2.00	4.00	
P 3.00	6.00	
PLL 4.00	8.00	
PLL 5.00	10.00	
SPAN: 2		
LOADS SAME AS SPAN 1		
SPAN: 3		
LOADS SAME AS SPAN 1		
SPAN: 4		
LOADS SAME AS SPAN 1		
SPAN: 5		
LOADS SAME AS SPAN 1		
SPAN: 6		
LOADS SAME AS SPAN 1		
SPAN: 7		
LOADS SAME AS SPAN 1		
SPAN: 8		
LOADS SAME AS SPAN 1		
SPAN: 9		
LOADS SAME AS SPAN 1		
SPAN: 10		
LOADS SAME AS SPAN 1		

JOINT 0
COLUMN ABOVE 83.54 kft
COLUMN BELOW 83.54 kft
CLOCKWISE +

SPAN 1

X	SHEAR	MOMENT
0.00	107.38	-167.08
1.50	84.88	-22.88
3.00	61.38	86.57
4.50	36.88	160.77
6.00	14.38	199.22
7.50	-11.12	199.42
9.00	-37.62	161.87
10.50	-65.12	86.07
12.00	-87.62	-28.48
13.50	-110.12	-176.78
15.00	-132.62	-358.84

INFLECTION POINTS:
1.81 ft 11.63 ft
MAX. DEFLECTION=
1.810 in +↓

JOINT 1
COLUMN ABOVE -15.83 kft
COLUMN BELOW -15.83 kft

SPAN 2

X	SHEAR	MOMENT
0.00	122.09	-327.18
1.50	99.59	-160.93
3.00	76.09	-29.42
4.50	51.59	66.83
6.00	29.09	127.34
7.50	3.59	149.59
9.00	-22.91	134.10
10.50	-50.41	80.35
12.00	-72.91	-12.15
13.50	-95.41	-138.39
15.00	-117.91	-298.39

INFLECTION POINTS:
3.46 ft 11.80 ft
MAX. DEFLECTION=
1.064 in +↓

JOINT 2
COLUMN ABOVE 2.32 kft
COLUMN BELOW 2.32 kft

SPAN 3

X	SHEAR	MOMENT
0.00	119.87	-303.03
1.50	97.37	-140.10
3.00	73.87	-11.92
4.50	49.37	81.01
6.00	26.87	138.19
7.50	1.37	157.12
9.00	-25.13	138.30
10.50	-52.63	81.23
12.00	-75.13	-14.59
13.50	-97.63	-144.16
15.00	-120.13	-307.48

INFLECTION POINTS:
3.19 ft 11.77 ft
MAX. DEFLECTION=
1.177 in +↓

JOINT 3
COLUMN ABOVE -0.35 kft
COLUMN BELOW -0.44 kft

SPAN 4

X	SHEAR	MOMENT
0.00	120.20	-306.69
1.50	97.70	-143.26
3.00	74.20	-14.58
4.50	49.70	78.85
6.00	27.20	136.54
7.50	1.70	155.97
9.00	-24.80	137.65
10.50	-52.30	81.08
12.00	-74.80	-14.24
13.50	-97.30	-143.31
15.00	-119.80	-306.12

INFLECTION POINTS:
3.23 ft 11.78 ft
MAX. DEFLECTION=
1.160 in +↓

JOINT 4
COLUMN ABOVE 0.00 kft
COLUMN BELOW 0.00 kft

SPAN 5

X	SHEAR	MOMENT
0.00	120.15	-306.13
1.50	97.65	-142.77
3.00	74.15	-14.16
4.50	49.65	79.19
6.00	27.15	136.80
7.50	1.65	156.16
9.00	-24.85	137.77
10.50	-52.35	81.12
12.00	-74.85	-14.27
13.50	-97.35	-143.41
15.00	-119.85	-306.31

INFLECTION POINTS:
3.23 ft 11.78 ft
MAX. DEFLECTION=
1.162 in +↓

FIGURE 3

PROGRAM PRINT-OUT OF ALL LOADS ON
ALL SPANS FOR EXAMPLE 1-1 FRAME

```
JOINT 5
COLUMN ABOVE  -0.00 kft
COLUMN BELOW  -0.07 kft
```

```
SPAN 6
   X     SHEAR    MOMENT
  0.00  120.17 -306.23
  1.50   97.67 -142.86
  3.00   74.17  -14.23
  4.50   49.67   79.14
  6.00   27.17  136.77
  7.50    1.67  156.15
  9.00  -24.83  137.77
 10.50  -52.33   81.15
 12.00  -74.83  -14.23
 13.50  -97.33 -143.35
 15.00 -119.83 -306.23
INFLECTION POINTS:
  3.23 ft 11.78 ft
MAX. DEFLECTION=
          1.162 in +↓
```

```
JOINT 6
COLUMN ABOVE  -0.10 kft
COLUMN BELOW  -0.10 kft
```

```
SPAN 7
   X     SHEAR    MOMENT
  0.00  120.12 -306.02
  1.50   97.62 -142.72
  3.00   74.12  -14.17
  4.50   49.62   79.13
  6.00   27.12  136.67
  7.50    1.62  155.97
  9.00  -24.88  137.52
 10.50  -52.38   80.82
 12.00  -74.88  -14.63
 13.50  -97.38 -143.83
 15.00 -119.88 -306.78
INFLECTION POINTS:
  3.23 ft 11.77 ft
MAX. DEFLECTION=
          1.160 in +↓
```

```
JOINT 7
COLUMN ABOVE   0.29 kft
COLUMN BELOW   0.29 kft
```

```
SPAN 8
   X     SHEAR    MOMENT
  0.00  120.44 -307.35
  1.50   97.94 -143.57
  3.00   74.44  -14.53
  4.50   49.94   79.26
  6.00   27.44  137.30
  7.50    1.94  157.09
  9.00  -24.56  139.13
 10.50  -52.06   82.92
 12.00  -74.56  -12.04
 13.50  -97.06 -140.75
 15.00 -119.56 -303.21
INFLECTION POINTS:
  3.23 ft 11.81 ft
MAX. DEFLECTION=
          1.176 in +↓
```

```
JOINT 8
COLUMN ABOVE  -2.39 kft
COLUMN BELOW  -2.39 kft
```

```
SPAN 9
   X     SHEAR    MOMENT
  0.00  118.27 -298.44
  1.50   95.77 -137.90
  3.00   72.27  -12.12
  4.50   47.77   78.42
  6.00   25.27  133.20
  7.50   -0.23  149.73
  9.00  -26.73  128.52
 10.50  -54.23   69.05
 12.00  -76.73  -29.16
 13.50  -99.23 -161.13
 15.00 -121.73 -326.84
INFLECTION POINTS:
  3.20 ft 11.55 ft
MAX. DEFLECTION=
          1.066 in +↓
```

```
JOINT 9
COLUMN ABOVE  12.29 kft
COLUMN BELOW  15.36 kft
```

```
SPAN 10
   X     SHEAR    MOMENT
  0.00  132.04 -354.49
  1.50  109.54 -173.31
  3.00   86.04  -26.87
  4.50   61.54   84.31
  6.00   39.04  159.75
  7.50   13.54  196.93
  9.00  -12.96  196.37
 10.50  -40.46  157.55
 12.00  -62.96   79.99
 13.50  -85.46  -31.32
 15.00 -107.96 -176.39
INFLECTION POINTS:
  3.36 ft 13.08 ft
MAX. DEFLECTION=
          1.773 in +↓
```

```
JOINT 10
COLUMN ABOVE -97.99 kft
COLUMN BELOW -78.40 kft
```

FIGURE 3 (Continued)

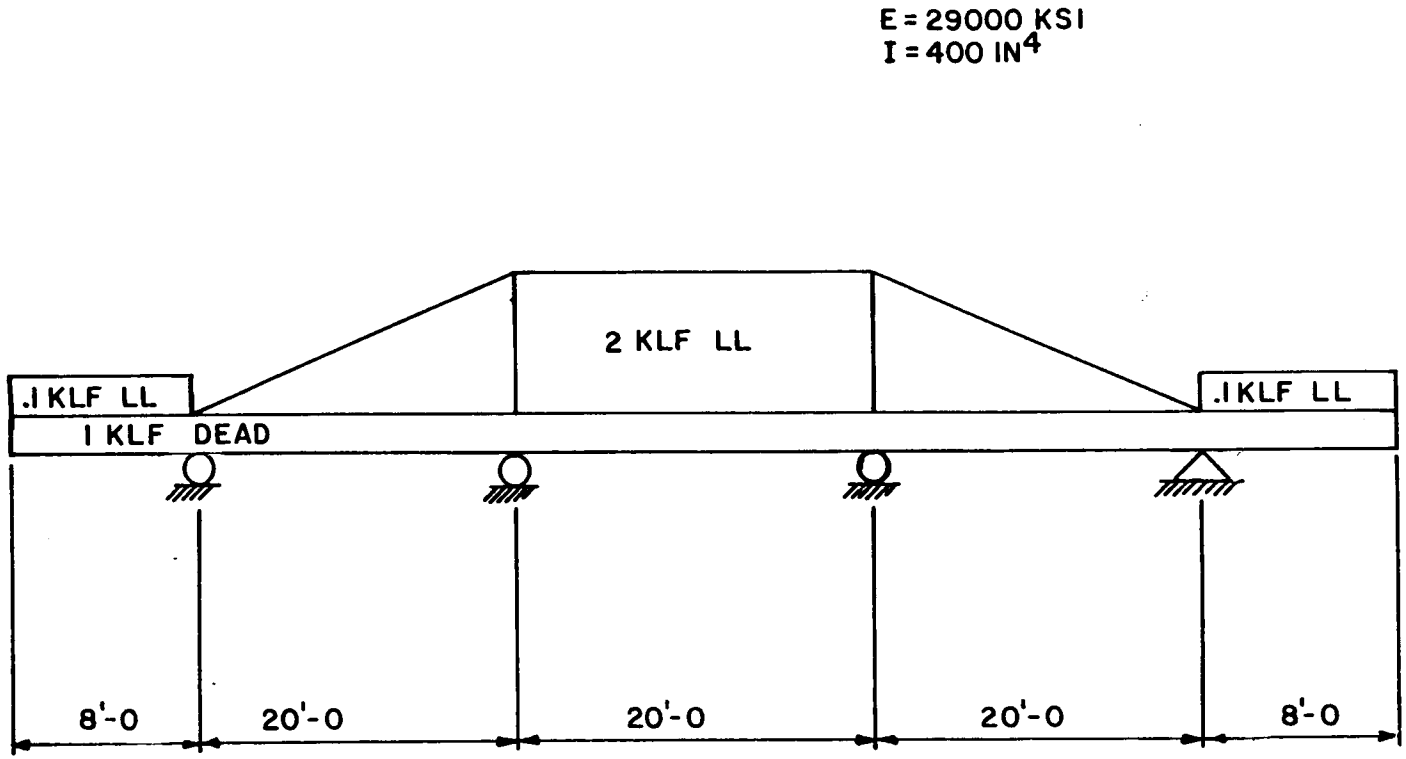


FIGURE 4

EXAMPLE 1-2 FRAME CONFIGURATION
AND LOADING

TABLE IV: FRAME EXAMPLE 1-2 ALL LOADS ON ALL SPANS

	(K-FT) MOMENT AT LEFT END		(K-FT) MOMENT AT RIGHT END		(K) SHEAR AT LEFT END		(K) SHEAR AT RIGHT END	
	A	B	A	B	A	B	A	B
SPAN 1	-35.2	-35.2	-94.29	-94.29	13.71	13.71	-26.29	26.29
SPAN 2	-94.29	-94.29	-94.29	-94.29	30.0	30.0	-30.0	-30.0
SPAN 3	-94.29	-94.29	-35.2	-35.2	26.29	26.29	-13.71	-13.71

A - THESIS PROGRAM B- CHECK COMPUTING SYSTEM

TABLE V: FRAME EXAMPLE 1-2 DEAD LOAD ON ALL SPANS, LIVE LOAD ON EVEN SPANS

	(K-FT) MOMENT AT LEFT END		(K-FT) MOMENT AT RIGHT END		(K) SHEAR AT LEFT END		(K) SHEAR AT RIGHT END	
	A	B	A	B	A	B	A	B
SPAN 1	-32.0	-32.0	-73.6	-73.6	7.92	7.92	-12.08	12.08
SPAN 2	-73.6	-73.6	-73.6	-73.6	30.0	30.0	-30.0	-30.0
SPAN 3	-73.6	-73.6	-32.0	-32.0	12.08	12.08	-7.92	-7.92

A - THESIS PROGRAM B- CHECK COMPUTING SYSTEM

TABLE VI: FRAME EXAMPLE 1-2 DEAD LOAD ON ALL SPANS, LIVE LOAD ON ODD SPANS

	(K-FT) MOMENT AT LEFT END		(K-FT) MOMENT AT RIGHT END		(K) SHEAR AT LEFT END		(K) SHEAR AT RIGHT END	
	A	B	A	B	A	B	A	B
SPAN 1	-35.2	-35.2	-54.29	-54.29	15.71	15.71	-24.29	24.29
SPAN 2	-54.29	-54.29	-54.29	-54.29	10.0	10.0	-10.0	-10.0
SPAN 3	-54.29	-54.29	-35.2	-35.2	24.29	24.29	-15.71	-15.71

A - THESIS PROGRAM B- CHECK COMPUTING SYSTEM

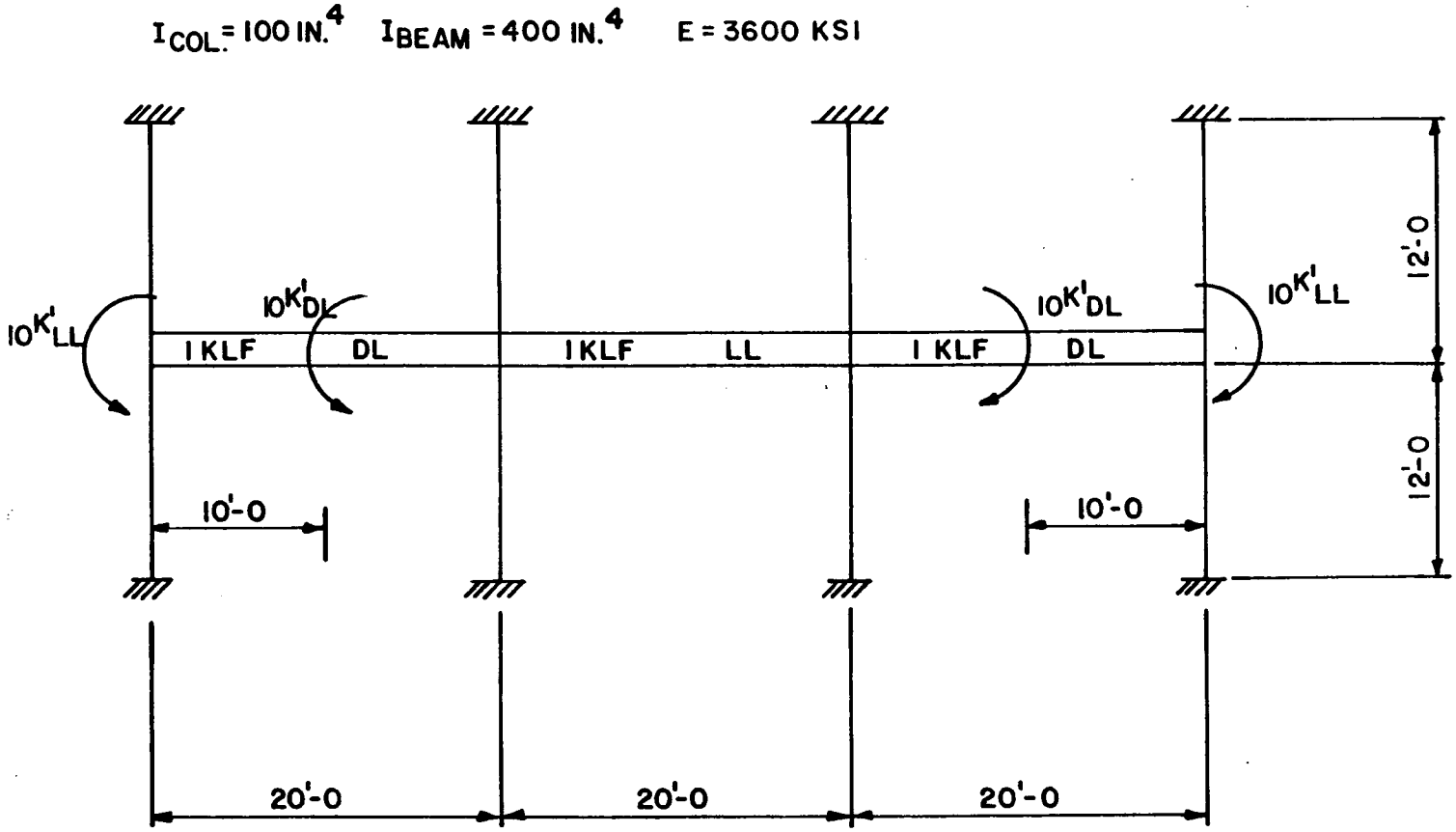


FIGURE 5

EXAMPLE 1-3 FRAME CONFIGURATION
AND LOADING

TABLE VII: FRAME EXAMPLE 1-3 ALL LOADS ON ALL SPANS

	(K-FT) MOMENT AT LEFT END		(K-FT) MOMENT AT RIGHT END		(K) SHEAR AT LEFT END		(K) SHEAR AT RIGHT END		(K-FT) MOMENT ABOVE		(K-FT) MOMENT BELOW		(IN) DEFLECTION AT MIDSPAN	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B
JOINT 0	-	-	-	-	-	-	-	-	6.11	6.11	6.11	6.11	-	-
SPAN 1	-22.21	-22.22	-36.09	-36.08	9.81	9.81	-10.19	-10.19	-	-	-	-	.75	.75
JOINT 1	-	-	-	-	-	-	-	-	-.86	-.86	-.86	-.86	-	-
SPAN 2	-34.37	-34.36	-34.37	-34.36	10.0	10.0	-10.0	-10.0	-	-	-	-	.437	-
JOINT 2	-	-	-	-	-	-	-	-	.86	.86	.86	.86	-	-
SPAN 3	-36.09	-36.08	-22.21	-22.22	10.19	10.19	-9.81	-9.81	-	-	-	-	.75	.75
JOINT 3	-	-	-	-	-	-	-	-	-6.11	-6.11	-6.11	-6.11	-	-

A - THESIS PROGRAM B - CHECK PROGRAM

TABLE VIII: FRAME EXAMPLE 1-3 DEAD LOAD ON ALL SPANS, LIVE LOAD ON EVEN SPANS

	(K-FT) MOMENT AT LEFT END		(K-FT) MOMENT AT RIGHT END		(K) SHEAR AT LEFT END		(K) SHEAR AT RIGHT END		(K-FT) MOMENT ABOVE		(K-FT) MOMENT BELOW		(IN) DEFLECTION AT MIDSPAN	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B
JOINT 0	-	-	-	-	-	-	-	-	8.52	8.53	8.52	8.53	-	-
SPAN 1	-17.04	-17.05	-37.75	37.73	9.46	9.47	-10.54	-10.53	-	-	-	-	.87	.86
JOINT 1	-	-	-	-	-	-	-	-	-1.38	-1.38	-1.38	-1.38	-	-
SPAN 2	-34.99	-34.98	-34.99	-34.98	10.0	10.0	-10.0	-10.0	-	-	-	-	.4	-
JOINT 2	-	-	-	-	-	-	-	-	1.38	1.38	1.38	1.38	-	-
SPAN 3	-37.75	-37.73	-17.04	-17.05	10.54	10.53	-9.46	-9.47	-	-	-	-	.87	.86
JOINT 3	-	-	-	-	-	-	-	-	-8.52	-8.53	-8.52	-8.53	-	-

A - THESIS PROGRAM B - CHECK PROGRAM

TABLE IX: FRAME EXAMPLE 1-3 DEAD LOAD ON ALL SPANS, LIVE LOAD ON ODD SPANS

	(K-FT) MOMENT AT LEFT END		(K-FT) MOMENT AT RIGHT END		(K) SHEAR AT LEFT END		(K) SHEAR AT RIGHT END		(K-FT) MOMENT ABOVE		(K-FT) MOMENT BELOW		(IN) DEFLECTION AT MIDSPAN	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B
JOINT 0	-	-	-	-	-	-	-	-	7.83	7.83	7.83	7.83	-	-
SPAN 1	-25..66	-25.66	-22.99	22.99	10.63	10.63	-9.37	-9.37	-	-	-	-	1.04	1.04
JOINT 1	-	-	-	-	-	-	-	-	-7.18	-7.18	-7.18	-7.18	-	-
SPAN 2	-8.62	-8.62	-8.62	-8.62	0.0	0.0	0.0	0.0	-	-	-	-	-.52	-
JOINT 2	-	-	-	-	-	-	-	-	7.18	7.18	7.18	7.18	-	-
SPAN 3	-22.99	-22.99	-25.66	-25.66	9.37	9.37	-10.63	-10.63	-	-	-	-	1.04	1.04
JOINT 3	-	-	-	-	-	-	-	-	-7.83	-7.83	-7.83	-7.83	-	-

A - THESIS PROGRAM B - CHECK PROGRAM

concentrated moment applied in the span of the beam. Referring to Figure 6, it is seen that the columns above are standard and the columns below are standard; but the columns above and below are different lengths. Comparative results as described in Example 1-1 are shown in Table X.

Example 1-5

Example 1-5 illustrates the use of the program to analyze an unusual frame with various loads as shown in Figure 7. The use of partial uniform loads is also introduced in this example. Comparative results as described in Example 1-1 are shown in Table XI.

Flow Chart

Figure 8 describes the chronological operation of the program.

Program Copy

Figure 9 is a print-out of the "FRAME" program. A wide margin is provided to allow the user to make notes, if desired.

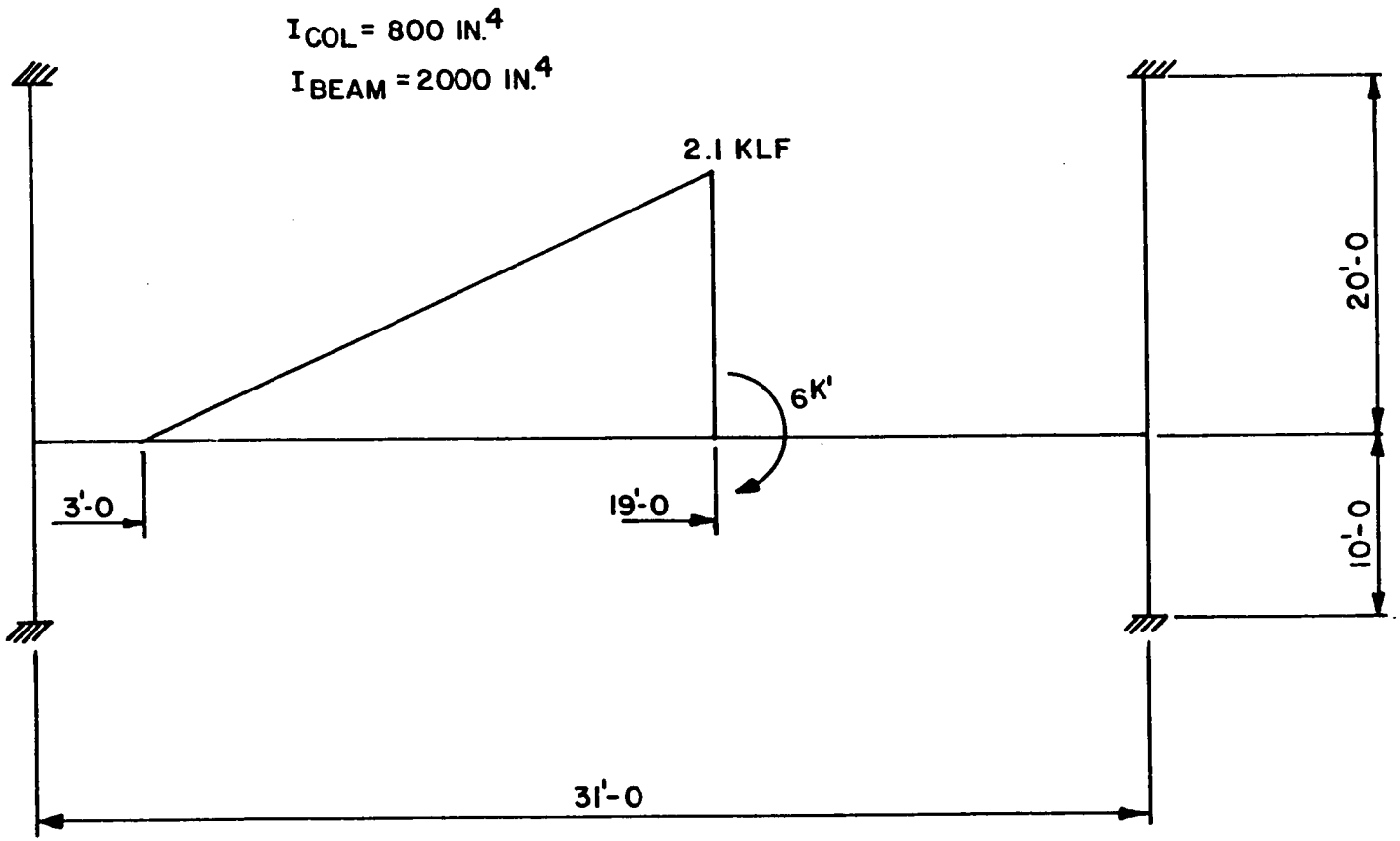


FIGURE 6

EXAMPLE 1-4 FRAME CONFIGURATION
AND LOADING

TABLE X: FRAME EXAMPLE 1-4

	(K-FT) MOMENT AT LEFT END		(K-FT) MOMENT AT RIGHT END		(K) SHEAR AT LEFT END		(K) SHEAR AT RIGHT END		(K-FT) MOMENT ABOVE		(K-FT) MOMENT BELOW	
	A	B	A	B	A	B	A	B	A	B	A	B
JOINT 0	-	-	-	-	-	-	-	-	16.49	16.15	32.98	32.92
SPAN 1	-49.47	-49.44	-44.57	-44.48	9.36	9.31	-7.44	-7.45	-	-	-	-
JOINT 1	-	-	-	-	-	-	-	-	-14.86	-14.85	-29.71	-29.63

A - THESIS PROGRAM B - HAND SOLUTION

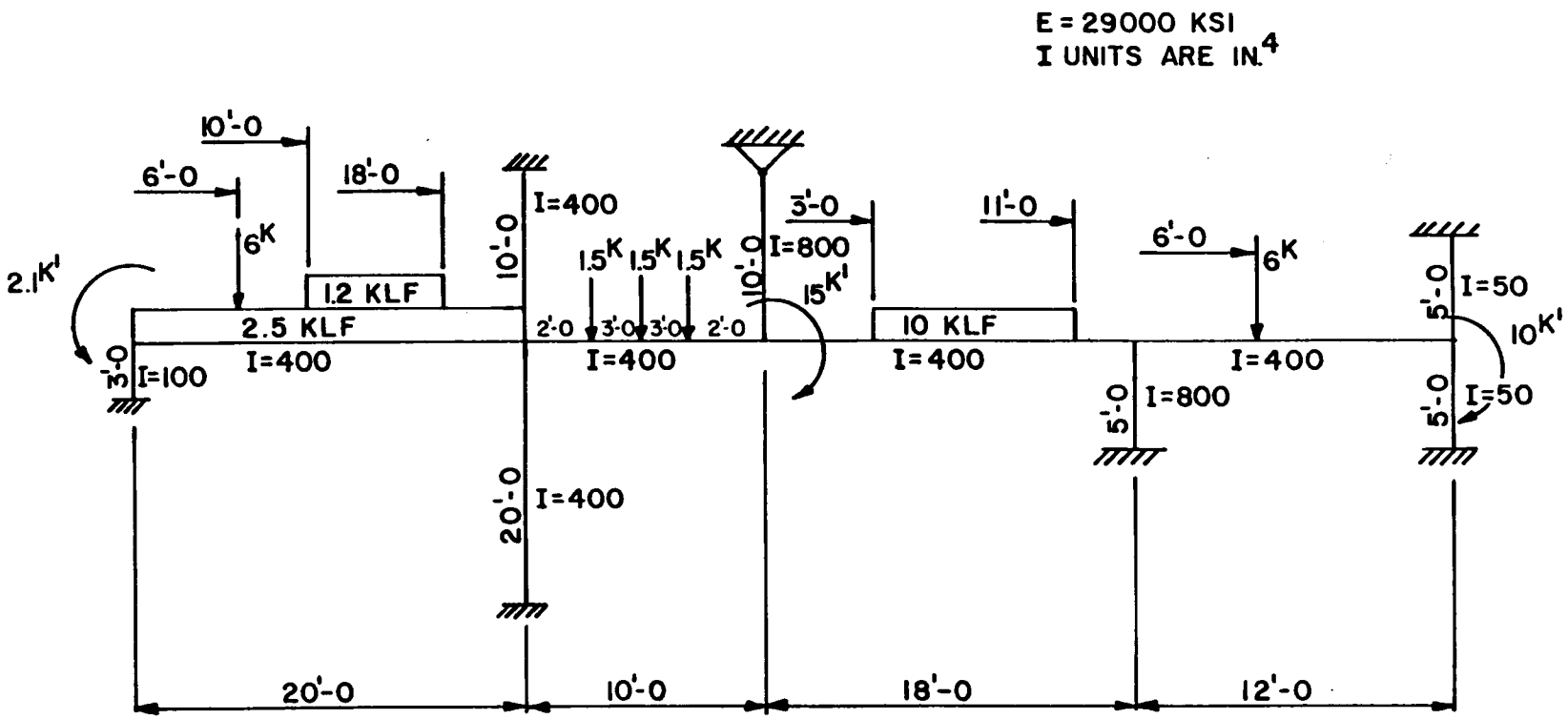


FIGURE 7

EXAMPLE 1-5 FRAME CONFIGURATION
AND LOADING

TABLE XI: FRAME EXAMPLE 1-5 ALL LOADS ON ALL SPANS

	(K-FT) MOMENT AT LEFT END		(K-FT) MOMENT AT RIGHT END		(K) SHEAR AT LEFT END		(K) SHEAR AT RIGHT END		(K-FT) MOMENT ABOVE		(K-FT) MOMENT BELOW	
	A	B	A	B	A	B	A	B	A	B	A	B
JOINT 0	-	-	-	-	-	-	-	-	-	-	66.97	68.25
SPAN 1	-69.07	-70.35	-101.67	-101.22	26.25	26.34	-33.35	-33.26	-	-	-	-
JOINT 1	-	-	-	-	-	-	-	-	-54.32	-55.23	-27.16	-26.56
SPAN 2	-20.19	19.43	-53.94	-54.77	-1.13	1.28	-5.63	-5.78	-	-	-	-
JOINT 2	-	-	-	-	-	-	-	-	115.24	114.72	-	-
SPAN 3	-154.19	-154.49	-135.5	-134.35	49.93	50.01	-30.07	-30.0	-	-	-	-
JOINT 3	-	-	-	-	-	-	-	-	-	-	-107.85	-105.01
SPAN 4	-27.65	-29.34	-5.41	-5.04	4.85	5.02	-1.15	-.98	-	-	-	-
JOINT 4	-	-	-	-	-	-	-	-	2.29	1.7	2.29	3.26

A - THESIS PROGRAM B - CHECK PROGRAM

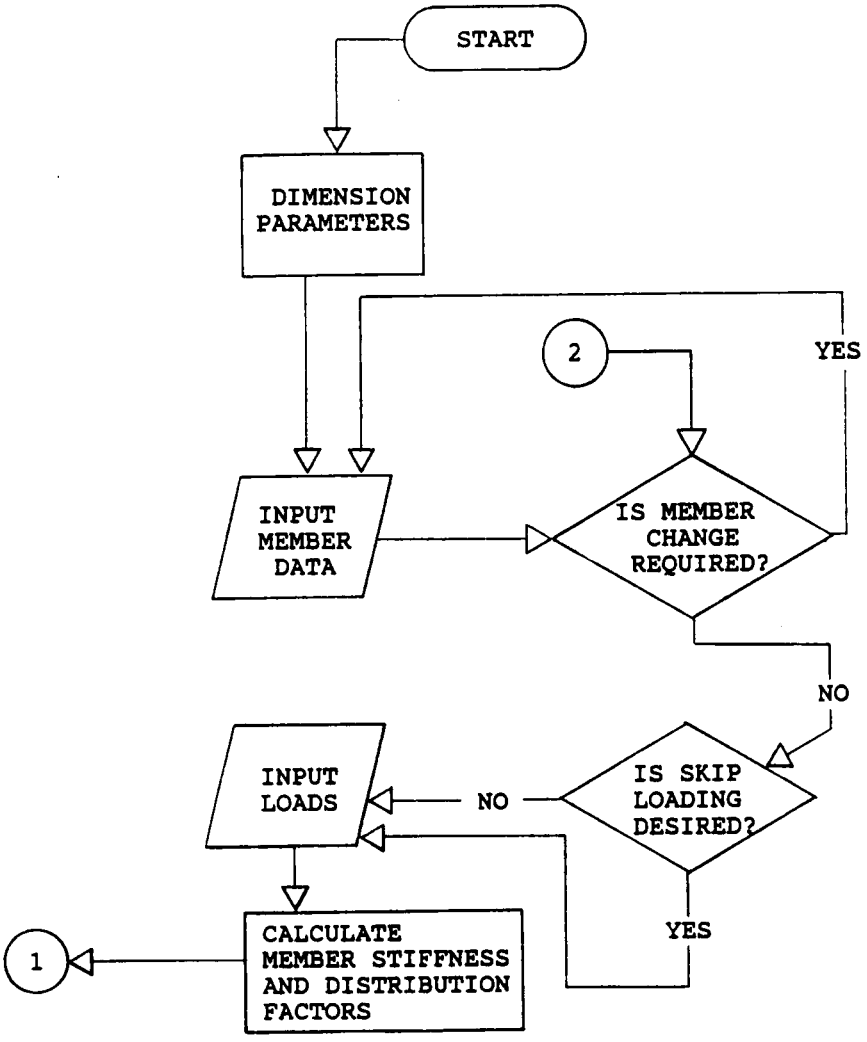


FIGURE 8

FRAME PROGRAM FLOW CHART

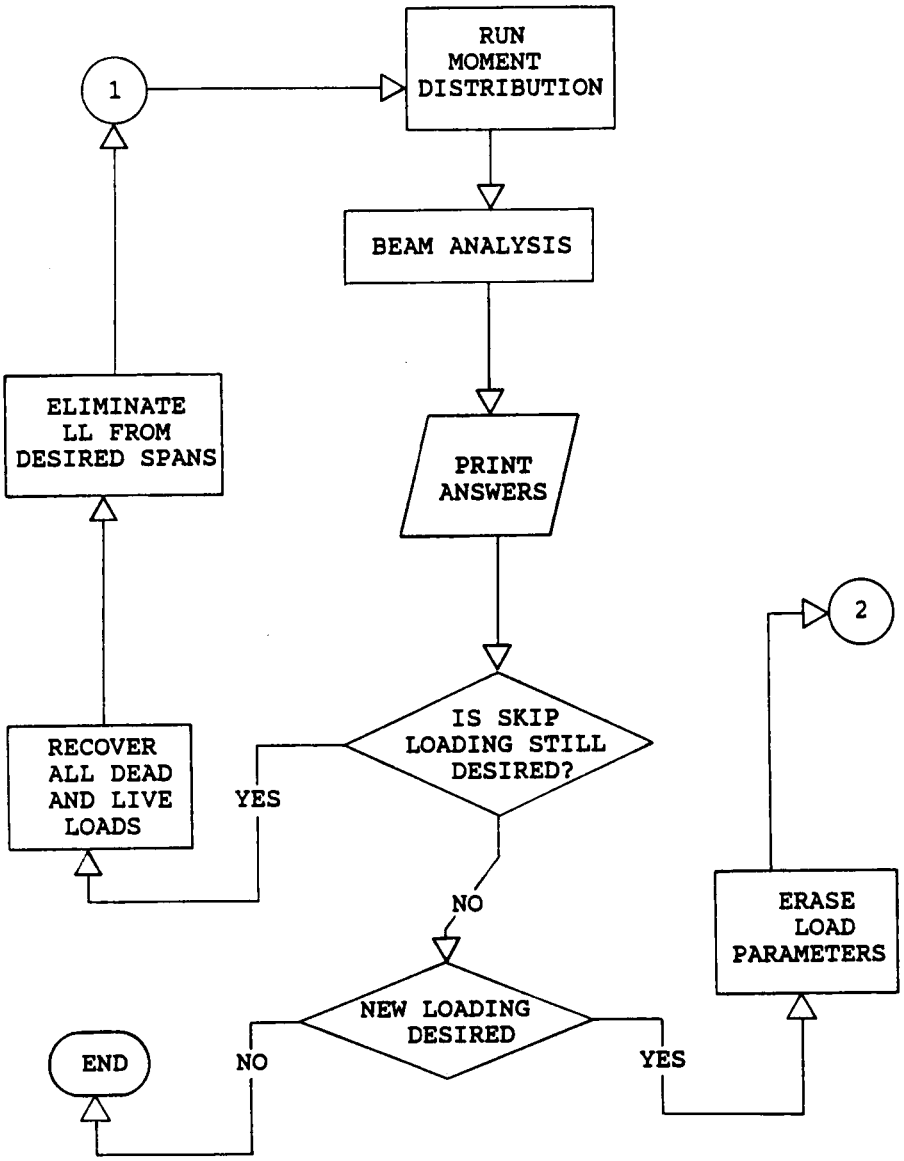


FIGURE 8 (Continued)

START

```
1 CLS
2 PRINT"[illegible]
[illegible]"
3 PRINT"[illegible] ONE STORY
[illegible]
4 PRINT"[illegible] FRAME ANALYSI
S [illegible]"
5 PRINT"[illegible]
[illegible]"
6 EEK=EEK+1
7 IF EEK=200 GOTO 8 ELSE
 GOTO 6
8 CLS
9 PRINT"INPUT FRAME"
10 PRINT"IDENTIFICATION"
11 INPUT D$
12 CLS
```

DIMENSION

```
13 DIM P(12,10),X(12,10)
,W1(5,10),DB(5,10),DE(5,
10),W(5,10),D0(5,10),DW(
5,10),M1(5,10),DM(5,10),
PSKIP(12,10),PSAVE(12,10
),W1SKIP(5,10),W1SAVE(5,
10),WSKIP(5,10),WSAVE(5,
10),M1SKIP(5,10),M1SAVE(
5,10)
14 DIM M1DSAV(5,10),W1DS
AV(5,10)
15 DIM L(32),I(32),K(32)
,DF(11,32),TJM(11),FEM(1
1,32),EM(11,32),AJM(11)
16 DIM M(11),V(11),D(11)
,RA(22),RB(22)
```

BUILD FRAME

```
17 PRINT"INPUT NUMBER"
18 PRINT"OF SPANS"
19 INPUT NOS
20 CLS
21 PRINT"INPUT MODULUS"
22 PRINT"OF ELASTICITY"
23 INPUT ELA
24 CLS
25 P=NOS*3+2
26 CLS
27 PRINT"INPUT L(FT.),I(
IN^4)"
28 FOR I=1 TO NOS
29 PRINT "SPAN";I
30 INPUT L(I),I(I)
31 CLS
32 NEXT I
33 PRINT "COLUMNS ABOVE
OR"
```

FIGURE 9

FRAME PROGRAM PRINT-OUT

```
34 PRINT "BELOW? 1=YES 0
=NO"
35 INPUT NOC
36 CLS
37 IF NOC=1 GOTO 43
38 FOR I=(NOS+1) TO P
39 I(I)=.01
40 L(I)=100
41 NEXT I
42 GOTO 85
43 PRINT "ALL COLUMNS AB
OVE"
44 PRINT "STANDARD 1=YES
"
45 INPUT "0=NO";SCT
46 CLS
47 IF SCT=0 GOTO 56
48 PRINT "STANDARD COL.
ABOVE"
49 PRINT "LENGTH AND INE
RTIA?"
50 INPUT LAS,IAS
51 FOR I=(NOS+1)TO(2*NOS
+1)
52 L(I)=LAS
53 I(I)=IAS
54 NEXT I
55 CLS
56 PRINT "ALL COLUMNS BE
LOW"
57 PRINT "STANDARD 1=YES
"
58 INPUT "0=NO";SCB
59 CLS
60 IF SCB=0 GOTO 71
61 PRINT "STANDARD COL.
BELOW"
62 PRINT "LENGTH AND INE
RTIA?"
63 INPUT LBS,IBS
64 FOR I=(2*NOS+2) TO P
65 L(I)=LBS
66 I(I)=IBS
67 NEXT I
68 CLS
69 IF SCT=0 GOTO 71
70 GOTO 85
71 PRINT "INPUT COLUMN L
ENGTH,"
72 PRINT "INERTIA (NEG.I
F PIN)"
73 IF SCT=1 GOTO 79
74 PRINT "COL. ABOVE (L
to R)"
75 FOR I=(NOS+1) TO (2*N
OS+1)
76 INPUT L(I),I(I)
77 NEXT I
78 CLS
79 IF SCB=1 GOTO 85
80 PRINT "COL. BELOW (L
to R)"
81 FOR I=(2*NOS+2) TO P
82 INPUT L(I),I(I)
83 NEXT I
84 CLS
85 GOSUB 478
```

FIGURE 9 (Continued)

```
86 FOR I=(NOS+1) TO P
87 IF I(I)<0 THEN I(I)=I
(I)*(-.75)
88 NEXT I
89 GOSUB 138
```

CALCULATE K AND DF

```
90 FOR N=1 TO P
91 K(N)=I(N)/L(N)
92 NEXT N
93 FOR J=0 TO NOS
94 N=J
95 IF J=NOS THEN K(J+1)=
0
96 DOM = K(J)+K(J+1)+K(J
+NOS+1)+K(J+2*NOS+2)
97 DF(J,N) = K(N)/DOM
98 N=J+1
99 DF(J,N)=K(N)/DOM
100 N=J+NOS+1
101 DF(J,N)=K(N)/DOM
102 N=J+2*NOS+2
103 DF(J,N)=K(N)/DOM
104 NEXT J
105 REM **** MOMENT DIST
. ***
106 FOR J=0 TO NOS
107 N=J
108 T=1
109 TJM(J)=FEM(J,J)+FEM(
J,J+1)+AJM(J)
110 AJM(J)=0
111 IF N=0 GOTO 120
112 EM(J,N)=EM(J,N)-DF(J
,N)*TJM(J)+FEM(J,N)
113 IF N>J+1 GOTO 120
114 FEM(J,N)=0
115 IF J=0 GOTO 118
116 IF J=J+1 GOTO 118
117 FEM(J-1,N)=FEM(J-1,N
)-DF(J,N)*TJM(J)/2
118 IF J=NOS GOTO 120
119 FEM(J+1,N)=FEM(J+1,N
)-DF(J,N)*TJM(J)/2
120 T=T+1
121 IF T=2 THEN N=J+1
122 IF T=3 THEN N=J+NOS+
1
123 IF T=4 THEN N=J+2*NO
S+2
124 IF T=5 GOTO 126
125 GOTO 112
126 NEXT J
127 SOUND 20,1
128 SOUND 25,1
129 SOUND 15,1
130 SOUND 18,1
131 IF KIC=1 GOTO 137
132 FOR J=0 TO NOS
133 KIC=1
134 IF ABS(TJM(J))>1 THE
N KIC=0
135 NEXT J
136 GOTO 106
```

FIGURE 9 (Continued)

```
137 GOSUB 313
```

LOAD INPUT

```
138 REM****LOAD INPUT***
*
139 PRINT"DO YOU WANT TO
"
140 PRINT"SKIP LOAD?"
141 PRINT"1=YES 0=N0"
142 INPUT SKIPPY
143 CLS
144 LPRINT"▬▬▬▬▬▬▬▬▬▬▬
▬▬▬▬▬▬▬▬▬"
145 LPRINT"      LOAD OP
TIONS"
146 LPRINT"1=UNIFORM LOA
D (5)"
147 LPRINT"2=CONCENTRATE
D LOAD (12)"
148 LPRINT"3=TRIANGULAR
LOAD (5)"
149 LPRINT"4=CONCENTRATE
D MOMENT(5)"
150 LPRINT"5=DUPLICATE L
OADS"
151 LPRINT"6=END LOADING
"
152 LPRINT"() INDICATES
THE MAX. NO. OF LOADS(D+L)
PER SPAN"
153 IF SKIPPY=0 THEN GOT
O 158
154 LPRINT""
155 LPRINT"INPUT LOAD OP
TIONS AS"
156 LPRINT"A NEGATIVE TO
 INDICATE"
157 LPRINT"LIVE LOAD."
158 LPRINT"▬▬▬▬▬▬▬▬▬▬▬
▬▬▬▬▬▬▬▬▬"
159 LPRINT "  LOAD    BE
GIN    ENDS"
160 LPRINT " K,K/FT    F
T       FT"
161 FOR S=1 TO NOS
162 PI=0
163 I2=0
164 I3=0
165 I4=0
166 L=L(S)*12
167 LPRINT "SPAN:";S
168 CLS
169 PRINT"CHOOSE LOAD OP
TION"
170 PRINT"FOR SPAN"S
171 INPUT ANS
172 CLS
173 IF ANS=1 GOTO 196
174 IF ANS=-1 GOTO 196
175 IF ANS=2 GOTO 186
176 IF ANS=-2 GOTO 186
177 IF ANS=3 GOTO 209
178 IF ANS=-3 GOTO 209
179 IF ANS=4 GOTO 222
```

FIGURE 9 (Continued)

```
180 IF ANS=-4 GOTO 222
181 IF ANS=5 GOTO183
182 IF ANS=6 GOTO 184
183 GOSUB 516
184 NEXT S
185 GOTO 236
186 PI=PI+1
187 INPUT "P,X";P(PI,S),
X(PI,S)
188 IF ANS=-2 THEN LPRIN
T"PLL";
189 IF ANS=-2 GOTO 191
190 LPRINT"P";
191 LPRINT USING "####.#
#";P(PI,S),X(PI,S)
192 IF ANS=2 GOTO 195
193 PSKIP(PI,S)=(-1)*P(P
I,S)
194 PSAVE(PI,S)=P(PI,S)
195 GOTO 168
196 REM****U.D.L****
197 I2=I2+1
198 PRINT "W,Db,De="
199 INPUT W1(I2,S),DB(I2
,S),DE(I2,S)
200 IF ANS=-1 THEN LPRIN
T"WLL";
201 IF ANS=-1 GOTO 203
202 LPRINT"W";
203 LPRINT USING "####.#
#";W1(I2,S),DB(I2,S),DE(
I2,S)
204 IF ANS=1 GOTO 207
205 W1SKIP(I2,S)=(-1)*W1
(I2,S)
206 W1SAVE(I2,S)=W1(I2,S
)
207 IF ANS=1 THEN W1DSAV
(I2,S)=W1(I2,S)
208 GOTO 168
209 REM****TRIANGULAR LO
AD
210 K=0
211 I3=I3+1
212 PRINT "W,Do,Dw="
213 INPUT W(I3,S),D0(I3,
S),DW(I3,S)
214 IF ANS=-3 THEN LPRIN
T"TLL";
215 IF ANS=-3 GOTO 217
216 LPRINT "T";
217 LPRINT USING "####.#
#";W(I3,S),D0(I3,S),DW(I
3,S)
218 IF ANS=3 GOTO 221
219 WSKIP(I3,S)=(-1)*W(I
3,S)
220 WSAVE(I3,S)=W(I3,S)
221 GOTO 168
222 REM****CON.MOMENT***
223 I4=I4+1
224 PRINT "M,X="
225 PRINT "CLOCKWISE +"
226 INPUT M1(I4,S),DM(I4
,S)
227 IF ANS=-4 THEN LPRIN
T"MLL";
228 IF ANS=-4 GOTO 230
```

FIGURE 9 (Continued)

```
229 LPRINT "M";
230 LPRINT USING "####.#
#";M1(I4,S),DM(I4,S)
231 IF ANS=4 GOTO 234
232 M1SKIP(I4,S)=(-1)*M1
(I4,S)
233 M1SAVE(I4,S)=M1(I4,S
)
234 IF ANS=4 THEN M1DSAV
(I4,S)=M1(I4,S)
235 GOTO 168
```

FEM CALCULATION

```
236 CLS
237 PRINT"[redacted]
[redacted]"
238 PRINT"      RUNNING"
239 PRINT"[redacted]
[redacted]"
240 FOR S=1 TO NOS
241 L=L(S)*12
242 PI=0
243 I2=0
244 I3=0
245 I4=0
246 PI=PI+1
247 IF PI>12 THEN GOTO 2
54
248 IF P(PI,S)=0 AND PSA
VE(PI,S)=0 GOTO 254
249 X(PI,S)=X(PI,S)*12:A
=X(PI,S)
250 B=L-A
251 FEM(S-1,S)=-1*P(PI,S
)*A*B^2/L^2+FEM(S-1,S)
252 FEM(S,S)=P(PI,S)*A^2
*B/L^2+FEM(S,S)
253 GOTO 246
254 I2=I2+1
255 IF I2>5 GOTO 268
256 IF W1(I2,S)=0 AND W1
SAVE(I2,S)=0 GOTO 268
257 W1(I2,S)=W1(I2,S)/12
258 DB(I2,S)=DB(I2,S)*12
259 DE(I2,S)=DE(I2,S)*12
260 A=DB(I2,S)
261 B=DE(I2,S)-DB(I2,S)
262 C=L-A-B
263 DP=A+B/2
264 E=L-DP
265 FEM(S-1,S)=W1(I2,S)*
B*(B^2*(L+3*(C-A))-24*E^
2*DP)/(24*L^2)+FEM(S-1,S
)
266 FEM(S,S)=-1*(W1(I2,S
)*B*((4*E^2*(L+2*DP)-B^2
*(C-A))/(4*L^3))*L-W1(I2
,S)*B*E+(W1(I2,S)*B*(B^2
*(L+3*(C-A))-24*E^2*DP)/
(24*L^2)))+FEM(S,S)
267 GOTO 254
268 I3=I3+1
269 K=0
270 IF I3>5 GOTO 292
271 IF W(I3,S)=0 AND WSA
```

FIGURE 9 (Continued)

```
VE(I3,S)=0 GOTO 292
272 D0(I3,S)=D0(I3,S)*12
273 DW(I3,S)=DW(I3,S)*12
274 I=I+1
275 IF DW(I3,S)<D0(I3,S)
 THEN B=D0(I3,S)-DW(I3,S
):C=DW(I3,S):A=L-C-B:DP=
A+2*B/3:E=L-DP:K=99:W(I3
,S)=W(I3,S)/(B*12):GO TO
 283
276 B=DW(I3,S)-D0(I3,S)
277 C=L-DW(I3,S)
278 A=L-B-C
279 DP=A+2*B/3
280 E=L-DP
281 W(I3,S)=W(I3,S)/(B*1
2)
282 IF K=99 GOTO 288
283 LEFT=W(I3,S)*B^2*(B^
2*(30*L-45*A-28*B)-270*D
P*E^2)/(540*L^2)
284 RIGT=(LEFT+W(I3,S)*B
^2*(56*B^3-45*B^2*(L-2*A
)+270*E^2*(L+2*DP))/(540
*L^2)-(W(I3,S)*B^2*E/2))
*(-1)
285 IF K=0 GOTO 288
286 IF K=99 THEN FEM(S-1
,S)=FEM(S-1,S)-RIGT:FEM(
S,S)=FEM(S,S)-LEFT
287 GOTO 290
288 FEM(S-1,S)=FEM(S-1,S
)+LEFT
289 FEM(S,S)=FEM(S,S)+RI
GT
290 K=0
291 GOTO 268
292 I4=I4+1
293 IF I4>5 GOTO 310
294 IF M1(I4,S)=0 AND M1
SAVE(I4,S)=0 GOTO 310
295 M1(I4,S)=M1(I4,S)*12
296 DM(I4,S)=DM(I4,S)*12
297 IF DM(I4,S)=0 GOTO 3
04
298 IF DM(I4,S)=L GOTO 3
07
299 A=DM(I4,S)
300 B=L-DM(I4,S)
301 FEM(S-1,S)=(M1(I4,S)
*B*(L-3*A)/L^2)*(-1)+FEM
(S-1,S)
302 FEM(S,S)=M1(I4,S)*A*
(2*L-3*A)/L^2+FEM(S,S)
303 GOTO 292
304 AJM(S-1)=-1*M1(I4,S)
+AJM(S-1)
305 M1(I4,S)=0
306 GOTO 292
307 AJM(S)=-1*M1(I4,S)+A
JM(S)
308 M1(I4,S)=0
309 GOTO 292
310 NEXT S
311 IF SKIPPY=1 GOTO 90
312 RETURN
```

FIGURE 9 (Continued)

BEAM ANALYSIS

```
313 REM***BEAM ANALYSIS*
**
314 FOR S=1 TO NOS
315 I=0
316 PI=0
317 I2=0
318 I3=0
319 I4=0
320 RRXN=0
321 LRXN=0
322 IP=0
323 IP2=0
324 L=L(S)*12
325 DMX=0
326 FOR Z=0 TO 10
327 M(Z)=0
328 V(Z)=0
329 D(Z)=0
330 NEXT Z
331 REM****CONC. LOAD****
332 PI=PI+1
333 IF PI>12 GOTO 345
334 IF P(PI,S)=0 AND PSA
VE(PI,S)=0 GOTO 345
335 A=X(PI,S)
336 B=L-A
337 RA(PI)=P(PI,S)*B/L
338 RB(PI)=P(PI,S)-RA(PI
)
339 FOR Z=0 TO 10
340 L1=Z*L/10
341 IF L1<=X(PI,S) THEN
M(Z)=RA(PI)*L1+M(Z):V(Z)
=RA(PI)+V(Z):D(Z)=D(Z)+P
(PI,S)*B*L1*(B^2-L^2+L1^
2)/(6*L):GO TO 343
342 IF L1>X(PI,S) THEN M
(Z)=RA(PI)*L1-P(PI,S)*(L
1-X(PI,S))+M(Z):V(Z)=RA(
PI)-P(PI,S)+V(Z):D(Z)=D(
Z)+P(PI,S)*A*(L-L1)*(A^2
-L^2+(L-L1)^2)*(1/(6*L))
: GO TO 343
343 NEXT Z
344 GOTO 332
345 REM****U. D. L****
346 I2=I2+1
347 IF I2>5 GOTO 363
348 IF W1(I2,S)=0 AND W1
SAVE(I2,S)=0 GOTO 363
349 A=DB(I2,S)
350 B=DE(I2,S)-DB(I2,S)
351 C=L-A-B
352 DP=A+B/2
353 E=L-DP
354 RA(I2)=W1(I2,S)*B*E/
L
355 RB(I2)=W1(I2,S)*B*DP
/L
356 FOR Z=0 TO 10
357 L1=Z*L/10
```

FIGURE 9 (Continued)

```
358 IF L1<=A THEN M(Z)=M
(Z)+RA(I2)*L1:V(Z)=RA(I2
)+V(Z):D(Z)=D(Z)+(W1(I2,
S)*B*E*L1)*(B^2+4*E^2-4*
L^2+4*L1^2)/(24*L):GO TO
 361
359 IF L1<=A+B THEN M(Z)
=M(Z)+RA(I2)*L1-(W1(I2,S
)*(L1-A)^2/2):V(Z)=V(Z)+
RA(I2)-W1(I2,S)*(L1-A):D
(Z)=D(Z)+W1(I2,S)*(B*E*L
1*(B^2+4*E^2-4*L^2+4*L1^
2)-L*(L1-A)^4)/(24*L):GO
 TO361
360 IF L1>A+B THEN M(Z)=
M(Z)+RB(I2)*(L-L1):V(Z)=
V(Z)-RB(I2):D(Z)=D(Z)+(W
1(I2,S)*B*DP*(L-L1))*(B^
2+4*DP^2-4*L^2+4*(L-L1)^
2)/(24*L): GO TO 361
361 NEXT Z
362 GOTO 346
363 REM****TRIANGULAR LO
AD
364 I3=I3+1
365 IF I3>5 GOTO 389
366 IF W(I3,S)=0 AND WSA
VE(I3,S)=0 GOTO 389
367 K=0
368 I=I+1
369 IF DW(I3,S)<D0(I3,S)
 THEN B=D0(I3,S)-DW(I3,S
):C=DW(I3,S):A=L-C-B:DP=
A+2*B/3:E=L-DP:K=99:GO T
O 375
370 B=DW(I3,S)-D0(I3,S)
371 C=L-DW(I3,S)
372 A=L-B-C
373 DP=A+2*B/3
374 E=L-DP
375 RA(I)=W(I3,S)*B^2*E/
(2*L)
376 RB(I)=W(I3,S)*B^2*DP
/(2*L)
377 FOR Z=0 TO 10
378 L1=L*Z/10
379 IF K=99 THEN L1=L-L*
Z/10:GOTO 383
380 IF L1<=A THEN V(Z)=V
(Z)+RA(I):M(Z)=M(Z)+W(I3
,S)*B^2*E*L1/(2*L):D(Z)=
D(Z)+W(I3,S)*B^2*L1*(45*
B^2*C+17*B^3-270*DP*E*(L
+E)+270*E*L1^2)/(3240*L)
:GO TO 386
381 IF L1<=A+B THEN V(Z)
=V(Z)+RA(I)-W(I3,S)*.5*(
L1-A)^2:M(Z)=M(Z)+W(I3,S
)*(3*B^2*E*L1-L*(L1-A)^3
)/(6*L):D(Z)=D(Z)+W(I3,S
)*(B^2*L1*(45*B^2*C+17*B
^3-270*DP*E*(L+E)+270*E*
L1^2)-27*L*(L1-A)^5)/(32
40*L):GO TO 386
382 IF L1>A+B THEN V(Z)=
V(Z)+RA(I)-W(I3,S)*B^2*.
5:M(Z)=M(Z)+W(I3,S)*B^2*
DP*(L-L1)/(2*L):D(Z)=D(Z
```

FIGURE 9 (Continued)

```
)+W(I3,S)*B^2*((L1/L)*(1
7*B^3-45*B^2*(L-C)-270*E
*(L^2-E^2)+270*E*L1^2)+B
^2*(45*A+28*B)-270*(L1-D
P)^3)/3240:GOTO386
383 IF L1<=A THEN V(Z)=V
(Z)-(RA(I)):M(Z)=M(Z)+W(
I3,S)*B^2*E*L1/(2*L):D(Z
)=D(Z)+W(I3,S)*B^2*L1*(4
5*B^2*C+17*B^3-270*DP*E*
(L+E)+270*E*L1^2)/(3240*
L):GO TO 386
384 IF L1<=A+B THEN V(Z)
=V(Z)-(RA(I)-W(I3,S)*.5*
(L1-A)^2):M(Z)=M(Z)+W(I3
,S)*(3*B^2*E*L1-L*(L1-A)
^3)/(6*L):D(Z)=D(Z)+W(I3
,S)*(B^2*L1*(45*B^2*C+17
*B^3-270*DP*E*(L+E)+270*
E*L1^2)-27*L*(L1-A)^5)/(
3240*L):GOTO 386
385 IF L1>A+B THEN V(Z)=
V(Z)-(RA(I)-W(I3,S)*B^2*
.5):M(Z)=M(Z)+W(I3,S)*B^
2*DP*(L-L1)/(2*L):D(Z)=D
(Z)+W(I3,S)*B^2*((L1/L)*
(17*B^3-45*B^2*(L-C)-270
*E*(L^2-E^2)+270*E*L1^2)
+B^2*(45*A+28*B)-270*(L1
-DP)^3)/3240:GOTO386
386 NEXT Z
387 W(I3,S)=W(I3,S)*B*12
388 GOTO 364
389 REM****CON. MOMENT***
390 I=I+1:I4=I4+1
391 IF I4>5 GOTO 404
392 IF M1(I4,S)=0 AND M1
SAVE(I4,S)=0 AND M1DSAV(
I4,S)=0 GOTO 404
393 A=DM(I4,S)
394 B=L-DM(I4,S)
395 RA(I)=-M1(I4,S)/L
396 RB(I)=M1(I4,S)/L
397 FOR Z=0 TO 10
398 L1=Z*L/10
399 IF L1<A THEN M(Z)=M(
Z)+RA(I)*L1:V(Z)=V(Z)+RA
(I):D(Z)=-M1(I4,S)*L1*(3
*B^2-L^2+L1^2)/(6*L)+D(Z
):GOTO 402
400 IF L1=A THEN M(Z)=M(
Z)+RA(I)*L1:V(Z)=V(Z)+RA
(I):D(Z)=-M1(I4,S)*L1*(3
*B^2-L^2+L1^2)/(6*L)+D(Z
):GOTO 402
401 IF L1>A THEN M(Z)=M(
Z)+RA(I)*L1+M1(I4,S):V(Z
)=V(Z)-RB(I):D(Z)=D(Z)+M
1(I4,S)*(L-L1)*(3*A^2-2*
L*L1+L1^2)/(6*L):GOTO 40
2
402 NEXT Z
403 GOTO 390
404 REM *END MOMENT*
405 I=0
406 I=I+1
407 RA(I)=-1*(EM(S-1,S)+
EM(S,S))/L
```

FIGURE 9 (Continued)

```
408 RB(I)=-1*RA(I)
409 FOR Z=0 TO 10
410 L1=Z*L/10
411 V(Z)=V(Z)+RA(I)
412 M(Z)=M(Z)+RA(I)*L1+E
M(S-1,S)
413 D(Z)=D(Z)-(EM(S-1,S)
*(L*L1/3-L1^2/2+L1^3/(6*
L))+EM(S,S)*(L*L1/6-L1^
3/(6*L))
414 NEXT Z
415 EM(S-1,S)=0
416 EM(S,S)=0
```

ANSWER PRINT-OUT

```
417 CLS
418 PRINT""
419 PRINT"[redacted] ANSWERS
[redacted]"
420 PRINT""
421 REM*****ANSWERS****
422 FOR Z=0 TO 9
423 IF M(Z)<0 GOTO 425
424 GOTO 427
425 IF M(Z+1)>0 THEN IP=
L*Z/10+(M(Z)/(M(Z)-M(Z+1
)))*L/10
426 GOTO 428
427 IF M(Z+1)<0 THEN IP2
=L*Z/10+(M(Z)/(M(Z)-M(Z+
1)))*L/10
428 NEXT Z
429 DMAX=D(1)
430 FOR Z= 2 TO 10
431 IF DMAX<ABS(D(Z)) TH
EN DMAX=ABS(D(Z)):DMX=D(
Z)
432 NEXT Z
433 IF S>1 GOTO 445
434 IF NOC=0 GOTO 444
435 LPRINT"-------------
----------"
436 LPRINT "JOINT";S-1
437 LPRINT USING"COLUMN
ABOVE####.##";EM(S-1,NOS
+1)/12;
438 LPRINT " kft"
439 LPRINT USING"COLUMN
BELOW####.##";EM(S-1,2*N
OS+2)/12;
440 LPRINT " kft"
441 EM(S-1,NOS+1)=0
442 EM(S-1,2*NOS+2)=0
443 LPRINT "CLOCKWISE +"
444 LPRINT"-------------
----------"
445 LPRINT "SPAN";S
446 LPRINT "   X    SHEA
R   MOMENT"
447 FOR Z=0 TO 10
448 LPRINT USING "####.#
# ";Z*L/(10*12),V(Z),M(Z
)/12
449 NEXT Z
```

FIGURE 9 (Continued)

```
450 LPRINT "INFLECTION P
OINTS:"
451 LPRINT USING "###.##
 ft";IP/12,IP2/12
452 LPRINT "MAX. DEFLECT
ION="
453 LPRINT USING "
   ###.### in +↓";DMX/(E
LA*I(S))*(-1)
454 LPRINT"-------------
----------"
455 IF NOC=0 GOTO 464
456 LPRINT "JOINT";S
457 LPRINT USING"COLUMN
ABOVE####.##";EM(S,S+NOS
+1)/12;
458 LPRINT " kft"
459 LPRINT USING"COLUMN
BELOW####.##";EM(S,S+2+2
*NOS)/12;
460 LPRINT " kft"
461 LPRINT"-------------
----------"
462 EM(S,S+NOS+1)=0
463 EM(S,S+2+2*NOS)=0
464 NEXT S
465 CLS
466 LPRINT
467 LPRINT
468 LPRINT
469 LPRINT
470 IF SKIPPY=1 GOTO 543
471 PRINT "CHANGE LOADIN
G"
472 INPUT "1=YES 0=NO";C
LO
473 CLS
474 IF CLO=1 GOTO 510
475 CLS
476 PRINT"END OF PROGRAM
"
477 END
```

INPUT PRINT-OUT

```
478 REM****INPUT PRINTOU
T***
479 LPRINT D$
480 LPRINT"
"
481 LPRINT
482 LPRINT "  E=";ELA;"K
SI"
483 LPRINT "SPAN  LENGTH
  INERTIA"
484 FOR I=1 TO NOS
485 LPRINT I;"    ";L(I);
"    ";I(I)
486 NEXT I
487 LPRINT
488 IF NOC=1 GOTO 491
489 LPRINT "NO COL. ABOV
E OR BELOW"
490 GOTO 503
491 LPRINT"JOINT  LENGTH
  INERTIA"
```

FIGURE 9 (Continued)

```
492 LPRINT" NO.     ft.
   in^4
493 IF SCT=0 GOTO 498
494 IF SCB=0 GOTO 498
495 LPRINT"ALL     ";LAS;
"   ";IAS
496 LPRINT"ALL     ";LBS;
"   ";IBS
497 GOTO 502
498 FOR J=0 TO NOS
499 LPRINT " ";J;"   ";L(
J+NOS+1);"   "I(J+NOS+1)
500 LPRINT "       ";L(J+
NOS*2+2);"   ";I(J+NOS*2+
2)
501 NEXT J
502 LPRINT"+I=FIXED -I=P
INNED"
503 LPRINT
504 PRINT
```

CHANGE DATA

```
505 PRINT "CHANGE MEMBER
 DATA"
506 INPUT "1=YES 0=NO";C
MD
507 CLS
508 IF CMD=1 GOTO 17
509 RETURN
510 ERASE M,V,D,RA,RB,P,
X,W1,DB,DE,W,D0,DW,M1,DM
,TJM,FEM,EM,AJM,PSAVE,W1
SAVE,WSAVE,M1SAVE,PSKIP,
W1SKIP,WSKIP,M1SKIP,M1DS
AV,W1DSAV
511 DIM P(12,10),X(12,10
),W1(5,10),DB(5,10),DE(5
,10),W(5,10),D0(5,10),DW
(5,10),M1(5,10),DM(5,10)
,PSKIP(12,10),PSAVE(12,1
0),W1SKIP(5,10),W1SAVE(5
,10),WSKIP(5,10),WSAVE(5
,10),M1SKIP(5,10),M1SAVE
(5,10)
512 DIM M1DSAV(5,10),W1D
SAV(5,10)
513 DIM M(11),V(11),D(11
),RA(22),RB(22),TJM(11),
FEM(11,32),EM(11,32),AJM
(11)
514 KIC=0
515 GOTO 85
```

LOAD DUPLICATION

```
516 PRINT "DUPLICATE WHI
CH"
517 INPUT "SPAN";DL
518 LPRINT "LOADS SAME A
S SPAN";DL
519 FOR Z=1 TO 12
```

FIGURE 9 (Continued)

```
520 P(Z,S)=P(Z,DL)
521 PSKIP(Z,S)=PSKIP(Z,D
L)
522 PSAVE(Z,S)=PSAVE(Z,D
L)
523 X(Z,S)=X(Z,DL):NEXT
Z
524 FOR Z=1 TO 5
525 W1(Z,S)=W1(Z,DL)
526 W1SKIP(Z,S)=W1SKIP(Z
,DL)
527 W1SAVE(Z,S)=W1SAVE(Z
,DL)
528 W1DSAV(Z,S)=W1DSAV(Z
,DL)
529 DB(Z,S)=DB(Z,DL)
530 DE(Z,S)=DE(Z,DL)
531 W(Z,S)=W(Z,DL)
532 WSKIP(Z,S)=WSKIP(Z,D
L)
533 WSAVE(Z,S)=WSAVE(Z,D
L)
534 D0(Z,S)=D0(Z,DL)
535 DW(Z,S)=DW(Z,DL)
536 M1(Z,S)=M1(Z,DL)
537 M1DSAV(Z,S)=M1DSAV(Z
,DL)
538 M1SKIP(Z,S)=M1SKIP(Z
,DL)
539 M1SAVE(Z,S)=M1SAVE(Z
,DL)
540 DM(Z,S)=DM(Z,DL)
541 NEXT Z
542 RETURN
```

LOAD RECOVERY

```
543 FOR S=1 TO NOS
544 PI=0
545 I2=0
546 I3=0
547 I4=0
548 PI=PI+1
549 IF PI>12 GOTO 554
550 IF PSAVE(PI,S)=0 THE
N P(PI,S)=P(PI,S)
551 IF ABS(PSAVE(PI,S))>
0 THEN P(PI,S)=PSAVE(PI,
S)
552 X(PI,S)=X(PI,S)/12
553 GOTO 548
554 I2=I2+1
555 IF I2>5 GOTO 561
556 IF W1SAVE(I2,S)=0 TH
EN W1(I2,S)=W1DSAV(I2,S)
557 IF ABS(W1SAVE(I2,S))
>0 THEN W1(I2,S)=W1SAVE(
I2,S)
558 DB(I2,S)=DB(I2,S)/12
559 DE(I2,S)=DE(I2,S)/12
560 GOTO 554
561 I3=I3+1
562 IF I3>5 GOTO 568
563 IF WSAVE(I3,S)=0 THE
N W(I3,S)=W(I3,S)
```

FIGURE 9 (Continued)

```
564 IF ABS(WSAVE(I3,S))>
0 THEN W(I3,S)=WSAVE(I3,
S)
565 D0(I3,S)=D0(I3,S)/12
566 DW(I3,S)=DW(I3,S)/12
567 GOTO 561
568 I4=I4+1
569 IF I4>5 GOTO 574
570 IF M1SAVE(I4,S)=0 TH
EN M1(I4,S)=M1DSAV(I4,S)
571 IF ABS(M1SAVE(I4,S))
>0 THEN M1(I4,S)=M1SAVE(
I4,S)
572 DM(I4,S)=DM(I4,S)/12
573 GOTO 568
574 NEXT S
```

SKIP OPTIONS

```
575 PRINT"INPUT DESIRED
SKIP:"
576 PRINT"1=ODD SKIP 2=E
VEN"
577 PRINT"SKIP 3=CHOICE
4=END"
578 INPUT CASE
579 CLS
580 IF CASE=1 GOTO 584
581 IF CASE=2 GOTO 593
582 IF CASE=3 GOTO 602
583 IF CASE=4 GOTO 621
584 FOR SA=1 TO NOS
585 S=(SA*2)-1
586 GOSUB 623
587 IF S= NOS-1 GOTO 589
588 NEXT SA
589 LPRINT"
"
590 LPRINT"LIVE LOAD ON
EVEN SPANS"
591 LPRINT"
"
592 GOTO 236
593 FOR SB=1 TO NOS
594 S=SB*2
595 GOSUB 623
596 IF S=NOS GOTO 598
597 NEXT SB
598 LPRINT"
"
599 LPRINT" LIVE LOAD ON
 ODD SPANS"
600 LPRINT"
"
601 GOTO 236
602 PRINT"SPAN LIVE LOAD
"
603 PRINT"REMOVAL OPTION
"
604 CHECK=1
605 PRINT"1=REMOVE 0=FIN
ISHED"
606 INPUT DROP
607 CLS
```

FIGURE 9 (Continued)

```
608 IF DROP=0 GOTO 236
609 IF CHECK=1 GOTO 610
ELSE GOTO 613
610 LPRINT"▬▬▬
```

CHAPTER 2

CONCRETE BEAM DESIGN

Description of Program

The concrete beam design program is written to analyze capacities and design reinforcement for flexure, shear, and torsion in rectangular beams as well as Tee-beams. The user has the option of choosing these three categories separately at the entrance point of the program (i.e., if only torsional analysis is necessary, flexure and shear may be omitted).

The program is written in compliance with Building Code Requirements for Reinforced Concrete (ACI 318-83),published by the American Concrete Institute. Many of the examples are taken directly from Notes on ACI 318-83: Building Code Requirements for Reinforced Concrete with Design Application, published by the Portland Cement Association.

The flexural section of the program includes analysis for tensile reinforcing alone or tensile and compression reinforcing for rectangular members as well as Tee-beams. The shear design portion of the program is written for members without axial loading, having only flexure and shear applied, which is the normal situation assumed for concrete beams. The torsional analysis portion of the program will evaluate rectangular sections as well as those having

multiple elements, such as flanges and ledges, that will increase the torsional moment capacity of the member.

All sections of the program are written to provide the user the opportunity to revise the reinforcing until a satisfactory selection is made. At that point, the program provides a documented record of the same.

In torsional reinforcement, the required spacing based on ACI Code limitations may be significantly smaller than that required to resist torsion at the section. The torsional analysis section of the program identifies this and will indicate to the user what portion of the reinforcing is not being used for torsion so that this portion may be applied to the shear capacity needs of the member.

All sections of the program are written to give indications when ACI Code limitations have been exceeded. All portions of the program may be used for either design of new reinforcing or analysis of existing reinforcing.

Nomenclature

AFORMAXCONM - Depth of compressive stress block using ASTENMAX.

AL - Required area of longitudinal reinforcing evenly spaced around the section containing AT.

AS - Area of tensile reinforcing.

ASF - Area of steel required to replace the compression flange.

ASTENMAX - Maximum allowable area of tensile reinforcement.

ASOFTOT - Total area of steel required to resist the ultimate moment if the compression block extends below the bottom of the flange.

AT - Area of one leg of a closed torsional reinforcing stirrup.

AV - Total area of shear reinforcing at a section.

B - Effective width of the flexural compression block.

BETA - Concrete strength factor.

BLOCKD - Theoretical depth of the flexural compressive block.

BW - Thickness of member web.

CAS - Area of compressive reinforcing.

CASMU - Ultimate moment that must be resisted by the compressive reinforcing.

CFAS - Area of steel required to use the full compression flange for flexural moment resistance.

D - Distance from extreme compression fiber to center of gravity of the tensile reinforcing.

DC - Distance from extreme compression fiber to center of gravity of compression reinforcing.

DIACAS - Diameter of compression steel reinforcing bars used.

FC - Specified 28-day compressive strength of the concrete.

FETECE - Factored ultimate torsional capacity of concrete alone.

FETEN - Factored ultimate torsional capacity of the section.

FETS - Factored ultimate torsional capacity of the torsional reinforcing.

FETUOK - Limit of torsional moment that may be neglected.

FEVECE - Factored ultimate shear capacity of concrete.

FEVEN - Factored ultimate shear capacity of a section.

FEVES - Factored ultimate shear capacity of shear reinforcing.

FY - Yield stress of the reinforcing in units of psi for flexure and ksi for shear.

MAXFACCAP - Factored ultimate shear capacity of a section using maximum reinforcing.

MAXFACCONM - Maximum factored ultimate moment capacity using ASTENMAX.

MAXVUSTL - Maximum ultimate shear that may be resisted by the shear reinforcing.

MR - Factored ultimate flexural moment capacity.

MU - Ultimate flexural moment due to factored loads.

MUF - Factored ultimate moment capacity of the member using ASF in the flange.

MUFACCFAS - Factored ultimate moment capacity of the member using CFAS.

MUFACTOT - Factored ultimate flexural moment capacity of a flanged member with compression reinforcing.

MUTEN - Ultimate moment to be resisted by the tensile reinforcement in a flanged member with compression reinforcing.

MUTOT - Ultimate factored moment capacity of tensile and compressive reinforcement combined.

MUW - Ultimate moment to be resisted by the member web.

SREQ - Required spacing of shear reinforcing stirrups.

SUM - Summation of X^2*Y of each element.

TSUDES - Torsional moment capacity required of the torsional reinforcing.

TF - Thickness of compression flange.

TU - Ultimate torsional moment.

TULT - Ultimate tensile capacity of AS selected.

VSREQ - Shear capacity required of the shear reinforcing.

VU - Ultimate shear.

W - Limit of tensile reinforcing acting alone (.75 balanced).

X - Shorter overall dimension of a torsional section element.

X1 - Shorter overall dimension of a closed stirrup.

Y - Longer overall dimension of a torsional section element.

Y1 - Longer overall dimension of a closed stirrup.

User Prompt Definitions

DESIGN OPTIONS: 1=FLEXURE 2=SHEAR 3=SHEAR & TORSION

Choose the desired design option.

IDENTIFICATION

Request to input the identification of the member being checked.

IS THERE A COMPRESSION FLANGE 1=YES 0=NO

Request to determine if there is a compression flange on this flexural member.

WHAT IS THE FLANGE THICKNESS (IN.)

Input the thickness of the flange in inches.

WHAT IS THE THICKNESS OF THE WEB (IN.) [bw]

Input the thickness of the web of the flexural member in inches (typically designated "bw").

INPUT EFFECTIVE COMPRESSION BLOCK WIDTH (IN.)

Request for the effective compression block width which would be the width of the web on a rectangular section or the ACI Code effective width of the flange on a Tee-beam in inches.

INPUT EFFECTIVE DEPTH OF TENSION STEEL, [d], IN (IN.)

Input the effective depth from the extreme compression fiber to the center of gravity of the tension steel (commonly designated as "d") in inches.

INPUT f'c (PSI)

Input the specified 28-day compressive strength of the concrete in psi.

INPUT CONCRETE STRENGTH FACTOR [BETA]

Input the concrete strength factor (.85 for 4,000 psi or less, .8 for 5,000 psi, .75 for 6,000 psi and .65 for 8,000 psi or greater.)

INPUT Mu (K-FT.)

Input the ultimate moment to be resisted by the section in kip feet.

INPUT YIELD STRESS OF REINFORCING (PSI)

Input the stress at which the reinforcing steel yields (commonly designated "Fy").

As/Ac=__ As=__ INPUT REVISED As

The area ratio of steel to concrete is __, and the area of steel required to resist the input ultimate moment is __. Input the area of steel that can be obtained from standard reinforcing bars which is closest to the area of steel required as indicated by As. Ac is the area of concrete attained using the effective depth of the reinforcing.

INPUT REVISED d

Input any revision in the distance from the extreme fiber in compression to the center of gravity of the tensile reinforcing.

As/Ac=__oMn=__K-FT__ REVISE? 1=YES 0=NO

The revised ratio of steel to concrete is __ and results in a factored moment capacity of __ kip-ft. The user has the option to revise the area of steel again.

INPUT REINFORCING CHOSEN

Request to input a description of the steel sized. An example would be "5-#9".

DO YOU WANT TO CONT. USING COMPRESSION STEEL? 1=YES 0=NO

The moment applied to this section cannot be resisted with tensile reinforcing only. The user may continue the analysis using compression steel or stop.

INPUT d'(IN.),[Dist from extreme comp. fiber to C.G. of A's]

Request to input the distance from the extreme compression fiber to the center of gravity of the compressive reinforcing (commonly designated "d'").

YOU DON'T NEED A's USE A BETTER As INPUT 1

Indicates that the moment at the section can be resisted using tensile reinforcing only and that the adjustment made at the point of revision caused the area of steel to exceed the code limit. The user is to input 1 and press RETURN, which will return him to the revision phase of the program for selection of a different arrangement of steel to avoid use of compression steel.

As REQ'D=__ A's REQ'D=__ INPUT REVISED As,A's

Analysis shows that the area of tensile reinforcing required equals __, and the area of compressive reinforcing equals __. The user is prompted to input the area of tensile and compressive reinforcing available through standard reinforcing bars that most closely approximates the area determined by analysis. These should be input first as tensile reinforcing

followed by compressive reinforcing with the area of steel in each case separated by ",".

INPUT REVISED d,d'

The user is prompted to input any change in the distance from the extreme compression fiber to the tensile reinforcing or from the extreme compression fiber to the compression reinforcing. These revised distances should be separated by a ",".

INPUT Fy OF SHEAR REINFORCEMENT (KSI)

Input the yield stress of the shear reinforcing in ksi.

INPUT Vu (KIPS)

Input the ultimate shear at the section in units of kips.

DO YOU WANT TO CHECK KNOWN REINF? 1=YES 0=NO

The user has the option to size the required reinforcing or to check the capacity of an existing member. "1" may be input to check known reinforcing; "0" may be input to design.

INPUT Av (IN.^ 2)

Input the total area of shear reinforcing effective at the section. For example, a #3 bar would be input as ".22".

INPUT SPACING (IN.)

Request to input the spacing of the known stirrups in inches.

INPUT NUMBER OF RECTANGULAR SECTION ELEMENTS

Input the number of rectangles in the section being considered for torsional moment capacity so that the program may calculate the torsional capacity of the concrete.

INPUT ELEMENT __ X,Y DIMENSIONS [SHORTER], [LONGER]

Request to input the dimensions of the element of the section being considered for torsion with "X" being the shorter overall dimension of the element and "Y" being the longer overall dimension of the element. These dimensions should be separated by a ",".

INPUT Tu (K-FT.)

Input the ultimate torsional moment applied to the section.

INPUT AREA OF ONE LEG OF CLOSED STIRRUP [At] (IN.∧ 2)

Input the cross-sectional area of one leg of closed stirrup to be used for torsional reinforcement (commonly designated "At").

INPUT X1 [SHORTER C-TO-C DIMENSION OF STIRRUP] (IN.)

Input the shorter center-to-center dimension of the closed stirrup in inches.

INPUT Y1 [LONGER C-TO-C DIMENSION OF STIRRUP] (IN.)

Input the longer center-to-center dimension of the closed stirrup in inches.

S REQ'D=__ IN. S MAX=__ IN. REVISE 1=YES 0=NO

The calculated required spacing is __ inches. The maximum spacing allowed by the code based on section properties is __ inches. The user may revise the section or use reinforcing specified.

Examples

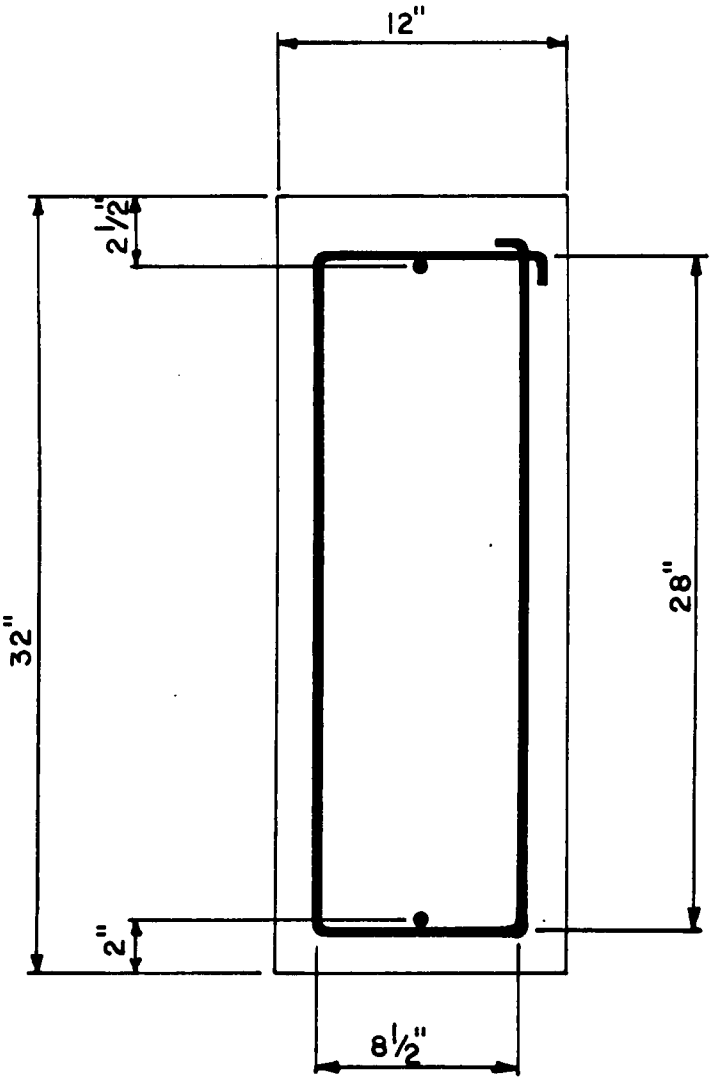
Example 2-1

Using the beam cross section and loading illustrated in Figure 10, the use of the program will be demonstrated.

The program begins with the screen prompt "DESIGN OPTIONS: 1=FLEXURE, 2=SHEAR, 3=SHEAR & TORSION?" This is a request for the user to input the option desired. Looking at moment first, input 1 and press RETURN. The screen then displays "IDENTIFICATION?" The user should input the appropriate title to identify the analysis. Referring to Figure 10, input SPANDREL RB-7 and press RETURN.

The printer then displays this identification and the screen displays "IS THERE A COMPRESSION FLANGE 1=YES 0=NO?". As this is not a Tee-beam, input 0 and press RETURN. The screen then displays "INPUT EFFECTIVE COMPRESSION BLOCK WIDTH (IN.)?". Input 12 and press RETURN.

The screen then displays "INPUT EFFECTIVE DEPTH OF TENSION STEEL [d], IN (IN.)?". Input 30 and press RETURN. The screen then displays "INPUT f'c (PSI)?" Input 4000 and press RETURN.



SPANDREL RB-7

$f'_c = 4000$ PSI
$Mu = 9000$ K'
$V_u = 50^K$
$T_u = 20^{K'}$
$F_y = 60$KSI

FIGURE 10

RECTANGULAR BEAM WITH APPLIED ULTIMATE FLEXURAL MOMENT, SHEAR AND TORSIONAL MOMENT

The screen next displays "INPUT CONCRETE STRENGTH FACTOR [BETA]?" For a compressive strength of 4000 psi, beta is .85. Input .85 and press RETURN. (This input was so written primarily to let the user know that this factor is properly considered.)

The screen then displays "INPUT Mu (K-FT.)?" Input 900 and press RETURN. The screen then displays "INPUT YIELD STRESS OF REINFORCING (PSI)?" Input 60000 and press RETURN.

The printer then displays a message indicating the area of tensile reinforcing needed to resist this moment exceeds 75% of the reinforcing that provides balanced conditions. The screen next displays "DO YOU WANT TO CONTINUE USING COMPRESSIVE STEEL 1=YES 0=NO?" Input 1 and press RETURN.

The screen then displays "INPUT d'(IN.),[Dist. from extreme comp. fiber to C.G. of A's]?" Input 2.5 and press RETURN.

The printer then displays the magnitude of the moment that must be resisted by the compression reinforcing which in this case is 56.946 kip-feet. The screen displays "As REQ'D=8.15701 A's REQ'D=.46017 INPUT REVISED As, A's?". This is the point at which the user will attempt to choose reinforcing that, as nearly as possible, matches the requirements.

Choose 8-#9 bars for As and 2-#5 bars for A's. Input 8,.62 and press RETURN. Note that the data should be separated by a ",".

The screen next displays "INPUT REVISED d,d'?" If the diameter of the reinforcing bars chosen significantly affects the effective depth of the reinforcing, revised depths may be input here. Assuming this is not the case, input 30,2.5 and press RETURN.

The screen then displays "oMn=892.812 K-FT. REVISE? 1=YES 0=NO?". The user may revise the reinforcing at this point if the reinforcing chosen or the revised effective depths have resulted in an unsatisfactory factored ultimate moment capacity. As this capacity is only .8% low, assume it is acceptable. Input 0 and press RETURN.

The screen then displays "INPUT REINFORCING USED As, A's?" Input 8-#9, 2-#5 and press RETURN. The screen then displays "INPUT THE DIAMETER OF THE COMPRESSION BAR USED (IN.)?" Input .625 and press RETURN. The printer then displays all input, capacities and reinforcing used. In addition, the printer indicates the spacing of #3 ties needed in the region of the compressive reinforcing. This completes the flexural design.

The screen then displays "DESIGN OPTIONS: 1=FLEXURE 2=SHEAR 3=SHEAR & TORSION?" Considering torsion next, input 3 and press RETURN.

The screen then displays "IDENTIFICATION?". As the first segment of analysis already established the identification of the beam being analyzed, input "TORSIONAL ANALYSIS" and press RETURN.

The screen then displays "INPUT f'c (PSI)?". Although this information was input in the flexural analysis section, the program was written to allow the user to analyze aspects of the beam singularly. Therefore, some of the input is redundant for consecutive analysis of all beam actions. Input 4000 and press RETURN.

The screen then displays "INPUT NUMBER OF RECTANGULAR SECTION ELEMENTS?". As this is a rectangular beam with no appendages, input 1 and press RETURN. The screen then displays "INPUT ELEMENT 1 X,Y DIMENSIONS [SHORTER],[LONGER]?". Referring to Figure 10, input 12, 32 and press RETURN.

The screen then displays "INPUT WEB WIDTH (IN.)?". Input 12 and press RETURN. The screen then displays "INPUT EFFECTIVE DEPTH OF TENSILE REINFORCING [d](IN.)?". Input 30 and press RETURN.

The screen then displays "INPUT Vu (KIPS)?". Input 50 and press RETURN. The screen then displays "INPUT Tu (K-FT.)?". Input 20 and press RETURN.

The printer then displays the heading and indicates the magnitude of the factored torsional capacity of the concrete acting alone, which in this example is 11.29 kip-feet. The printer further displays the magnitude of the torsional moment that must be resisted by torsional reinforcing, which in this case is 10.24 kip-feet.

The screen next displays "INPUT AREA OF ONE LEG OF CLOSED STIRRUP [At](IN.∧ 2)?". Trying #3 stirrups first, input .11 and press RETURN. The screen then displays "INPUT X1 [SHORTER C-TO-C DIMENSION OF STIRRUP](IN.)?". Input 8.5 and press RETURN. The screen displays "INPUT Y1 [LONGER C-TO-C DIMENSION OF STIRRUP](IN.)?". Input 28 and press return.

The screen then displays "S REQ'D=19.1728 IN. S MAX=9.125 IN. REVISE 1=YES 0=NO?". These are the required and maximum stirrup spacings respectively. It can be seen that #3 stirrups at 9.125 inches center-to-center is more reinforcing than is required to develop the factored ultimate torsional moment capacity needed; however, 9.125 is the maximum spacing based on the beam configuration and #3 ties are the smallest commonly used stirrup.

It is known from this information that some of the reinforcing provided for torsion may be used to resist shear. Input 0 and press RETURN.

The screen then displays "INPUT REINFORCING DESCRIPTION?". Input #3 CLOSED STIRRUPS and press RETURN. The printer then displays the input, the reinforcing used and the resulting capacity.

The printer next displays a very descriptive dialogue explaining that of the .11 square inches of steel placed at 9.125 inches center-to-center for torsional reinforcing, only .0523 $in.^2$ is needed to develop the required factored

ultimate torsional capacity. The print-out further explains that this leaves .0576 in.^{2} in each vertical leg that may be applied to shear reinforcing requirements.

The screen then displays "DESIGN OPTIONS: 1=FLEXURE 2=SHEAR 3=SHEAR & TORSION?". Input 2 for shear analysis and press RETURN. The screen displays "IDENTIFICATION?". Input SHEAR ANALYSIS and press RETURN. The screen displays "INPUT THICKNESS OF WEB [bw](IN.)?". Input 12 and press RETURN.

The screen next displays "INPUT EFFECT DEPTH [d](IN.)?". Input 30 and press RETURN. The screen displays "INPUT f'c (PSI)?". Input 4000 and press RETURN. The screen then displays "INPUT Fy OF SHEAR REINFORCEMENT (KSI)?". Input 60 and press RETURN. The screen then displays "INPUT Vu (KIPS)?". Input 50 and press RETURN.

The screen next displays "DO YOU WANT TO CHECK KNOWN REINF.? 1=YES 0=NO?". As we are in a design phase, input 0 and press RETURN. The screen displays "STIRRUPS ARE REQ'D" and the printer displays the factored ultimate shear capacity of the concrete acting alone, which in this example is 38.7 kips. The print-out further indicates the design shear strength required from the shear reinforcing, which in this example is 13.28 kips.

The screen then displays "INPUT Av (IN.^ 2)?". First, try using the unused portion of torsional reinforcing. Av is the total area of vertical steel acting to resist shear. The unused portion of torsional reinforcing was .0576 in.^{2}

in each leg. Input twice this value or .1152 and press RETURN.

The screen then displays "SPA.(IN) REQ'D WITH Av=.1152 IS 15.6066 REVISE? 1=YES 0=NO?". This indicates that the unused portion of torsional reinforcing is adequate to reinforce the beam to resist the applied ultimate shear. Input 0 and press RETURN. The screen then displays "INPUT FINAL S (IN.)?". Input 9.125 and press RETURN. The screen displays "INPUT REINFORCING DESCRIPTION?". Input UNUSED At and press RETURN.

The printer then displays the input, reinforcing used and the section capacity. The printer also indicates the maximum allowable shear stirrup spacing, which in this example is 11.52 in. This is greater than the 9.125 in. used, so this is acceptable. The print-out for these design options is as shown in Figure 11.

Numerous other design situations can be analyzed using the "CONCRETE" program. Figure 12 through Figure 26 illustrate examples of various beam cross-sections and loads, and the print-out resulting from use of the program. With reference to Example 2-1, the user should be able to discern the proper input for each example.

Flow Chart

Figure 27 describes the chronological operation of the "CONCRETE" program.

```
SPANDREL RB-7

**********************
As REQ'D > .75 BALANCED
As/Ac= 2.33148E-02
.75*BAL.= 2.13801E-02
**********************

ULTIMATE MOMENT TO BE
RESISTED BY COMPRESSION
STEEL= 56.946 K-FT.

b= 12 IN.
d= 30 IN.
d'= 2.5 IN.
Mu= 900 K-FT.
fy= 60000 PSI
f'c= 4000 PSI
As= 8 IN^2 [8-#9]
A's= .62 IN^2 [2-#5]
oMn= 892.812 K-FT.

MINIMUM STIRRUPS IN
COMPRESSION STEEL REGION
= #3 TIES @  10 IN.  C/C

TORSIONAL ANALYSIS

FACTORED TORSIONAL
CAPACITY OF CONCRETE
ALONE= 11.2951 K-FT.

TORSIONAL MOMENT TO BE
RESISTED BY REINFORCING
= 10.2411 K-FT.

f'c= 4000 PSI
fy= 60000 PSI
Vu= 50 KIPS
Tu= 20 K-FT.
At= .11 IN.^2
[#3 CLOSED STIRRUPS]

REQUIRED SPACING
= 19.1728 IN.C/C

MAXIMUM SPACING ALLOWED
= 9.125 IN.C/C

THE MAXIMUM ALLOWABLE
SPACING [ 9.125 ] IS
LESS THAN THE REQ'D
SPACING [ 19.1728 ]
SO NOT ALL OF THE REINF.
IS BEING USED.

WITH STIRRUPS SPACED AT
 9.125 IN.C/C THE REQ'D
AREA OF TORSIONAL REINF.
[At] IS 5.23529E-02
IN.^2
USING 5.23529E-02 IN.^2
oTn= 20 K-FT.

THE UNUSED PORTION OF
REINFORCING IS
 5.76471E-02
IN.^2 IN ONE LEG
AT 9.125 IN.C/C

LONGITUDINAL BARS
DISTRIBUTED AROUND
THE PERIMETER [Al]
= 1.12706 IN.^2

SHEAR ANALYSIS

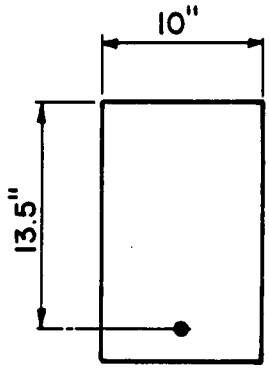
oVc= 38.7063 KIPS

DESIGN SHEAR STRENGTH
REQUIRED FROM REINF.
= 13.2867 KIPS

bw= 12 IN.
d= 30 IN.
f'c= 4000 PSI
Vu= 50 KIPS
Av= .1152 IN.^2
[UNUSED At]
SPACING= 9.125 IN.
oVn= 58.022 KIPS
MAXIMUM SPACING USING
UNUSED At
= 11.52 IN.
CAPACITY OF SECTION
USING MAXIMUM REINF.
= 193.531 KIPS
```

FIGURE 11

PROGRAM PRINT-OUT RESULTING FROM ANALYSIS OF EXAMPLE 2-1



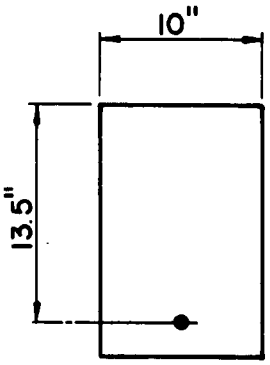
f'c = 4,000 PSI
Mu = 138.0 K-FT
Fy = 60,000 PSI

EXAMPLE 2-2

```
Mu= 138 K-FT.
fy= 60000 PSI
b= 10 IN.
d= 13.5 IN.
f'c= 4000 PSI
øMn= 138.199 K-FT
As/Ac= 2.05926E-02
As= 2.78 [EXACT]
DEPTH OF STRESS
BLOCK,[a],= 4.90588 IN.
```

FIGURE 12

RECTANGULAR BEAM REQUIRING TENSILE REINFORCING
AND EXAMPLE OF RESULTING
PRINT-OUT TAPE



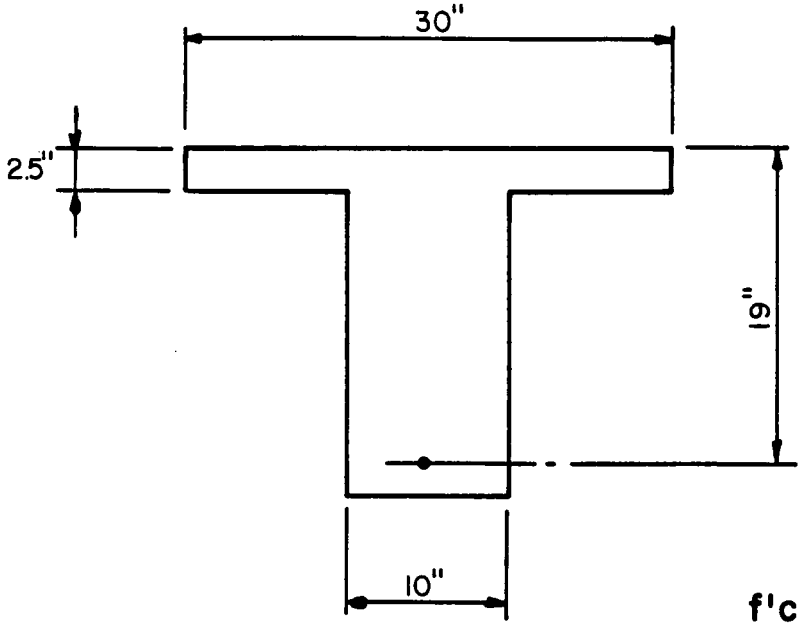
f'c = 4,000 PSI
Mu = 10.0 K-FT
Fy = 60,000 PSI

EXAMPLE 2-3

```
Mu= 10 K-FT.
fy= 60000 PSI
b= 10 IN.
d= 13.5 IN.
f'c= 4000 PSI
øMn= 9.97509 K-FT
As/Ac= 1.22963E-03
As= .166 [EXACT]
NOTE: As USED < As MIN
DEPTH OF STRESS
BLOCK,[a],= .292941 IN.
```

FIGURE 13

RECTANGULAR BEAM REQUIRING LESS THAN ACI CODE MINIMUM REINFORCING AND EXAMPLE OF RESULTING PRINT-OUT TAPE



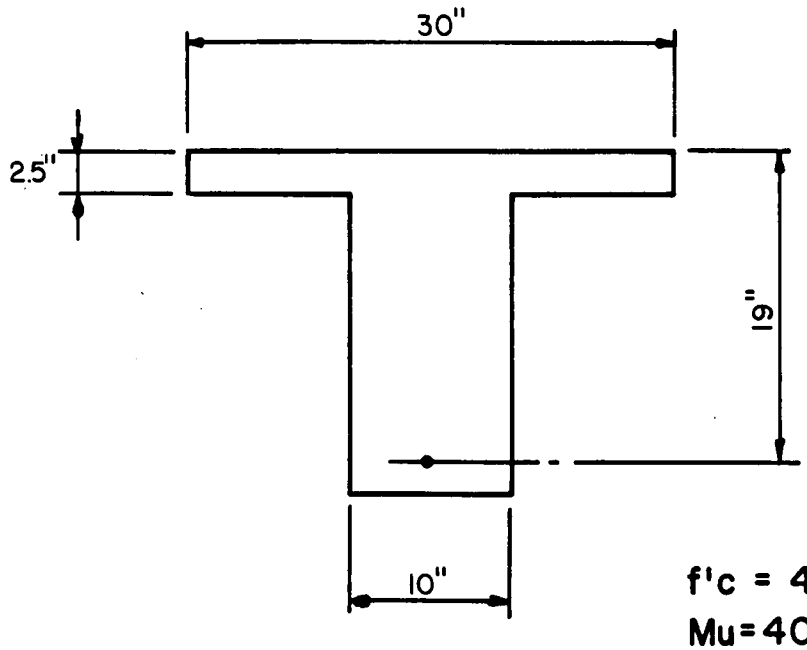
f'c = 4,000 PSI
Mu = 250.0 K-FT.
Fy = 60,000 PSI

EXAMPLE 2-4

```
Mu= 250 K-FT.
fy= 60000 PSI
b= 30 IN.
d= 19 IN.
Tf= 2.5 IN.
f'c= 4000 PSI
øMn= 244.588 K-FT
As/Ac= 5.26316E-03
As= 3 [3-#9]
DEPTH OF STRESS
BLOCK,[a],= 1.76471 IN.
```

FIGURE 14

TEE-BEAM WITH FLEXURAL COMPRESSION BLOCK WITHIN THE FLANGE DEPTH AND EXAMPLE OF RESULTING PRINT-OUT TAPE



f'c = 4,000 PSI
Mu=400.0 K-FT
Fy = 60,000 PSI

EXAMPLE 2-5

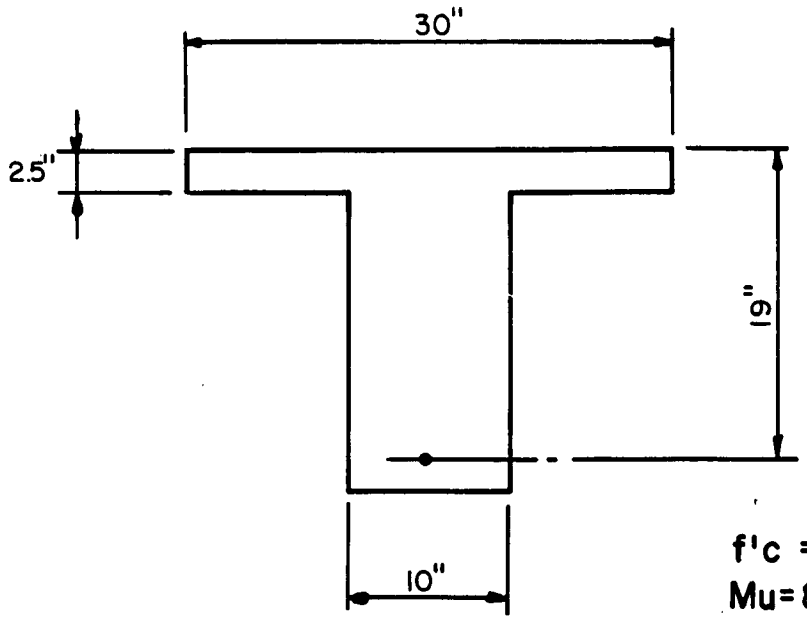
NOTE:THE COMPRESSION
BLOCK EXTENDS BELOW
THE BOTTOM OF THE FLANGE

****
ULTIMATE MOMENT TO BE
RESISTED BY THE WEB
= 173.688 K-FT.
****

bw= 10 IN.
Tf= 2.5 IN.
b= 30 IN.
d= 19 IN.
Mu= 400 K-FT.
f'c= 4000 PSI
Fy= 60000 PSI
As= 5.2 IN.^2 [
4-#9 2-#7]
øMn= 406.423 K-FT.
DEPTH OF THE STRESS
BLOCK= 4.17647 IN.

FIGURE 15

TEE-BEAM WITH FLEXURAL COMPRESSION BLOCK
BELOW BOTTOM OF FLANGE AND EXAMPLE OF
RESULTING PRINT-OUT TAPE



f'c = 4,000 PSI
Mu=800.0 K-FT
Fy = 60,000 PSI

EXAMPLE 2-6

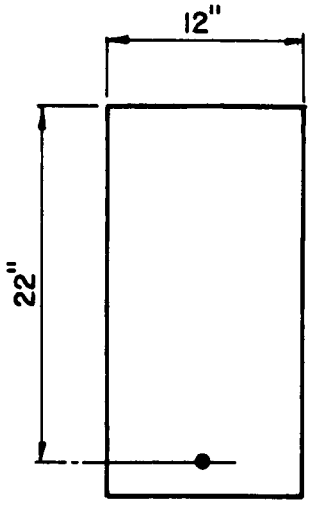
```
**************************
As REQ'D EXCEEDS .75*BAL
**************************


**************************
ULTIMATE MOMENT TO BE
RESISTED BY TENSIL
REINFORCING
= 548.542 K-FT.
**************************


b= 30 IN.
Tf= 2.5 IN.
bw= 10 IN.
d= 19 IN.
d'= 1.25 IN.
Mu= 800 K-FT.
Fy= 60000 PSI
As= 7 IN.^2 [7-#9]
A's= 3 IN.^2 [3-#9]
øMn= 799.897 K-FT.
```

FIGURE 16

TEE-BEAM REQUIRING COMPRESSION REINFORCING
AND EXAMPLE OF RESULTING
PRINT-OUT TAPE



f'c = 4,000 PSI
Vu = 10 K

EXAMPLE 2-7

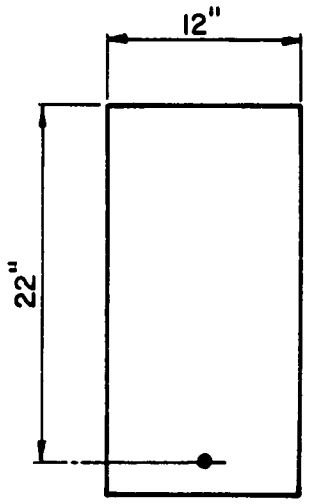
bw= 12 IN.
d= 22 IN.
f'c= 4000 PSI
Vu= 10 KIPS

FACTORED SHEAR STRENGTH
OF CONCRETE ALONE [oVc]
= 28.3846 KIPS WHICH IS
> TWICE THE ULTIMATE
SHEAR. SO

NO STIRRUPS REQ'D.

FIGURE 17

RECTANGULAR BEAM REQUIRING NO REINFORCING TO RESIST APPLIED ULTIMATE SHEAR AND EXAMPLE OF RESULTING PRINT-OUT TAPE



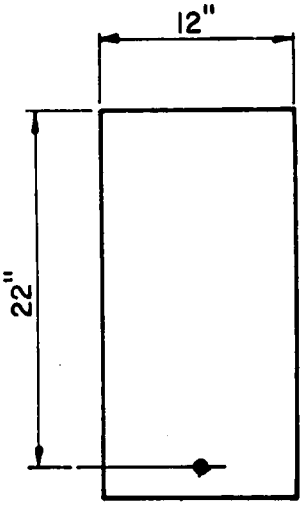
f'c = 4,000 PSI
Vu = 50 K
Fy = 60 KSI
Reinforcing
#3 @ 7" c/c

```
EXAMPLE 2-8
-----------------------------

bw= 12 IN.
d= 22 IN.
f'c= 4000 PSI
Vu= 50 KIPS
Av= .22 IN.^2
[#3 CLOSED STIRRUPS]
SPACING= 7 IN.
▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒
øVn= 63.6475 KIPS
▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒
MAXIMUM SPACING USING
#3 CLOSED STIRRUPS
= 11 IN.
CAPACITY OF SECTION
USING MAXIMUM REINF.
= 141.923 KIPS
-----------------------------
```

FIGURE 18

ANALYSIS OF RECTANGULAR BEAM WITH KNOWN REINFORCING AND EXAMPLE OF RESULTING PRINT-OUT TAPE



f'c = 4,000 PSI
Vu = 100 K
Fy = 60 KSI

EXAMPLE 2-9

øVc= 28.3846 KIPS

DESIGN SHEAR STRENGTH
REQUIRED FROM REINF.
= 84.2534 KIPS

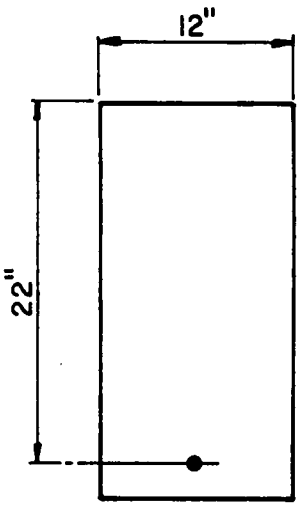
bw= 12 IN.
d= 22 IN.
f'c= 4000 PSI
Vu= 100 KIPS
Av= .22 IN.^2
[#3 OPEN STIRRUPS]
SPACING= 3.5 IN.

øVn= 98.9103 KIPS

MAXIMUM SPACING USING
#3 OPEN STIRRUPS
= 5.5 IN.
CAPACITY OF SECTION
USING MAXIMUM REINF.
= 141.923 KIPS

FIGURE 19

RECTANGULAR BEAM WITH APPLIED ULTIMATE SHEAR GREATER THAN HALF THE CAPACITY OF THE SECTION AND EXAMPLE OF RESULTING PRINT-OUT TAPE



f'c = 4,000 PSI
Vu = 60 K
Fy = 60 KSI

EXAMPLE 2-10

øVc= 28.3846 KIPS

DESIGN SHEAR STRENGTH
REQUIRED FROM REINF.
= 37.1946 KIPS

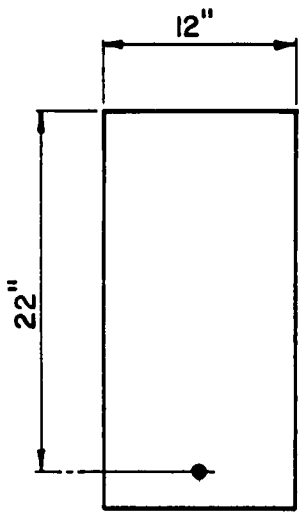
bw= 12 IN.
d= 22 IN.
f'c= 4000 PSI
Vu= 60 KIPS
Av= .22 IN.^2
[#3 OPEN STIRRUPS]
SPACING= 7 IN.

øVn= 63.6475 KIPS

MAXIMUM SPACING USING
#3 OPEN STIRRUPS
= 11 IN.
CAPACITY OF SECTION
USING MAXIMUM REINF.
= 141.923 KIPS

FIGURE 20

RECTANGULAR BEAM WITH APPLIED ULTIMATE SHEAR LESS THAN HALF THE CAPACITY OF THE SECTION AND EXAMPLE OF RESULTING PRINT-OUT TAPE



f'c = 4,000 PSI
Vu = 600 K
Fy = 60 KSI

EXAMPLE 2-11

øVc= 28.3846 KIPS

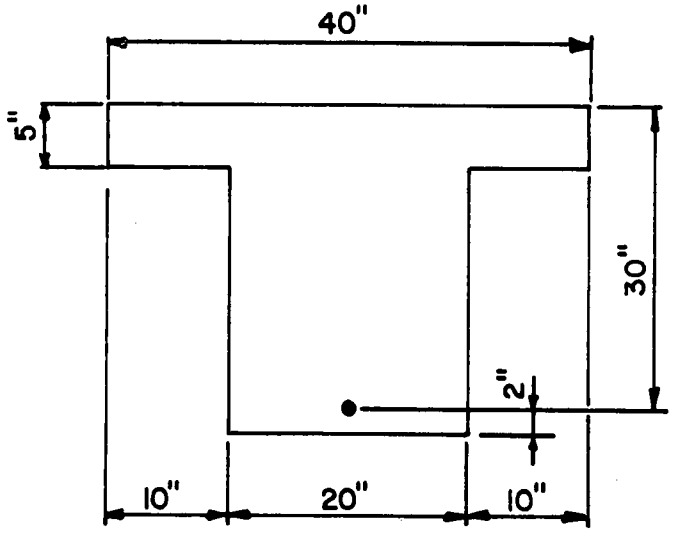
DESIGN SHEAR STRENGTH
REQUIRED FROM REINF.
= 672.489 KIPS

MAXIMUM ALLOWABLE
SHEAR TO BE RESISTED
BY REINFORCING
= 133.575 KIPS

REVISE SECTION

FIGURE 21

RECTANGULAR BEAM WITH INSUFFICIENT CAPACITY
TO RESIST APPLIED ULTIMATE SHEAR AND
EXAMPLE OF RESULTING PRINT-OUT TAPE



$f_c = 4{,}000$ PSI
$F_y = 60{,}000$ PSI
$V_u = 10^K$
$T_u = 5^{K'}$

EXAMPLE 2-12

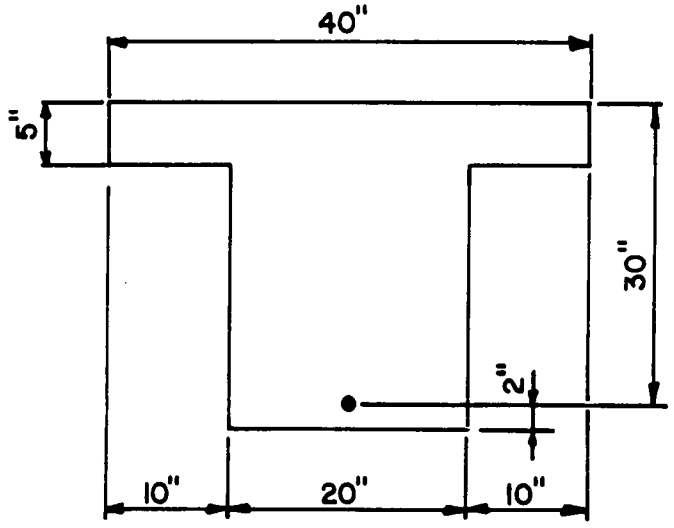
Tu MAX. THAT MAY BE
NEGLECTED= 29.7913 K-FT.

ACTUAL Tu= 5 K-FT.

NEGLECT TORSION

FIGURE 22

TEE-BEAM WITH APPLIED ULTIMATE TORSIONAL MOMENT THAT MAY BE NEGLECTED AND EXAMPLE OF RESULTING PRINT-OUT TAPE



$f'_c = 4{,}000$ PSI
$F_y = 60{,}000$ PSI
$V_u = 10^K$
$T_u = 40^{K'}$

EXAMPLE 2-13

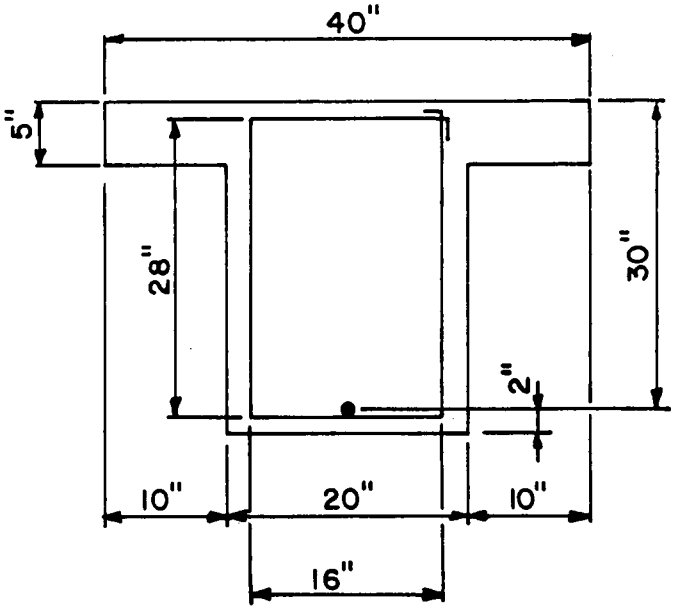
FACTORED TORSIONAL
CAPACITY OF CONCRETE
ALONE= 46.8731 K-FT.

THIS IS GREATER THAN
Tu= 40 K-FT.

NO REINFORCING REQ'D.

FIGURE 23

TEE-BEAM WITH SUFFICIENT CAPACITY TO RESIST APPLIED ULTIMATE TORSIONAL MOMENT WITHOUT REINFORCING AND EXAMPLE OF RESULTING PRINT-OUT TAPE



$f'_c = 4{,}000$ PSI
$F_y = 60{,}000$ PSI
$V_u = 10^K$
$T_u = 75^{K'}$

EXAMPLE 2-14

FACTORED TORSIONAL
CAPACITY OF CONCRETE
ALONE= 47.4365 K-FT.

TORSIONAL MOMENT TO BE
RESISTED BY REINFORCING
= 32.4277 K-FT.

f'c= 4000 PSI
fy= 60000 PSI
Vu= 10 KIPS
Tu= 75 K-FT.
At= .11 IN.^2
[#3 CLOSED STIRRUPS]

REQUIRED SPACING
= 9.40307 IN.C/C

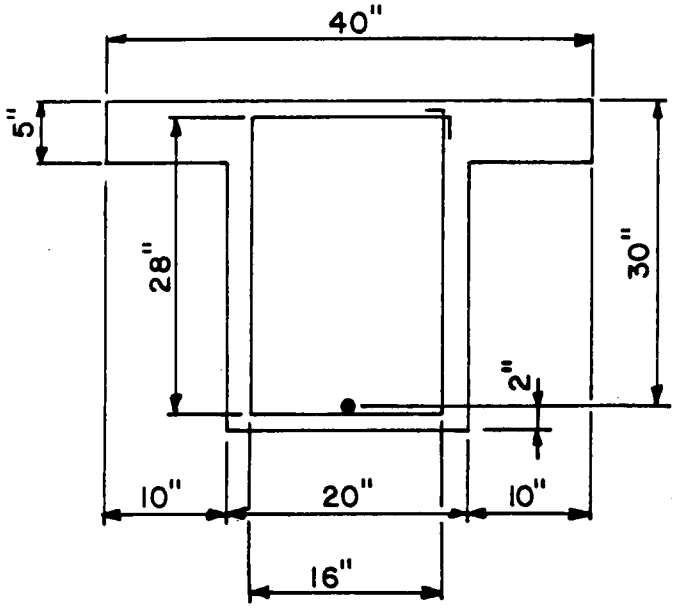
MAXIMUM SPACING ALLOWED
= 11 IN.C/C

øTn= 75 K-FT.

LONGITUDINAL BARS
DISTRIBUTED AROUND
THE PERIMETER [Al]
= 4.39211 IN.^2

FIGURE 24

TEE-BEAM REQUIRING REINFORCING TO RESIST
APPLIED ULTIMATE TORSIONAL MOMENT AND
EXAMPLE OF RESULTING PRINT-OUT TAPE



$f'_c = 4{,}000$ PSI

$F_y = 60{,}000$ PSI

$V_u = 10^K$

$T_u = 48^{K'}$

```
EXAMPLE 2-15
-----------------------------------

FACTORED TORSIONAL
CAPACITY OF CONCRETE
ALONE= 47.1112 K-FT.

TORSIONAL MOMENT TO BE
RESISTED BY REINFORCING
= 1.04565 K-FT.

f'c= 4000 PSI
fy= 60000 PSI
Vu= 10 KIPS
Tu= 48 K-FT.
At= .11 IN.^2
[#3 CLOSED STIRRUPS]

-----------------------------------
REQUIRED SPACING
= 291.607 IN.C/C

MAXIMUM SPACING ALLOWED
= 11 IN.C/C
-----------------------------------
```

```
THE MAXIMUM ALLOWABLE
SPACING [ 11 ] IS
LESS THAN THE REQ'D
SPACING [ 291.607 ]
SO NOT ALL OF THE REINF.
IS BEING USED.

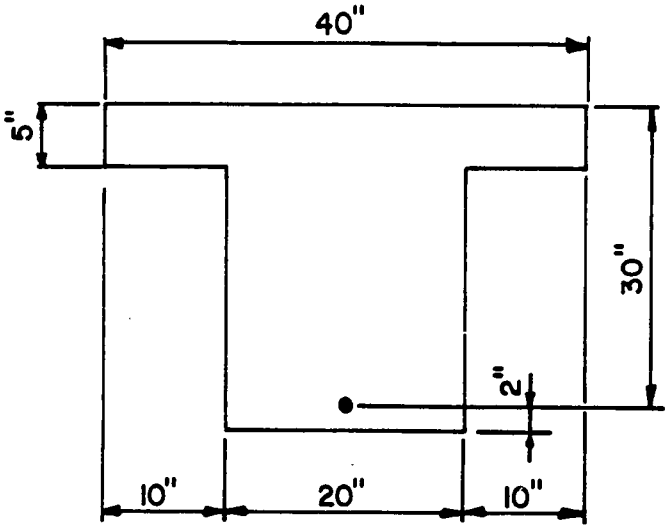
WITH STIRRUPS SPACED AT
 11 IN.C/C THE REQ'D
AREA OF TORSIONAL REINF.
[At] IS 4.14942E-03
IN.^2
USING 4.14942E-03 IN.^2
øTn= 48 K-FT.

THE UNUSED PORTION OF
REINFORCING IS
 .105851
IN.^2 IN ONE LEG
AT 11 IN.C/C

LONGITUDINAL BARS
DISTRIBUTED AROUND
THE PERIMETER [Al]
= 5.16646 IN.^2
```

FIGURE 25

TEE-BEAM WITH MINIMUM TORSIONAL REINFORCING GREATER THAN REQUIRED TO DEVELOP CAPACITY AND EXAMPLE OF RESULTING PRINT-OUT TAPE



$f'_c = 4{,}000$ PSI
$F_y = 60{,}000$ PSI
$V_u = 10^K$
$T_u = 600^{K'}$

EXAMPLE 2-16

FACTORED TORSIONAL
CAPACITY OF CONCRETE
ALONE= 47.6625 K-FT.

TORSIONAL MOMENT TO BE
RESISTED BY REINFORCING
= 649.809 K-FT.

MAXIMUM ALLOWABLE
TORSIONAL MOMENT THAT
CAN BE RESISTED BY
REINFORCING
= 224.294 K-FT.

REVISE SECTION

FIGURE 26

TEE-BEAM WITH INSUFFICIENT CAPACITY TO RESIST APPLIED ULTIMATE TORSIONAL MOMENT AND EXAMPLE OF RESULTING PRINT-OUT TAPE

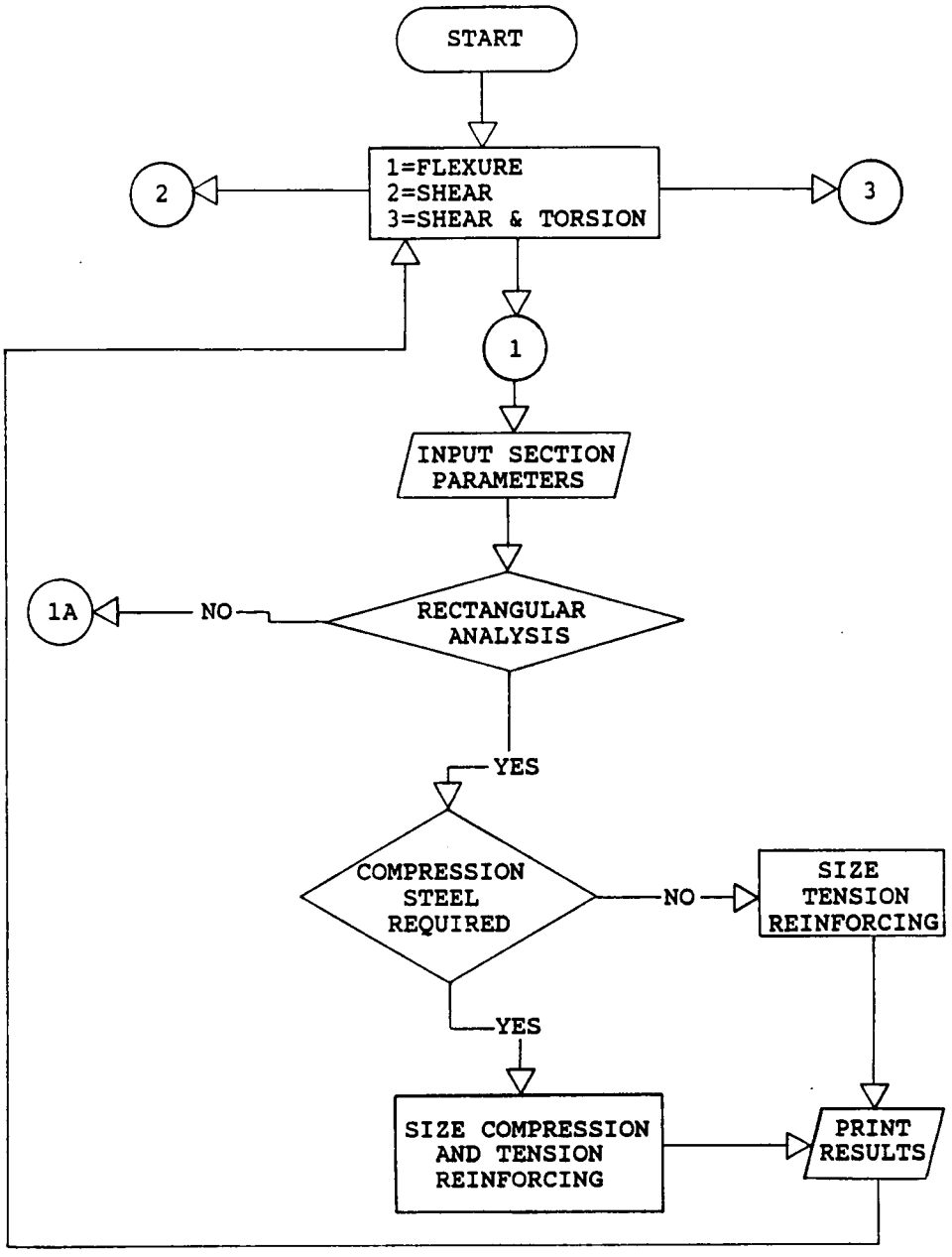


FIGURE 27

CONCRETE PROGRAM FLOW CHART

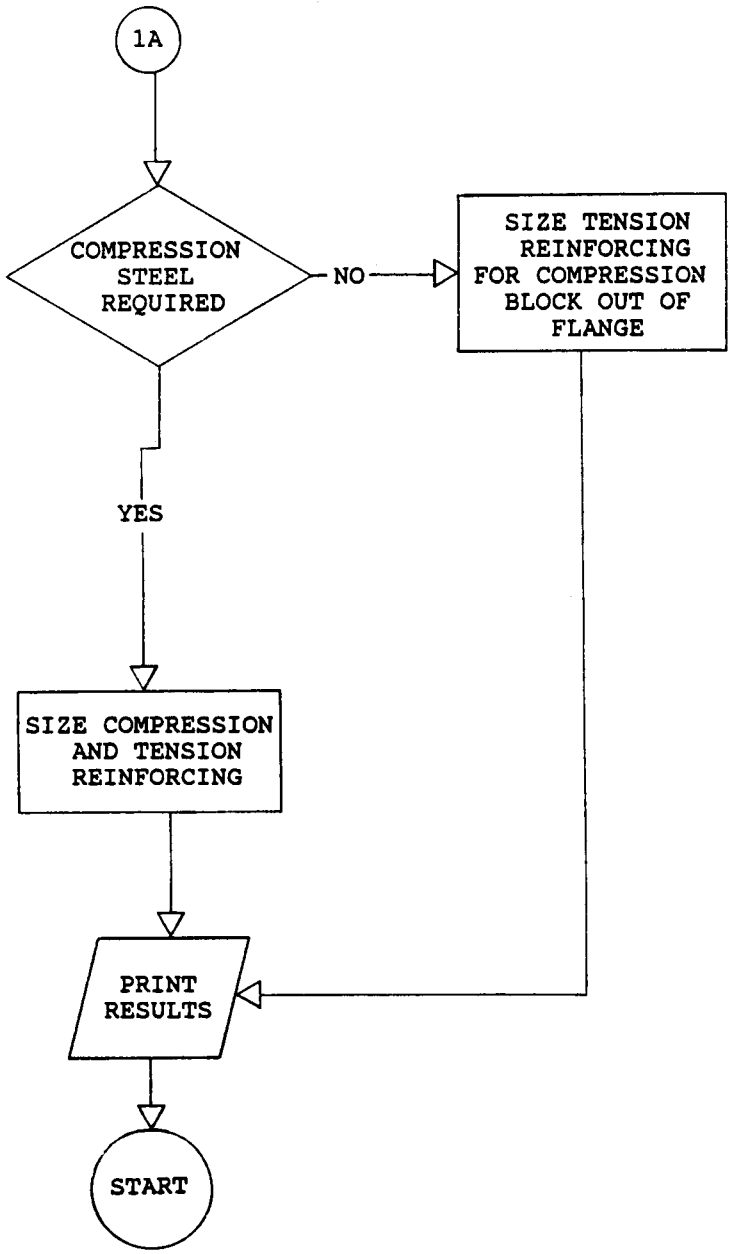


FIGURE 27 (Continued)

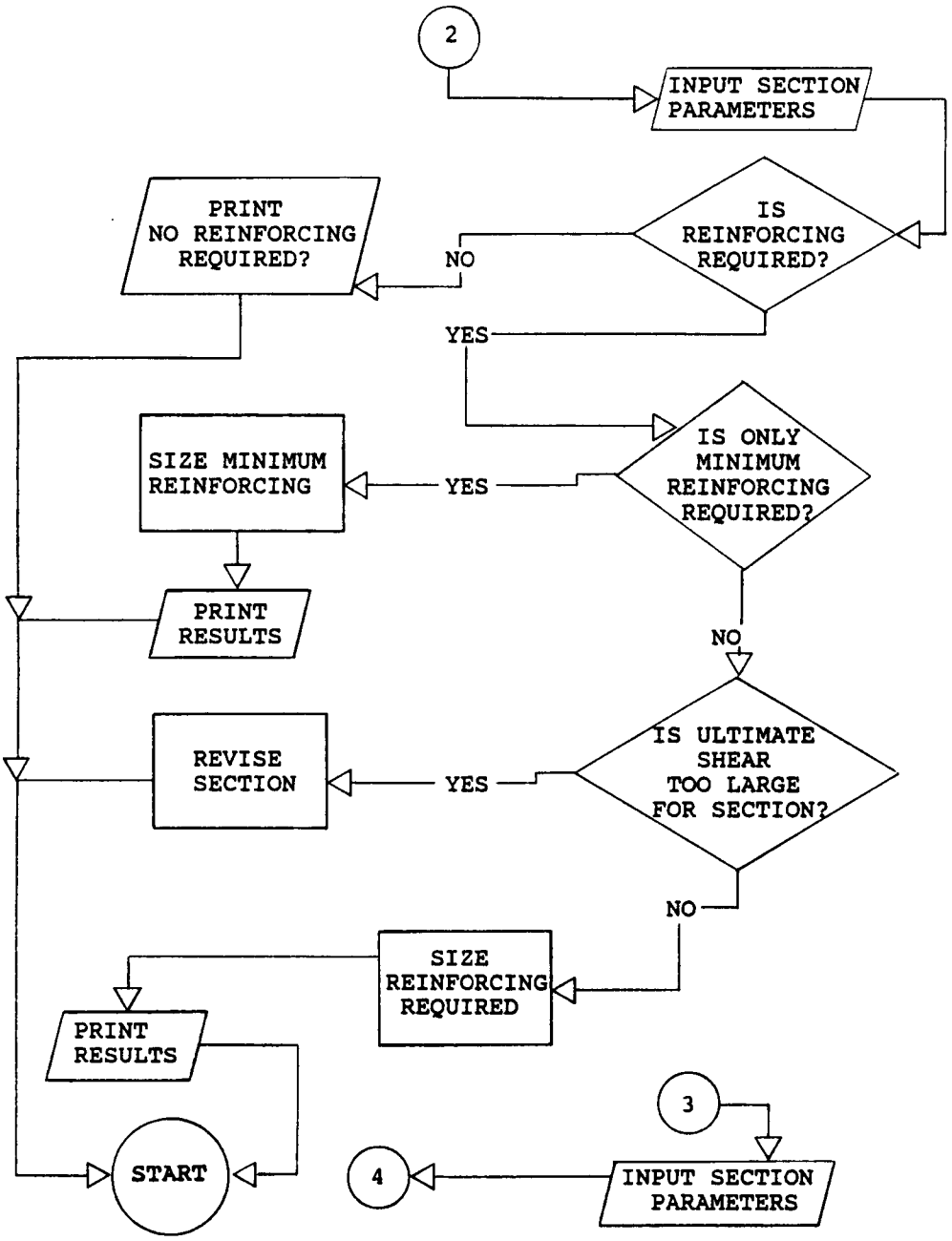


FIGURE 27 (Continued)

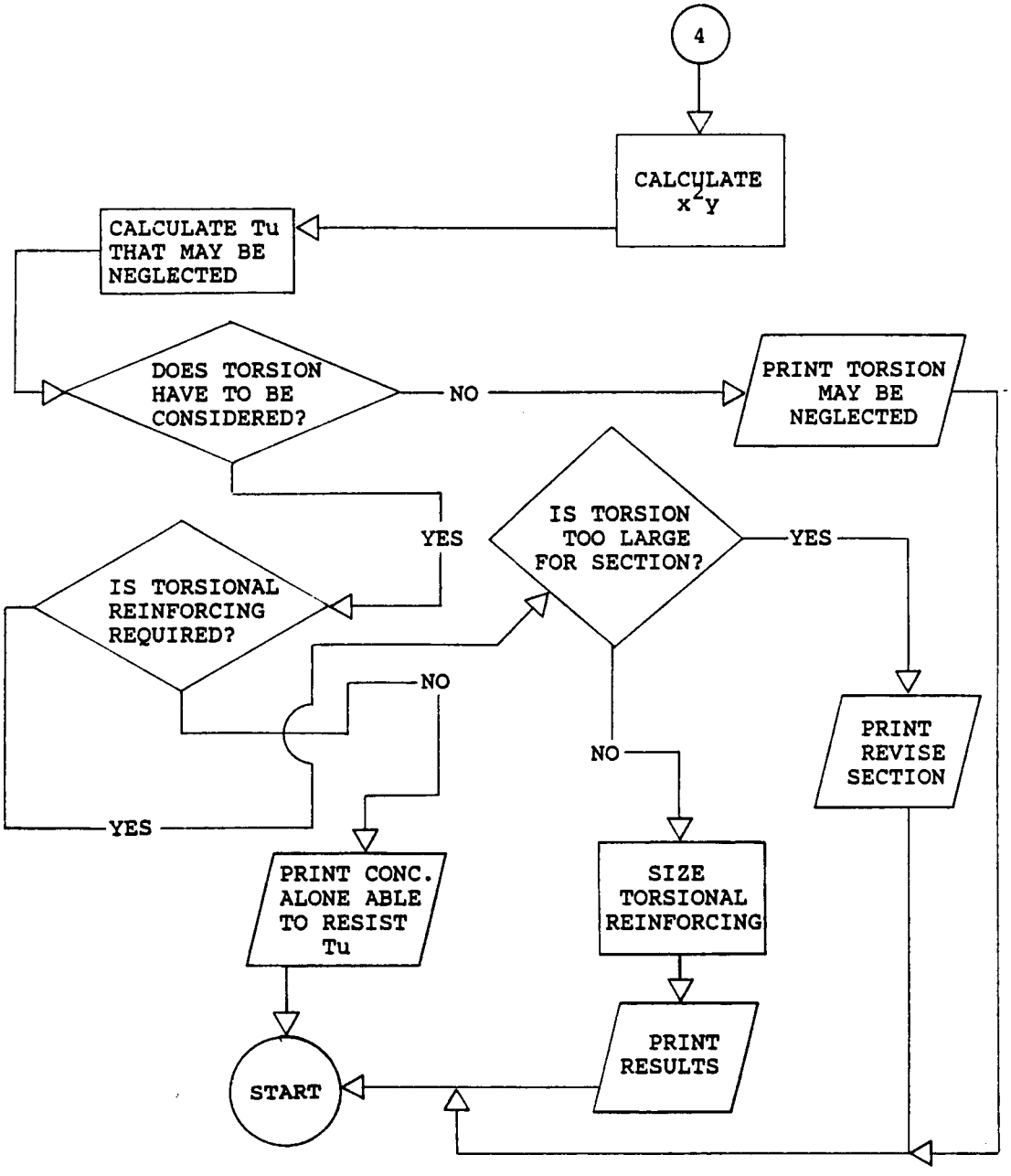


FIGURE 27 (Continued)

Program Copy

Figure 28 is a print-out of the "CONCRETE" program. A wide margin is provided to allow the user to make notes if desired.

START

```
1 CLS
2 KNOWN=0
3 MINNY=0
4 BIG=0
5 I=0
6 X=0
7 Y=0
8 SUM=0
9 BUG=0
10 PRINT"DESIGN OPTIONS:
"
11 PRINT"1=FLEXURE 2=SHE
AR"
12 PRINT"3=SHEAR & TORSI
ON"
13 INPUT CHOICE
14 CLS
15 IF CHOICE=1 GOTO 18
16 IF CHOICE=2 GOTO 398
17 IF CHOICE=3 GOTO 551
```

FLEXURE

```
18 PRINT"IDENTIFICATION"
19 INPUT A$
20 CLS
21 LPRINT A$
22 LPRINT"----------
----------"
23 LPRINT""
24 CLS
25 PRINT"IS THERE A"
26 PRINT"COMPRESSION FLA
NGE"
27 PRINT"1=YES 0=NO"
28 INPUT FLANGE
29 CLS
30 IF FLANGE=0 GOTO 40
31 PRINT"WHAT IS THE FLA
NGE
32 PRINT"THICKNESS(IN.)"
33 INPUT TF
34 CLS
35 PRINT"WHAT IS THE"
36 PRINT"THICKNESS OF TH
E"
37 PRINT"WEB (IN.) [bw]"
38 INPUT BW
39 CLS
40 CLS
41 PRINT"INPUT EFFECTIVE
"
42 PRINT"COMPRESSION BLO
CK"
43 PRINT"WIDTH(IN.)"
44 INPUT B
45 CLS
```

FIGURE 28

CONCRETE PROGRAM PRINT-OUT

```
46 PRINT"INPUT EFFECTIVE
"
47 PRINT"DEPTH OF TENSIO
N"
48 PRINT"STEEL,[d],IN (I
N.)"
49 INPUT D
50 CLS
51 PRINT"INPUT f'c (PSI)
"
52 INPUT FC
53 CLS
54 PRINT"INPUT CONCRETE"
55 PRINT"STRENGTH FACTOR
"
56 PRINT"[BETA]"
57 INPUT BETA
58 CLS
59 PRINT"INPUT Mu (K-FT.
)"
60 INPUT MU
61 CLS
62 PRINT"INPUT YIELD STR
ESS"
63 PRINT"OF REINFORCING(
PSI)"
64 INPUT FY
65 CLS
66 W=((.85*BETA*FC)/FY)*
(87000/(87000+FY))*(.75)
67 RN=(MU*12000)/(.9*(B*
D^2))
68 J=(.85*FC)/(FY)
69 K=(2*RN)/(.85*FC)
70 L=1-K
71 IF L<0 AND CATCH=1 GO
TO 390
72 IF L<0 GOTO 142
73 M=SQR(L)
74 N=1-M
75 P=J*N
76 IF CATCH=1 GOTO 78
77 IF P>W GOTO 142
78 AS=P*B*D
79 IF CATCH=1 GOTO 365
80 TULT=AS*(FY/1000)
81 BLOCKD=(TULT)/((.85)*
(FC/1000)*(B))
82 IF BLOCKD>TF AND TF>0
 GOTO 257
83 A=(AS*FY)/(.85*FC*B)
84 MR=.9*AS*FY*(D-A/2)
85 MR=MR/12000
86 PRINT"As/Ac="P
87 PRINT"As="AS
88 PRINT"INPUT REVISED A
s"
89 INPUT ASNEW
90  CLS
91 PRINT"INPUT REVISED d
"
92 INPUT DNEW
93 CLS
94 ANEW=(ASNEW*FY)/(.85*
FC*B)
95 MRNEW=.9*ASNEW*FY*(DN
EW-ANEW/2)
```

FIGURE 28 (Continued)

```
96 MRNEW=MRNEW/12000
97 IF CATCH=1 GOTO 368
98 ROWNEW=ASNEW/(B*DNEW)
99 TULTNEW=ASNEW*(FY/100
0)
100 BLOCKDNEW=(TULTNEW)/
((.85)*(FC/1000)*(B))
101 IF BLOCKDNEW>TF AND
TF>0 GOTO 257
102 IF ROWNEW>W GOTO 142
103 PRINT"As/Ac="ROWNEW
104 PRINT"oMn="MRNEW"K-F
T"
105 PRINT"REVISE? 1=YES
0=NO"
106 INPUT REVISE
107 IF REVISE=0 GOTO 110
108 CLS
109 GOTO 88
110 CLS
111 PRINT"INPUT REINFORC
ING"
112 PRINT"CHOSEN"
113 INPUT B$
114 CLS
115 ROWMIN=.0033
116 IF DUMMY=0 GOTO 119
117 LPRINT A$
118 LPRINT"----------
----------"
119 LPRINT"Mu="MU"K-FT."
120 LPRINT"fy="FY"PSI"
121 LPRINT"b="B"IN."
122 LPRINT"d="DNEW"IN."
123 IF TF=0 GOTO 125
124 LPRINT"Tf="TF"IN."
125 LPRINT"f'c="FC"PSI"
126 LPRINT"oMn="MRNEW"K-
FT"
127 LPRINT"As/Ac="ROWNEW
128 LPRINT"As="ASNEW"["B
$"]"
129 IF ROWNEW>ROWMIN GOT
O 133
130 LPRINT"[redacted]"
131 LPRINT"NOTE: As USED
 < As MIN"
132 LPRINT"[redacted]"
133 LPRINT"DEPTH OF STRE
SS"
134 LPRINT"BLOCK,[a],="B
LOCKDNEW"IN."
135 LPRINT"----------
----------"
136 LPRINT""
137 LPRINT""
138 LPRINT""
139 LPRINT""
140 ROWNEW=0
141 GOTO   1
142 IF TF>0 GOTO 257
143 IF L>0 GOTO 159
144 LPRINT"**********
**********"
```

FIGURE 28 (Continued)

```
145 LPRINT"SECTION IS TO
O SMALL TO"
146 LPRINT"RESIST Mu. As
/Ac EXCEEDS"
147 LPRINT"BALANCED COND
ITION!"
148 LPRINT"**************
***********"
149 LPRINT""
150 LPRINT""
151 LPRINT""
152 LPRINT""
153 PRINT"DO YOU WANT TO
 CONT."
154 PRINT"USING COMPRESS
ION"
155 PRINT"STEEL? 1=YES 0
=NO"
156 INPUT CAS:CLS
157 IF CAS=0 GOTO 1
158 IF CAS=1 GOTO 169
159 IF ROWNEW>0 THEN ROW
=ROWNEW ELSE ROW=P
160 LPRINT"**************
***********"
161 LPRINT"As REQ'D > .7
5 BALANCED"
162 LPRINT"As/Ac="ROW
163 LPRINT".75*BAL.="W
164 LPRINT"**************
***********"
165 LPRINT""
166 LPRINT""
167 LPRINT""
168 GOTO 153
169 PRINT"INPUT d'(IN.),
[Dist."
170 PRINT"from extreme c
omp."
171 PRINT"fiber to C.G.o
f A's]"
172 INPUT DC:CLS
173 ASTENMAX=B*D*W
174 AFORMAXCONM=(ASTENMA
X*FY)/(.85*FC*B)
175 MAXFACCONM=.9*ASTENM
AX*FY*(D-AFORMAXCONM/2)
176 CASMU=MU-MAXFACCONM/
12000
177 IF CASMU>0 GOTO 183
178 PRINT"YOU DON'T NEED
 A's"
179 PRINT"USE A BETTER A
s"
180 PRINT"[redacted] INPUT 1
[redacted]"
181 INPUT DUMMY:CLS
182 GOTO 88
183 LPRINT"----------
----------"
184 LPRINT"ULTIMATE MOME
NT TO BE"
185 LPRINT"RESISTED BY C
OMPRESSION"
186 LPRINT"STEEL="CASMU"
K-FT."
```

FIGURE 28 (Continued)

```
187 LPRINT"-------------
-------------"
188 LPRINT""
189 LPRINT""
190 LPRINT""
191 ROWCAS=(CASMU*(12000
))/((.9*FY)*(D-DC)*B*D)
192 ROWTOT=W+ROWCAS
193 CAS=ROWCAS*B*D
194 AS=ROWTOT*B*D
195 PRINT"As REQ'D="AS
196 PRINT"A's REQ'D="CAS
197 PRINT"INPUT REVISED
As,A's"
198 INPUT ASNEW,CASNEW:C
LS
199 PRINT"INPUT REVISED
d,d'"
200 INPUT DNEW,DCNEW:CLS
201 YIELDCHKA=(ASNEW-CAS
NEW)/(B*DNEW)
202 YIELDCHKB=(((.85)*(B
ETA)*(FC)*(DCNEW))/(FY*D
NEW))*((87000)/(87000-FY
))
203 IF YIELDCHKA>YIELDCH
KB GOTO 219
204 LPRINT"**************
**********"
205 LPRINT"COMPRESSIVE S
TEEL DOES"
206 LPRINT"NOT YIELD! "
207 LPRINT""
208 LPRINT"As-A's/b*d="Y
IELDCHKA
209 LPRINT""
210 LPRINT".85*BETA*f'c*
d'  87000"
211 LPRINT"-------------
-- (-------)"
212 LPRINT"     fy*d
   87000-fy"
213 LPRINT"="YIELDCHKB
214 LPRINT"**************
**********"
215 LPRINT""
216 LPRINT""
217 LPRINT""
218 LPRINT"":GOTO 1
219 ANEW=(ASNEW-CASNEW)*
(FY/1000)/(.85*(FC/1000)
*B)
220 MUTOT=.9*((ASNEW-CAS
NEW)*FY*(DNEW-(ANEW/2))+
CASNEW*FY*(DNEW-DCNEW))
221 MUTOT=MUTOT/12000
222 PRINT"oMn="MUTOT"K-F
T."
223 PRINT"REVISE? 1=YES
0=NO"
224 INPUT JUMP
225 CLS
226 IF JUMP=1 GOTO 197
227 PRINT"INPUT REINFORC
ING"
228 PRINT"USED    As,A's
"
```

FIGURE 28 (Continued)

```
229 INPUT AS$,CAS$:CLS
230 PRINT"INPUT THE DIAM
ETER"
231 PRINT"OF THE COMPRES
SION"
232 PRINT"BAR USED (IN.)
233 INPUT DIACAS
234 CLS
235 LGREQ=16*DIACAS
236 IF B<DNEW THEN RQSPA
=B ELSE RQSPA=DNEW
237 IF LGREQ<RQSPA THEN
RQSPA=LGREQ
238 IF 18<RQSPA THEN RQS
PA=18
239 LPRINT"b="B"IN."
240 LPRINT"d="DNEW"IN."
241 LPRINT"d'="DCNEW"IN.
"
242 LPRINT"Mu="MU"K-FT."
243 LPRINT"fy="FY"PSI"
244 LPRINT"f'c="FC"PSI"
245 LPRINT"As="ASNEW"IN^
2 ["AS$"]"
246 LPRINT"A's="CASNEW"I
N^2 ["CAS$"]"
247 LPRINT"oMn="MUTOT"K-
FT."
248 LPRINT""
249 LPRINT"MINIMUM STIRR
UPS IN"
250 LPRINT"COMPRESSION S
TEEL REGION"
251 LPRINT"= #3 TIES @ "
RQSPA"IN. C/C"
252 LPRINT""
253 LPRINT""
254 LPRINT""
255 LPRINT"":GOTO 1
256 REM ****BLOCKD OUT O
F FLG.
257 CF=.85*(FC/1000)*(B-
BW)*TF
258 CFAS=CF/(FY/1000)
259 MUFACCFAS=.9*CFAS*(F
Y/1000)*(D-(TF/2))
260 MUFACCFAS=MUFACCFAS/
12
261 MUW=MU-MUFACCFAS
262 RNW=(MUW*12000)/(.9*
BW*D^2)
263 KW=(2*RNW)/(.85*FC)
264 LW=1-KW
265 IF LW<0 GOTO 271
266 MW=SQR(LW)
267 NW=1-MW
268 ROWW=J*NW
269 ASW=ROWW*BW*D
270 ASOFTOT=ASW+CFAS
271 ROWF=((.85)*(FC/FY)*
(B-BW)*TF)/(BW*D)
272 ROWB=((.85*BETA*FC)/
FY*(87000/(87000+FY)))
273 ROWMAX=.75*((BW/B)*(
ROWB+ROWF))
274 ASMAX=ROWMAX*B*D
275 IF LW<0 GOTO 331
```

FIGURE 28 (Continued)

```
276 IF ASOFTOT>ASMAX GOT
O 331
277 LPRINT"NOTE:THE COMP
RESSION"
278 LPRINT"BLOCK EXTENDS
 BELOW"
279 LPRINT"THE BOTTOM OF
 THE FLANGE"
280 LPRINT""
281 LPRINT"**********
**********"
282 LPRINT"ULTIMATE MOME
NT TO BE"
283 LPRINT"RESISTED BY T
HE WEB"
284 LPRINT"="MUW"K-FT."
285 LPRINT"**********
**********"
286 LPRINT""
287 LPRINT""
288 PRINT"TOTAL AREA OF
STEEL"
289 PRINT"REQ'D="ASOFTOT
"IN.^2"
290 PRINT"INPUT REVISED
As"
291 INPUT ASOFTOTNEW
292 CLS
293 PRINT"INPUT REVISED
d"
294 INPUT DNEW
295 CLS
296 ASWNEW=ASOFTOTNEW-CF
AS
297 TULTWNEW=ASWNEW*(FY/
1000)
298 AWNEW=(ASWNEW*FY)/(.
85*FC*BW)
299 MUFACWNEW=.9*ASWNEW*
FY*(DNEW-(AWNEW/2))
300 MUFACWNEW=MUFACWNEW/
12000
301 ROWFNEW=((.85)*(FC/F
Y)*(B-BW)*TF)/(BW*DNEW)
302 ROWMAXNEW=.75*((BW/B
)*(ROWB+ROWFNEW))
303 ASMAXNEW=ROWMAXNEW*B
*DNEW
304 IF ASOFTOTNEW>ASMAXN
EW GOTO 331
305 MUFACOFTOTNEW=MUFACC
FAS+MUFACWNEW
306 PRINT"oMn="MUFACOFTO
TNEW"K-FT."
307 PRINT"REVISE 1=YES 0
=NO"
308 INPUT CHANGE
309 CLS
310 IF CHANGE=1 GOTO 290
311 PRINT"INPUT REINFORC
ING"
312 PRINT"USED"
313 INPUT J$
314 CLS
315 LPRINT"bw="BW"IN."
316 LPRINT"Tf="TF"IN."
317 LPRINT"b="B"IN."
```

FIGURE 28 (Continued)

```
318 LPRINT"d="DNEW"IN."
319 LPRINT"Mu="MU"K-FT."
320 LPRINT"f'c="FC"PSI"
321 LPRINT"Fy="FY"PSI"
322 LPRINT"As="ASOFTOTNE
W"IN.^2  ["J$"]"
323 LPRINT"oMn="MUFACOFT
OTNEW"K-FT."
324 LPRINT"DEPTH OF THE
STRESS"
325 LPRINT"BLOCK="AWNEW"
IN."
326 LPRINT""
327 LPRINT""
328 LPRINT""
329 LPRINT""
330 GOTO 1
331 LPRINT"**********
**********"
332 LPRINT"As REQ'D EXCE
EDS .75*BAL"
333 LPRINT"**********
**********"
334 LPRINT""
335 LPRINT""
336 LPRINT""
337 PRINT"DO YOU WANT TO
 CONT."
338 PRINT"USING COMPRESS
ION"
339 PRINT"STEEL? 1=YES 0
=N0"
340 INPUT CHOICEA
341 CLS
342 IF CHOICEA=0 GOTO 1
343 ASF=((.85)*(FC/1000)
*(B-BW)*(TF))/(FY/1000)
344 DC=TF/2
345 MUF=(ASF*(FY/1000)*(
D-DC))/12
346 MUTEN=MU-MUF
347 LPRINT"**********
**********"
348 LPRINT"ULTIMATE MOME
NT TO BE"
349 LPRINT"RESISTED BY T
ENSIL"
350 LPRINT"REINFORCING"
351 LPRINT"="MUTEN"K-FT.
"
352 LPRINT"**********
**********"
353 LPRINT"":LPRINT"":LP
RINT""
354 PRINT"COMPRESSION RE
INF."
355 PRINT"REQ'D="ASF"IN.
^2"
356 PRINT"INPUT REVISED
A's"
357 INPUT ASFNEW
358 CLS
359 MUFNEW=(ASFNEW*(FY/1
000)*(D-DC))/12
360 MUTENNEW=MU-MUFNEW
361 MUSAVE=MU
362 CATCH=1
```

FIGURE 28 (Continued)

```
363 MU=MUTENNEW
364 GOTO 67
365 PRINT"REQ'D TENSION
REINF."
366 PRINT"="AS"IN.^2"
367 GOTO 88
368 MUFACTOT=MUFNEW+MRNE
W
369 PRINT"øMn="MUFACTOT"
K-FT."
370 PRINT"REVISE? 1=YES
0=NØ
371 INPUT CHANGET
372 CLS
373 IF CHANGET=1 GOTO 88
374 PRINT"INPUT REINFORC
ING"
375 PRINT"USED: As,A's"
376 INPUT L$,H$
377 CLS
378 LPRINT"b="B"IN."
379 LPRINT"Tf="TF"IN."
380 LPRINT"bw="BW"IN."
381 LPRINT"d="D"IN."
382 LPRINT"d'="TF/2"IN."
383 LPRINT"Mu="MUSAVE"K-
FT."
384 LPRINT"Fy="FY"PSI"
385 LPRINT"As="ASNEW"IN.
^2 ["L$"]"
386 LPRINT"A's="ASFNEW"I
N.^2 ["H$"]"
387 LPRINT"øMn="MUFACTOT
"K-FT."
388 LPRINT"":LPRINT"":LP
RINT"":LPRINT""
389 GOTO 1
390 LPRINT"**************
***********"
391 LPRINT"TOO MUCH MOME
NT!"
392 LPRINT"REVISE SECTIO
N"
393 LPRINT"**************
***********"
394 LPRINT""
395 LPRINT""
396 LPRINT""
397 GOTO 1
```

SHEAR

```
398 PRINT"IDENTIFICATION
?
399 INPUT S$
400 CLS
401 PRINT"INPUT THICKNES
S"
402 PRINT"OF WEB [bw] (I
N.)"
403 INPUT BW
404 CLS
405 PRINT"INPUT EFFECTIV
E"
```

FIGURE 28 (Continued)

```
406 PRINT"DEPTH [d] (IN.
)"
407 INPUT D
408 CLS
409 PRINT"INPUT f'c (PSI
)"
410 INPUT FC
411 CLS
412 PRINT"INPUT Fy OF SH
EAR"
413 PRINT"REINFORCEMENT
(KSI)"
414 INPUT FY
415 CLS
416 PRINT"INPUT Vu (KIPS
)
417 INPUT VU
418 CLS
419 PRINT"DO YOU WANT TO
"
420 PRINT"CHECK KNOWN RE
INF.?"
421 PRINT"1=YES 0=NO"
422 INPUT KNOWN
423 CLS
424 IF KNOWN=0 GOTO 436
425 PRINT"INPUT Av (IN.^
2)"
426 INPUT AV
427 CLS
428 PRINT"INPUT REINFORC
ING"
429 PRINT"DESCRIPTION"
430 INPUT AVK$
431 CLS
432 PRINT"INPUT SPACING
(IN.)"
433 INPUT S
434 CLS
435 GOTO 436
436 FEVECE=((.85)*(2)*(F
C^.5)*(BW)*(D))/1000
437 CA=2*VU
438 IF FEVECE>CA GOTO 47
4
439 IF KNOWN=0 GOTO 491
440 FEVES=((AV*FY*D)/S)*
.85
441 VSREQ=FEVES/.85
442 VSCHK=4*((FC^.5)/100
0)*BW*D
443 MAXSPA=(AV*FY*1000)/
(50*BW)
444 IF(D/2)<MAXSPA THEN
MAXSPA=D/2
445 IF VSREQ>VSCHK THEN
BUG=D/4
446 IF BUG<MAXSPA AND BU
G>0 THEN MAXSPA=BUG
447 MAXVUSTL=(8*(FC^.5)*
BW*D)/1000
448 FEVEN=FEVECE+FEVES
449 MAXFACCAP=FEVECE+.85
*(MAXVUSTL)
450 IF BIG=1 GOTO 453
451 LPRINT S$
452 LPRINT"----------
----------"
```

FIGURE 28 (Continued)

```
453 LPRINT""
454 LPRINT"bw="BW"IN."
455 LPRINT"d="D"IN."
456 LPRINT"f'c="FC"PSI"
457 LPRINT"Vu="VU"KIPS"
458 IF MINNY=1 THEN GOTO
 537
459 LPRINT"Av="AV"IN.^2"
460 LPRINT"["AVK$"]"
461 LPRINT"SPACING="S"IN
."
462 LPRINT"[redacted]
[redacted]"
463 LPRINT"øVn="FEVEN"KI
PS"
464 LPRINT"[redacted]
[redacted]"
465 LPRINT"MAXIMUM SPACI
NG USING"
466 LPRINT AVK$
467 LPRINT"="MAXSPA"IN."
468 LPRINT"CAPACITY OF S
ECTION"
469 LPRINT"USING MAXIMUM
 REINF."
470 LPRINT"="MAXFACCAP"K
IPS"
471 LPRINT"----------
----------"
472 LPRINT"":LPRINT"":LP
RINT"":LPRINT""
473 GOTO 1
474 LPRINT S$
475 LPRINT"----------
----------"
476 LPRINT"bw="BW"IN."
477 LPRINT"d="D"IN."
478 LPRINT"f'c="FC"PSI"
479 LPRINT"Vu="VU"KIPS"
480 LPRINT""
481 LPRINT"FACTORED SHEA
R STRENGTH"
482 LPRINT"OF CONCRETE A
LONE [øVc]"
483 LPRINT"="FEVECE"KIPS
 WHICH IS"
484 LPRINT"> TWICE THE U
LTIMATE"
485 LPRINT"SHEAR, SO"
486 LPRINT"[redacted]
[redacted]"
487 LPRINT"NO STIRRUPS R
EQ'D."
488 LPRINT"[redacted]
[redacted]"
489 LPRINT"":LPRINT"":LP
RINT"":LPRINT""
490 GOTO 1
491 PRINT"[redacted]
[redacted]"
492 PRINT"STIRRUPS ARE R
EQ'D."
493 PRINT"[redacted]
[redacted]"
494 LPRINT S$
495 LPRINT"----------
----------"
```

FIGURE 28 (Continued)

```
496 LPRINT""
497 LPRINT"oUc="FEUECE"K
IPS"
498 LPRINT""

499 LPRINT""
500 CLS
501 USREQ=(UU-FEUECE)/.8
5
502 USCHK=4*((FC^.5)/100
0)*BW*D
503 IF USREQ<0 THEN MINN
Y=1
504 IF MINNY=1 GOTO 453
505 LPRINT"DESIGN SHEAR
STRENGTH"
506 LPRINT"REQUIRED FROM
 REINF."
507 LPRINT"="USREQ"KIPS"
508 LPRINT""
509 MAXUUSTL=(8*(FC^.5)*
BW*D)/1000
510 IF USREQ<MAXUUSTL GO
TO 519
511 LPRINT"MAXIMUM ALLOW
ABLE"
512 LPRINT"SHEAR TO BE R
ESISTED"
513 LPRINT"BY REINFORCIN
G"
514 LPRINT"="MAXUUSTL"KI
PS"
515 LPRINT"[illegible]"
516 LPRINT"REUISE SECTIO
N"
517 LPRINT"[illegible]"
518 LPRINT"":LPRINT"":LP
RINT"":LPRINT"":GOTO 1
519 PRINT"INPUT Au (IN.^
2)"
520 INPUT AU:CLS
521 SREQ=(AU*FY*D)/USREQ
522 PRINT"SPA.(IN.) REQ'
D WITH"
523 PRINT"Au="AU"IS"SREQ
524 PRINT"REUISE? 1=YES
0=NO"
525 INPUT AUREU:CLS
526 IF AUREU=1 GOTO 519:
CLS
527 CLS
528 PRINT"INPUT FINAL S
(IN.)"
529 INPUT S
530 CLS
531 PRINT"INPUT REINFORC
ING"
532 PRINT"DESCRIPTION"
533 INPUT AUK$
534 CLS
535 BIG=1
536 GOTO 440
537 LPRINT""
538 LPRINT"ONLY MIN.REIN
FORCING"
```

FIGURE 28 (Continued)

```
539 LPRINT"IS REQ'D. USE
 #3'S"
540 LPRINT""
541 AV=.22
542 S=((AV)*(FY*1000))/(
50*BW)
543 IF D/2<S THEN S=D/2
544 FEVES=(.85*AV*FY*D)/
S
545 FEVEN=FEVECE+FEVES
546 LPRINT"MAXIMUM SPACI
NG"
547 LPRINT"="S"IN."
548 LPRINT"oUn="FEVEN"KI
PS"
549 LPRINT"":LPRINT"":LP
RINT"":LPRINT""
550 GOTO 1
```

SHEAR AND TORSION

```
551 PRINT"IDENTIFICATION
?"
552 INPUT T$
553 CLS
554 PRINT"INPUT f'c (PSI
)"
555 INPUT FC
556 CLS
557 PRINT"INPUT NUMBER O
F"
558 PRINT"RETANGULAR SEC
TION"
559 PRINT"ELEMENTS"
560 INPUT ELEM
561 CLS
562 FOR I=1 TO ELEM
563 PRINT"INPUT ELEMENT"
I"X,Y"
564 PRINT"DIMENSIONS"
565 PRINT"[SHORTER],[LON
GER]"
566 INPUT X,Y
567 CLS
568 X2=X^2:PROD=X2*Y
569 SUM=SUM+PROD
570 NEXT I
571 PRINT"INPUT WEB WIDT
H(IN.)"
572 INPUT BW
573 CLS
574 PRINT"INPUT EFFECTIV
E"
575 PRINT"DEPTH OF TENSI
L"
576 PRINT"REINF.[d] (IN.
)"
577 INPUT D
578 CLS
579 PRINT"INPUT Vu (KIPS
)"
580 INPUT VU
581 CLS
582 PRINT"INPUT Tu (K-FT
.)"
```

FIGURE 28 (Continued)

```
583 INPUT TU
584 CLS
585 LPRINT T$
586 LPRINT"————————————————————"
587 LPRINT""
588 FETUOK=(.85*.5*(FC^.5)*SUM)/12000
589 IF TU>FETUOK GOTO 597
590 LPRINT"Tu MAX. THAT MAY BE"
591 LPRINT"NEGLECTED="FETUOK"K-FT.":LPRINT""
592 LPRINT"ACTUAL Tu="TU"K-FT.":LPRINT""
593 LPRINT"[redacted]"
594 LPRINT"NEGLECT TORSION"
595 LPRINT"[redacted]"
596 LPRINT"":LPRINT"":LPRINT"":LPRINT"":GOTO 1
597 CT=(BW*D)/SUM
598 FETECE=(.85*.8*((FC^.5)/1000)*SUM)/(1+(((.4*UU)/(CT*TU*12))^2))^.5
599 FETECE=FETECE/12
600 LPRINT"FACTORED TORSIONAL"
601 LPRINT"CAPACITY OF CONCRETE"
602 LPRINT"ALONE="FETECE"K-FT."
603 LPRINT""
604 IF FETECE<TU GOTO 612
605 LPRINT"THIS IS GREATER THAN"
606 LPRINT"Tu="TU"K-FT."
607 LPRINT""
608 LPRINT"[redacted]"
609 LPRINT"  NO REINFORCING REQ'D."
610 LPRINT"[redacted]"
611 LPRINT"":LPRINT"":LPRINT"":LPRINT"":GOTO 1
612 PRINT"[redacted]"
613 PRINT" STIRRUPS ARE REQ'D."
614 PRINT"[redacted]"
615 TSUDES=(TU-FETECE)/.85
616 LPRINT"TORSIONAL MOMENT TO BE"
617 LPRINT"RESISTED BY REINFORCING"
618 LPRINT"="TSUDES"K-FT."
619 LPRINT""
620 CLS
621 CHECK=4*(FETECE/.85)
```

FIGURE 28 (Continued)

```
622 IF TSUDES<CHECK GOTO
 633
623 LPRINT"MAXIMUM ALLOW
ABLE"
624 LPRINT"TORSIONAL MOM
ENT THAT"
625 LPRINT"CAN BE RESIST
ED BY"
626 LPRINT"REINFORCING"
627 LPRINT"="CHECK"K-FT.
"
628 LPRINT""
629 LPRINT"[redacted]
[redacted]"
630 LPRINT"REVISE SECTIO
N"
631 LPRINT"[redacted]
[redacted]"
632 LPRINT"":LPRINT"":LP
RINT"":LPRINT"":GOTO 1
633 PRINT"INPUT AREA OF
ONE"
634 PRINT"LEG OF CLOSED"
635 PRINT"STIRRUP [At](I
N.^2)"
636 INPUT AT
637 CLS
638 PRINT"INPUT X1 [SHOR
TER"
639 PRINT"C-TO-C DIMENSI
ON"
640 PRINT"OF STIRRUP] (I
N.)"
641 INPUT X1:CLS
642 PRINT"INPUT Y1 [LONG
ER"
643 PRINT"C-TO-C DIMENSI
ON"
644 PRINT"OF STIRRUP] (I
N.)"
645 INPUT Y1:CLS
646 ALFAT=.66+.33*(Y1/X1
)
647 IF ALFAT>1.5 THEN AL
FAT=1.5
648 SREQ=(AT*ALFAT*X1*Y1
*60)/(TSUDES*12)
649 MAXSPA=(X1+Y1)/4
650 IF 12<MAXSPA THEN MA
XSPA=12
651 PRINT"S REQ'D="SREQ"
IN."
652 PRINT"S MAX="MAXSPA"
IN."
653 PRINT"REVISE 1=YES 0
=NO
654 INPUT CHANGE
655 IF CHANGE=1 GOTO 633
656 CLS
657 PRINT"INPUT REINFORC
ING"
658 PRINT"DESCRIPTION"
659 INPUT AT$
660 CLS
661 AL1=2*AT*((X1+Y1)/SR
EQ)
```

FIGURE 28 (Continued)

```
662 AL2A=((400)*(BW)*(SR
EQ))/60000
663 AL2B=(TU*12)/((TU*12
)+(VU/(3*CT)))
664 AL2C=AL2A*AL2B
665 AL2D=AL2C-2*AT
666 AL2E=AL2D*((X1+Y1)/S
REQ)
667 AL2=AL2E
668 AL3=(50*(SREQ/2)*BW)
/60
669 AL=AL1
670 IF AL2>AL THEN AL=AL
2
671 IF AL>AL3 THEN AL=AL
3
672 LPRINT"f'c="FC"PSI"
673 LPRINT"fy= 60000 PSI
"
674 LPRINT"Vu="VU"KIPS"
675 LPRINT"Tu="TU"K-FT."
676 LPRINT"At="AT"IN.^2"
677 LPRINT"["AT$"]"
678 LPRINT""
679 LPRINT"----------
----------"
680 LPRINT"REQUIRED SPAC
ING"
681 LPRINT"="SREQ"IN.C/C
"
682 LPRINT""
683 LPRINT"MAXIMUM SPACI
NG ALLOWED"
684 LPRINT"="MAXSPA"IN.C
/C"
685 LPRINT"----------
----------"
686 LPRINT""
687 IF SREQ<MAXSPA GOTO
691
688 ATREQ=(TSUDES*12*MAX
SPA)/(ALFAT*X1*Y1*60)
689 ATUNUSED=AT-ATREQ
690 GOTO 696
691 S=SREQ
692 FETS=(.85*AT*ALFAT*X
1*Y1*60)/(S*12)
693 FETEN=FETS+FETECE
694 LPRINT"oTn="FETEN"K-
FT."
695 LPRINT"":GOTO 716
696 FETS=(.85*ATREQ*ALFA
T*X1*Y1*60)/(MAXSPA*12)
697 FETEN=FETS+FETECE
698 LPRINT"THE MAXIMUM A
LLOWABLE"
699 LPRINT"SPACING ["MAX
SPA"] IS"
700 LPRINT"LESS THAN THE
 REQ'D"
701 LPRINT"SPACING ["SRE
Q"]"
702 LPRINT"SO NOT ALL OF
 THE REINF."
703 LPRINT"IS BEING USED
.":LPRINT""
```

FIGURE 28 (Continued)

```
704 LPRINT"WITH STIRRUPS
 SPACED AT"
705 LPRINT MAXSPA"IN. C/C
 THE REQ'D"
706 LPRINT"AREA OF TORSI
ONAL REINF."
707 LPRINT"[At] IS"ATREQ
"IN.^2"
708 LPRINT"USING"ATREQ"I
N.^2"
709 LPRINT"øTn="FETEN"K-
FT."
710 LPRINT""
711 LPRINT"THE UNUSED PO
RTION OF"
712 LPRINT"REINFORCING I
S"
713 LPRINT ATUNUSED"IN.^
2 IN ONE LEG"
714 LPRINT"AT"MAXSPA"IN.
C/C"
715 LPRINT""
716 LPRINT"LONGITUDINAL
BARS"
717 LPRINT"DISTRIBUTED A
ROUND"
718 LPRINT"THE PERIMETER
 [Al]"
719 LPRINT"="AL"IN.^2"
720 LPRINT"":LPRINT"":LP
RINT"":LPRINT"":GOTO 1
```

FIGURE 28 (Continued)

CHAPTER 3

COLUMN ANALYSIS AND DESIGN

Description of Program

This program is actually a combination of three separate programs written to analyze columns of concrete, steel and timber. The option desired is selected at the beginning of the program.

The concrete column option is written to analyze columns for slenderness and biaxial bending in compliance with Building Code Requirements for Reinforced Concrete (ACI 318-83), published by the American Concrete Institute. It is designed to give the user the correct magnified moments to go to a column interaction diagram (many sources) and select reinforcing. Two such diagrams, Figures 29 and 30, are included in this paper having been reproduced from the Design Handbook in Accordance with the Strength Design Method of ACI 318-77 (Volume 2 Columns), published by the American Concrete Institute.

The biaxial bending analysis gives the user an approximate uniaxial (magnified, if required) moment for preliminary sizing and provides a check on reinforcing chosen using the P.C.A. Load Contour Method, taken from Notes on ACI 318-83: Building Code Requirements for Reinforced Concrete with Design Applications, published by

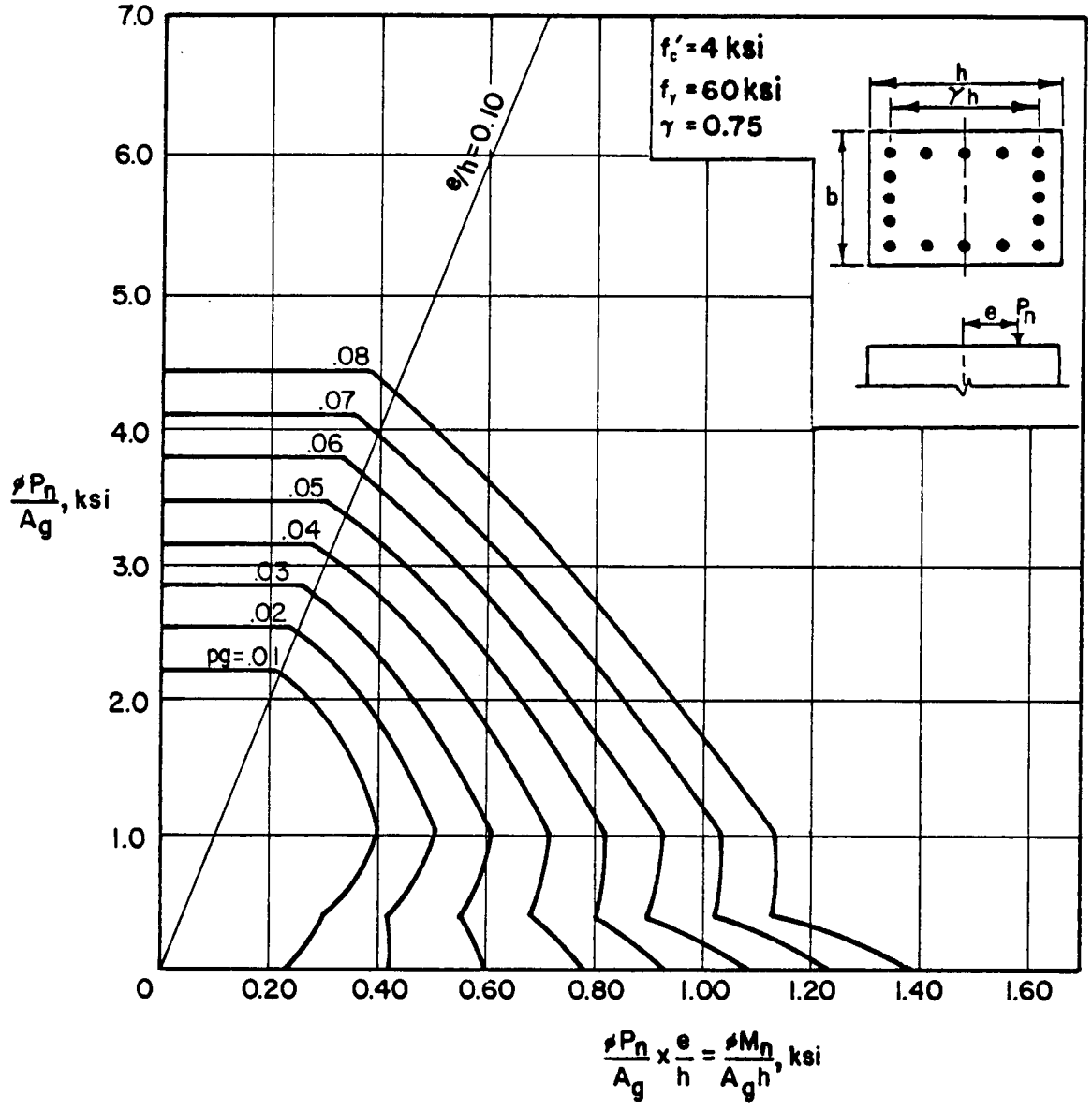


FIGURE 29

COLUMN INTERACTION DIAGRAM FOR γ = .75

SOURCE: American Concrete Institute. Design Handbook in Accordance with the Strength Design Method of ACI 318-77 Volumn 2 Columns. Detroit: American Concrete Institute, 1978.

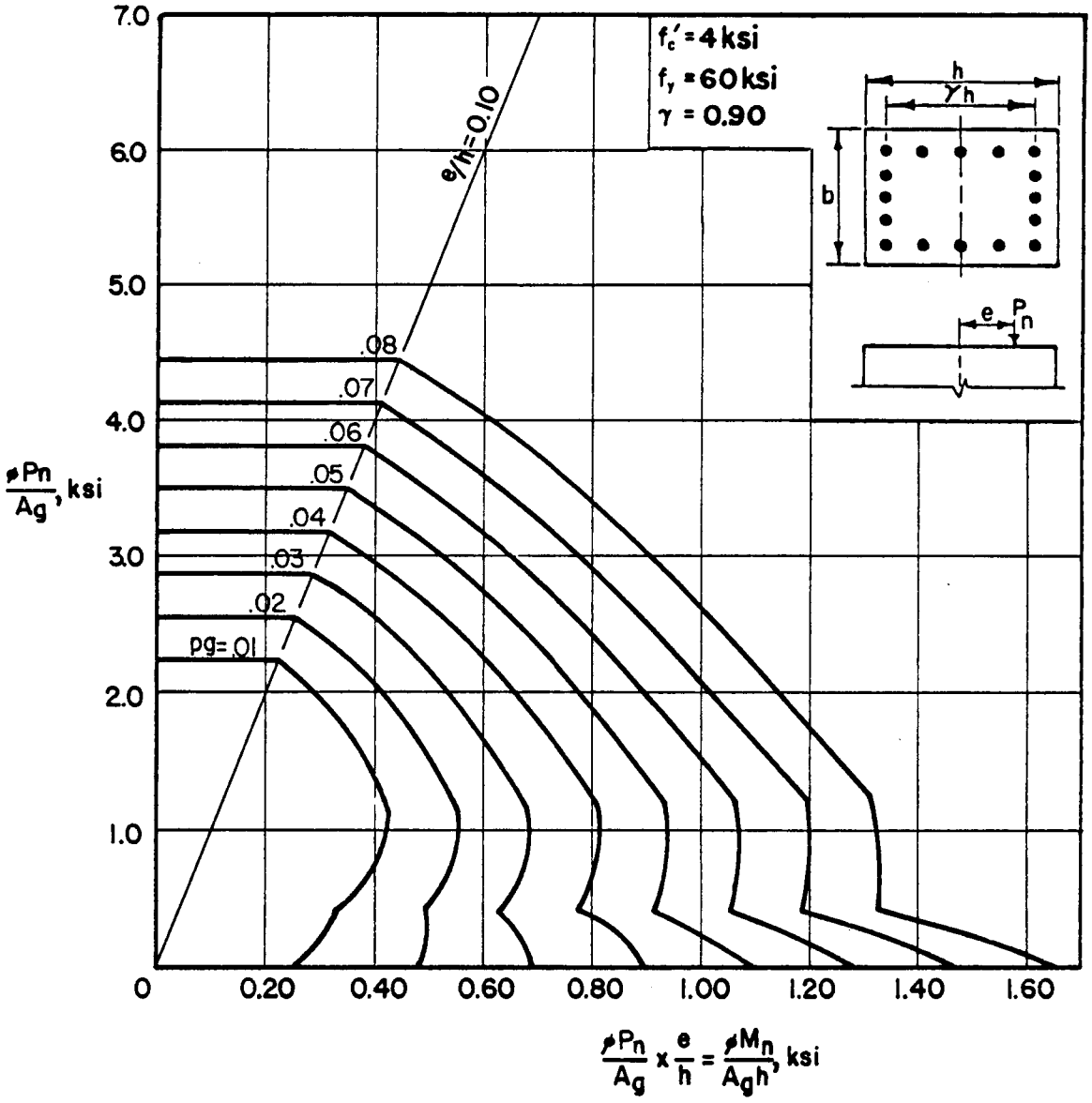


FIGURE 30

COLUMN INTERACTION DIAGRAM FOR γ = .9

SOURCE: American Concrete Institute. Design Handbook in Accordance with the Strength Design Method of ACI 318-77 Volumn 2 Columns. Detroit: American Concrete Institute, 1978.

the Portland Cement Association. Figures 31, 32 and 33 are biaxial bending design constants from the same source.

The steel column option is written to analyze structural pipes and tubes, single angles, double angles with separators, double angles in contact, I-beam shapes, split tees and channels for combined axial and bending loads in compliance with the Manual of Steel Construction (Eighth Edition), published by the American Institute of Steel Construction, Inc. The allowable axial stress is determined based on unbraced length and member properties. Members with unstiffened elements satisfying the requirements of Section 1.9.1 of the above mentioned reference are analyzed. If the width-to thickness ratio of an unstiffened element exceeds these specified limits, the program refers the user to Appendix C of the same publication.

Allowable bending stress (Fb) is determined in compliance with Section 1.5.1.4 of the Manual of Steel Construction (Eighth Edition), published by the American Institute of Steel Construction, Inc. Evaluation of the individual shapes included in the program for allowable bending stress is as follows:

I-Shapes

I-Shapes are evaluated under Section 1.5.1.4.1 to determine if they qualify as compact sections. If compact, Fb = .66Fy is assigned for bending in the strong direction. Otherwise, Fb for bending in the

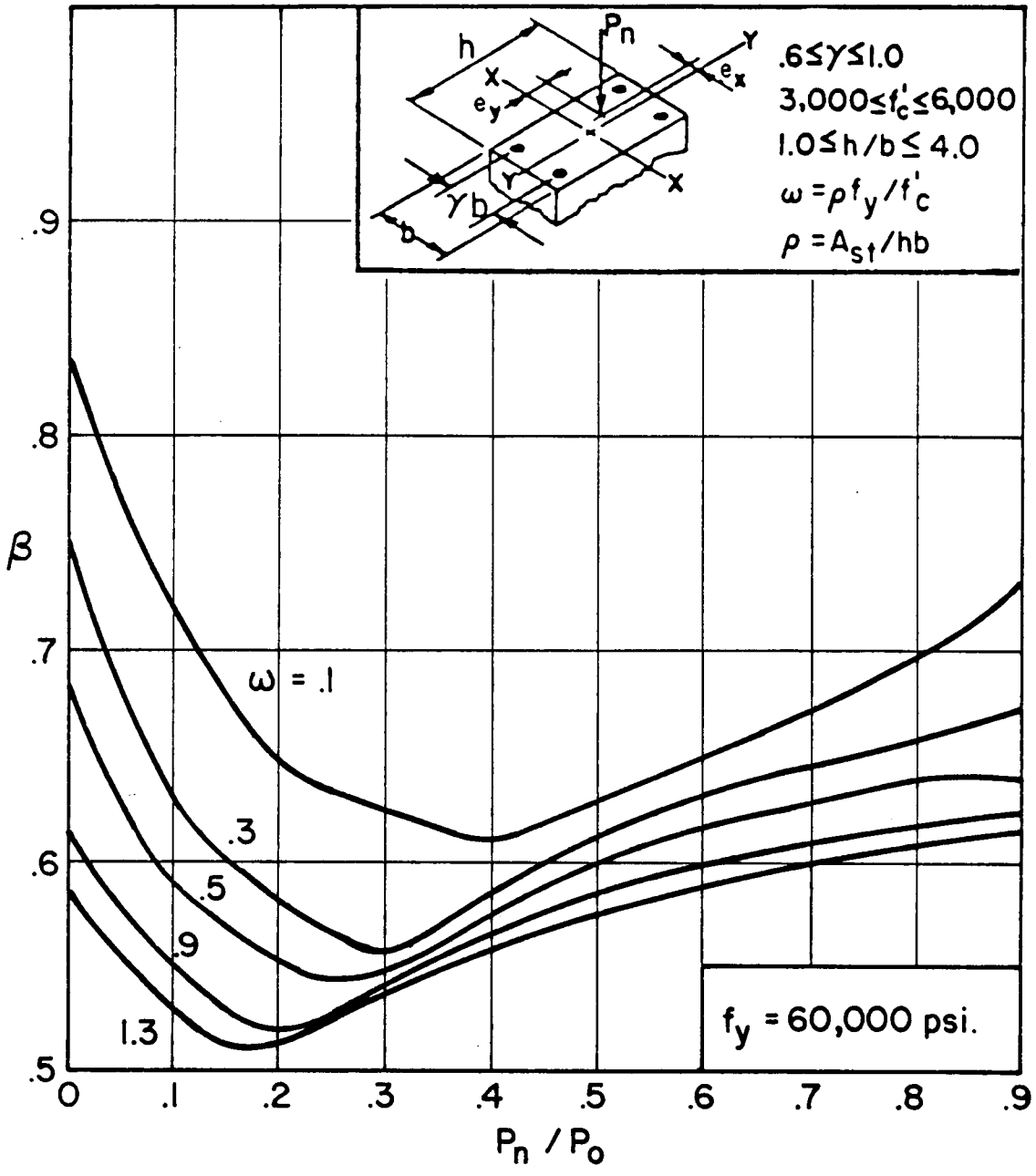


FIGURE 31

BIAXIAL BENDING DESIGN CONSTANTS FOR
A FOUR BAR ARRANGEMENT

SOURCE: Neville, Gerald B., ed. Notes on ACI 318-83: Building Code Requirements for Reinforced Concrete with Design Applications. Fourth Edition. Skokie, Illinois: Portland Cement Association, 1984.

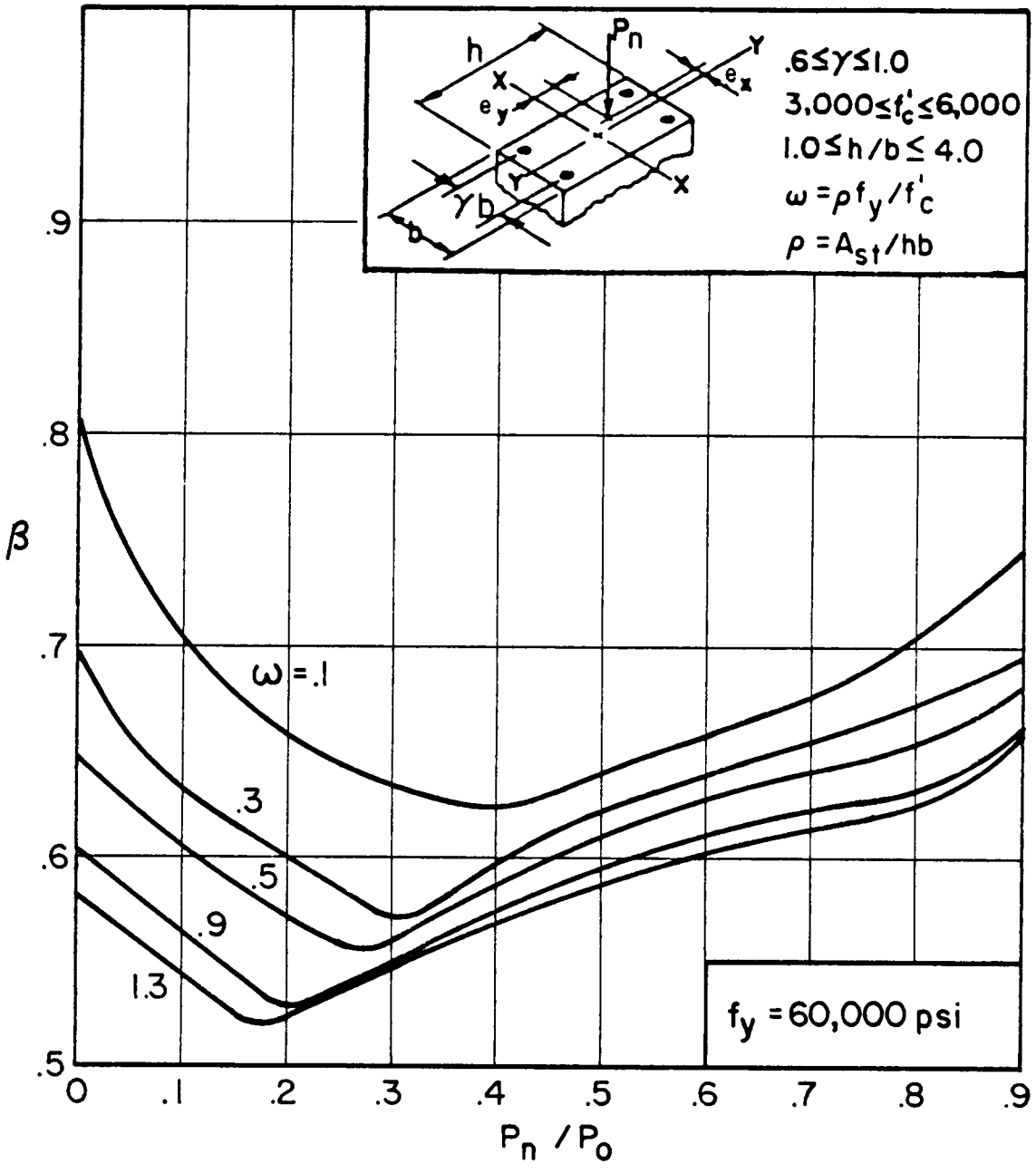


FIGURE 32

BIAXIAL BENDING DESIGN CONSTANTS FOR
A SIX, EIGHT OR TEN BAR ARRANGEMENT

SOURCE: Neville, Gerald B., ed. Notes on ACI 318-83: Building Code Requirements for Reinforced Concrete with Design Applications. Fourth Edition. Skokie, Illinois: Portland Cement Association, 1984.

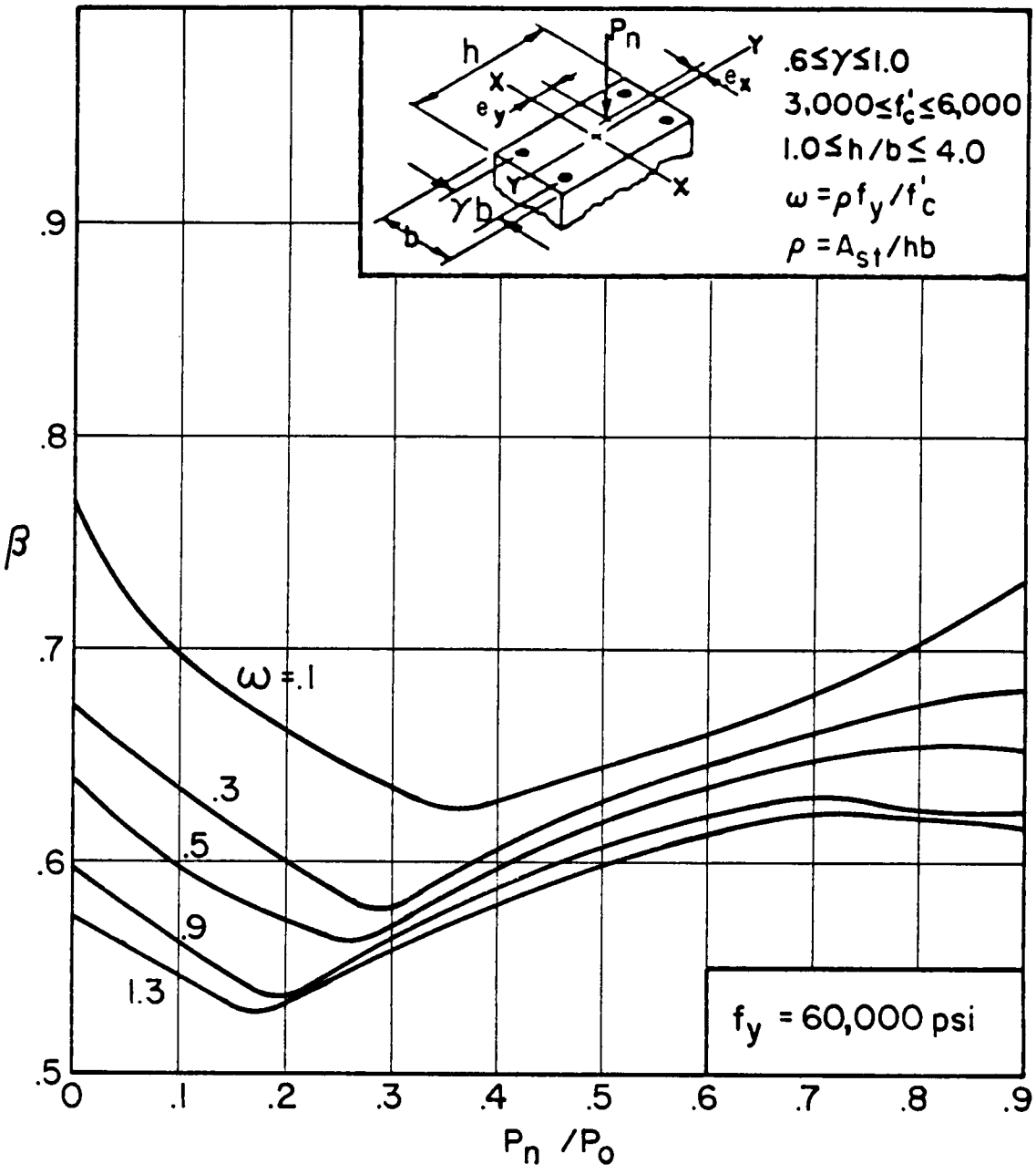


FIGURE 33

BIAXIAL BENDING DESIGN CONSTANTS FOR AN ARRANGEMENT OF TWELVE OR MORE BARS

SOURCE: Neville, Gerald B., ed. Notes on ACI 318-83: Building Code Requirements for Reinforced Concrete with Design Applications. Fourth Edition. Skokie, Illinois: Portland Cement Association, 1984.

strong direction is determined using equation 1.5-7. For bending in the weak direction, Fb = .75Fy is assigned as indicated in Section 1.5.1.4.3.

Channels, Split-Tees and Double Angles in Contact

These members are evaluated under Section 1.5.1.4.5-2a for determination of allowable bending stress in the strong direction. Double angles in contact and split-tees are analyzed for bending moment compression in the flange only. For bending in the weak direction, Fb = .6Fy is assigned as indicated in Section 1.5.1.4.5-2b. The user should note that double angles in contact are assumed to have a sufficient number of connections between each angle to allow the shape to act as a split-tee, thereby giving a means to calculate a reduced Fb based on unbraced length. Double angles with separators or single angles must be braced at specified limits to allow bending and no provisions are given for reduction of Fb based on unbraced length.

Single Angles and Double Angles with Separators

These members are assigned a value of Fb = .6Fy under Section 1.5.1.4.5-2b. The program then prints a warning which indicates the maximum unbraced length allowed for any bending to occur about the strong axis as dictated by the flange description input by the user. The user should note that it was the writer's

assumption that when these type members are used, applied moments would likely be zero. The reference to strong axis bending in the warning is the terminology used in Section 1.5.1.4.5-2b, and no effort is made in the program to determine if this criteria is satisfied except to calculate the maximum unbraced length based on the input width of the compression flange. It may be seen that if single curvature bending occurs in an angle which is oriented such that one leg is in the vertical up position, the required bracing length is very restrictive. The user should be very careful evaluating these type members when bending is present.

Rectangular Tubes

Rectangular tubes are evaluated under Section 1.5.1.4.1, Paragraphs 1, 3, 4 and 6 to determine if they qualify as compact sections. If compact, Fb = .66Fy is assigned for bending in the strong direction. Otherwise, Fb = .6Fy is assigned for bending in the strong direction as indicated in Section 1.5.1.4.4. For bending in the weak direction, Fb = .66Fy is assigned as indicated in Section 1.5.1.4.3 in the last paragraph.

Round Pipes

Round pipes are evaluated under Section 1.5.1.4.1, Paragraph 7 to determine if they qualify as a compact section. If compact, Fb = .66Fy is assigned for the

allowable bending stress. Otherwise, Fb = .6Fy is assigned.

Interaction of the combined loads is evaluated on a particular shape and the user is given the option to revise the member if necessary.

The timber column option is written to analyze timber columns under axial and bending loads in compliance with the National Design Specification for Wood Construction (1982 Edition), published by the National Forrest Products Association. Properties used in examples in this paper are as indicated in A Supplement to the 1982 Edition National Design Specification for Wood Construction, published by the National Forrest Products Association.

Nomenclature

The following is an explanation of the variable names used in the program.

ACTTWEB - Total thickness of element acting as the web.

BFC - Width of element acting as the compression flange.

BFIN - Width of the flange of a rectangular tube from inside of web to inside of web.

BFWTTR - Rectangular tube flange width-to-thickness ratio.

BLIMITX - Braced frame limit of Klu/r in the weak direction for which slenderness may be neglected.

BLIMITY - Braced frame limit of Klu/r in the weak direction for which slenderness may be neglected.

DELTABX - Moment magnifier for gravity load moments in the strong direction.

DELTABY - Moment magnifier for gravity load moments in the weak direction.

DELTASX - Moment magnifier for lateral load moments in the strong direction.

DELTASY - Moment magnifier for lateral load moments in the weak direction.

E - Modulus of elasticity (KSI concrete and steel).

E - Modulus of elasticity (PSI wood).

FAACT - Actual Compressive stress.

FB - Allowable bending stress in timber column.

FB - Allowable bending stress with respect to the strong direction in a steel column.

FBACT - Actual bending stress with respect to the strong direction in a steel column.

FBY - Allowable bending stress with respect to the weak direction in a steel column.

FBYACT - Actual bending stress with respect to the weak direction in a steel column.

FPC - Reduced allowable axial compression.

FWTTR - Flange width-to-thickness ratio.

Ke - Column factor for timber columns.

LU - Unbraced length of compression flange.

LWTTR - Angle width-to-thickness ratio.

M1BX - Smaller gravity load end moment in the strong direction.

M1BY - Smaller gravity load end moment in the weak direction.

M2BX - Larger gravity load end moment in the strong direction.

M2BY - Larger gravity load end moment in the weak direction.

MAXFACDLX - Maximum factored dead load moment in the strong direction.

MAXFACDLY - Maximum factored dead load moment in the weak direction.

MAXFACTX - Maximum factored total load moment in the strong direction.

MAXFACTY - Maximum factored total load moment in the weak direction.

MUCOMBX - Equivalent uniaxial moment in the strong direction.

MUCOMBY - Equivalent uniaxial moment in the weak direction.

MUDX - Ultimate lateral load moment in the strong direction.

MUDY - Ultimate lateral load moment in the weak direction.

MUGX - Ultimate gravity load moment in the strong direction.

MUGY - Ultimate gravity load moment in the weak direction.

MWTTR - Maximum width-to-thickness ratio for single angle struts or double angle struts with separators to be considered fully effective.

MWTTRB - Maximum width-to-thickness ratio for double angle struts in contact, flanges of beams and flanges of channels to be considered fully effective.

MWTTRC - Maximum width-to-thickness ratio for split tee stems to be considered fully effective.

PCX - Critical load with respect to strong axis.

PCY - Critical load with respect to weak axis.

PU - Ultimate axial load.

PUSUM - Sum of ultimate axial loads for all columns in a story.

STD - Split tee depth.

SWTTR - Split tee stem width-to-thickness ratio.

TFC - Thickness of element acting as the compression flange.

TS - Thickness of split tee stem.

WDTTR - Rectangular tube web width-to-thickness ratio.

User Prompt Definitions

CHOOSE COLUMN OPTION

Select and input the number which corresponds with the column analysis desired.

IDENTIFICATION

Input a brief description of the member being analyzed (i.e., Col. B-7).

INPUT UNBRACED LENGTH WRT STRONG DIRECTION (FT.)

Input the unbraced length of the member in feet with respect to its strong direction.

INPUT UNBRACED LENGTH WRT WEAK DIRECTION (FT.)

Input the unbraced length of the member in feet with respect to its weak direction.

INPUT COLUMN FACTOR WRT STRONG AND WEAK AXIS Kx, Ky (318R-54)

Refer to Commentary on Building Code Requirements for Reinforced Concrete (ACI 318R-83), published by the American Concrete Institute. In that publication, on Page 54, will be a reference for determination of Kx and Ky. Input Kx and Ky by separating the values with a ",".

INPUT COLUMN DEPTH IN STRONG DIRECTION (IN.)

Input the depth of the column in its strong direction (in.). If square, input in any fashion.

INPUT COLUMN DEPTH IN WEAK DIRECTION (IN.)

Input the depth of the column in its weak direction (in.). If square, input in any fashion.

IS THIS COLUMN IN A BRACED FRAME? 1=YES 0=NO

Input 1 if column is not subject to sidesway. Input 0 if column is subject to sidesway.

INPUT SMALLER AND LARGER GL MOMENTS M1bx, M2bx, (K-FT.)

Input first the smaller gravity load end moment in the strong direction followed by input of the larger gravity load end moment in the strong direction, separating the values by a ",". (K-FT.) Input M1bx as a negative if the column is in double curvature.

INPUT SMALLER AND LARGER GL MOMENTS M1by, M2by (K-FT.)

Input first the smaller gravity load end moment in the weak direction followed by input of the larger gravity load end moment in the weak direction, separating the values by a ",". (K-FT.) Input M1by as a negative if the column is in double curvature.

INPUT ULTIMATE AXIAL LOAD (KIPS)

Input the factored axial load on the column (KIPS).

INPUT MODULUS OF ELASTICITY

Input modulus of elasticity of the concrete column (KSI).

INPUT GROSS INERTIA WRT X AND Y AXIS (IN.^ 4).

Input the gross moment of inertia with respect to the strong direction and the gross moment of inertia with

respect to the weak direction separating the values with a ",". (IN.^{4})

INPUT MAX. FACTORED DL MOMENT WRT X-DIR (POSITIVE K-FT.)

Input the maximum factored dead load moment with respect to the strong direction. The value should be entered as positive. (K-FT.)

INPUT MAX. FACTORED TOTAL MOMENT WRT X-DIR (POSITIVE K-FT.)

Input the maximum factored total load moment (including lateral effects) with respect to the weak direction. The value should be entered as a positive. (K-FT.)

INPUT MAX. FACTORED DL MOMENT WRT Y-DIR (POSITIVE K-FT.)

Input the maximum factored dead load moment with respect to the weak direction. The value should be entered as positive. (K-FT.)

INPUT MAX. FACTORED TOTAL MOMENT WRT Y-DIR (POSITIVE K-FT.)

Input the maximum factored total load moment (including lateral effects) with respect to the strong direction. The value should be entered as a positive. (K-FT.)

INPUT SUM OF ALL ULTIMATE AXIAL LOADS FOR ONE STORY (KIPS)

Input the total of all the ultimate axial loads for one story of the building. (KIPS)

DO YOU WANT TO CALC. SUM Pcx, Pcy OR SHALL I? 1=ME 0=YOU

If the user wishes to calculate the sum of Pcx and Pcy for all the columns in a story due to different sizes and orientation, he may do so by inputting 0. If not, the program will assume all column sizes and

orientations are the same as the one being considered and calculate the sum of Pcx and Pcy.

INPUT TOTAL NUMBER OF COLUMNS IN A STORY

Input the total number of columns in a story so the program can calculate sum of Pcx and Pcy.

INPUT ULT. GRAVITY LOAD MOMENT IN THE X-DIRECTION (K-FT.)

Input the ultimate moment in the strong direction resulting from only gravity loads. (K-FT.)

INPUT ULT. LATERAL LOAD MOMENT IN THE X-DIRECTION (K-FT.)

Input the ultimate moment in the strong direction resulting from only lateral loads. (K-FT.)

INPUT ULT. GRAVITY LOAD MOMENT IN THE Y-DIRECTION (K-FT.)

Input the ultimate moment in the weak direction resulting from only gravity loads. (K-FT.)

INPUT ULT. LATERAL LOAD MOMENT IN THE Y-DIRECTION (K-FT.)

Input the ultimate moment in the weak direction resulting from only lateral loads. (K-FT.)

DO YOU WANT TO ANALYZE FOR BIAXIAL BENDING? 1=YES 0=NO

Even if you have entered moments in two directions before this point, the program only recognizes biaxial bending at this point. Input 1 for biaxial analysis.

GO SELECT A SECTION AND COME BACK AND ENTER As (IN.^ 2).

With the equivalent one directional moment you now have and knowing the ultimate axial load, go to an appropriate column interaction curve and select the required reinforcing. Then input that reinforcing in

IN.^{2} so that the program may check the reinforcing by the PCA Load Contour Method.

INPUT $\frac{oMn}{Agh}$ From interact diagram

For the steel chosen read oMn/Agh at the curve point that corresponds with oPn/Ag.

Pn/Po = _____ OMEGA = _____ INPUT BETA (FIG. 31, 32 & 33)

Based on the area of steel input, the variables Pn/Po and OMEGA are as shown. These values are to be used to read beta from Figures 31, 32 or 33. When beta is read, it should be input.

INPUT LOG (BETA) EX. LOG (.5) = -.3

Calculate and input the Log of Beta.

SELECT MEMBER TYPE: 1=TUBE OR PIPE 2=OTHER

In steel shapes analyzed by this program, structural pipes and tubes are Type 1 and all other shapes are Type 2. Input corresponding shape.

INPUT UNBRACED LENGTH WRT X AND Y AXIS Lx, Ly (FT.)

Input the unbraced length of the member in the strong and weak directions. (FT.)

INPUT COLUMN FACTOR WRT X AND Y AXIS Kx, Ky (AISC 5-124)

Referring to Page 5-124 of the Manual of Steel Construction (Eighth Edition), published by the American Institute of Steel Construction, Inc., input

the appropriate K factors with respect to the strong and weak directions separating the values with a ",".

INPUT Cm WRT X AND Y AXIS Cmx, Cmy (AISC 5-26)

Referring to Page 5-26 of the above mentioned publication, input Cm with respect to the strong and weak directions separating the values with a ",".

1=L OR ⌋⌊ , 2=⌋⌊ IN CONTACT, 3=I, 4=T, 5=CHANNEL (CHOOSE)

Select and input the number that corresponds to the section being considered. 1=single angle or double angles with separators, 2=double angles in contact, 3=beam shape, 4=split tee, 5=channel.

INPUT MAXIMUM ANGLE LEG LENGTH (IN.)

Input the longest leg length (IN.).

INPUT ANGLE LEG THICKNESS (IN.)

Input the thickness of the angle (IN.).

INPUT FLANGE WIDTH (IN.)

Input the flange width of the beam shape or channel being checked (IN.).

INPUT FLANGE THICKNESS (IN.)

Input the thickness of the flange of the beam shape or channel being checked (IN.).

INPUT DEPTH OF SPLIT-TEE (IN.)

Input the total depth of the split-tee shape being checked (IN.).

INPUT THICKNESS OF STEM (IN.)

Input the thickness of the stem of the split-tee shape being checked (IN.).

IS THIS A ROUND PIPE SHAPE? 1=YES 0=NO

Request to determine if the member is a rectangular structural tube or a round pipe.

INPUT THE BOX WIDTH, DEPTH, WALL THICKNESS W, D, Tw (IN.)

Input the nominal width, depth and wall thickness of the rectangular structural tube being checked.

INPUT SECTION AREA (IN.∧ 2)

Input the cross sectional area of the section being considered ($IN.^2$).

INPUT RADIUS OF GYRATION WRT X AND Y AXIS (IN.) rx, ry

Input the radius of gyration of the member being considered in its strong and weak directions separating the data by a ",".

IS THIS A SECONDARY OR BRACING MEMBER? 1=YES 0=NO

The allowable axial stress for a secondary or bracing member is calculated differently than for a main member if KL/R is greater than 120. Input 1 if this is a bracing member.

INPUT SECTION DEPTH (IN.)

Input the total depth of the beam shape being considered (IN.).

INPUT THICKNESS OF WEB (IN.)

Input the thickness of the web of the beam shape being considered.

INPUT UNBRACED LGTH. OF COMPRESSION FLG. WRT BENDING (FT.)

Input the unbraced length of the beam shape column flange with respect to bending in the strong direction (FT.).

INPUT Cb WRT STRONG DIRECTION BENDING (AISC 5-22)

Referring to Page 5-22 of the above mentioned publication, input Cb with respect to bending in the strong direction. This is used to determine the allowable bending stress in beam shapes, channels, split-tees and double angles in contact.

INPUT WIDTH OF ANGLE LEG ACTING AS COMP. FLANGE (IN.)

Input the width of the angle leg acting as a compression flange. (IN.) This input is used to calculate the maximum unbraced length that will allow bending in a fashion where an angle leg is acting as a flange. If a vertical leg is in compression, the result will be that almost continuous support is required. It is the user's responsibility to assure that these criteria are acceptable.

INPUT TOTAL WIDTH OF ELEMENT ACTING AS COMP. FLG. (IN.)

Input the total width of the section being considered acting as a compression flange. (IN.) This is used to

calculate the allowable bending stress in split-tees, channels and double angles in contact.

INPUT DIST. FROM EXTREME COMPRESSION FIBER TO N.A. (IN.)

Input the distance from the neutral axis of the section being considered to the extreme compression fiber. (IN.) This is used to calculate the allowable bending stress in split-tees, channels and double angles in contact.

INPUT THICKNESS OF ELEMENT ACTING AS THE WEB (IN.)

Input the thickness of the element acting as the web. If the double angles in contact are used, input twice the leg thickness.

INPUT UNBRACED LENGTH WRT COMP. FLANGE (FT.)

Input the unbraced length of the element acting as the compression flange. This is used to calculate the allowable bending stress in split-tees, channels and double angles in contact.

INPUT X-BAR OF CHNL. AS LISTED IN AISC TABLES (IN.)

Input the distance from the channel face to its center of gravity as listed in the above mentioned publication.

INPUT UNBRACED LGTH. OF MAJOR COMP. FLG. WRT BENDING (FT.)

This is input to check a tube for allowable bending stress under Section 1.5.1.4.1, Paragraph 6 of the Manual of Steel Construction (Eighth Edition). Although biaxial bending may be applied, this check is

for maximum unbraced length of the obvious or major compression flange (i.e., in a 6" x 4" tube, the major compression flange would be the 4" side.).

INPUT THE SMALLER END MOM. IN MAJOR. DIR. [M1](K-FT.)

Similar to above.

INPUT THE LARGER END MOM. IN MAJOR DIR. [M2](K-FT.)

Similar to above.

INPUT OUTSIDE DIAMETER OF PIPE (IN.)

Input the actual outside diameter of the structural pipe being considered (IN.) (Usually larger than nominal dimension.).

INPUT PIPE WALL THICKNESS (IN.)

Input the actual wall thickness of the structural pipe being considered (IN.).

INPUT Sx, Sy (IN.^ 3)

Input the section modulus of the section being considered with respect to the strong and weak directions separating the values with a ",". For double angles with separators, use twice the value of Sy for a single angle. For double angles in contact, the user must calculate Sy.

INPUT Mx, My (K-FT.)

Input the applied moments to be analyzed (may be different from end moments) in the strong and weak directions (K-FT.).

(1.6-1a)= _____ (1.6-1b)= _____ REVISE? 1=YES 0=NO

The program is providing the solution to the column interaction equations required by the Manual of Steel Construction (Eighth Edition) The user has the option to revise the shape if necessary.

(1.6-2)= _____ REVISE? 1=YES 0=NO

Similar to above.

INPUT COLUMN FACTOR [Ke] (NDS 80)

Referring to Page 80 of the National Design Specification for Wood Construction, input Ke.

INPUT MATERIAL DESCRIPTION

Input species identification (i.e., So. Pine, No.2 KD-15)

INPUT MODULUS OF ELASTICITY (PSI) [NDS SUPPLEMENT]

Referring to A Supplement to the 1982 Edition National Design Specification for Wood Construction, input E for the species chosen (PSI).

INPUT ALLOWABLE COMPRESSION PARALLEL TO GRAIN (PSI)

Input the allowable compressive stress parallel to the grain as listed in the above publication for the species chosen.

ARE MOMENTS APPLIED TO THE COLUMN? 1=YES 0=NO

Request to determine if interaction analysis is necessary.

INPUT ALLOWABLE COMPRESSIVE BENDING STRESS (PSI)

Input the allowable compressive bending stress as listed in the above publication for the species chosen.

Examples

Example 3-1

Before demonstration of the program, it should be pointed out that the following concrete column assumptions have been made. 1) Gravity loads do not result in appreciable lateral deflection; therefore, Cm is always calculated under braced frame conditions. 2) No transverse loading occurs between supports. 3) End moments are of a magnitude that preclude the use of minimum eccentricities to determine the minimum end moments. 4) To properly evaluate the gravity load moment magnifier described in Assumption 1, the value of K in evaluating Pc is always taken as 1.0 in both braced and unbraced frames for determination of δb. This is proper for an unbraced frame fitting the above assumptions, but is restrictive for a braced frame that could qualify for a K value of less than 1.0 and would result in a higher than necessary gravity load magnifier. It should be pointed out that K=1 for a braced frame is allowed by the ACI Code. K for calculation of δs remains as input. The user should carefully review the situation being analyzed to assure that these conditions are satisfied and are not overly conservative.

Referring to Figure 34, the use of the program to analyze an unbraced slender concrete column with biaxial bending will be demonstrated.

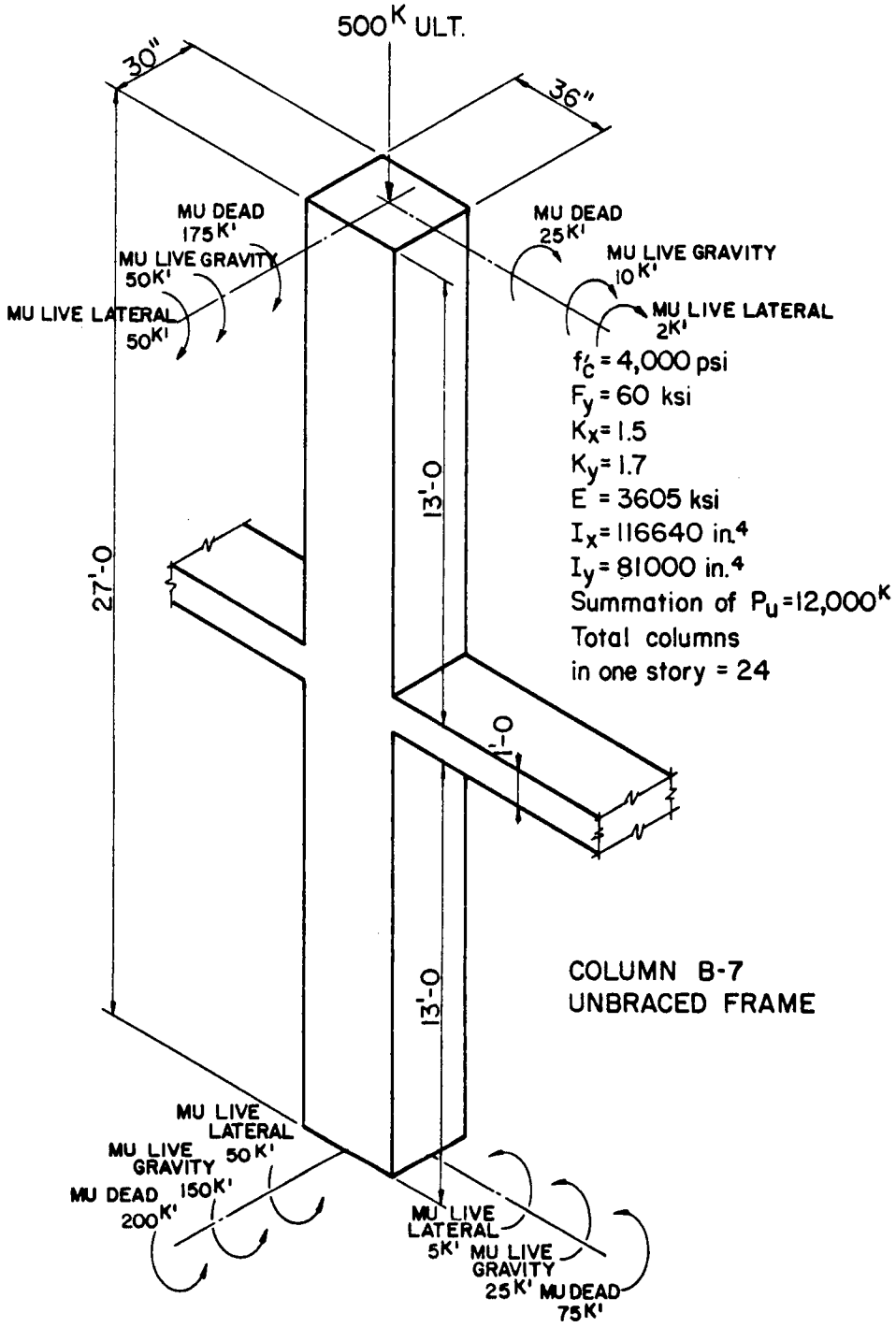


FIGURE 34

EXAMPLE 3-1 COLUMN CONFIGURATION

The program begins with the screen displaying "CHOOSE COL. OPTION: 1=CONCRETE 2=STEEL 3=TIMBER?". Input 1 and press RETURN. The screen then displays "IDENTIFICATION?". This is a request for some identifying number or name. Input COLUMN B-7 and press RETURN.

The printer then displays this identification. The screen then displays "INPUT UNBRACED LGTH. WRT STRONG DIRECTION (FT.)". The strong direction would be in the plane of the 36" column dimension. Input 13 and press RETURN. The screen then displays "INPUT UNBRACED LGTH. WRT WEAK DIRECTION (FT.)?". Input 27 and press RETURN.

The screen then displays "INPUT COLUMN FACTOR WRT STRONG AND WEAK AXIS Kx, Ky (318R-54)?". This is a request for the effective length factor (K), which describes the end restraint of the column in both directions. The information in parenthesis is a reference to the concrete code commentary giving information on K selection. Input 1.5,1.7 and press RETURN. Note that the input is separated by a ",".

The screen next displays "INPUT COLUMN DEPTH IN STRONG DIRECTION (IN.)?". Input 36 and press RETURN. The screen then displays "INPUT COLUMN DEPTH IN WEAK DIRECTION (IN.)?". Input 30 and press RETURN. The screen then displays "IS THIS COLUMN IN A BRACED FRAME? 1=YES 0=NO?". Input 0 and press RETURN.

The printer then indicates the limits at which slenderness may be neglected and further indicates that this column must include slenderness effects due to the unbraced length in the weak direction.

The screen next displays "INPUT ULTIMATE AXIAL LOAD (KIPS)?". Input 500 and press RETURN. The screen then displays "INPUT MODULUS OF ELASTICITY (KSI)?". Input 3605 and press RETURN. The screen then displays "INPUT GROSS INERTIA WRT X AND Y AXIS Ix, Iy (IN.^ 4)?". It should be noted that throughout the program the x-axis is understood to be the axis about which bending in the strong direction of the member occurs. Input 116640,81000 and press RETURN.

The screen then displays "INPUT MAX. FACTORED DL MOMENT WRT X-DIR (POSITIVE K-FT)?". Input 200 and press RETURN. The screen then displays "INPUT MAX. FACTORED TOT. MOMENT WRT X-DIR (POSITIVE K-FT)?". Referring to Figure 34, this total would be 200 K-Ft. dead added to 200 K-Ft. total live. Input 400 and press RETURN. This input is used to calculate β_d in code equation (10-11).

The screen next displays "INPUT MAX. FACTORED DL MOMENT WRT Y-DIR. (POSITIVE K-FT.)?". Input 75 and press RETURN. The screen then displays "INPUT MAX. FACTORED TOT. MOMENT WRT Y-DIR (POSITIVE K-FT.)?". Input 105 and press RETURN.

The screen then displays "INPUT SMALLER AND LARGER GL MOMENTS M1bx, M2bx (K-FT.)?". It can be seen from Figure 34 that the column is bent in single curvature in both

directions; therefore, M1bx and M1by will be input as positive values. Input 225,350 and press RETURN. The screen then displays "INPUT SMALLER AND LARGER GL MOMENTS M1by, M2by (K-FT.)?". Input 35,100 and press RETURN.

The printer then displays the moment magnifiers for gravity load moments in the x and y directions, which in this case is 1.0 for both.

The screen then displays "INPUT SUM OF ALL ULTIMATE AXIAL LOADS FOR ONE STORY (KIPS)?". As this is an unbraced frame, a separate magnifier must be used for lateral drift moments. This information is used to calculate this factor. Input 12000 and press RETURN.

The screen next displays "DO YOU WANT TO CALC. SUM Pcx, Pcy OR SHALL I? 1=ME 0=YOU?". In order to calculate the drift magnifier, it is necessary to know the sum of all of the critical buckling loads with respect to the x and y axis for all the columns in the story being considered. If various column sizes, orientations and bracing conditions are used, the user should calculate this data for input. If the option is used to let the program calculate these values, the assumption is that all columns are the same size and are oriented and braced in the same way as the column being considered. Input 1 and press RETURN.

The screen then displays "INPUT TOTAL NUMBER OF COLUMNS IN A STORY?". Input 24 and press RETURN.

The printer then displays the assumptions used to calculate the critical buckling loads as described previously. The printer further indicates the lateral load moment magnifiers for the x and y directions, which in this example are 1.03664 and 1.47547 respectively.

The screen then displays "INPUT ULT. GRAVITY LOAD MOMENT IN THE X-DIRECTION (K-FT.)?". Input 350 and press RETURN. The screen then displays "INPUT ULT. LATERAL LOAD MOMENT IN THE X-DIRECTION (K-FT.)?". Input 50 and press RETURN.

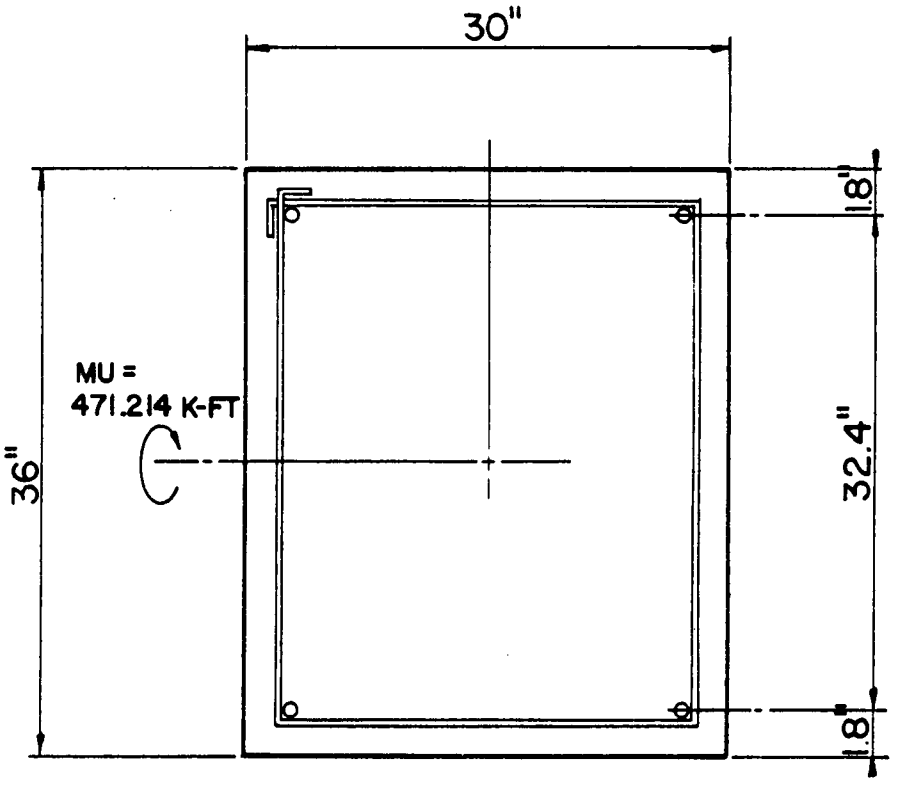
The screen then displays "INPUT ULT. GRAVITY LOAD MOMENT IN THE Y-DIRECTION (K-FT.)?". Input 100 and press RETURN. The screen then displays "INPUT ULT. LATERAL LOAD MOMENT IN THE Y-DIRECTION (K-FT.)?". Input 5 and press RETURN. The printer then displays the magnified moments in the strong and weak directions, which in this example are 401.832 kip-feet and 107.377 kip-feet respectively.

The screen then displays "DO YOU WANT TO ANALYZE FOR BIAXIAL BENDING? 1=YES 0=NO?". Input 1 and press RETURN. Because a slenderness analysis has just been run, the program knows the ultimate moments in the strong and weak directions. The printer displays the approximate uniaxial ultimate moment for which the column is to be designed, which in this example is 471.214 kip-feet. The printer further displays the relationship that must be satisfied by

the reinforcing chosen in order to verify the capacity of the column using the PCA Load Contour Method (Neville 11-8).

The screen displays "GO SELECT A SECTION AND COME BACK AND ENTER As (IN.^ 2)?". It is the intention of the program to verify by the above mentioned method, reinforcing chosen for the uniaxial moment indicated. Therefore, referring to Figure 35, it may been seen from the reinforcing layout that χ is .9. For Pu=500 kips and Mu about the x-axis=471.214 kip-feet and referring to Figure 30, it appears that minimum reinforcing is all that is required. Select 16-#8 bars yielding a reinforcing ratio of .0117. In response to the prompt that remains on the screen, input 12.64 and press RETURN.

The screen then displays "INPUT REINFORCING DESCRIPTION?". Input 16-#8 and press RETURN. The screen then displays "INPUT f'c (KSI)?". Input 4 and press RETURN. The screen then displays "INPUT Fy (KSI)?". Input 60 and press RETURN. The printer then displays the reinforcing ratio and the input data. The printer further displays the value of oPn/Ag as .462963 and the screen displays "INPUT oMn/Agh From interact. diagram?". This is a request to do the following: From the vertical scale of the interaction diagram shown in Figure 30, find oPn/Ag=.46. From this point, move horizontally to the right until intersection with a reinforcing ratio of .0117 is attained. At this point, move vertically down the page to the bottom



$P_u = 500^K$

$\alpha = 32.4 / 36 = .9$

FIGURE 35

EXAMPLE 3-1 COLUMN REINFORCING LAYOUT

horizontal scale and read oMn/Agh=.33±. Input .33 and press RETURN. The screen then displays "Pn/Po=.162803 OMEGA=.175556 INPUT BETA (FIGURE 31,32 OR 33)?". Referring to Figure 33 for 12 or more bars and using the values displayed on the screen, read the biaxial bending design constant =.67±. Input .67 and press RETURN.

The screen then displays "INPUT LOG (.67) EX. LOG (.5)=-.3?". The Epson Computer used for programming has only a natural logrhythm function. Therefore, the LOG of a number must be input. Input -.1739 and press RETURN.

The printer then displays the values required for input into the PCA verification equation and indicates the value of this equation to be .210821. Since this value is less than 1.0, the relationship is satisfied and the reinforcing chosen is valid. The screen then displays "REVISE? 1=YES 0=NO?". Input 0 and press RETURN.

The printer then displays the remaining input. A print-out of the tape resulting from this example is illustrated in Figure 36.

Figures 37 through 49 illustrate other applications of this program and the resulting print-out tapes. Input for the steel and timber options is significantly less complicated than that for concrete. Review of user prompt definitions should provide adequate guidance to the user without additional detailed example dialogue.

```
COLUMN B-7
```

```
SLENDERNESS MUST BE
CONSIDERED!
(K*Lx*12)/rx= 21.6667
(K*Ly*12)/ry= 61.2
LIMIT TO NEGLECT=22
```

```
MOMENT MAGNIFIER FOR
GRAVITY LOAD MOMENTS
IN X-DIRECTION
= 1

MOMENT MAGNIFIER FOR
GRAVITY LOAD MOMENTS
IN Y-DIRECTION
= 1
◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆
NOTE:
ALL COLUMNS ASSUMED TO
BE THE SAME SIZE AND TO
BE ORIENTED IN THE SAME
DIRECTION
◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆
MOMENT MAGNIFIER FOR
LATERAL LOAD MOMENTS
IN X-DIRECTION
= 1.03664
MOMENT MAGNIFIER FOR
LATERAL LOAD MOMENTS
IN Y-DIRECTION
= 1.47547
   MAGNIFIED MOMENTS
Mux= 401.832 K-FT.
Muy= 107.377 K-FT.
APPROXIMATE UNIAXIAL ULT
MOMENT APPLIED IN THE
STRONG DIRECTION IS
 471.214 K-FT.
```

```
VERIFICATION BY P.C.A
LOAD CONTOUR METHOD:

  Mnx   log[.5]/log[beta]
(------)
  Mnox
+
  Mny   log[.5]/log[beta]
(------)
  Mnoy

<1.0       EQ.(8)
```

```
As/Ac= 1.17037E-02
Fy= 60 KSI
f'c= 4 KSI
As= 12.64 IN.^2
[16-#8]
Po= 4387.42 KIPS
```

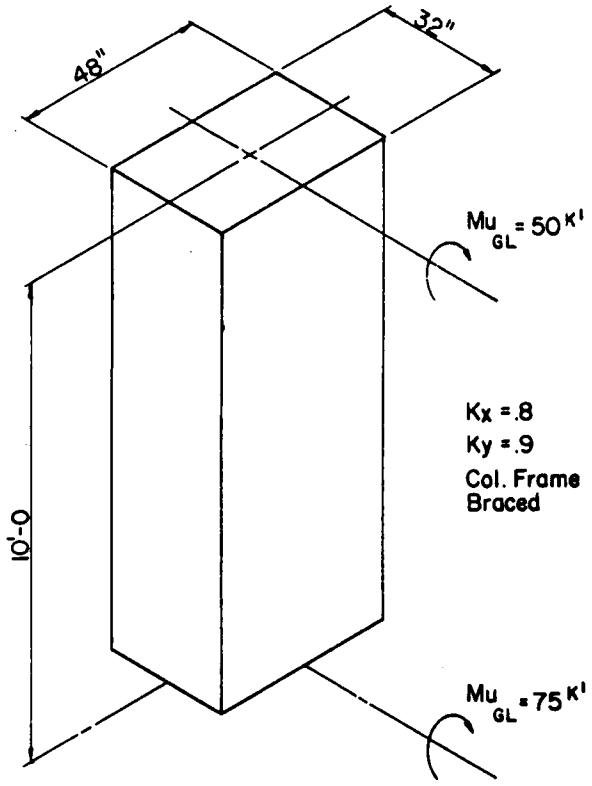
$$\frac{\phi P_N}{A_s} = \frac{500}{1080} = .462963$$

```
Mnx= 574.046 K-FT.
Mnox= 1527.43 K-FT.
Mny= 153.396 K-FT.
Mnoy= 1272.86 K-FT.
log[.5]/log[beta]=
 1.72513
EQ(8)= .210821
```

```
COLUMN 36 x 30 IN.
Lx= 13 FT.
Ly= 27 FT.
Kx= 1.5
Ky= 1.7
COLUMN FRAME SYSTEM IS
UNBRACED
Cmx= .857143
Cmy= .74
SUM OF Pu= 12000 KIPS
SUM OF ΦPcx= 339546 KIPS
SUM OF ΦPCY= 37238.2
KIPS
Ix= 116640 IN.^4
Iy= 81000 IN.^4
E= 3605 KSI
Mux= 401.832 K-FT.
Muy= 107.377 K-FT.
ACI EQ.(10-11) USED
TO CALCULATE EI
```

FIGURE 36

COLUMN EXAMPLE 3-1 TAPE PRINT-OUT



EXAMPLE 3-2

```
(K*Lx*12)/rx= 6.66667
(K*Ly*12)/ry= 11.25
LIMIT TO NEGLECT
WRT X-DIRECTION
= 26
LIMIT TO NEGLECT
WRT Y-DIRECTION
= 34
NEGLECT SLENDERNESS
```

```
COLUMN 48 x 32 IN.
Lx= 10 FT.
Ly= 10 FT.
Kx= .8
Ky= .9
COLUMN FRAME SYSTEM IS
BRACED
```

FIGURE 37

NON-SLENDER CONCRETE COLUMN IN A BRACED FRAME AND EXAMPLE OF RESULTING PRINT-OUT TAPE

Kx = 1.8

Ky = 1.9

Pu = 1000^{K}

E = 3605 KSI

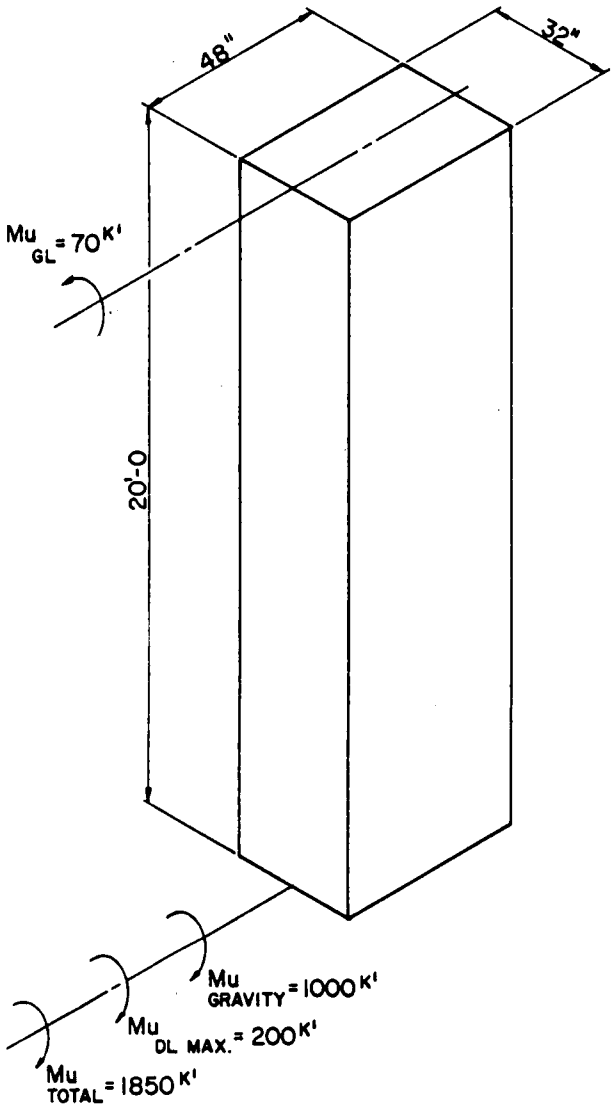
Ix = 294912 IN^4

Iy = 131072 IN^4

Σ Pu = 10,000 KIPS

10 COLUMNS TOTAL

COLUMN FRAME UNBRACED




```
EXAMPLE 3-3
-------------------------------
SLENDERNESS MUST BE
CONSIDERED!
(K*Lx*12)/rx= 30
(K*Ly*12)/ry= 47.5
LIMIT TO NEGLECT=22
-------------------------------
MOMENT MAGNIFIER FOR
GRAVITY LOAD MOMENTS
IN X-DIRECTION
= 1

MOMENT MAGNIFIER FOR
GRAVITY LOAD MOMENTS
IN Y-DIRECTION
= 1
◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆
NOTE:
ALL COLUMNS ASSUMED TO
BE THE SAME SIZE AND TO
BE ORIENTED IN THE SAME
DIRECTION
◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆
MOMENT MAGNIFIER FOR
LATERAL LOAD MOMENTS
IN X-DIRECTION
= 1.06783
MOMENT MAGNIFIER FOR
LATERAL LOAD MOMENTS
IN Y-DIRECTION
= 1.21427
-------------------------------
   MAGNIFIED MOMENTS
Mux= 0 K-FT.
Muy= 1789.27 K-FT.
-------------------------------

-------------------------------
COLUMN 48 X 32 IN.
Lx= 20 FT.
Ly= 20 FT.
Kx= 1.8
Ky= 1.9
COLUMN FRAME SYSTEM IS
UNBRACED
Cmx= .6
Cmy= .623333
SUM OF Pu= 10000 KIPS
SUM OF oPcx= 157430 KIPS
SUM OF oPCY= 56671 KIPS
Ix= 294912 IN.^4
Iy= 131072 IN.^4
E= 3605 KSI
ACI EQ.(10-11) USED
TO CALCULATE EI
-------------------------------
```

FIGURE 38

SLENDER CONCRETE COLUMN IN AN UNBRACED FRAME WITH BENDING ABOUT THE MINOR AXIS AND EXAMPLE OF RESULTING PRINT-OUT TAPE

Kx = .8

Ky = .8

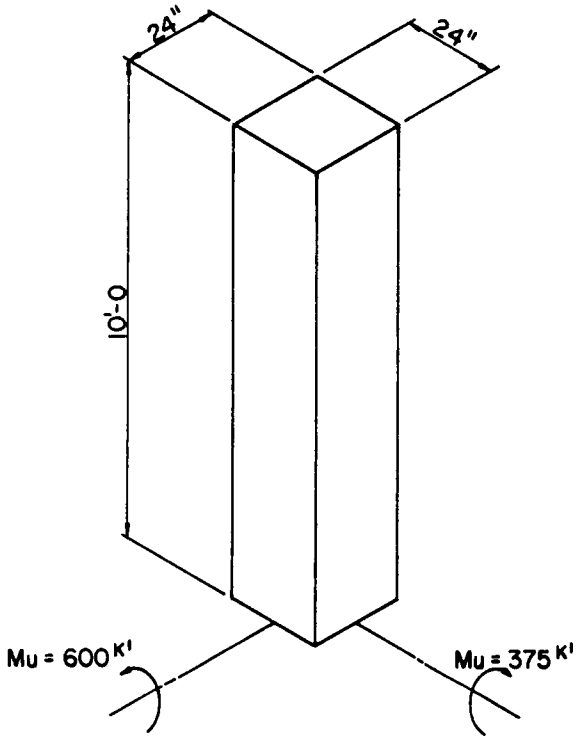
Pu = 1000^{K}

$f'c$ = 4 KSI

Fy = 60 KSI

δ = .8

COLUMN FRAME
UNBRACED



EXAMPLE 3-4

(K*Lx*12)/rx= 13.3333
(K*Ly*12)/ry= 13.3333
LIMIT TO NEGLECT=22
NEGLECT SLENDERNESS

APPROXIMATE UNIAXIAL ULT
MOMENT APPLIED IN THE
STRONG DIRECTION IS
801.923 K-FT.

VERIFICATION BY P.C.A
LOAD CONTOUR METHOD:

$$\left(\frac{Mnx}{Mnox}\right)^{\log[.5]/\log[beta]} + \left(\frac{Mny}{Mnoy}\right)^{\log[.5]/\log[beta]} < 1.0 \qquad \text{EQ. (8)}$$

As/Ac= 5.20833E-02
Fy= 60 KSI
f'c= 4 KSI
As= 30 IN.^2
[30-#9]
Po= 3656.4 KIPS

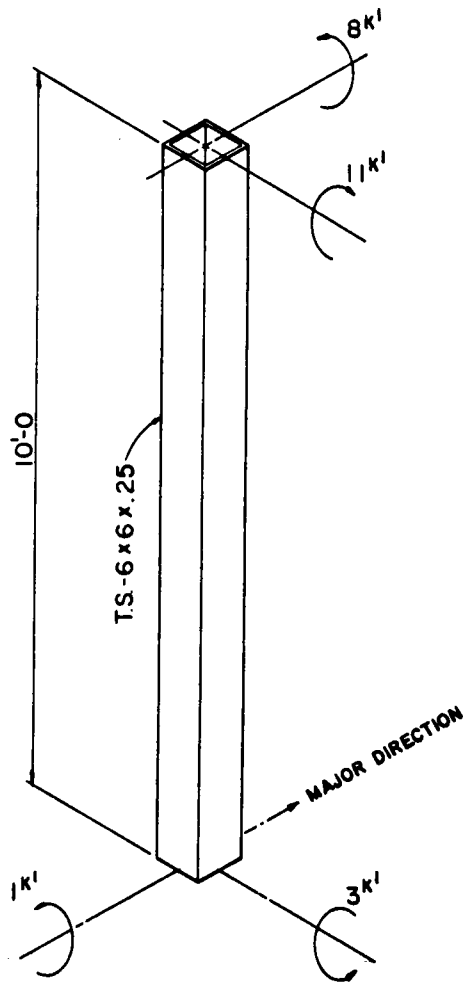
$$\frac{\phi PN}{As} = \frac{1000}{576} = 1.73611$$

Mnx= 857.143 K-FT.
Mnox= 1234.29 K-FT.
Mny= 535.714 K-FT.
Mnoy= 1234.29 K-FT.
log[.5]/log[beta]=
1.30947
EQ(8)= .955566

COLUMN 24 x 24 IN.
Lx= 10 FT.
Ly= 10 FT.
Kx= .8
Ky= .8
COLUMN FRAME SYSTEM IS
UNBRACED
Mux= 600 K-FT.
Muy= 375 K-FT.

FIGURE 39

NON-SLENDER CONCRETE COLUMN WITH BIAXIAL BENDING AND EXAMPLE OF RESULTING PRINT-OUT TAPE



Fy = 46 KSI

E = 29,000 KSI

Kx = 1.2

Ky = 1.2

Cmx = .85

Cmy = .85

P = 20K

COLUMN FRAME
UNBRACED

EXAMPLE 3-5

TS6X6X1/4 IS
FULLY EFFECTIVE

Fy= 46 KSI
E= 29000 KSI
Lx= 10 FT.
Ly= 10 FT.
Kx= 1.2
Ky= 1.2
Cmx= .85
Cmy= .85
AXIAL LOAD= 20 KIPS
Mx= 11 K-FT.
My= 8 K-FT.
UNBRACED LENGTH OF THE
COMPRESSION FLANGE IN
BENDING= 10 FT.

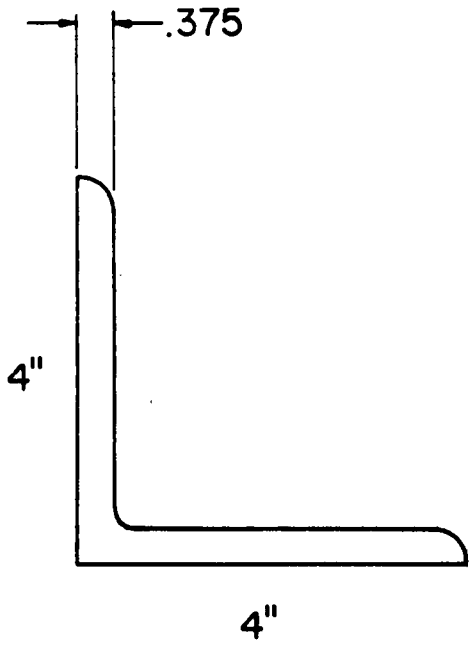
Fa= 21.0126 KSI
Fbx= 30.36 KSI
Fby= 30.36 KSI

fa= 3.57782 KSI
fbx= 13.0693 KSI
fby= 9.50495 KSI

(1.6-1a)= .865954
(1.6-1b)= .873184

FIGURE 40

STRUCTURAL RECTANGULAR STEEL TUBE IN FRAME SYSTEM SUBJECTED TO SIDESWAY WITH BIAXIAL BENDING AND EXAMPLE OF RESULTING PRINT-OUT TAPE



Fy = 36 KSI
E = 29,000 KSI
Lx = Ly = 6'
Kx = 1 Kz = 1
Ky = 1
Cmx = .6
Cmy = .6
P = 20^{K}

EXAMPLE 3-6

L4X4X3/8 IS
FULLY EFFECTIVE

NOTE:L4X4X3/8 MUST BE
BRACED AT INTERVALS NOT
LESS THAN 4.22222 FT.
IN ORDER TO ALLOW
BENDING ABOUT THE
STRONG AXIS.(AISC 5-23)

Fy= 36 KSI
E= 29000 KSI
Lx= 6 FT.
Ly= 6 FT.
Lz= 6 FT.
Kx= 1
Ky= 1
Kz= 1
Cmx= .6
Cmy= .6
AXIAL LOAD= 20 KIPS
Mx= 0 K-FT.
My= 0 K-FT.

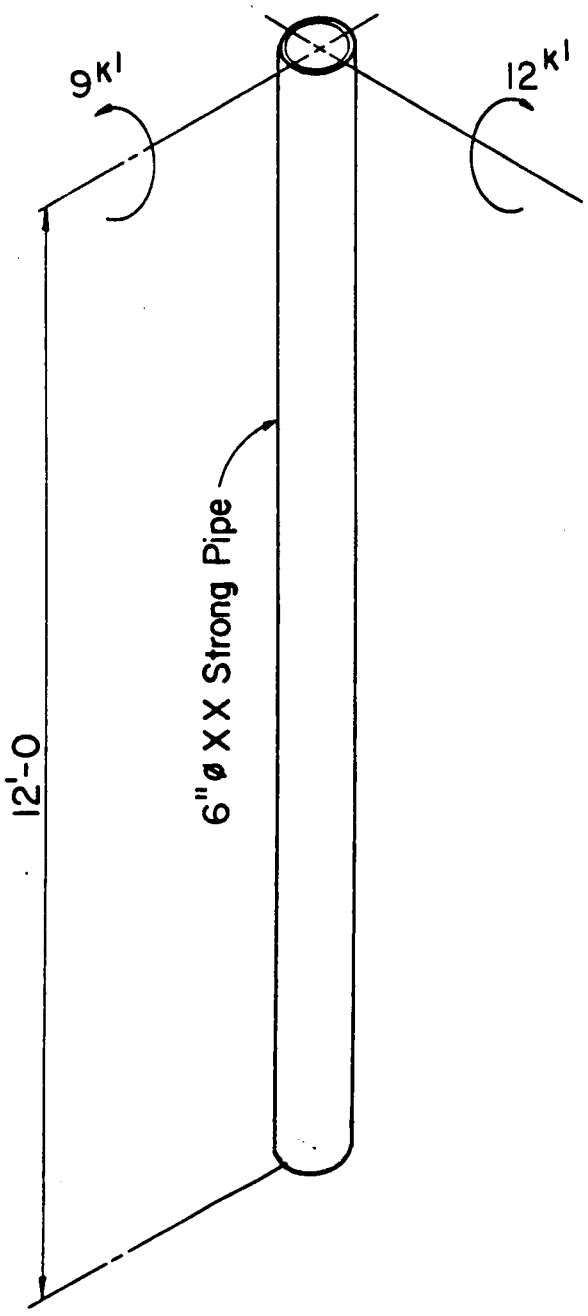
Fa= 14.0409 KSI
Fbx= 21.6 KSI
Fby= 21.6 KSI

fa= 6.99301 KSI
fbx= 0 KSI
fby= 0 KSI

(1.6-1a)= .498047
(1.6-1b)= .32375

FIGURE 41

SINGLE STEEL ANGLE ACTING AS A COMPRESSION
BRACE WITH NO APPLIED MOMENTS AND
EXAMPLE OF RESULTING PRINT-OUT TAPE



Fy = 36 KSI

E = 29,000 KSI

Kx = 1.2

Ky = 1.2

Cmx = .85

Cmy = .85

P = 20K

COLUMN FRAME
UNBRACED

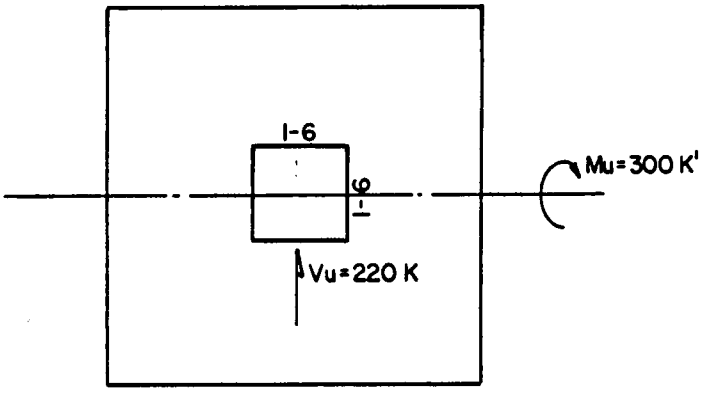
```
EXAMPLE 3-7
-------------------------------
6 IN. DIA. XX-STRONG IS
FULLY EFFECTIVE

Fy= 36 KSI
E= 29000 KSI
Lx= 12 FT.
Ly= 12 FT.
Kx= 1.2
Ky= 1.2
Cmx= .85
Cmy= .85
AXIAL LOAD= 20 KIPS
Mx= 9 K-FT.
My= 12 K-FT.
-------------------------------
Fa= 14.9172 KSI
Fbx= 23.76 KSI
Fby= 23.76 KSI
-------------------------------
fa= 1.28205 KSI
fbx= 5.4 KSI
fby= 7.2 KSI
-------------------------------
(1.6-2)= .616248
```

FIGURE 42

STRUCTURAL STEEL ROUND STEEL PIPE IN A FRAME SYSTEM SUBJECTED TO SIDESWAY WITH BIAXIAL BENDING AND EXAMPLE OF RESULTING PRINT-OUT TAPE

TYPICAL INTERIOR FOOTING



f'c = 3000 PSI
Fy = 60 KSI
Safe Bearing Pressure = 10 KSF
Overburden = 3-6
Pu = 800 K

```
TYP. INT. FTG.

FOOTING: 9.5 X 9.5 X
 2.25
P= 516.13 KIPS
Mx= 193.55 K-FT
My= 0 K-FT
Vx= 141.94 KIPS
Vy= 0 KIPS
OVERBURDEN= 3.5 FT

FSOTX= 5.36493
FSOTY=INFINITE
MAXIMUM BEARING
PRESSURE= 9.99605 KSF
ULT. BEAM SHEAR=
 277.324 KIPS
  ALLOWABLE=
 293.47 KIPS
ULT. PUNCHING SHEAR=
 800.002 KIPS
PUNCHING CAPACITY=
 1089.7 KIPS
PUNCHING CAPACITY
LIMIT= 854.666 KIPS

▒▒ ULTIMATE MOMENTS ▒▒

PRIM. BOTT. = 1058.82 K-FT
WEAK BOTT. = 754.692 K-FT
PRIM. TOP= 0 K-FT
WEAK TOP= 0 K-FT

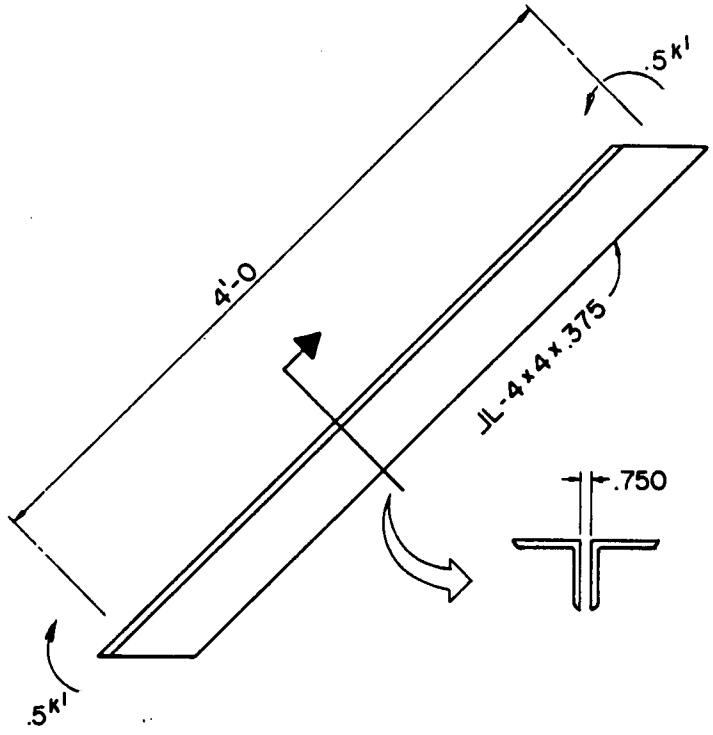

▀▀▀ REINFORCING ▀▀▀

BOTT. STEEL PRIMARY=
    10.4963 SQ. IN. [TOT.]
BOTT. STEEL WEAK=
    9.80934 SQ. IN. [TOT.]
NO PRIM. TOP STL. REQ'D.

NO WEAK TOP STL. REQ'D.
```

FIGURE 55

SQUARE FOOTING AND LOADING AND EXAMPLE
OF RESULTING PRINT-OUT TAPE



Fy = 36
E = 29,000 KSI
Kx = .75 Kz = .75
Ky = .75
Cmx = .4
Cmy = .4
P = 49k

EXAMPLE 3-8

LL4X4X3/8 IS
FULLY EFFECTIVE

NOTE:LL4X4X3/8 MUST BE
BRACED AT INTERVALS NOT
LESS THAN 4.22222 FT.
IN ORDER TO ALLOW
BENDING ABOUT THE
STRONG AXIS. (AISC 5-23)

Fy= 36 KSI
E= 29000 KSI
Lx= 4 FT.
Ly= 4 FT.
Lz= 4 FT.
Kx= .75
Ky= .75
Kz= .75
Cmx= .4
Cmy= .4
AXIAL LOAD= 49 KIPS
Mx= .5 K-FT.
My= 0 K-FT.

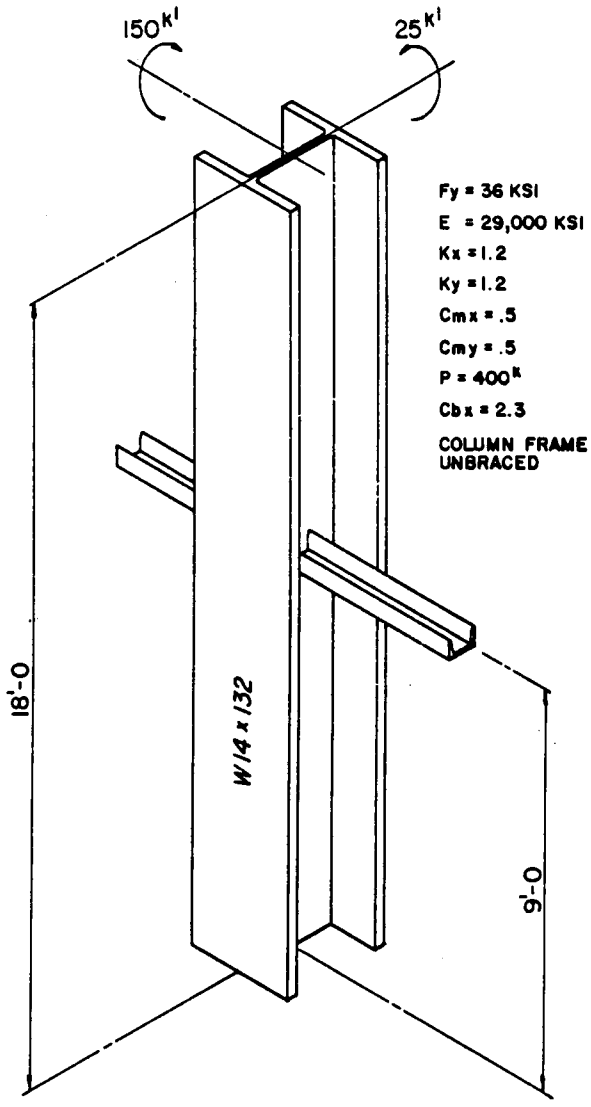
Fa= 18.7226 KSI
Fbx= 21.6 KSI
Fby= 21.6 KSI

fa= 8.56643 KSI
fbx= 1.96721 KSI
fby= 0 KSI

(1.6-1a)= .495857
(1.6-1b)= .487669

FIGURE 43

DOUBLE STEEL ANGLES WITH SEPARATORS ACTING AS A TRUSS DIAGONAL MEMBER WITH SMALL MOMENTS APPLIED TO ENDS AND EXAMPLE OF RESULTING PRINT-OUT TAPE




```
EXAMPLE 3-9

W14X132 IS
FULLY EFFECTIVE

**************************
SECTION NON-COMPACT

Lu= 15.5431 FT.

**************************

Fy= 36 KSI
E= 29000 KSI
Lx= 18 FT.
Ly= 9 FT.
Kx= 1.2
Ky= 1.2
Cmx= .5
Cmy= .5
AXIAL LOAD= 400 KIPS
Mx= 150 K-FT.
My= 25 K-FT.
UNBRACED LENGTH OF THE
COMPRESSION FLANGE IN
BENDING= 18 FT.

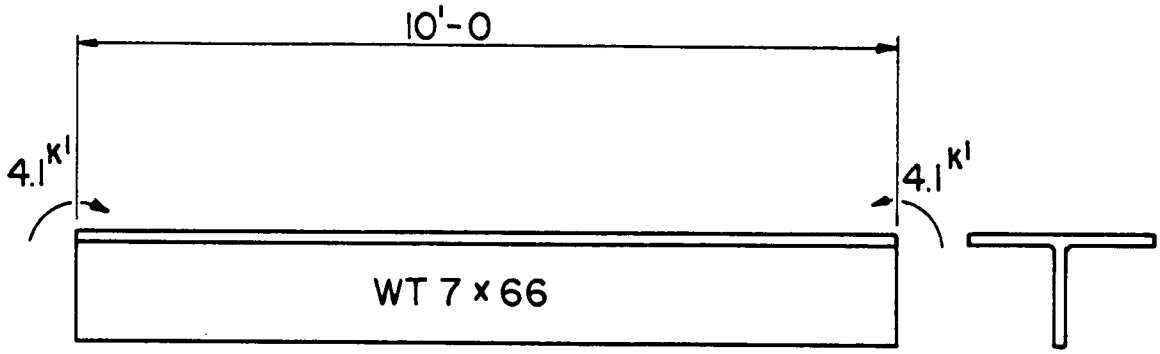
Fa= 19.0871 KSI
Fbx= 21.6 KSI
Fby= 27 KSI

fa= 10.3093 KSI
fbx= 8.61244 KSI
fby= 4.02685 KSI

(1.6-1a)= .847285
(1.6-1b)= 1.02515
```

FIGURE 44

WIDE FLANGE STEEL COLUMN IN A FRAME SYSTEM SUBJECTED TO SIDESWAY WITH BIAXIAL BENDING AND EXAMPLE OF RESULTING PRINT-OUT TAPE



Fy = 36 KSI
E = 29,000 KSI
Kx = .65
Ky = .65
Cmx = .5
Cmy = .5
P = 290 K
Cb = 1.9

```
EXAMPLE 3-10
-------------------------------

WT7X66 IS
FULLY EFFECTIVE

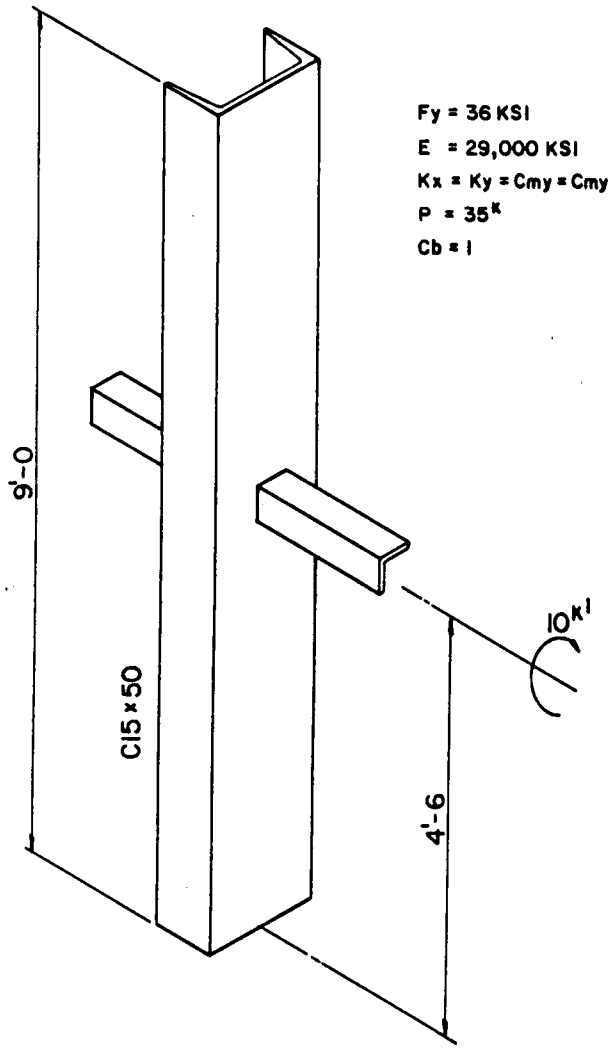
EXAMPLE 3-10
-------------------------------

WT7X66 IS
FULLY EFFECTIVE

Fy= 36 KSI
E= 29000 KSI
Lx= 10 FT.
Ly= 10 FT.
Kx= .65
Ky= .65
Cmx= .5
Cmy= .5
AXIAL LOAD= 290 KIPS
Mx= 4.1 K-FT.
My= 0 K-FT.
UNBRACED LENGTH OF THE
COMPRESSION FLANGE IN
BENDING= 10 FT.
-------------------------------
Fa= 18.773 KSI
Fbx= 21.6 KSI
Fby= 21.6 KSI
-------------------------------
fa= 14.9485 KSI
fbx= 5.14107 KSI
fby= 0 KSI
-------------------------------
(1.6-1a)= .945682
(1.6-1b)= .93007
```

FIGURE 45

STEEL SPLIT-TEE ACTING AS TOP CHORD OF A TRUSS WITH APPLIED END MOMENTS AND EXAMPLE OF RESULTING PRINT-OUT TAPE




```
EXAMPLE 3-11

C10X15.3 IS
FULLY EFFECTIVE

EXAMPLE 3-11

C15X50 IS
FULLY EFFECTIVE

Fy= 36 KSI
E= 29000 KSI
Lx= 9 FT.
Ly= 4.5 FT.
Kx= 1
Ky= 1
Cmx= 1
Cmy= 1
AXIAL LOAD= 35 KIPS
Mx= 10 K-FT.
My= 0 K-FT.
UNBRACED LENGTH OF THE
COMPRESSION FLANGE IN
BENDING= 9 FT.

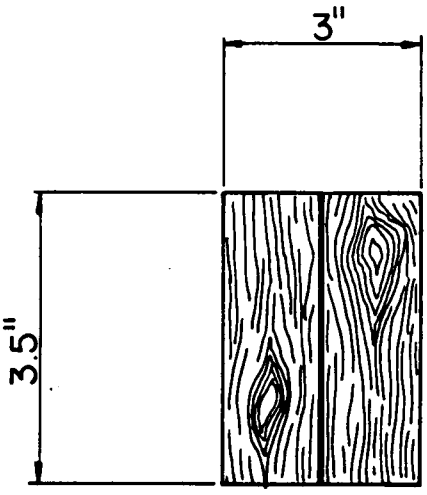
Fa= 17.208 KSI
Fbx= 3.44408 KSI
Fby= 21.6 KSI

fa= 2.38095 KSI
fbx= 2.23048 KSI
fby= 0 KSI

(1.6-2)= .785992
```

FIGURE 46

STEEL CHANNEL WITH SIMPLE SPAN MOMENT RESULTING FROM A GIRT REACTION WHERE GIRT DOES NOT BRACE COMPRESSION FLANGE AND EXAMPLE OF RESULTING PRINT-OUT TAPE



Lx = 10'
Ly = 3'
Ke = 1.0
E = 1,600,000 PSI
Fc = 1,150 PSI
P = 4,000#

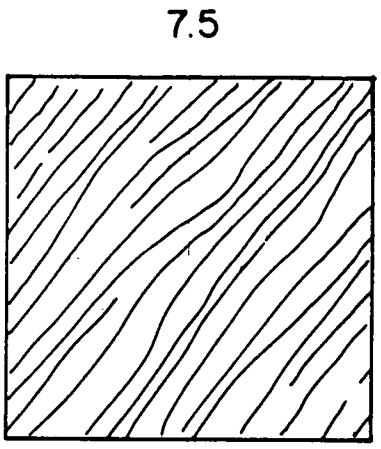
```
EXAMPLE 3-12
 3 x 3.5
NO.2 SO.PINE KD 15

LONG COLUMN
F'c= 408.334 PSI

Lx= 10 FT.
Ly= 3 FT.
Ke= 1
E= 1.6E+06 PSI
Fc= 1150 PSI
AREA= 10.5 IN.^2
P= 4000 POUNDS
fa= 380.952 PSI
```

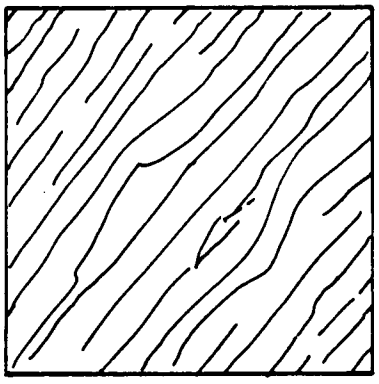
FIGURE 47

DOUBLE TIMBER STUDS ACTING TO RESIST A LINTEL REACTION AND EXAMPLE OF RESULTING PRINT-OUT TAPE



Lx = 10'
Ly = 10'
Ke = 1.0
E = 1,500,000 PSI
Fc = 725 PSI
P = 15,000
Mx = My = 18,000 in-lb
Fb = 750 PSI
Sx = Sy = 70.313 in.^{3}

```
EXAMPLE 3-13
▒▒▒
```



Lx = 4'
Ly = 4'
Ke = 1.0
E = 1,500,000 PSI
Fc = 725 PSI
P = 40,000#

EXAMPLE 3-14

7.5 x 7.5
NO.3 SO.PINE KD 15

SHORT COLUMN
F'c= 725 PSI

Lx= 4 FT.
Ly= 4 FT.
Ke= 1
E= 1.5E+06 PSI
Fc= 725 PSI
AREA= 56.25 IN.^2
P= 40000 POUNDS
fa= 711.111 PSI

FIGURE 49

TIMBER STUB COLUMN SUBJECTED TO AXIAL LOAD ONLY AND EXAMPLE OF RESULTING PRINT-OUT TAPE

Flow Chart

Figure 50 describes the chronological operation of the program.

Program Copy

Figure 51 is a print-out of the "COLUMNS" program. A wide margin is provided to allow the user to make notes, if desired.

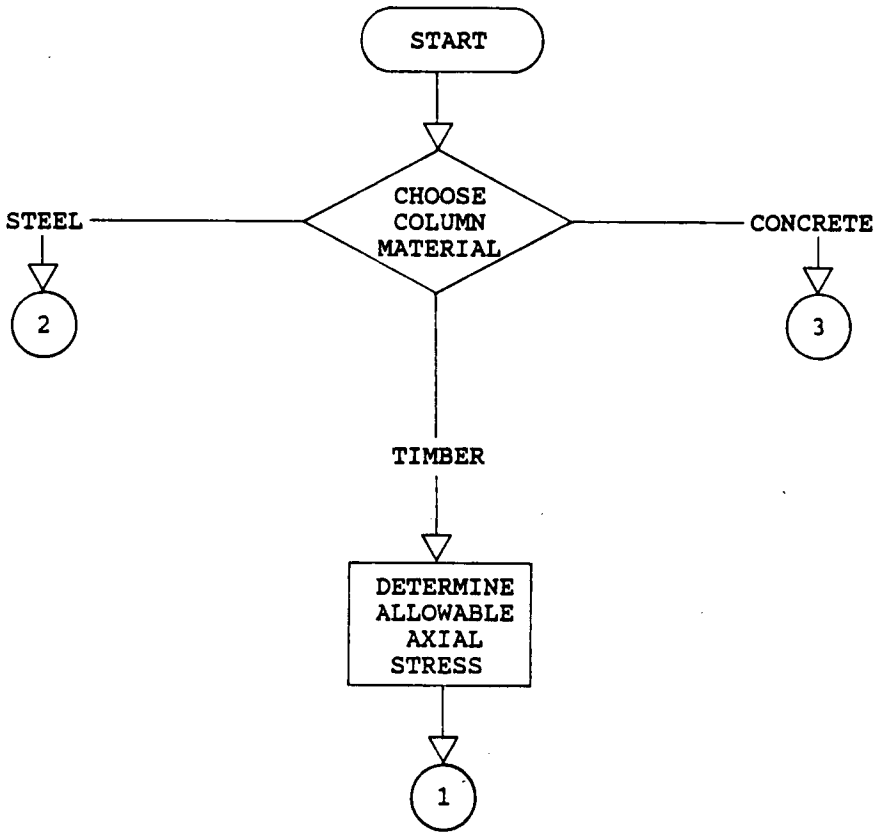


FIGURE 50

COLUMNS PROGRAM FLOW CHART

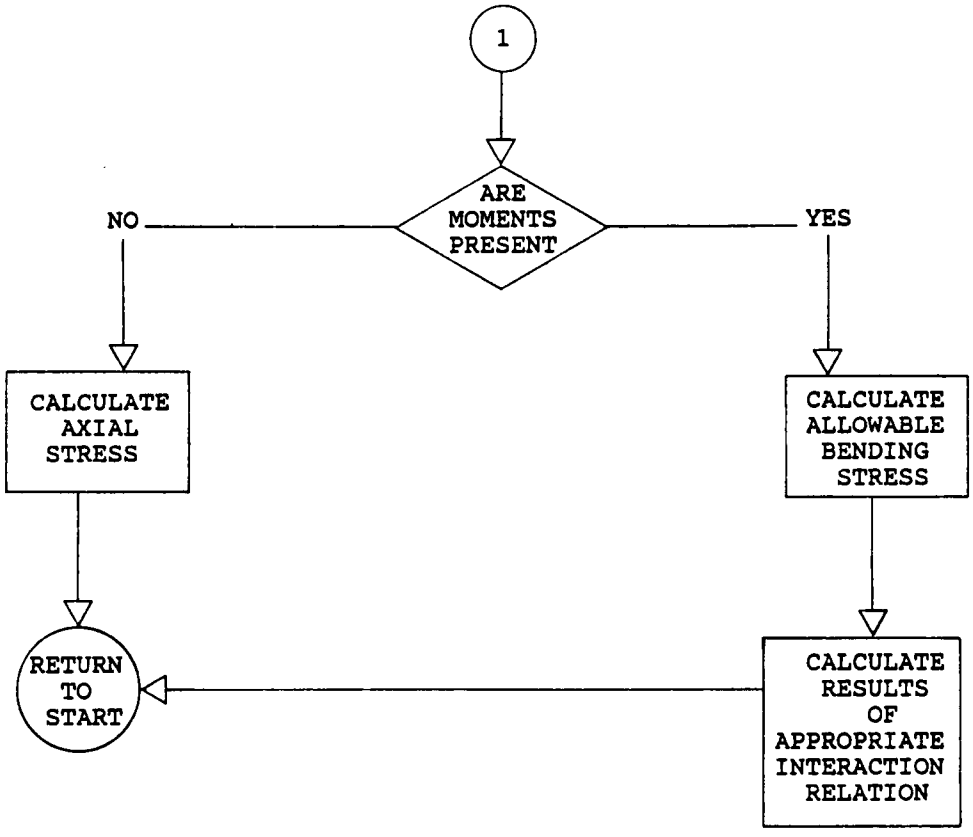


FIGURE 50 (Continued)

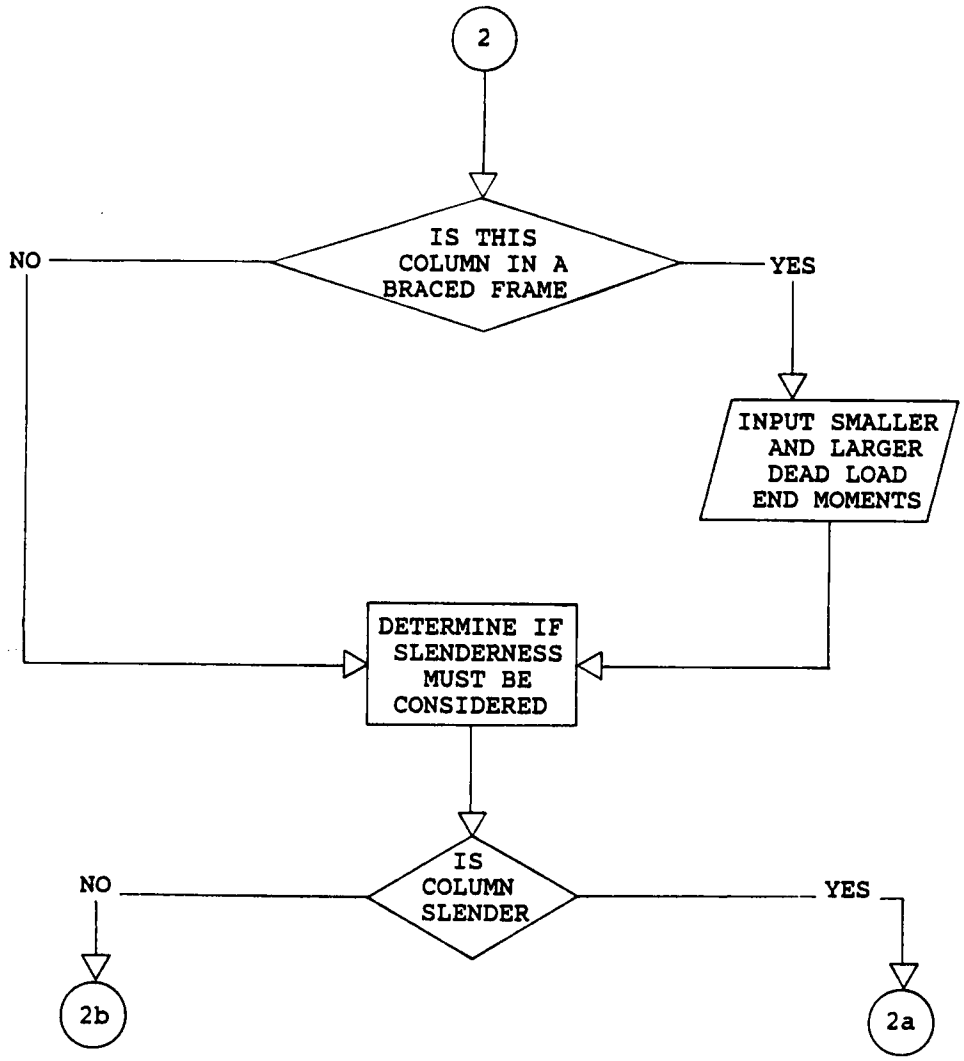


FIGURE 50 (Continued)

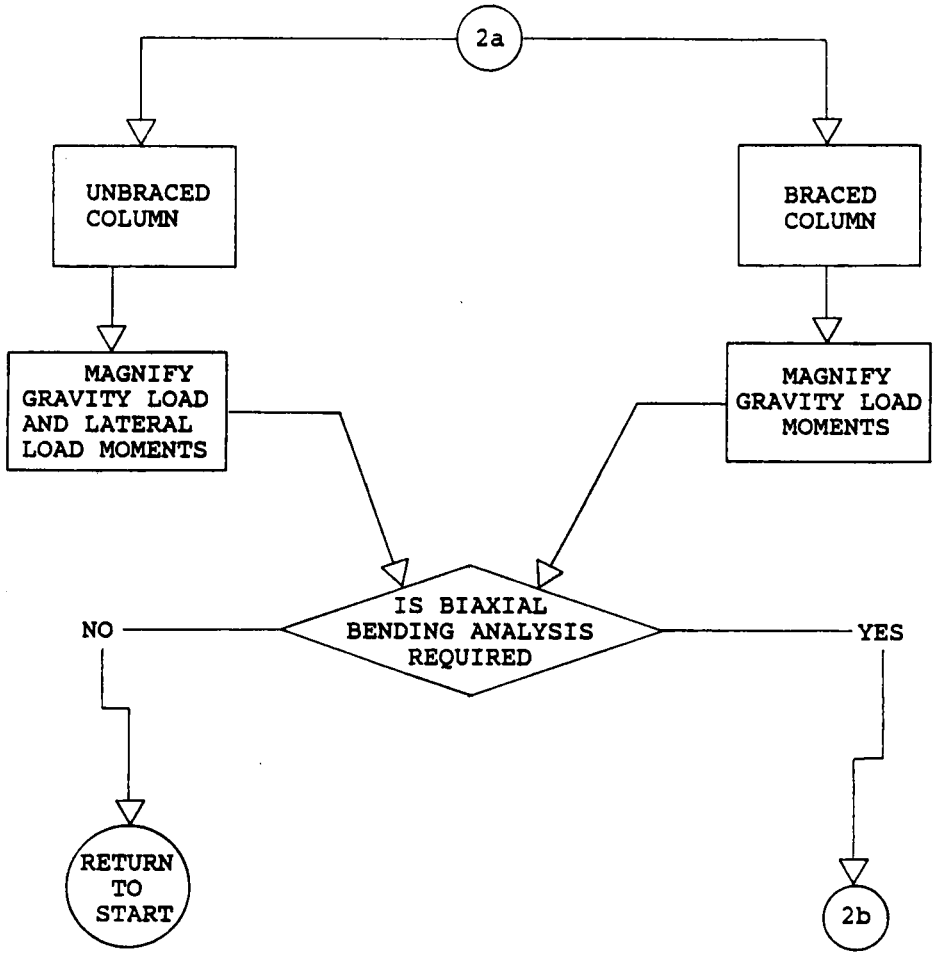


FIGURE 50 (Continued)

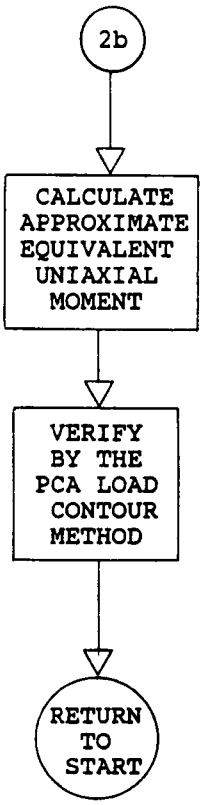


FIGURE 50 (Continued)

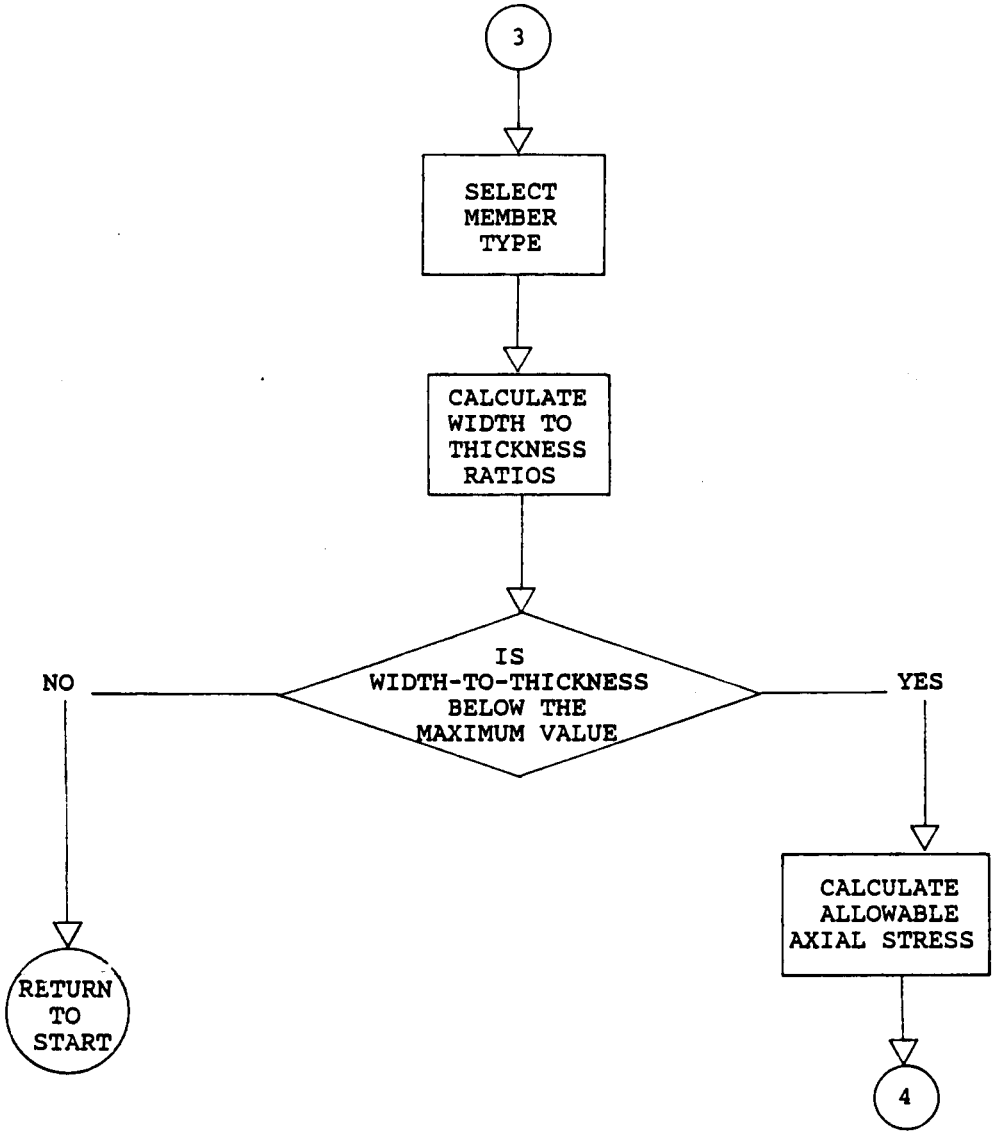


FIGURE 50 (Continued)

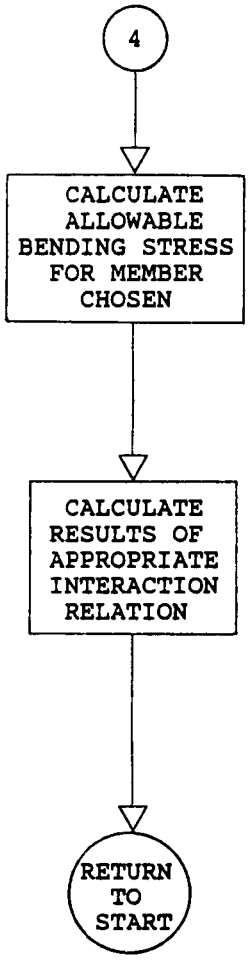


FIGURE 50 (Continued)

START

```
1 CLS
2 MUCO^BX=0
3 MUCO^BY=0
4 WEAK=0
5 BAD=0:BILL=0
6 LONG=0:PU=0
7 SHOR^=0
8 REVI 3E=0
9 YO=0
10 PRINT"CHOOSE COL. OPTI
ON:"
11 PRINT"1=CONCRETE 2=ST
EEL"
12 PRINT"3=TIMBER"
13 INPUT CHOICE
14 CLS
15 IF CHOICE=1 GOTO 18
16 IF CHOICE=2 GOTO 254
17 IF CHOICE=3 GOTO 652
```

CONCRETE

```
18 PRINT"IDENTIFICATION"
19 INPUT C$:CLS
20 LPRINT C$:LPRINT"[redacted]"
21 LPRINT""
22 PRINT"INPUT UNBRACED
LGTH."
23 PRINT"WRT STRONG DIRE
CTION"
24 PRINT"(FT.)"
25 INPUT LX:CLS
26 PRINT"INPUT UNBRACED
LGTH."
27 PRINT"WRT WEAK DIRECT
ION"
28 PRINT"(FT.)"
29 INPUT LY:CLS
30 PRINT"INPUT COLUMN FA
CTOR"
31 PRINT"WRT STRONG AND
WEAK"
32 PRINT"AXIS Kx,Ky (318
R-54)"
33 INPUT KX,KY:CLS
34 PRINT"INPUT COLUMN DE
PTH"
35 PRINT"IN STRONG DIREC
TION"
36 PRINT"(IN.)"
37 INPUT DX:CLS
38 PRINT"INPUT COLUMN DE
PTH"
39 PRINT"IN WEAK DIRECTI
ON"
40 PRINT"(IN.)"
41 INPUT DY:CLS
42 RX=.3*DX
43 RY=.3*DY
```

FIGURE 51

COLUMNS PROGRAM PRINT-OUT

```
44 KLRX=(KX*LX*12)/RX
45 KLRY=(KY*LY*12)/RY
46 PRINT"IS THIS COLUMN
IN"
47 PRINT"A BRACED FRAME?
"
48 PRINT"1=YES 0=NO"
49 INPUT BRACED:CLS
50 IF KLRX>KLRY THEN KLR
=KLRX ELSE KLR=KLRY
51 IF BRACED=0 AND KLR<2
2 THEN GOTO 150
52 IF BRACED=0 GOTO 60
53 IF BRACED=1 THEN PRIN
T"INPUT SMALLER AND":PRI
NT"LARGER GL MOMENTS":PR
INT"M1bx,M2bx (K-FT.)":I
NPUT M1BX,M2BX:CLS
54 IF BRACED=1 THEN PRIN
T"INPUT SMALLER AND":PRI
NT"LARGER GL MOMENTS":PR
INT"M1by,M2by (K-FT.)":I
NPUT M1BY,M2BY:CLS
55 IF M1BX=0 THEN BLIMIT
X=34 ELSE BLIMITX=34-(12
*(M1BX/M2BX))
56 IF M1BY=0 THEN BLIMIT
Y=34 ELSE BLIMITY=34-(12
*(M1BY/M2BY))
57 IF BRACED=1 AND KLRX>
BLIMITX THEN GOTO 60
58 IF BRACED=1 AND KLRY>
BLIMITY THEN GOTO 60
59 IF BRACED=1 GOTO 150
60 LPRINT"----------
----------"
61 LPRINT"SLENDERNESS MU
ST BE"
62 LPRINT"CONSIDERED!"
63 LPRINT"(K*Lx*12)/rx="
KLRX
64 LPRINT"(K*Ly*12)/ry="
KLRY
65 IF BRACED=0 THEN LPRI
NT"LIMIT TO NEGLECT=22"
66 IF BRACED=1 THEN LPRI
NT"LIMIT TO NEGLECT":LPR
INT"WRT X-DIR.="BLIMITX:
LPRINT"LIMIT TO NEGLECT"
:LPRINT"WRT Y-DIR.="BLIM
ITY
67 LPRINT"----------
----------"
68 PRINT"INPUT ULTIMATE"
69 PRINT"AXIAL LOAD (KIP
S)"
70 INPUT PU:CLS
71 PRINT"INPUT MODULUS O
F"
72 PRINT"ELASTICITY (KSI
)"
73 INPUT E:CLS
74 PRINT"INPUT GROSS INE
RTIA"
75 PRINT"WRT X AND Y AXI
S"
76 PRINT"Ix,Iy (IN.^4)
77 INPUT IX,IY:CLS
```

FIGURE 51 (Continued)

```
78 PRINT"INPUT MAX. FACT
ORED"
79 PRINT"DL MOMENT WRT X
-DIR."
80 PRINT"(POSITIVE K-FT.
)"
81 INPUT MAXFACDLX:CLS
82 PRINT"INPUT MAX. FACT
ORED"
83 PRINT"TOT.MOMENT WRT
X-DIR."
84 PRINT"(POSITIVE K-FT.
)"
85 INPUT MAXFACTX:CLS
86 PRINT"INPUT MAX. FACT
ORED"
87 PRINT"DL MOMENT WRT Y
-DIR."
88 PRINT"(POSITIVE K-FT.
)"
89 INPUT MAXFACDLY:CLS
90 PRINT"INPUT MAX. FACT
ORED"
91 PRINT"TOT.MOMENT WRT
Y-DIR."
92 PRINT"(POSITIVE K-FT.
)"
93 INPUT MAXFACTY:CLS
94 IF MAXFACDLX=0 THEN B
ETADX=0 ELSE BETADX=MAXF
ACDLX/MAXFACTX
95 IF MAXFACDLY=0 THEN B
ETADY=0 ELSE BETADY=MAXF
ACDLY/MAXFACTY
96 EIX=((E*IX)/2.5)/(1+B
ETADX)
97 EIY=((E*IY)/2.5)/(1+B
ETADY)
98 IF BRACED=0 THEN PRIN
T"INPUT SMALLER AND":PRI
NT"LARGER GL MOMENTS":PR
INT"M1bx,M2bx (K-FT.)":I
NPUT M1BX,M2BX:CLS
99 IF BRACED=0 THEN PRIN
T"INPUT SMALLER AND":PRI
NT"LARGER GL MOMENTS":PR
INT"M1by,M2by (K-FT.)":I
NPUT M1BY,M2BY:CLS
100 IF M1BX=0 THEN CMX=.
6 ELSE CMX=.6+.4*(M1BX/M
2BX)
101 IF CMX<.4 THEN CMX=.
4
102 IF M1BY=0 THEN CMY=.
6 ELSE CMY=.6+.4*(M1BY/M
2BY)
103 IF CMY<.4 THEN CMY=.
4
104 FEPCXDELTAB=(.7*9.86
96*EIX)/((1*LX*12)^2)
105 FEPCYDELTAB=(.7*9.86
96*EIY)/((1*LY*12)^2)
106 FEPCX=(.7*9.8696*EIX
)/((KX*LX*12)^2)
107 FEPCY=(.7*9.8696*EIY
)/((KY*LY*12)^2)
108 DELTABX=(CMX)/(1-((P
U)/(FEPCXDELTAB)))
```

FIGURE 51 (Continued)

```
109 IF DELTABX<1 THEN DE
LTABX=1
110 DELTABY=(CMY)/(1-((P
U)/(FEPCYDELTAB)))
111 IF DELTABY<1 THEN DE
LTABY=1
112 LPRINT"MOMENT MAGNIF
IER FOR":LPRINT"GRAVITY
LOAD MOMENTS":LPRINT"IN
X-DIRECTION":LPRINT"="DE
LTABX:LPRINT"":LPRINT"MO
MENT MAGNIFIER FOR":LPRI
NT"GRAVITY LOAD MOMENTS"
:LPRINT"IN Y-DIRECTION":
LPRINT"="DELTABY
113 IF BRACED=0 THEN PRI
NT"INPUT SUM OF ALL":PRI
NT"ULTIMATE AXIAL LOADS"
:PRINT"FOR ONE STORY (KI
PS)":INPUT PUSUM:CLS
114 IF BRACED=0 THEN PRI
NT"DO YOU WANT TO":PRINT
"CALC. SUM Pcx,Pcy OR":P
RINT"SHALL I? 1=ME 0=YOU
":INPUT CALC:CLS
115 IF CALC=0 AND BRACED
=0 THEN PRINT"INPUT Pcx,
Pcy (KIPS)":INPUT PCXTOT
,PCYTOT:CLS
116 IF BRACED=0 AND CALC
=1 THEN PRINT"INPUT TOTA
L NUMBER":PRINT"OF COLUM
NS IN A":PRINT"STORY":IN
PUT NOCOL:CLS
117 IF BRACED=0 AND  CAL
C=1 THEN LPRINT"♦♦♦♦♦♦♦♦
♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦":LPRINT
"NOTE:":LPRINT"ALL COLUM
NS ASSUMED TO":LPRINT"BE
 THE SAME SIZE AND TO":L
PRINT"BE ORIENTED IN THE
 SAME":LPRINT"DIRECTION"
:LPRINT"♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦
♦♦♦♦♦♦♦♦"
118 IF BRACED=0 AND CALC
=1 THEN FEPCXTOT=NOCOL*F
EPCX:FEPCYTOT=NOCOL*FEPC
Y
119 IF BRACED=0 AND CALC
=0 THEN FEPCXTOT=.7*PCXT
OT:FEPCYTOT=.7*PCYTOT
120 IF BRACED=0 THEN DEL
TASX=1/(1-(PUSUM/FEPCXTO
T))
121 IF BRACED=0 THEN DEL
TASY=1/(1-(PUSUM/FEPCYTO
T))
122 IF BRACED=0 AND DELT
ASX<1 THEN DELTASX=1
123 IF BRACED=0 AND DELT
ASY<1 THEN DELTASY=1
124 IF BRACED=0 THEN LPR
INT"MOMENT MAGNIFIER FOR
":LPRINT"LATERAL LOAD MO
MENTS":LPRINT"IN X-DIREC
TION":LPRINT"="DELTASX
```

FIGURE 51 (Continued)

```
125 IF BRACED=0 THEN LPR
INT"MOMENT MAGNIFIER FOR
":LPRINT"LATERAL LOAD MO
MENTS":LPRINT"IN Y-DIREC
TION":LPRINT"="DELTASY
126 PRINT"INPUT ULT. GRA
VITY"
127 PRINT"LOAD MOMENT IN
 THE"
128 PRINT"X-DIRECTION (K
-FT.)"
129 INPUT MUGX:CLS
130 PRINT"INPUT ULT.LATE
RAL"
131 PRINT"LOAD MOMENT IN
 THE"
132 PRINT"X-DIRECTION (K
-FT.)"
133 INPUT MUDX:CLS
134 PRINT"INPUT ULT.GRAV
ITY"
135 PRINT"LOAD MOMENT IN
 THE"
136 PRINT"Y-DIRECTION (K
-FT.)"
137 INPUT MUGY:CLS
138 PRINT"INPUT ULT. LAT
ERAL"
139 PRINT"LOAD MOMENT IN
 THE"
140 PRINT"Y-DIRECTION (K
-FT.)"
141 INPUT MUDY:CLS
142 IF BRACED=1 THEN MAG
MUX=(DELTABX*MUGX)+MUDX:
MAGMUY=(DELTABY*MUGY)+MU
DY
143 IF BRACED=0 THEN MAG
MUX=(DELTABX*MUGX)+(DELT
ASX*MUDX):MAGMUY=(DELTAB
Y*MUGY)+(DELTASY*MUDY)
144 LPRINT"[illegible]
[illegible]"
145 LPRINT"    MAGNIFIED
MOMENTS"
146 LPRINT"Mux="MAGMUX"K
-FT."
147 LPRINT"Muy="MAGMUY"K
-FT."
148 LPRINT"[illegible]
[illegible]"
149 GOTO 157
150 LPRINT"----------
----------"
151 LPRINT"(K*Lx*12)/rx=
"KLRX
152 LPRINT"(K*Ly*12)/ry=
"KLRY
153 IF BRACED=0 THEN LPR
INT"LIMIT TO NEGLECT=22"
154 IF BRACED=1 THEN LPR
INT"LIMIT TO NEGLECT":LP
RINT"WRT X-DIRECTION":LP
RINT"="BLIMITX:LPRINT"LI
MIT TO NEGLECT":LPRINT"W
RT Y-DIRECTION":LPRINT"=
"BLIMITY
155 LPRINT"NEGLECT SLEND
ERNESS":YO=1
```

FIGURE 51 (Continued)

```
156 LPRINT"-----------
----------"
157 PRINT"DO YOU WANT TO
"
158 PRINT"ANALIZE FOR BI
AXIAL"
159 PRINT"BENDING? 1=YES
 0=NO"
160 INPUT BIAX:CLS
161 IF BIAX=0 GOTO 236
162 BETA=.65
163 IF PU=0 THEN PRINT"I
NPUT ULTIMATE":PRINT"AXI
AL LOAD (KIPS)":INPUT PU
:CLS
164 CHK20=DY/DX
165 IF YO=1 THEN PRINT"I
NPUT Mux,Muy (K-FT.)":IN
PUT MUX,MUY:CLS
166 IF YO=0 THEN MUX=MAG
MUX:MUY=MAGMUY
167 CHK21=MUY/MUX
168 IF CHK20=1 AND CHK21
=1 THEN MUCOMBX=(MUY*(1/
CHK20)*((1-BETA)/BETA))+
MUX
169 IF CHK21>CHK20 THEN
MUCOMBY=MUY+(MUX*CHK20*(
(1-BETA)/BETA))
170 IF CHK21<CHK20 THEN
MUCOMBX=(MUY*(1/CHK20)*(
(1-BETA)/BETA))+MUX
171 IF MUCOMBX=0 THEN LP
RINT"APPROXIMATE UNIAXIA
L ULT":LPRINT"MOMENT APP
LIED IN THE":LPRINT"WEAK
 DIRECTION IS":LPRINT MU
COMBY"K-FT."
172 IF MUCOMBY=0 THEN LP
RINT"APPROXIMATE UNIAXIA
L ULT":LPRINT"MOMENT APP
LIED IN THE":LPRINT"STRO
NG DIRECTION IS":LPRINT
MUCOMBX"K-FT."
173 LPRINT""
174 LPRINT"-----------
----------"
175 LPRINT"VERIFICATION
BY P.C.A"
176 LPRINT"LOAD CONTOUR
METHOD:":LPRINT""
177 LPRINT"  Mnx  log[.5
]/log[beta]"
178 LPRINT"(-------)"
179 LPRINT"  Mnox"
180 LPRINT"+"
181 LPRINT"  Mny  log[.5
]/log[beta]"
182 LPRINT"(-------)"
183 LPRINT"  Mnoy":LPRIN
T""
184 LPRINT"<1.0      EQ.
(8)":LPRINT"":LPRINT"---
-------------------------"
185 PRINT"GO SELECT A SE
CTION"
186 PRINT"AND COME BACK
AND"
```

FIGURE 51 (Continued)

```
187 PRINT"ENTER As (IN.^
2)"
188 INPUT AS:CLS
189 PRINT"INPUT REINFORC
ING"
190 PRINT"DESCRIPTION"
191 INPUT RE$:CLS
192 PRINT"INPUT f'c (KSI
)"
193 INPUT FC:CLS
194 PRINT"INPUT Fy (KSI)
"
195 INPUT FY:CLS
196 PO=.85*FC*((DX*DY)-(
AS))+AS*FY
197 ROW=AS/(DX*DY)
198 LPRINT"As/Ac="ROW
199 LPRINT"Fy="FY"KSI"
200 LPRINT"f'c="FC"KSI"
201 LPRINT"As="AS"IN.^2"
202 LPRINT"["RE$"]"
203 LPRINT"Po="PO"KIPS"
204 CA=PU/(DX*DY):LPRINT
""
205 LPRINT" øPN    "PU
206 LPRINT" ——  =  ——
 ="CA
207 LPRINT" As     "DX*DY
208 LPRINT""
209 PRINT"       øMn    F
rom"
210 PRINT"INPUT ——  int
eract."
211 PRINT"       Ash   di
agram"
212 INPUT FEMNAGH:CLS
213 MXCHK=(FEMNAGH*DX*DY
*DX)/12
214 MYCHK=(FEMNAGH*DX*DY
*DY)/12
215 PNPO=(PU/.7)/PO
216 OMEGA=(ROW*FY)/FC
217 PRINT"Pn/Po="PNPO"OM
EGA"
218 PRINT"="OMEGA"INPUT
BETA"
219 PRINT"(FIG.31,32 OR
33)"
220 INPUT BETA:CLS
221 PRINT"INPUT LOG("BET
A")"
222 PRINT"EX. LOG(.5)=-.
3"
223 INPUT ILOG:CLS:XX=-.
3/ILOG
224 ANS=((MUX/MXCHK)^XX)
+((MUY/MYCHK)^XX)
225 LPRINT"Mnx="MUX/.7"K
-FT."
226 LPRINT"Mnox="MXCHK/.
7"K-FT."
227 LPRINT"Mny="MUY/.7"K
-FT."
228 LPRINT"Mnoy="MYCHK/.
7"K-FT."
229 LPRINT"log[.5]/log[b
eta]="XX
230 LPRINT"EQ(8)="ANS
```

FIGURE 51 (Continued)

```
231 IF ANS>1 THEN LPRINT
"":LPRINT"[illegible]":LPRINT ""ANS
"IS >1.0 SO N.G.":LPRINT
"[illegible]
"
232 LPRINT"":LPRINT""
233 PRINT"REVISE? 1=YES
0=N0
234 INPUT REVISE:CLS
235 IF REVISE=1 GOTO 185
236 LPRINT"":LPRINT"----
--------------------"
237 LPRINT"COLUMN"DX"x"D
Y"IN."
238 LPRINT"Lx="LX"FT."
239 LPRINT"Ly="LY"FT."
240 LPRINT"Kx="KX
241 LPRINT"Ky="KY
242 LPRINT"COLUMN FRAME
SYSTEM IS"
243 IF BRACED=1 THEN LPR
INT"BRACED"
244 IF BRACED=0 THEN LPR
INT"UNBRACED"
245 IF YO=0 THEN LPRINT"
Cmx="CMX:LPRINT"Cmy="CMY
246 IF BRACED=1 AND YO=0
 THEN LPRINT"M1bx="M1BX"
K-FT.":LPRINT"M2bx="M2BX
"K-FT.":LPRINT"M1by="M1B
Y"K-FT.":LPRINT"M2by="M2
BY"K-FT."
247 IF BRACED=0 AND YO=0
 THEN LPRINT"SUM OF Pu="
PUSUM"KIPS":LPRINT"SUM O
F oPcx="FEPCXTOT"KIPS":L
PRINT"SUM OF oPCY="FEPCY
TOT"KIPS"
248 IF YO=0 THEN LPRINT"
Ix="IX"IN.^4":LPRINT"Iy=
"IY"IN.^4
249 IF YO=0 THEN LPRINT"
E="E"KSI"
250 IF BIAX=1 THEN LPRIN
T"Mux="MUX"K-FT.":LPRINT
"Muy="MUY"K-FT."
251 IF YO=0 THEN LPRINT"
ACI EQ.(10-11) USED":LPR
INT"TO CALCULATE EI"
252 LPRINT"----------
----------"
253 LPRINT"":LPRINT"":LP
RINT"":LPRINT"":GOTO 1
```

STEEL

```
254 PRINT"SELECT MEMBER
TYPE:"
255 PRINT"1=TUBE OR PIPE
"
256 PRINT"2=OTHER"
257 INPUT TYPE
258 CLS
259 PRINT"INPUT Fy (KSI)
260 INPUT FY:CLS
```

FIGURE 51 (Continued)

```
261 PRINT"INPUT MODULUS"
262 PRINT"OF ELASTICITY"
263 PRINT"(KSI)"
264 INPUT E:CLS
265 PRINT"INPUT UNBRACED
 "
266 PRINT"LENGTH WRT X&Y
 AXIS"
267 PRINT"Lx,Ly (FT.)"
268 INPUT LX,LY:CLS
269 PRINT"INPUT COLUMN F
ACTOR"
270 PRINT"WRT X&Y AXIS"
271 PRINT"Kx,Ky (AISC 5-
124)"
272 INPUT KX,KY:CLS
273 PRINT"INPUT Cm WRT"
274 PRINT"X & Y AXIS"
275 PRINT"Cmx,Cmy (AISC
5-26)"
276 INPUT CMX,CMY:CLS
277 IF TYPE=1 GOTO 330
278 MWTTRA=76/(FY^.5)
279 MWTTRB=95/(FY^.5)
280 MWTTRC=127/(FY^.5)
281 PRINT"1=└ OR ┘└,2=┘└
 IN"
282 PRINT"CONTACT,3=I,4=
T,"
283 PRINT"5=CHANNEL  (CH
OOSE)
284 INPUT MEMBER:CLS
285 IF MEMBER=1 GOTO 290
286 IF MEMBER=2 GOTO 290
287 IF MEMBER=3 GOTO 304
288 IF MEMBER=5 GOTO 304
289 IF MEMBER=4 GOTO 317
290 PRINT"INPUT MEMBER"
291 PRINT"DESCRIPTION"
292 INPUT M$:CLS
293 PRINT"INPUT MAXIMUM
ANGLE"
294 PRINT"LEG LENGTH (IN
.)"
295 INPUT LMAX:CLS
296 PRINT"INPUT ANGLE LE
G"
297 PRINT"THICKNESS (IN.
)"
298 INPUT LT:CLS
299 LWTTR=LMAX/LT
300 IF MEMBER=2 GOTO 302
301 IF LWTTR>MWTTRA GOTO
 766
302 IF LWTTR>MWTTRB GOTO
 766
303 GOTO 346
304 PRINT"INPUT MEMBER"
305 PRINT"DESCRIPTION"
306 INPUT M$:CLS
307 PRINT"INPUT FLANGE"
308 PRINT"WIDTH (IN.)"
309 INPUT BF:CLS
310 PRINT"INPUT FLANGE"
311 PRINT"THICKNESS (IN.
)"
312 INPUT TF:CLS
313 IF MEMBER=3 THEN FWT
TR=(BF*.5)/TF
```

FIGURE 51 (Continued)

```
314 IF MEMBER=5 THEN FWT
TR=BF/TF
315 IF FWTTR>MWTTRB GOTO
 766
316 GOTO 346
317 PRINT"INPUT MEMBER"
318 PRINT"DESCRPTION"
319 INPUT M$:CLS
320 PRINT"INPUT DEPTH OF
"
321 PRINT"SPLIT-TEE (IN.
)"
322 INPUT STD:CLS
323 PRINT"INPUT THICKNES
S"
324 PRINT"OF STEM (IN.)"
325 INPUT TS:CLS
326 SWTTR=STD/TS
327 IF SWTTR>MWTTRC GOTO
 766
328 GOTO 346
329 PRINT"[M1] (K-FT.)"
330 PRINT"INPUT MEMBER"
331 PRINT"DESCRIPTION"
332 INPUT M$:CLS
333 PRINT"IS THIS A ROUN
D"
334 PRINT"PIPE SHAPE?"
335 PRINT"1=YES 0=NO"
336 INPUT ROUND:CLS
337 IF ROUND=1 GOTO 346
338 PRINT"INPUT THE BOX
WIDTH,"
339 PRINT"DEPTH,WALL THI
CKNESS"
340 PRINT"W,D,Tw (IN.)"
341 INPUT BF,DW,TF:CLS
342 BFIN=BF-(2*TF)
343 BFWTTR=BFIN/TF
344 CHK13=(238)/(FY^.5)
345 IF BFWTTR>CHK13 GOTO
 766
346 IF TYPE=1 GOTO 347
347 PRINT"IDENTIFICATION
"
348 INPUT I$:CLS
349 LPRINT I$
350 LPRINT"----------
----------"
351 LPRINT""
352 LPRINT"[redacted]
[redacted]"
353 LPRINT M$" IS"
354 LPRINT"FULLY EFFECTI
VE"
355 LPRINT"[redacted]
[redacted]"
356 LPRINT""
357 PRINT"INPUT SECTION"
358 PRINT"AREA (IN.^2)"
359 INPUT A:CLS
360 PRINT"INPUT RADIUS O
F"
361 PRINT"GYRATION WRT X
&Y"
362 PRINT"AXIS (IN.) rx,
ry"
363 INPUT RX,RY:CLS
```

FIGURE 51 (Continued)

```
364 IF MEMBER=1 THEN PRI
NT"INPUT RADIUS OF":PRIN
T"GYRATION WRT":PRINT"Z-
AXIS (IN.)":INPUT RZ:CLS
365 IF MEMBER=1 THEN PRI
NT"INPUT UNBRACED":PRINT
"LENGTH WRT":PRINT"Z-AXI
S (FT.)":INPUT LZ:CLS
366 IF MEMBER=1 THEN PRI
NT"INPUT COLUMN FACTOR":
PRINT"WRT Z-AXIS":INPUT
KZ:CLS
367 IF MEMBER=1 THEN STI
FFZ=(KZ*LZ*12)/RZ ELSE S
TIFFZ=0
368 STIFFX=(KX*LX*12)/RX
369 STIFFY=(KY*LY*12)/RY
370 IF STIFFX>STIFFY THE
N STIFF=STIFFX ELSE STIF
F=STIFFY
371 IF STIFFZ>STIFF THEN
 STIFF=STIFFZ
372 CC=((19.7392*E)/(FY)
)^.5
373 IF STIFF<CC GOTO 376
374 FA=((118.4353)*(E))/
(23*(STIFF^2))
375 GOTO 379
376 FAA=(1-((STIFF^2)/((
2)*(CC^2))))*FY
377 FAB=(1.6667)+((3*STI
FF)/(8*CC))-((STIFF^3)/(
(8)*(CC^3)))
378 FA=FAA/FAB
379 PRINT"IS THIS A SECO
NDARY"
380 PRINT"OR BRACING MEM
BER?"
381 PRINT"1=YES 0=NO"
382 INPUT BRACE:CLS
383 IF BRACE=0 GOTO 390
384 IF STIFF<120 GOTO 39
0
385 IF STIFF=STIFFX THEN
 L=LX:R=RX:K=KX
386 IF STIFF=STIFFY THEN
 L=LY:R=RY:K=KY
387 IF STIFF=STIFFZ THEN
 L=LZ:R=RZ:K=KZ
388 IF(L*12/R)<120 THEN
GOTO 390
389 FA=FA/((1.6)-((L*12)
/(200*R)))
390 IF MEMBER=1 GOTO 446
391 IF MEMBER=2 GOTO 467
392 IF MEMBER=4 GOTO 467
393 IF MEMBER=5 GOTO 467
394 IF TYPE=1 GOTO 524
395 REM *****BEAM SHAPES
****
396 PRINT"INPUT SECTION"
397 PRINT"DEPTH (IN.)"
398 INPUT DW:CLS
399 PRINT"INPUT THICKNES
S OF"
400 PRINT"WEB (IN.)"
401 INPUT TW:CLS
402 DOT=DW/TW
403 CHK1=65/(FY^.5)
```

FIGURE 51 (Continued)

```
404 PRINT"INPUT UNBRACED
 LGTH."
405 PRINT"OF COMPRESSION
 FLG."
406 PRINT"WRT BENDING (F
T.)"
407 INPUT LU:CLS:CHK2=25
7/(FY^.5)
408 PRINT"INPUT AXIAL LO
AD"
409 PRINT"(KIPS)"
410 INPUT P:CLS
411 FAACT=P/A
412 IF(BF/2*TF)>CHK1 GOT
O 425
413 IF(FAACT/FY)>.16 GOT
O 416
414 CHK3=((640)/(FY^.5))
*(1-(3.74*(FAACT/FY)))
415 IF DOT>CHK3 GOTO 425
416 IF (FAACT/FY)<.16 GO
TO 418
417 IF DOT>CHK2 GOTO 425
418 CHK4=(76*BF)/(FY^.5)
419 CHK5=(20000)/((DW/(B
F*TF))*FY)
420 IF(LU*12)>CHK4 GOTO
425
421 IF(LU*12)>CHK5 GOTO
425
422 FB=.66*FY
423 FBY=.75*FY
424 GOTO 597
425 LPRINT"**************
**********"
426 LPRINT"SECTION NON-C
OMPACT":LPRINT"----------
----------"
427 CHK2=257/(FY^.5)
428 CHK3=((640)/(FY^.5))
*(1-(3.74*(FAACT/FY)))
429 CHK4=(76*BF)/(FY^.5)
430 CHK5=(20000)/((DW/(B
F*TF))*FY)
431 IF (BF/2*TF)>CHK1 TH
EN LPRINT"EXCEEDS AISC 1
.5.1.4.1-2":LPRINT"-----
----------"
432 IF(FAACT/FA)<.16 AND
 DOT>CHK3 THEN LPRINT"EX
CEEDS AISC EQ.(1.5-4a)":
LPRINT"----------
---------"
433 IF(FAACT/FA)>.16 AND
 DOT>CHK2 THEN LPRINT"EX
CEEDS AISC EQ.(1.5-4b)":
LPRINT"----------
---------"
434 IF CHK4<CHK5 THEN CH
K=CHK4 ELSE CHK=CHK5
435 IF(LU*12)>CHK THEN L
PRINT"Lu="CHK/12"FT.":LP
RINT"----------
-----"
436 LPRINT"**************
***********":LPRINT""
437 PRINT"INPUT Cb WRT"
438 PRINT"STRONG DIRECTI
ON"
439 PRINT"BENDING (AISC
5-22)"
```

FIGURE 51 (Continued)

```
440 INPUT CBX:CLS
441 FB=(12000*CBX)/((LU*
12*DW)/(BF*TF))
442 IF FB>(.6*FY)THEN FB
=(.6*FY)
443 FBY=FY*(1.075-((.005
)*(BF/(2*TF)))*(FY^.5)))
444 IF FBY>(.75*FY)THEN
FBY=(.75*FY)
445 GOTO 597
446 FB=.6*FY
447 FBY=.6*FY
448 PRINT"INPUT WIDTH OF
 THE"
449 PRINT"ANGLE LEG ACTI
NG"
450 PRINT"AS COMP. FLANGE
(IN.)"
451 INPUT BFA:CLS
452 CHK8=(76*BFA)/(FY^.5
)
453 LPRINT"▬▬▬▬▬▬▬▬▬▬▬
▬▬▬▬▬▬▬▬▬▬▬
```

```
485 INPUT TFC:CLS
486 PRINT"INPUT DIST.FRO
M"
487 PRINT"EXTREME COMP.F
IBER"
488 PRINT"TO N.A.(IN.)"
489 INPUT YT:CLS
490 IF MEMBER=4 THEN ACT
TWEB=TS
491 IF MEMBER=4 GOTO 496
492 PRINT"INPUT THICKNES
S OF"
493 PRINT"ELEMENT ACTING
 AS"
494 PRINT"THE WEB (IN.)"
495 INPUT ACTTWEB:CLS
496 PRINT"INPUT UNBRACED
"
497 PRINT"LENGTH WRT COM
P."
498 PRINT"FLANGE (FT.)"
499 INPUT LU:CLS
500 AA=(YT-TFC)/3
501 AREART=(BFC*TFC)+(AA
*ACTTWEB)
502 IF MEMBER=5 GOTO 506
503 ITOTRT=(.0833*TFC*(B
FC^3))+(.0833*AA*(ACTTWE
B^3))
504 RT=((ITOTRT)/(AREART
))^.5
505 GOTO 514
506 PRINT"INPUT X-BAR OF
 CHNL."
507 PRINT"AS LISTED IN A
ISC"
508 PRINT"TABLES (IN.)"
509 INPUT Y:CLS
510 BB=(BFC/2)-Y
511 CCC=Y-(ACTTWEB/2)
512 ITOTRT=(.0833*TFC*(B
FC^3))+(BFC*TFC*(BB^2))+
(.0833*AA*(ACTTWEB^3))+(
ACTTWEB*AA*(CCC^2))
513 RT=((ITOTRT)/(AREART
))^.5
514 CHK10=(LU*12)/RT
515 CHK11=((102*1000*CBX
)/(FY))^.5
516 CHK12=((510*1000*CBX
)/(FY))^.5
517 IF CHK10>CHK12 GOTO
520
518 FB=((2/3)-(((FY)*(CH
K10^2))/(1530*1000*CBX))
)*FY
519 GOTO 521
520 FB=(170*1000*CBX)/(C
HK10^2)
521 IF FB>(.6*FY) THEN F
B=(.6*FY)
522 FBY=.6*FY
523 GOTO 597
524 IF ROUND=1 GOTO 570
525 PRINT"INPUT AXIAL"
526 PRINT"LOAD (KIPS)"
527 INPUT P:CLS
528 FAACT=P/A
529 CHK14=(190)/(FY^.5)
```

FIGURE 51 (Continued)

```
530 CHK3=((640)/(FY^.5))
*(1-(3.74*(FAACT/FY)))
531 CHK2=257/(FY^.5)
532 IF BFWTTR>CHK14 GOTO
 557
533 WDTTR=(DW-(2*TF))/TF
534 IF(FAACT/FY)>.16 GOT
O 537
535 IF WDTTR>CHK3 GOTO 5
57
536 GOTO 538
537 IF WDTTR>CHK2 GOTO 5
57
538 WEAK=1
539 PRINT"INPUT UNBRACED
 LGTH. "
540 PRINT"OF MAJOR COMP.
 FLG. "
541 PRINT"WRT BENDING (F
T.)"
542 INPUT LU:CLS
543 IF DW>(6*BF) GOTO 55
7
544 PRINT"INPUT THE SMAL
LER"
545 PRINT"END MOM. IN MAJ
OR"
546 PRINT"DIR. [M1] (K-F
T.)"
547 INPUT M1:CLS
548 PRINT"INPUT THE LARG
ER"
549 PRINT"END MOM. IN MAJ
OR"
550 PRINT"DIR.[M2] (K-FT
.)"
551 INPUT M2:CLS
552 IF M1=0 THEN MOMRAT=
0 ELSE MOMRAT=M1/M2
553 CHK15=(1950+(1200*(M
OMRAT)))*(BFIN/FY)
554 IF (LU*12)>CHK15  GO
TO 557
555 FB=.66*FY
556 GOTO 568
557 LPRINT"************
**********":IF TYPE=1 T
HEN FB=.6*FY:BILL=1
558 LPRINT M$" DOES NOT"
559 LPRINT"QUALIFY AS A
COMPACT"
560 LPRINT"SECTION!"
561 LPRINT"──────────
──────────"
562 IF BFWTTR>CHK14 THEN
 LPRINT"Bf/Tf="BFWTTR:LP
RINT"LIMIT="CHK14:LPRINT
"──────────────────
─"
563 IF WDTTR>CHK3 THEN L
PRINT"D/Tw="WDTTR:LPRINT
"LIMIT="CHK3:LPRINT"────
──────────────────"
564 IF WDTTR>CHK2 THEN L
PRINT"D/Tw="WDTTR:LPRINT
"LIMIT="CHK2:LPRINT"────
──────────────────"
```

FIGURE 51 (Continued)

```
565 IF DW>(6*BF) THEN LP
RINT"6*BF="6*BF"IN.":LPR
INT"LIMIT="D"IN.[D]":LPR
INT"————————————————
————"
566 IF (LU*12)>CHK15 AND
 CHK15>0 THEN LPRINT"Lu=
"CHK15/12"FT.":LPRINT"——
————————————————"
567 LPRINT"**************
**********"
568 IF WEAK=1 THEN FBY=(
.66*FY) ELSE FBY=(.6*FY)
569 GOTO 597
570 PRINT"INPUT OUTSIDE"
571 PRINT"DIAMETER OF PI
PE"
572 PRINT"(IN.)"
573 INPUT DIA:CLS
574 PRINT"INPUT PIPE WAL
L"
575 PRINT"THICKNESS (IN.
)"
576 INPUT WALL:CLS
577 PRINT"INPUT AXIAL"
578 PRINT"LOAD (KIPS)"
579 INPUT P:CLS
580 FAACT=P/A
581 DIAWALL=DIA/WALL
582 CHK16=3300/FY
583 IF DIAWALL<CHK16 GOT
O 595
584 LPRINT"**************
**********"
585 LPRINT M$" DOES NOT"
586 LPRINT"QUALIFY AS A
COMPACT"
587 LPRINT"SECTION!"
588 LPRINT"DIAMETER/WALL
 THICKNESS"
589 LPRINT"="DIAWALL
590 LPRINT"LIMIT="CHK16
591 LPRINT"**************
**********"
592 FB=.6*FY
593 FBY=.6*FY
594 GOTO 597
595 FB=.66*FY
596 FBY=.66*FY
597 PRINT"INPUT Sx,Sy (I
N.^3)"
598 INPUT SX,SY:CLS
599 FPRIMEEX=(118.4353*E
)/(23*(STIFFX^2))
600 FPRIMEEY=(118.4353*E
)/(23*(STIFFY^2))
601 PRINT"INPUT Mx,My (K
-FT.)"
602 INPUT MX,MY:CLS
603 FBACT=(MX*12/SX)
604 FBYACT=(MY*12/SY)
605 IF(FAACT/FA)<.15 GOT
O 614
606 CHK161A=(FAACT/FA)+(
(CMX*FBACT)/((1-(FAACT)/
(FPRIMEEX))*FB))+((CMY*F
BYACT)/((1-(FAACT)/(FPRI
MEEY))*FBY))
```

FIGURE 51 (Continued)

```
607 CHK161B=(FAACT/(.6*F
Y))+(FBACT/FB)+(FBYACT/F
BY)
608 PRINT"(1.6-1a)="CHK1
61A
609 PRINT"(1.6-1b)="CHK1
61B
610 PRINT"REVISE? 1=YES
0=NO
611 INPUT REVISE:CLS
612 IF REVISE=1 GOTO 254
613 GOTO 619
614 CHK162=(FAACT/FA)+(F
BACT/FB)+(FBYACT/FBY)
615 PRINT"(1.6-2)="CHK16
2
616 PRINT"REVISE? 1=YES
0=NO
617 INPUT REVISE:CLS
618 IF REVISE=1 GOTO 254
619 LPRINT"Fy="FY"KSI"
620 LPRINT"E="E"KSI"
621 LPRINT"Lx="LX"FT."
622 LPRINT"Ly="LY"FT."
623 IF MEMBER=1 THEN LPR
INT"Lz="LZ"FT."
624 LPRINT"Kx="KX
625 LPRINT"Ky="KY
626 IF MEMBER=1 THEN LPR
INT"Kz="KZ
627 LPRINT"Cmx="CMX
628 LPRINT"Cmy="CMY
629 LPRINT"AXIAL LOAD="P
"KIPS
630 LPRINT"Mx="MX"K-FT."
631 LPRINT"My="MY"K-FT."
632 IF ROUND=1 THEN GOTO
 637
633 IF MEMBER=1 GOTO 637
634 IF BILL=1 GOTO 637
635 LPRINT"UNBRACED LENG
TH OF THE":LPRINT"COMPRE
SSION FLANGE IN"
636 LPRINT"BENDING="LU"F
T."
637 LPRINT"----------
----------"
638 LPRINT"Fa="FA"KSI"
639 LPRINT"Fbx="FB"KSI"
640 LPRINT"Fby="FBY"KSI"
641 LPRINT"----------
----------"
642 LPRINT"fa="FAACT"KSI
"
643 LPRINT"fbx="FBACT"KS
I"
644 LPRINT"fby="FBYACT"K
SI"
645 LPRINT"----------
----------"
646 IF(FAACT/FA)<.15 GOT
O 650
647 LPRINT"(1.6-1a)="CHK
161A
648 LPRINT"(1.6-1b)="CHK
161B
649 GOTO 651
650 LPRINT"(1.6-2)="CHK1
62
651 LPRINT"":LPRINT"":LP
RINT"":LPRINT"":GOTO 1
```

FIGURE 51 (Continued)

TIMBER

```
652 PRINT"IDENTIFICATION
"
653 INPUT I$:CLS
654 LPRINT I$:LPRINT"[illegible]"
655 LPRINT""
656 PRINT"INPUT UNBRACED
 LGTH."
657 PRINT"WRT STRONG DIR
ECTION"
658 PRINT"(FT.)"
659 INPUT LX:CLS
660 PRINT"INPUT UNBRACED
 LGTH."
661 PRINT"WRT WEAK DIREC
TION"
662 PRINT"(FT.)"
663 INPUT LY:CLS
664 PRINT"INPUT DEPTH OF
 COL."
665 PRINT"IN STRONG DIRE
CTION"
666 PRINT"(IN.)"
667 INPUT DX:CLS
668 PRINT"INPUT DEPTH OF
 COL."
669 PRINT"IN WEAK DIRECT
ION"
670 PRINT"(IN.)"
671 INPUT DY:CLS
672 PRINT"INPUT COLUMN F
ACTOR"
673 PRINT"[Ke] (NDS 80)"
674 INPUT KE:CLS
675 LEX=LX*12*KE
676 LEY=LY*12*KE
677 IF(LEX/DX)>(LEY/DY)
THEN LED=(LEX/DX) ELSE L
ED=(LEY/DY)
678 IF LED>50 GOTO 759
679 PRINT"INPUT MATERIAL
"
680 PRINT"DESCRIPTION"
681 INPUT W$:CLS
682 LPRINT DY"X"DX""W$
683 LPRINT"
684 PRINT"INPUT MODULUS
OF"
685 PRINT"ELASTICITY (PS
I)"
686 PRINT"[NDS SUPPLEMEN
T]"
687 INPUT E:CLS
688 PRINT"INPUT ALLOWABL
E"
689 PRINT"COMPRESSION PA
RALLEL"
690 PRINT"TO GRAIN (PSI)
"
691 INPUT FC:CLS
692 K=(.617)*((E/FC)^.5)
```

FIGURE 51 (Continued)

```
693 IF LED<11 THEN LPRIN
T"----------
----":LPRINT"SHORT COLUMN"
:FPC=FC:LPRINT"F'c="FC"P
SI":LPRINT"----------
----------":SHORT=1
694 IF 11<LED AND LED<K
THEN LPRINT"----------
----------":LPRINT"INT
ERMEDIATE COLUMN":FPC=FC
*(1-((1/3)*((LED/K)^4)))
:LPRINT"F'c="FPC"PSI":LP
RINT"----------
----------":BAD=1
695 IF LED>K THEN LPRINT
"----------
-":LPRINT"LONG COLUMN":F
PC=(.3*E)/(LED^2):LPRINT
"F'c="FPC"PSI":LPRINT"---
----------":
LONG=1
696 LPRINT""
697 PRINT"INPUT AXIAL"
698 PRINT"LOAD (POUNDS)"
699 INPUT P:CLS
700 PRINT"ARE MOMENTS AP
PLIED"
701 PRINT"TO THE COLUMN?
"
702 PRINT"1=YES 0=NO"
703 INPUT MOM:CLS
704 IF MOM=0 GOTO 717
705 PRINT"INPUT MOMENTS
IN"
706 PRINT"THE STRONG AND
 WEAK"
707 PRINT"DIR. Mx,My (IN.
-LBS.)"
708 INPUT MX,MY:CLS
709 PRINT"INPUT Sx,Sy (I
N.^3)"
710 INPUT SX,SY:CLS
711 PRINT"INPUT ALLOWABL
E"
712 PRINT"COMPRESSIVE BE
NDING"
713 PRINT"STRESS (PSI)"
714 INPUT FB:CLS
715 FBXACT=MX/SX
716 FBYACT=MY/SY
717 AREA=DX*DY
718 FAACT=P/AREA
719 IF MOM=1 GOTO 725
720 PRINT"fa="FAACT"PSI"
721 PRINT"REVISE? 1=YES
0=NO"
722 INPUT REVISE:CLS
723 IF REVISE=1 GOTO 652
724 GOTO 737
725 J=(LED-11)/(K-11)
726 IF J>1 THEN J=1
727 IF J<0 THEN J=1
728 IF SHORT=1 THEN COMB
=((FAACT/FPC)+(FBXACT/FB
)+(FBYACT/FB))
729 IF BAD=1 THEN COMB=(
(FAACT/FPC)+((FBXACT)/(F
B-(J*FAACT)))+((FBYACT)/
(FB-(J*FAACT))))
```

FIGURE 51 (Continued)

```
730 IF LONG=1 THEN COMB=
((FAACT/FPC)+(FBXACT/(FB
-FAACT))+(FBYACT/(FB-FAA
CT)))
731 IF BAD=1 THEN PRINT"
3.10.2.1="COMB
732 IF SHORT=1 THEN PRIN
T"3.10.2.2="COMB
733 IF LONG=1 THEN PRINT
"3.10.2.3="COMB
734 PRINT"REVISE? 1=YES
0=NO"
735 INPUT REVISE:CLS
736 IF REVISE=1 GOTO 652
737 LPRINT"Lx="LX"FT."
738 LPRINT"Ly="LY"FT."
739 LPRINT"Ke="KE
740 LPRINT"E="E"PSI"
741 LPRINT"Fc="FC"PSI"
742 LPRINT"AREA="AREA"IN
.^2"
743 LPRINT"P="P"POUNDS"
744 LPRINT"fa="FAACT"PSI
"
745 IF MOM=1 GOTO 747
746 LPRINT"":LPRINT"":LP
RINT"":LPRINT"":GOTO 1
747 LPRINT"----------
----------"
748 LPRINT"Fb="FB"PSI"
749 LPRINT"Mx="MX"IN.-LB
S."
750 LPRINT"fbx="FBXACT"P
SI"
751 LPRINT"My="MY"IN.-LB
S."
752 LPRINT"fby="FBYACT"P
SI"
753 LPRINT""
754 IF SHORT=1 THEN LPRI
NT"3.10.2.2="COMB
755 IF BAD=1 THEN LPRINT
"3.10.2.1="COMB
756 IF LONG=1 THEN LPRIN
T"3.10.2.3="COMB"
757 LPRINT"----------
----------"
758 LPRINT"":LPRINT"":LP
RINT"":LPRINT"":GOTO 1
759 LPRINT"[redacted]
[redacted]"
760 LPRINT"L*Ke/D="LED"
761 LPRINT"LIMIT=50 (NDS
 3.7.2.2)"
762 LPRINT""
763 LPRINT"REVISE SECTIO
N"
764 LPRINT"[redacted]
[redacted]"
765 LPRINT"":LPRINT"":LP
RINT"":LPRINT"":GOTO1
766 IF MEMBER=1 THEN RAT
=LWTTR
767 IF MEMBER=2 THEN RAT
=LWTTR
768 IF MEMBER=3 THEN RAT
=FWTTR
769 IF MEMBER=5 THEN RAT
=FWTTR
```

FIGURE 51 (Continued)

```
770 IF MEMBER=4 THEN RAT
=SWTTR
771 IF TYPE=1 AND ROUND=
0 THEN RAT=BFWTTR
772 LPRINT"[illegible]
[illegible]"
773 LPRINT M$
774 LPRINT "IS NOT FULLY
 EFFECTIVE"
775 LPRINT"ACTUAL WIDTH
TO "
776 LPRINT"THICKNESS RAT
IO"
777 LPRINT"="RAT
778 IF MEMBER=1 THEN MAX
=MWTTRA
779 IF MEMBER=2 THEN MAX
=MWTTRB
780 IF MEMBER=3 THEN MAX
=MWTTRB
781 IF MEMBER=5 THEN MAX
=MWTTRS
782 IF MEMBER=4 THEN MAX
=MWTTRC
783 IF TYPE=1 AND ROUND=
0 THEN MAX=CHK13
784 LPRINT"MAXIMUM="MAX
785 LPRINT"REFER TO APPE
NDIX C OF"
786 LPRINT"AISC OR REVIS
E MEMBER"
787 LPRINT"[illegible]
[illegible]"
788 LPRINT"":LPRINT"":LP
RINT"":LPRINT""
789 PRINT"REVISE MEMBER?
"
790 PRINT"1=YES 0=NO"
791 INPUT REVISE:CLS
792 IF REVISE=1 GOTO 254
793 IF REVISE=0 GOTO 1
```

FIGURE 51 (Continued)

CHAPTER 4

TWO-WAY FOOTING DESIGN

Description of Program

The two-way footing design program is written to analyze and design single column shallow spread footings for axial load and bending moment and shear in one or two directions. The user has the option to select designs of square or rectangular footings. After the design routine for input data, the user also has the option to check a known footing. This would allow for evaluation of a more standard footing of say 8 x 10 feet as opposed to specifying the 7'-7" x 10'-2" that might result from the design routine.

The program is written to satisfy the requirements of the Building Code Requirements for Reinforced Concrete (ACI-318-83), published by the American Concrete Institute. Footing moments are taken about the face of the pedestal or base plate. Top steel is provided if the negative moment in the footing exceeds cracking moment capacity. After an appropriate footing has been sized and designed, the program will then provide the required reinforcing, top and bottom.

The loads input in the beginning of the program are to be service loads. The program applies a 1.55 factor to these loads to bring them to approximate ultimate values. To allow exact ultimate analysis, the user should calculate

exact ultimate moments and shears and then divide these values by 1.55 for service input or modify the program factor.

The thickness of the footing is determined based on punching and beam shear requirements with one foot being the minimum thickness. The length and width of the footing are controlled by the factor of safety against overturning as well as the allowable bearing pressure. After the routine is complete, the program provides a complete documented copy of all aspects of the design.

If a very high bearing capacity exists, say 40 KSF, the program will likely size a footing that is too large in the design routine. This results from the beginning footing size being set equal to the punching shear peripheral boundary. If the user inputs a known footing in this case, the resulting analysis will be correct and a minimum footing may be attained by iteration.

Nomenclature

FC	- Specified 28-day compressive strength of concrete.
FY	- Yield stress of the reinforcing steel.
SBC	- Safe bearing capacity.
OB	- Overburden.
P	- Axial load.
VX	- Shear in the primary direction.
VY	- Shear in the weak direction.

MX - Moment in the primary direction.

MY - Moment in the weak direction.

PEDX - Pedestal or plate dimension in the primary direction.

PEDY - Pedestal or plate dimension in the weak direction.

FSOTX - Factor of safety against overturning in the primary direction.

FSOTY - Factor of safety against overturning in the weak direction.

BMSHRULT - Ultimate beam shear.

BO - Punching shear peripheral boundary.

VECEE - Punching shear capacity of the footing.

MU - Ultimate moment.

PULT - Ultimate axial load.

LX - Footing length in the primary direction.

LY - Footing length in the weak direction.

ROW - Ratio of the area of steel provided over the area of concrete with the depth of the section being equal to the effective depth of the reinforcing.

MXOT - Overturning moment in the primary direction.

MYOT - Overturning moment in the weak direction.

MXCAP - Overturning moment capacity in the primary direction.

MYCAP - Overturning moment capacity in the weak direction.

QAXIAL - Uniform bearing stress resulting from axial load and footing weight.

INERTX - Inertia of the footing with respect to the primary direction.

INERTY - Inertia of the footing with respect to the weak direction.

QMX - Bearing stress resulting from the applied moment in the primary direction.

QMY - Bearing stress resulting from the applied moment in the weak direction.

QTOT - Total of the axial bearing stress and the applied moment bearing stresses.

BMSHRCAP - Beam shear capacity of the footing.

QTOTXPEDFC - Total bearing pressure at the face of the pedestal in the primary direction.

QTOTYPEDFC - Total bearing pressure at the face of the pedestal in weak direction.

User Prompt Definitions

DO YOU NEED TO SEE THE FOOTING ORIENT BEFORE START? 1=YES

This is a request that allows the user to see a printout which designates the orientation of the footing. It should be kept in mind by the user that in all cases, the primary direction referred to throughout the program is simply the strong direction of the

footing. Review of the printout for this prompt will indicate that the standard arrangement for this situation would be for the primary loads to be applied in the strong or primary direction of the footing; however, the user is not limited to this application. Input 0 if the orientation print-out is not desired.

IDENTIFICATION OF FOOTING OR GROUP

Input a brief description that will identify the footings being analyzed.

ALLOWABLE SOIL BEARING PRESSURE (KSF)

Input the allowable soil bearing pressure in units of kips per square foot.

AXIAL LOAD (KIPS)

Input the axial load in units of kips.

SHEAR IN PRIMARY DIRECTION AT TOP OF FOOTING (KIPS)

Input the shear occurring at the top of the footing acting in the primary direction in units of kips.

SHEAR IN WEAK DIRECTION AT TOP OF FOOTING (KIPS)

Similar to above.

MOMENT IN PRIMARY DIRECTION AT TOP OF FOOTING (K-FT)

Input the moment applied at the top of the footing in the primary direction in units of kip-feet.

MOMENT IN WEAK DIRECTION AT TOP OF FOOTING (K-FT)

Similar to above.

PEDESTAL OR PLATE DIMENSION IN PRIMARY DIR.(FT)

Input the dimension of the column base plate or concrete pedestal in the same direction as the primary footing dimension in units of feet.

PEDESTAL OR PLATE DIMENSION IN WEAK DIR.(FT)

Similar to above.

DO YOU WANT TO CHECK A KNOWN FOOTING? 1=YES 0=NO

If analysis of a known footing is desired, respond with a 1. If design of a new footing is desired, respond with 0.

DO YOU WANT TO DESIGN A FOOTING? 1=YES 0=NO

If it is desired to analyze and design a new footing, input 1; if not input 0.

NEW FOOTING WITH DIFFERENT LOADS? 1=YES 0=NO

If it is desired to consider a different footing with different loadings, input 1; otherwise input 0.

DO YOU WANT TO CHECK ANOTHER KNOWN FTG? 1=Y 0=N

The user has the option to evaluate another known footing shape based on the loads already input. If this is desired input 1; otherwise input 0.

LENGTH IN PRIMARY DIRECTION (FT)

Input the length of the known footing in the primary direction in units of feet.

LENGTH IN WEAK DIRECTION (FT)

Similar to above.

THICKNESS (FT)

Input the total thickness of the known footing in units of feet.

DO YOU WANT REINF. THIS FTG? 1=YES 0=NO

If the user is satisfied with the resulting footing and desires to know required reinforcement, respond with 1. If another footing option is desired, input 0.

WHICH DO YOU WANT? 1=SQUARE 0=RECT.

The user has the option to design either a square or rectangular footing. If a square footing is desired, input 1. If a rectangular footing is desired, input 0.

INPUT DESIRED WEAK/PRIMARY RATIO

The user has chosen to analyze and design a rectangular footing. The user must specify what relationship of width to length is desired. Select a ratio and input.

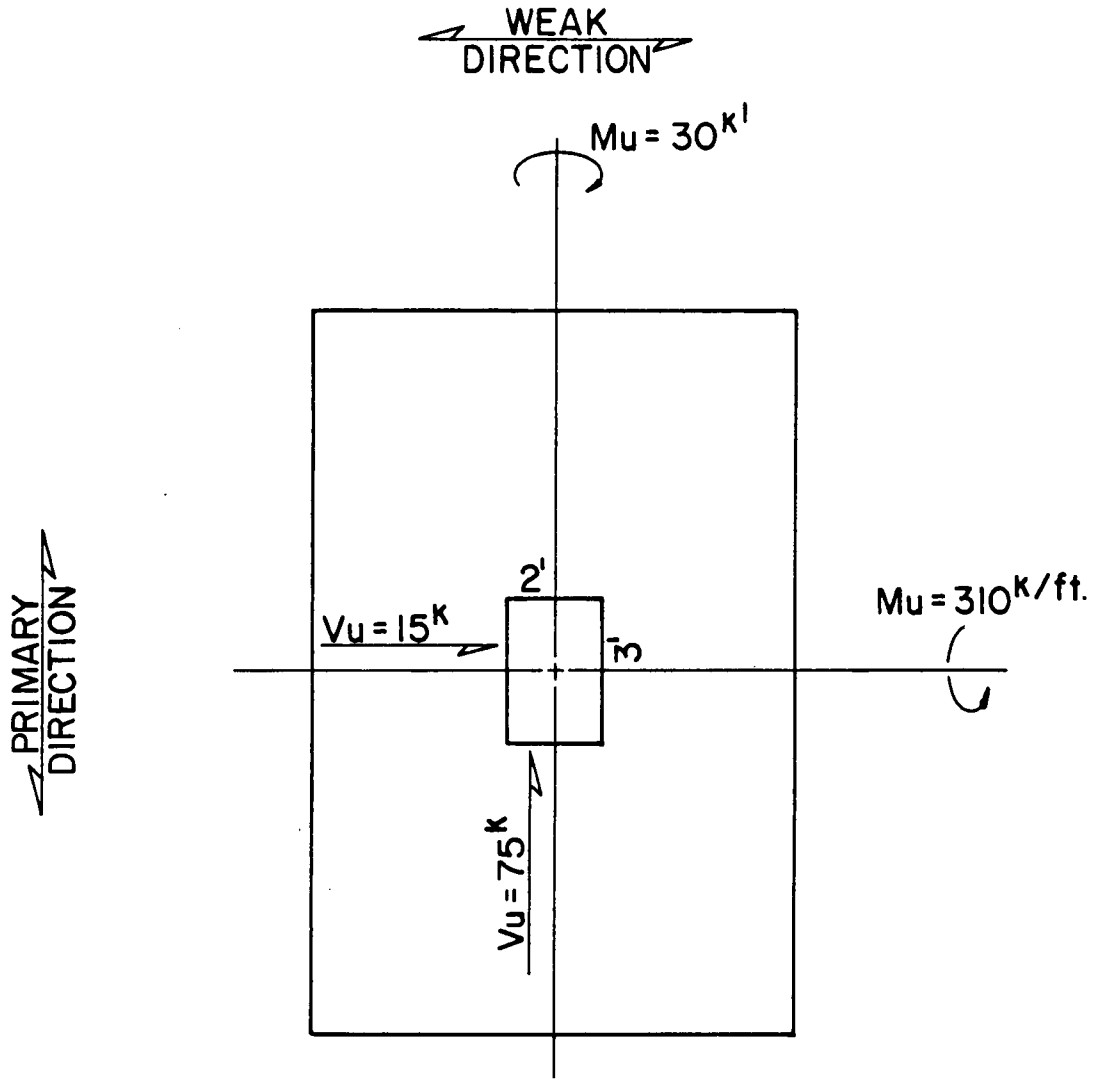
DO YOU WANT TO CHANGE THE RATIO OF WEAK/PRIMARY? 1=YES

The program has analyzed the previously input weak to primary dimension ratio. The user now has the option to change this ratio. If this is desired, input 1. If not, respond with a 0 input.

Examples

Example 4-1

Using the footing loads depicted in Figure 52, the use of the program to design a two-way rectangular footing is demonstrated.



f'c = 3000 PSI
Fy = 60 KSI
Safe Bearing Pressure = 3 KSF
Overburden = 0'
Pu = 100^k

Footings B-7 B-8

FIGURE 52

EXAMPLE 4-1
FOOTING ARRANGEMENT AND LOADING

The program begins with the screen prompt "DO YOU NEED TO SEE THE FOOTING ORIENT. BEFORE START? 1=YES?" This prompt is to allow the user to see the typical primary/weak loading relationship of a footing. Input 1 and press RETURN. The printer then displays a rectangular shaped footing with a notation indicating that the long dimension of the footing is the primary direction. An additional note on this figure indicates that the primary direction is the X direction and the weak direction is the Y direction. The user should be very careful to note at this point that this merely demonstrates that the primary direction referred to throughout the program is the strong direction of the footing. A situation where the primary or maximum loads are applied about the weak axis of the member can be analyzed and designed by simply applying these primary loads in what is identified in the program as the weak direction. The program analysis will satisfy all requirements and size the footing accordingly.

The screen next displays "IDENTIFICATION OF FOOTING OR GROUP?". Referring to Figure 52, input FTG'S B-7 B-8 and press RETURN. The screen then displays "F'c (PSI)?" Input 3000 and press RETURN. The screen then displays "Fy (KSI)?" Input 60 and press RETURN.

The screen then displays "ALLOWABLE SOIL BEARING PRESSURE (KSF)?". Input 3 and press RETURN. The screen then displays "OVERBURDEN (FT)?". Input 0 and press RETURN.

The screen next displays "AXIAL LOAD (KIPS)?". As can be seen in Figure 52, the ultimate axial load is 100 kips. Reducing this ultimate load to service loading, divide 100 by 1.55, which results in 64.52 kips. Input 64.52 and press RETURN.

The screen then displays "SHEAR IN PRIMARY DIRECTION AT TOP OF FOOTING (KIPS)?". The ultimate shear in the primary direction of the footing is 75 kips. Dividing this by 1.55 yields 48.39 kips. Input 48.39 and press RETURN. The screen next displays "SHEAR IN WEAK DIRECTION AT TOP OF FOOTING (KIPS)?". The ultimate shear in the weak direction of the footing is 15 kips. Dividing this 1.55 yields 9.68 kips. Input 9.68 and press RETURN. The screen next displays "MOMENT IN PRIMARY DIRECTION AT TOP OF FOOTING (K-FT)?". The ultimate moment in the primary direction is 310 kip-feet. Dividing this by 1.55 yields 200 kip-feet. Input 200 and press RETURN. The screen next displays "MOMENT IN WEAK DIRECTION AT TOP OF FOOTING (K-FT)?". The ultimate moment in the weak direction is 30 kip-feet. Dividing this by 1.55 yields 19.35 kip-feet. Input 19.35 and press RETURN. It should be noted at this point that the program was set up to make a conservative estimate of the ultimate moments in the footing by multiplying service input by a factor of 1.55. If an exact ultimate analysis is required, the user may take the steps just described and divide the already determined ultimate moments by the

program conversion factor of 1.55. This will result in correct ultimate actions for ultimate analysis of the footing section. This may, however, cause minor errors in the service load evaluation.

The screen next displays "PEDESTAL OR PLATE DIMENSION IN PRIMARY DIR. (FT)?". Input 3 and press RETURN. The screen next displays "PEDESTAL OR PLATE DIMENSION IN WEAK DIR. (FT)?". Input 2 and press RETURN.

The screen then displays "DO YOU WANT TO CHECK A KNOWN FOOTING? 1=YES?". As this is a design example, respond by inputting 0 and pressing RETURN. The screen next displays "DO YOU WANT TO DESIGN A FOOTING? 1=YES?". Input 1 and press RETURN. The screen next displays "WHICH DO YOU WANT? SQUARE=1 RECT.=0?". As it appears that a rectangular footing would be most efficient as the loading is very large in one direction, input 0 for a rectangular footing and press RETURN. The screen next displays "INPUT DESIRED WEAK/PRIMARY RATIO?". This ratio is totally a function of the user's discretion. A common rectangular footing width-to-length relationship is 2 to 3. Input .67 and press RETURN. The screen then displays "RUNNING".

The program emits tones specifically designed to advise the user that different aspects of the sizing operation are being conducted. Thickness of the slab is first sized based on punching shear requirements, incrementing in 1" units. Length in the primary and weak directions is increased in 3"

increments until allowable bearing pressure and overturning capacities are satisfied. Beam shear is then analyzed and increments of 1" are used if shear capacity is exceeded. After each increment, the program returns to the beginning of the sizing routine to assure that subsequent iterations and resulting increments have not affected the capacity of the footing at that point. For example, if beam shear capacity requires that the footing thickness be increased by 2", this occurs at a point after bearing pressure and overturning capacity have been checked. The program will re-analyze these aspects and it is conceivable that the bearing pressure could be compromised as a result of this increased thickness. The program will then increment the length to increase the area of the footing and decrease the bearing pressure. The beam shear will then be reevaluated based on these new footing dimensions.

The printer then displays a full complement of information regarding this footing. The footing required based on the previous input is 7.37 feet wide by 11 feet long by 1.08333 feet thick. The screen then displays "DO YOU WANT TO CHANGE THE RATIO OF WEAK/PRIMARY? 1=YES?". Input 0 and press RETURN. The screen then displays "DO YOU WANT TO CHECK ANOTHER KNOWN FOOTING? 1=YES?". As the previously described footing dimensions are an odd size, the user would want to try to approximate a more standard set of

dimensions to satisfy these footing requirements. Input 1 and press RETURN.

The screen then displays "LENGTH IN PRIMARY DIRECTION (FT)?". As we know that a 7.37 feet by 11 feet by 1.08333 footing will work, let us check a 7'-6" by 11' by 1'-3" footing. Input 11 and press RETURN. The screen next displays "LENGTH IN WEAK DIRECTION (FT)?". Input 7.5 and press RETURN. The screen next displays "THICKNESS (FT)?" Input 1.25 and press RETURN. The program then analyzes the input footing dimensions and the printer then displays the resulting capacities and bearing pressures. For this example, input of the known footing dimensions results in a factor of safety against overturning in the primary direction of 1.69172, a maximum bearing pressure of 2.99676 KSF and punching shear capacity and beam shear capacities above the requirements.

The screen next displays "DO YOU WANT TO CHECK ANOTHER KNOWN FOOTING? 1=YES?". As this footing appears to be satisfactory, respond by inputting 0 and pressing RETURN. The screen then displays "DO YOU WANT TO REINF. THIS FTG? 1=YES 0=NO?". Input 1 and press RETURN. The printer then displays the total bottom steel required in the primary and weak directions and indicates that no top steel is required. The screen next displays "NEW FOOTING WITH DIFFERENT LOADS? 1=YES?". As this completes the design of this footing, input 0 and press RETURN. This completes the design of this

footing. A print-out of the tape resulting from this analysis is shown in Figure 53.

Figure 54 shows the loading of a rectangular footing with the primary loads being applied in the weak direction of the footing orientation. Also included in this figure is a tape print-out resulting from analysis of these loadings.

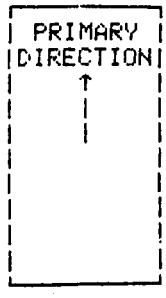
Figure 55 illustrates a loading of a square footing and the resulting print-out tape for analysis of these loads.

Flow Charts

Figure 56 describes the chronological operation of the "TWO-WAY" program.

Program Copy

Figure 57 is a print-out of the "TWO-WAY" program. A wide margin is provided to allow the user to make notes, if desired.



PRIMARY DIRECTION=
X-DIRECTION

WEAK DIRECTION=
Y-DIRECTION

FTG'S B-7 B-8

FOOTING: 7.37 X 11 X
1.08333
P= 64.52 KIPS
Mx= 200 K-FT
My= 19.35 K-FT
Vx= 48.39 KIPS
Vy= 9.68 KIPS
OVERBURDEN= 0 FT

FSOTX= 1.69472
FSOTY= 9.61908
MAXIMUM BEARING
PRESSURE= 2.95632 KSF
ULT. BEAM SHEAR=
87.3745 KIPS
ALLOWABLE=
92.0371 KIPS
ULT. PUNCHING SHEAR=
100.006 KIPS
PUNCHING CAPACITY=
326.112 KIPS
PUNCHING CAPACITY
LIMIT= 328.853 KIPS

ULTIMATE MOMENTS

PRIM. BOTT. = 205.164 K-FT
WEAK BOTT. = 72.8412 K-FT
PRIM. TOP= 10.5016 K-FT
WEAK TOP= 0 K-FT

FTG'S B-7 B-8

FOOTING: 7.5 X 11 X 1.25

P= 64.52 KIPS
Mx= 200 K-FT
My= 19.35 K-FT
Vx= 48.39 KIPS
Vy= 9.68 KIPS
OVERBURDEN= 0 FT

FSOTX= 1.69172
FSOTY= 9.57177
MAXIMUM BEARING
PRESSURE= 2.99676 KSF
ULT. BEAM SHEAR=
86.5486 KIPS
ALLOWABLE=
113.379 KIPS
ULT. PUNCHING SHEAR=
100.006 KIPS
PUNCHING CAPACITY=
414.756 KIPS
PUNCHING CAPACITY
LIMIT= 418.241 KIPS

ULTIMATE MOMENTS

PRIM. BOTT. = 211.508 K-FT
WEAK BOTT. = 77.3632 K-FT
PRIM. TOP= 14.9579 K-FT
WEAK TOP= 0 K-FT

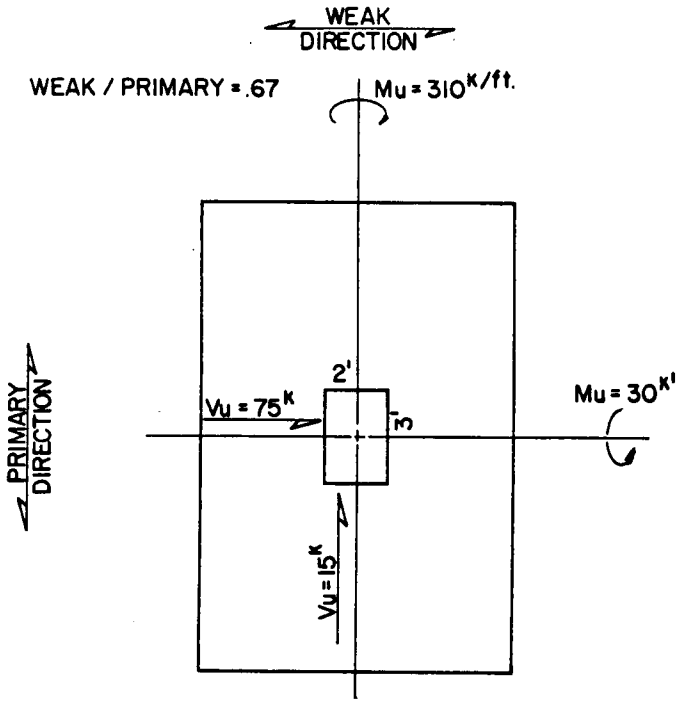
REINFORCING

BOTT. STEEL PRIMARY=
4.29698 SQ. IN. [TOT.]
BOTT. STEEL WEAK=
2.01185 SQ. IN. [TOT.]
NO PRIM. TOP STL. REQ'D.

NO WEAK TOP STL. REQ'D.

FIGURE 53

EXAMPLE 4-1
RESULTING PRINT-OUT TAPE




```
FTG'S B-9 B-10

FOOTING: 9.045 X 13.5 X
 1.08333
P= 64.52 KIPS
Mx= 19.35 K-FT
My= 200 K-FT
Vx= 9.68 KIPS
Vy= 48.39 KIPS
OVERBURDEN= 0 FT

FSOTX= 19.1047
FSOTY= 1.51487
MAXIMUM BEARING
PRESSURE= 2.17077 KSF
ULT. BEAM SHEAR=
 107.564 KIPS
  ALLOWABLE=
 112.955 KIPS
ULT. PUNCHING SHEAR=
 100.006 KIPS
PUNCHING CAPACITY=
 326.112 KIPS
PUNCHING CAPACITY
LIMIT= 328.853 KIPS

▒▒ ULTIMATE MOMENTS ▒▒

PRIM. BOTT. = 149.029 K-FT
WEAK BOTT. = 221.49 K-FT
PRIM. TOP= 0 K-FT
WEAK TOP= 22.264 K-FT


▒▒▒ REINFORCING ▒▒▒

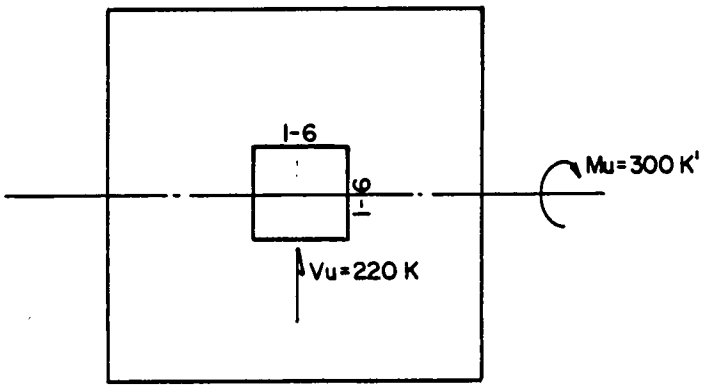
BOTT. STEEL PRIMARY=
    3.63696 SQ. IN. [TOT.]
BOTT. STEEL WEAK=
    5.40432 SQ. IN. [TOT.]
NO PRIM. TOP STL. REQ'D.

NO WEAK TOP STL. REQ'D.
```

FIGURE 54

RECTANGULAR FOOTING WITH PRIMARY LOADS APPLIED IN THE WEAK DIRECTION AND EXAMPLE OF RESULTING PRINT-OUT TAPE

TYPICAL INTERIOR FOOTING



f'_c = 3000 PSI
Fy = 60 KSI
Safe Bearing Pressure = 10 KSF
Overburden = 3-6
Pu = 800 K

```
TYP. INT. FTG.

FOOTING: 9.5 X 9.5 X
 2.25
P= 516.13 KIPS
Mx= 193.55 K-FT
My= 0 K-FT
Vx= 141.94 KIPS
Vy= 0 KIPS
OVERBURDEN= 3.5 FT

FSOTX= 5.36493
FSOTY=INFINITE
MAXIMUM BEARING
PRESSURE= 9.99605 KSF
ULT. BEAM SHEAR=
 277.324 KIPS
  ALLOWABLE=
 293.47 KIPS
ULT. PUNCHING SHEAR=
 800.002 KIPS
PUNCHING CAPACITY=
 1089.7 KIPS
PUNCHING CAPACITY
LIMIT= 854.666 KIPS

▒▒▒ ULTIMATE MOMENTS ▒▒▒

PRIM. BOTT. = 1058.82 K-FT
WEAK BOTT. = 754.692 K-FT
PRIM. TOP= 0 K-FT
WEAK TOP= 0 K-FT

▬▬ REINFORCING ▬▬

BOTT. STEEL PRIMARY=
     10.4963 SQ. IN. [TOT. ]
BOTT. STEEL WEAK=
     9.80934 SQ. IN. [TOT. ]
NO PRIM. TOP STL. REQ'D.

NO WEAK TOP STL. REQ'D.
```

FIGURE 55

SQUARE FOOTING AND LOADING AND EXAMPLE
OF RESULTING PRINT-OUT TAPE

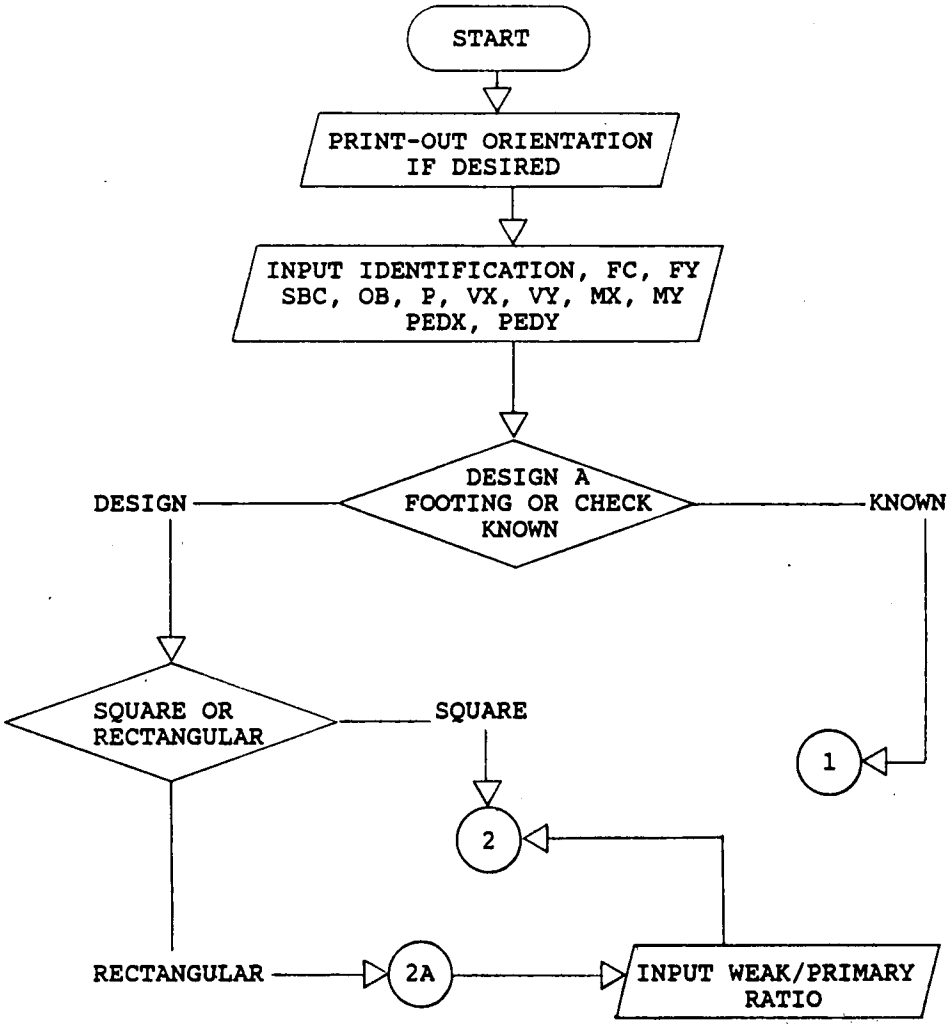


FIGURE 56

TWO-WAY PROGRAM FLOW CHART

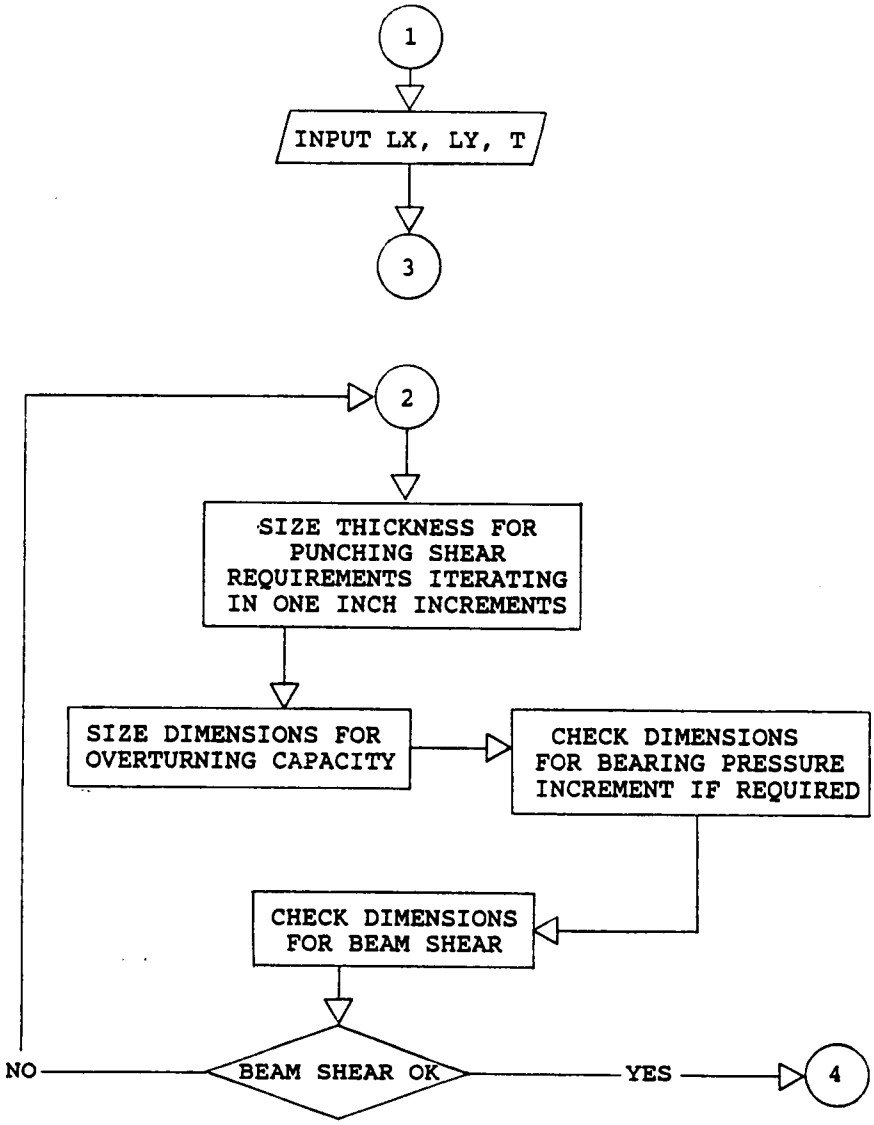


FIGURE 56 (Continued)

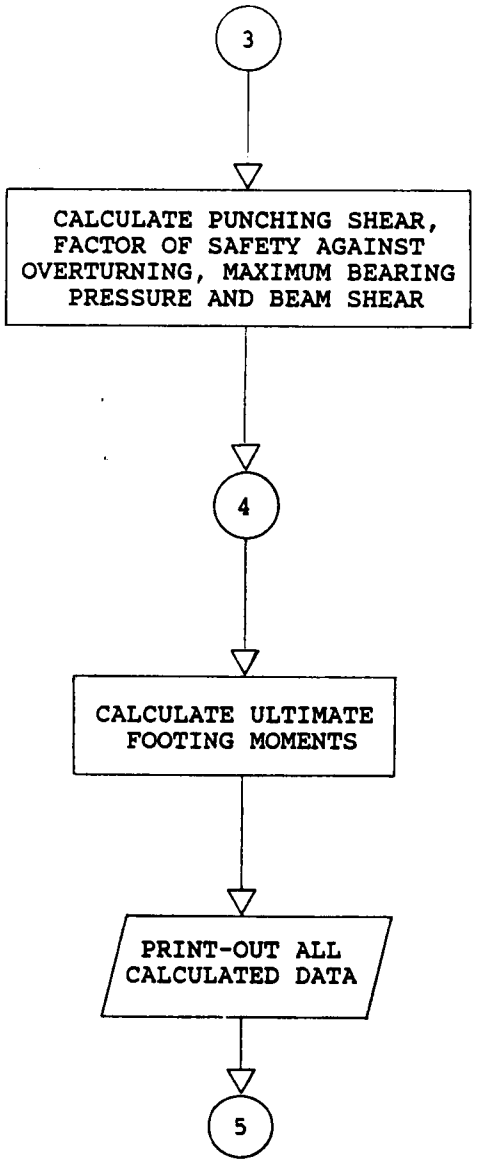


FIGURE 56 (Continued)

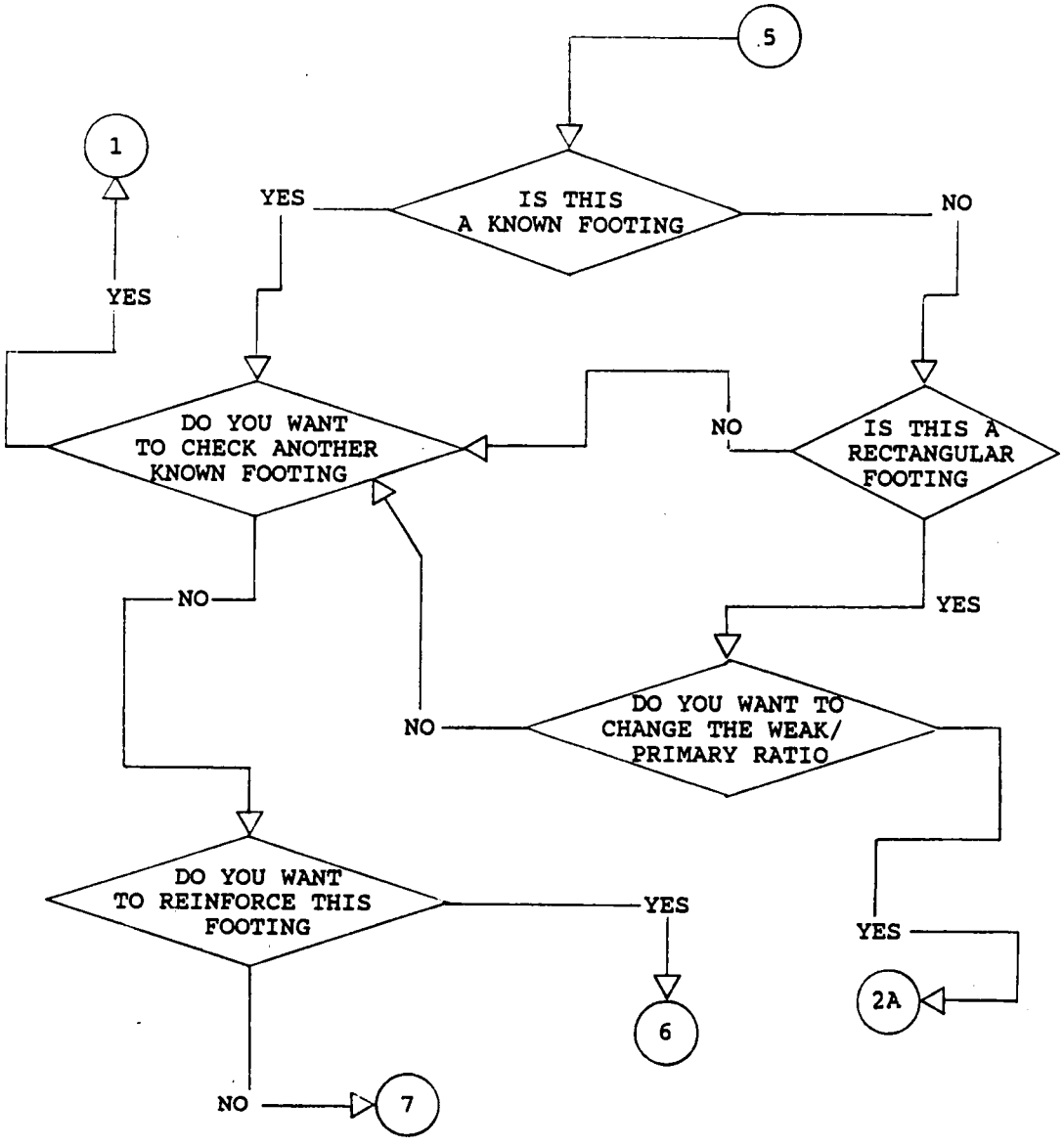


FIGURE 56 (Continued)

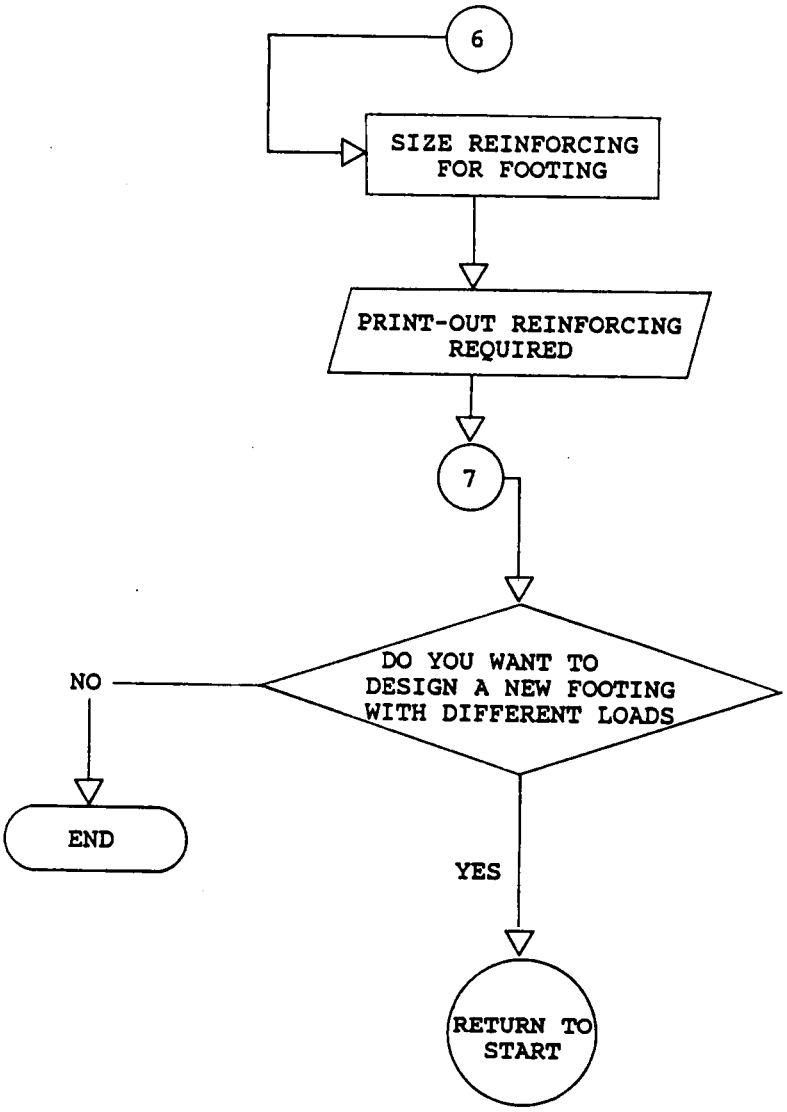


FIGURE 56 (Continued)

```
1 PRINT"DO YOU NEED TO S
EE"
2 PRINT"THE FOOTING ORIE
NT."
3 PRINT"BEFORE START? 1=
YES"
4 INPUT SEE
5 IF SEE=1 GOTO 6 ELSE G
OTO 29
6 CLS
7 LPRINT"        ┌──────
──┐"
8 LPRINT"        | PRIMAR
Y |"
9 LPRINT"        |DIRECTI
ON|"
10 LPRINT"       |    ↑
  |"
11 LPRINT"       |    |
  |"
12 LPRINT"       |    |
  |"
13 LPRINT"       |
  |"
14 LPRINT"       |
  |"
15 LPRINT"       |
  |"
16 LPRINT"       |
  |"
17 LPRINT"       |
  |"
18 LPRINT"       └──────
──┘"
19 LPRINT""
20 LPRINT"PRIMARY DIRECT
ION="
21 LPRINT"X-DIRECTION"
22 LPRINT""
23 LPRINT"WEAK DIRECTION
="
24 LPRINT"Y-DIRECTION"
25 LPRINT""
26 LPRINT""
27 LPRINT""
28 LPRINT""
29 CLS
30 PRINT"IDENTIFICATION
OF"
31 PRINT"OF FOOTING OR"
32 PRINT"GROUP?"
33 INPUT A$
34 CLS
35 PRINT"F'c (PSI)?"
36 INPUT FC
37 CLS
38 PRINT"Fy (KSI)?"
39 INPUT FY
40 CLS
41 PRINT"ALLOWABLE SOIL"
42 PRINT"BEARING PRESSUR
E"
```

FIGURE 57

TWO-WAY PROGRAM PRINT-OUT

```
43 PRINT"(KSF)?"
44 INPUT SBC
45 CLS
46 PRINT"OVERBURDEN (FT)
?"
47 INPUT OB
48 CLS
49 PRINT"AXIAL LOAD (KIP
S)?"
50 INPUT P
51 CLS
52 PRINT"SHEAR IN PRIMAR
Y"
53 PRINT"DIRECTION AT TO
P"
54 PRINT"OF FOOTING (KIP
S)?"
55 INPUT VX
56 CLS
57 PRINT"SHEAR IN WEAK"
58 PRINT"DIRECTION AT TO
P"
59 PRINT"OF FOOTING (KIP
S)?"
60 INPUT VY
61 CLS
62 PRINT"MOMENT IN PRIMA
RY"
63 PRINT"DIRECTION AT TO
P"
64 PRINT"OF FOOTING (K-F
T)?"
65 INPUT MX
66 CLS
67 PRINT"MOMENT IN WEAK"
68 PRINT"DIRECTION AT TO
P"
69 PRINT"OF FOOTING (K-F
T)?"
70 INPUT MY
71 CLS
72 PRINT"PEDESTAL OR PLA
TE"
73 PRINT"DIMENSION IN"
74 PRINT"PRIMARY DIR. (FT
)?"
75 INPUT PEDX
76 CLS
77 PRINT"PEDESTAL OR PLA
TE"
78 PRINT"DIMENSION IN"
79 PRINT"WEAK DIR. (FT)?"
80 INPUT PEDY
81 CLS
82 PRINT"DO YOU WANT TO"
83 PRINT"CHECK A KNOWN"
84 PRINT"FOOTING? 1=YES
0=NO"
85 INPUT CHECK
86 CLS
87 IF CHECK=1 GOTO 108
88 PRINT"DO YOU WANT TO"
89 PRINT"DESIGN A FOOTIN
G?"
90 PRINT"1=YES 0=NO"
91 INPUT DESIGN
92 CLS
93 IF DESIGN=1 GOTO 225
94 PRINT"NEW FOOTING"
```

FIGURE 57 (Continued)

```
95 PRINT"WITH DIFFERENT"
96 PRINT"LOADS? 1=YES 0=
NO"
97 INPUT DIFOT
98 IF DIFOT=1 GOTO 30
99 CLS
100 END
101 PRINT"DO YOU WANT TO
"
102 PRINT"TO CHECK ANOTH
ER"
103 PRINT"KNOWN FTG? 1=Y
 0=N"
104 INPUT ANOTKNOW
105 CLS
106 IF ANOTKNOW=1 GOTO 1
08
107 GOTO 171
108 PRINT"LENGTH IN"
109 PRINT"PRIMARY"
110 PRINT"DIRECTION (FT)
?"
111 INPUT LX
112 CLS
113 PRINT"LENGTH IN WEAK
"
114 PRINT"DIRECTION (FT)
?"
115 INPUT LY
116 CLS
117 PRINT"THICKNESS (FT)
?"
118 INPUT T
119 CLS
120 DESIGN=0
121 GOSUB 279
122 LPRINT A$
123 LPRINT""
124 LPRINT"FOOTING:"LY"X
"LX"X"T
125 LPRINT"P="P"KIPS"
126 LPRINT"Mx="MX"K-FT"
127 LPRINT"My="MY"K-FT"
128 LPRINT"Vx="VX"KIPS"
129 LPRINT"Vy="VY"KIPS"
130 LPRINT"OVERBURDEN="O
B"FT"
131 LPRINT""
132 IF FSOTX>500 GOTO 13
3 ELSE GOTO 135
133 LPRINT"FSOTX=INFINIT
E"
134 GOTO 136
135 LPRINT"FSOTX="FSOTX
136 IF FSOTY>500 GOTO 13
7 ELSE GOTO 139
137 LPRINT"FSOTY=INFINIT
E"
138 GOTO 140
139 LPRINT"FSOTY="FSOTY
140 LPRINT"MAXIMUM BEARI
NG"
141 LPRINT"PRESSURE="QTO
T"KSF"
142 IF BMSHRULT<0 THEN B
MSHRULT=0
143 LPRINT"ULT. BEAM SHEA
R="
```

FIGURE 57 (Continued)

```
144 LPRINT BMSHRULT"KIPS
"
145 LPRINT"  ALLOWABLE="
146 LPRINT BMSHRCAP"KIPS
"
147 BETAC=PEDX/PEDY
148 LPRINT"ULT. PUNCHING
SHEAR="
149 PUNCHULT=P*1.55
150 LPRINT PUNCHULT"KIPS
"
151 BO=((PEDY*12)+D)*(2)
+((PEDX*12)+D)*(2)
152 VECEE=((.85)*(2+4/BE
TAC)*(FC^.5)*(BO)*(D))/1
000
153 VECEELIMIT=((4)*(FC^
.5)*(BO)*(D))/1000
154 LPRINT"PUNCHING CAPA
CITY="
155 LPRINT VECEE"KIPS"
156 LPRINT"PUNCHING CAPA
CITY"
157 LPRINT"LIMIT="VECEEL
IMIT"KIPS"
158 LPRINT""
159 LPRINT"▒▒ ULTIMATE
MOMENTS ▒▒"
160 LPRINT""
161 LPRINT"PRIM. BOTT. ="F
OOTMXULT"K-FT"
162 LPRINT"WEAK BOTT. ="F
OOTMYULT"K-FT"
163 LPRINT"PRIM. TOP="MXT
OPULT"K-FT"
164 LPRINT"WEAK TOP="MYT
OPULT"K-FT"
165 LPRINT""
166 LPRINT""
167 LPRINT""
168 CLS
169 IF DESIGN=1 GOTO 258
170 GOTO 101
171 PRINT"DO YOU WANT TO
"
172 PRINT"REINF. THIS FTG
?"
173 PRINT"1=YES 0=NO"
174 INPUT REINF
175 CLS
176 IF REINF=0 GOTO 88
177 MU=FOOTMXULT
178 B=LY*12
179 GOSUB 266
180 LPRINT"▒▒▒▒ REINFOR
CING ▒▒▒▒▒"
181 LPRINT""
182 LPRINT"BOTT. STEEL PR
IMARY="
183 LPRINT "    "AS"SQ. IN
. [TOT. ]"
184 MU=FOOTMYULT
185 B=LX*12
186 GOSUB 266
187 LPRINT"BOTT. STEEL WE
AK="
188 LPRINT"    "AS"SQ. IN.
[TOT. ]"
189 IF MXTOPULT=0 GOTO 2
```

FIGURE 57 (Continued)

```
14 ELSE GOTO 191
190 IF MYTOPULT=0 GOTO 2
16 ELSE GOTO 200
191 OKSTRESS=(5)*(.9)*(F
C^.5)
192 XTOPSTRESSX=(MYTOPUL
T*12000)*((T*12)/2)/((1/
12)*(LX*12)*((T*12)^3))
193 IF XTOPSTRESSX<OKSTR
ESS GOTO 214
194 MU=MYTOPULT
195 B=LY*12
196 GOSUB 265
197 LPRINT"TOP STEEL PRI
MARY="
198 LPRINT"    "AS"SQ. IN.
[TOT.]"
199 GOTO 190
200 OKSTRESS=(5)*(.9)*(F
C^.5)
201 YTOPSTRESSY=(MYTOPUL
T*12000)*((T*12)/2)/((1/
12)*(LX*12)*((T*12)^3))
202 IF YTOPSTRESSY<OKSTR
ESS GOTO 216
203 MU=MYTOPULT
204 B=LX*12
205 GOSUB 265
206 LPRINT"TOP STEEL WEA
K="
207 LPRINT"    "AS"SQ. IN.
[TOT.]"
208 LPRINT""
209 LPRINT""
210 LPRINT""
211 LPRINT""
212 LPRINT""
213 GOTO 218
214 LPRINT"NO PRIM. TOP S
TL. REQ'D."
215 GOTO 190
216 LPRINT""
217 LPRINT"NO WEAK TOP S
TL. REQ'D."
218 LPRINT"-------------
---------"
219 LPRINT""
220 LPRINT""
221 LPRINT""
222 LPRINT""
223 CLS
224 GOTO 94
225 PRINT"WHICH DO YOU W
ANT?"
226 PRINT"1=SQUARE 0=REC
T."
227 INPUT WHICH
228 CLS
229 IF WHICH=0 GOTO 231
230 GOTO 234
231 PRINT"INPUT DESIRED"
232 PRINT"WEAK/PRIMARY R
ATIO"
233 INPUT RATIO
234 CLS
235 PRINT"[redacted]
[redacted]"
236 PRINT"      RUNNING"
```

FIGURE 57 (Continued)

```
237 PRINT"
Y
"
238 PULT=P*1.55
239 BETAC=PEDX/PEDY
240 D=3.5
241 BO=((PEDY*12)+D)*(2)
+((PEDX*12)+D)*(2)
242 VECEE=((.85)*(2+4/BE
TAC)*(FC^.5)*(BO)*(D))/1
000
243 VECEELIMIT=((4)*(FC^
.5)*(BO)*(D))/1000
244 IF VECEE>VECEELIMIT
THEN VECEE=VECEELIMIT
245 IF PULT<VECEE GOTO 2
49
246 D=D+1
247 SOUND 20,1
248 GOTO 241
249 T=(D+3.5)/12
250 LX=PEDX+(2*(D/12))
251 LX=FIX(LX)+1
252 IF WHICH=0 THEN LY=L
X*RATIO
253 IF WHICH=1 THEN LY=L
X
254 GOSUB 279
255 GOTO 122
256 END
257 GOTO 265
258 IF WHICH=1 GOTO 170
259 PRINT"DO YOU WANT TO
"
260 PRINT"CHANGE THE RAT
IO OF"
261 PRINT"WEAK/PRIMARY?
1=YES"
262 INPUT BOLT
263 CLS
264 IF BOLT=1 GOTO 231 E
LSE GOTO 170
265 GOTO 256
266 W=.2/FY
267 RN=(MU*12000)/(.9*B*
(D^2))
268 J=(.85*FC)/(FY*1000)
269 K=(2*RN)/(.85*FC)
270 L=1-K
271 M=SQR(L)
272 N=1-M
273 ROW=J*N
274 IF ROW<W GOTO 277
275 AS=ROW*B*D
276 RETURN
277 AS=1.33*ROW*B*D
278 RETURN
279 IF MY=0 AND VY=0 GOT
O 281
280 GOTO 283
281 MY=.01
282 VY=.01
283 GOTO 284
284 IF MX=0 AND VX=0 GOT
O 286
285 GOTO 288
286 MX=.01
287 VX=.01
288 GOTO 289
289 MXOT=MX + VX*T
```

FIGURE 57 (Continued)

```
290 MYOT=MY + UY*T
291 MXCAP=(P)*(LX/2)+(OB
)*(LX)*(LY)*(.1)*(LX/2)+
(LX)*(LY)*(T)*(.15)*(LX/
2)+(.5)*(T)*(.3*T)*(LY)*
(T/3)
292 FSOTX=MXCAP/MXOT
293 IF DESIGN=0 GOTO 301
294 IF FSOTX>1.5 GOTO 30
1
295 LX=LX+.25
296 IF WHICH=0 THEN LY=L
X*RATIO
297 IF WHICH=1 THEN LY=L
X
298 SOUND 15,1
299 SOUND 14,1
300 GOTO 279
301 MYCAP=(P)*(LY/2)+(OB
)*(LX)*(LY)*(.1)*(LY/2)+
(LX)*(LY)*(T)*(.15)*(LY/
2)+(.5)*(T)*(.3*T)*(LX)*
(T/3)
302 FSOTY=MYCAP/MYOT
303 IF DESIGN=0 GOTO 312
304 IF FSOTY>1.5 GOTO 31
2
305 LX=LX+.25
306 IF WHICH=0 THEN LY=L
X*RATIO
307 IF WHICH=1 THEN LY=L
X
308 SOUND 13,1
309 SOUND 12,1
310 SOUND 11,1
311 GOTO 279
312 AREA=LX*LY
313 AXLOAD=P+(AREA)*(OB)
*(.1)+(AREA)*(T)*(.15)
314 QAXIAL=AXLOAD/AREA
315 INERTX=(1/12)*(LY)*(
LX^3)
316 INERTY=(1/12)*(LX)*(
LY^3)
317 QMX=((MXOT)*(LX/2))/
INERTX
318 QMY=((MYOT)*(LY/2))/
INERTY
319 QTOT=QAXIAL+QMX+QMY
320 IF DESIGN=0 GOTO 330
321 IF QTOT<SBC GOTO 330
322 LX=LX+.25
323 IF WHICH=0 THEN LY=L
X*RATIO
324 IF WHICH=1 THEN LY=L
X
325 SOUND 10,1
326 SOUND 9,1
327 SOUND 8,1
328 SOUND 7,1
329 GOTO 279
330 D=((T)*(12)-3.5)
331 BMSHRCAP=((2)*(FC^.5
)*(LY*12)*(D))/1000
332 SHRTRIBENDX=(LX/2)-(
PEDX/2)-(D/12)
333 SHRTRIBENDY=(LY/2)-(
PEDY/2)-(D/12)
```

FIGURE 57 (Continued)

```
334 QMSHRTRIBENDX=(((MXO
T)*((LX/2)-(SHRTRIBENDX)
))/INERTX)
335 QMSHRTRIBENDY=(MYOT)
*(((LY/2)-(SHRTRIBENDY))
/INERTY)
336 QTOTSHRTRIBEND=QMSHR
TRIBENDX+QMSHRTRIBENDY+Q
AXIAL
337 AVGQTOT=(QTOT+QTOTSH
RTRIBEND)/2
338 BMSHR=(SHRTRIBENDX)*
(LY)*(AVGQTOT)
339 BMSHRULT=BMSHR*1.55
340 IF DESIGN=0 GOTO 350
341 IF BMSHRULT<BMSHRCAP
 GOTO 350
342 D=D+1
343 T=(D+3.5)/12
344 SOUND 8,1
345 SOUND 7,1
346 SOUND 6,1
347 SOUND 5,1
348 SOUND 4,1
349 GOTO 279
350 QTOTX=QAXIAL+QMX
351 QTOTY=QAXIAL+QMY
352 QTOTXPEDFC=QAXIAL+((
(MXOT)*(PEDX/2))/INERTX)
353 QTOTYPEDFC=QAXIAL+((
(MYOT)*(PEDY/2))/INERTY)
354 FOOTMXA=(QTOTXPEDFC)
*((LX/2)-(PEDX/2))*(LY)*
(((LX/2)-(PEDX)/2)/2)
355 FOOTMYA=(QTOTYPEDFC)
*((LY/2)-(PEDY/2))*(LX)*
(((LY/2)-(PEDY)/2)/2)
356 FOOTMXB=(.5*((LX/2)-
(PEDX/2))*(QTOTX-QTOTXPE
DFC)*(LY))*(((LX/2)-(PED
X/2))*(2/3))
357 FOOTMYB=(.5*((LY/2)-
(PEDY/2))*(QTOTY-QTOTYPE
DFC)*(LX))*(((LY/2)-(PED
Y/2))*(2/3))
358 FOOTMX=FOOTMXA+FOOTM
XB
359 FOOTMY=FOOTMYA+FOOTM
YB
360 FOOTMXULT=FOOTMX*1.5
5
361 FOOTMYULT=FOOTMY*1.5
5
362 SLOPEX=(QMX)/(LX/2)
363 SLOPEY=(QMY)/(LY/2)
364 XLENX=(QAXIAL)/(SLOP
EX)
365 YLENY=(QAXIAL)/(SLOP
EY)
366 MUPX=(.5)*(XLENX)*(Q
AXIAL)*(LY)*(XLENX/3)
367 MUPY=(.5)*(YLENY)*(Q
AXIAL)*(LX)*(YLENY/3)
368 PEQUALTOPX=(AREA/2)*
(T)*(.15)+(AREA/2)*(OB)*
(.1)
369 ARMXTOP=LX/4
```

FIGURE 57 (Continued)

```
370 MXTOP=MUPX-(ARMXTOP*
PEQUALTOPX)
371 MXTOPULT=MXTOP*1.55
372 PEQUALTOPY=PEQUALTOP
X
373 ARMYTOP=LY/4
374 MYTOP=MUPY-(ARMYTOP*
PEQUALTOPY)
375 MYTOPULT=MYTOP*1.55
376 IF VLENY>(L'Y/2) THEN
 MYTOPULT=0
377 IF MXTOPULT>0 THEN M
XTOPULT=0
378 IF MYTOPULT>0 THEN M
YTOPULT=0
379 IF MX=.01 AND VX=.01
 GOTO 381
380 GOTO 383
381 MX=0
382 VX=0
383 GOTO 384
384 IF MY=.01 AND VY=.01
 GOTO 386
385 GOTO 388
386 MY=0
387 VY=0
388 IF MXTOPULT<0 THEN M
XTOPULT=(-1)*(MXTOPULT)
389 IF MYTOPULT<0 THEN M
YTOPULT=(-1)*(MYTOPULT)
390 SOUND 5,2
391 CLS
392 PRINT"**************
******"
393 PRINT"      ANSWERS"
394 PRINT"**************
******"
395 RETURN
```

FIGURE 57 (Continued)

CHAPTER 5

PILING ANALYSIS

Description of Program

The piling analysis program is relatively simple and is designed to analyze a particular pile pattern and foundation cap for maximum net bearing and uplift forces on the pile pattern resulting from gravity loads and applied moments.

It is specifically designed to be an iterative tool allowing the user to use his judgement for a beginning pattern and to modify original assumptions to give the most economical pile pattern and cap configuration.

It is assumed that the user has been provided with a recommendation from a geotechnical engineer indicating what is acceptable for uplift and bearing of a particular size pile for a given project. It is the user's task to combine the most effecient number of piles and cap configuration by process of trial and error. Using this program greatly expedites this process.

Nomenclature

APILE - Area of one pile.

AXIAL - Axial load.

BRG - Bearing load on the pile.

DEPTH - Depth of the cap footing.

DIA - Diameter of the pile.

IPILE - Inertia of one pile.

ITOT - Inertia of the total pile pattern.

LEGTH - Length of the pile.

ROWS - Number of rows of piling in the pattern.

UPL - Uplift load on the pile.

WDTH - Width of the cap footing.

WTFT - Weight of the cap footing.

User Prompt Definitions

IDENTIFICATION

Input a brief description that will identify the analysis.

PILE DIAMETER? (FT)

Input the diameter of the pile being considered in units of feet.

CONCRETE FOOTING LENGTH? (FT)

Input the total length of the concrete footing acting as a pile cap in units of feet.

CONCRETE FOOTING WIDTH? (FT)

Similar to above.

CONCRETE FOOTING DEPTH? (FT)

Input the total thickness of the concrete footing acting as a pile cap in units of feet.

NUMBER OF ROWS OF PILING

For the piling pattern assumed, input the number of horizontal rows of piling.

ABS. VALUE OF DIST. FROM CL PILE ROW TO CL GROUP-ROW _ (FT)

This is a request for the user to input the distance from the center line of the pile row indicated on the screen to the center line of the group. This is done for all rows in the pattern at this point. The program is written assuming that the patterns will always be symmetrical.

NUMBER OF PILES IN ROW __

For each row of piling previously described, the user should input the number of piles in that row.

MOMENT? (K-FT)

The user should input the service moment applied to the pile pattern.

AXIAL LOAD EXCLUDING FOOTING WEIGHT? (KIPS)

The user should input the applied service axial load to the pattern. The program calculates the weight induced by the footing.

Examples

Example 5-1

Referring to Figure 58, the use of the program will be demonstrated. Assuming that a interstate sign is to be erected on a site previously used as a landfill, a geotechnical engineer has reported that a pile foundation must be used. Based on the conditions of the soil, his report indicates that 18" diameter piles will develop an allowable bearing capacity of eight tons and an allowable

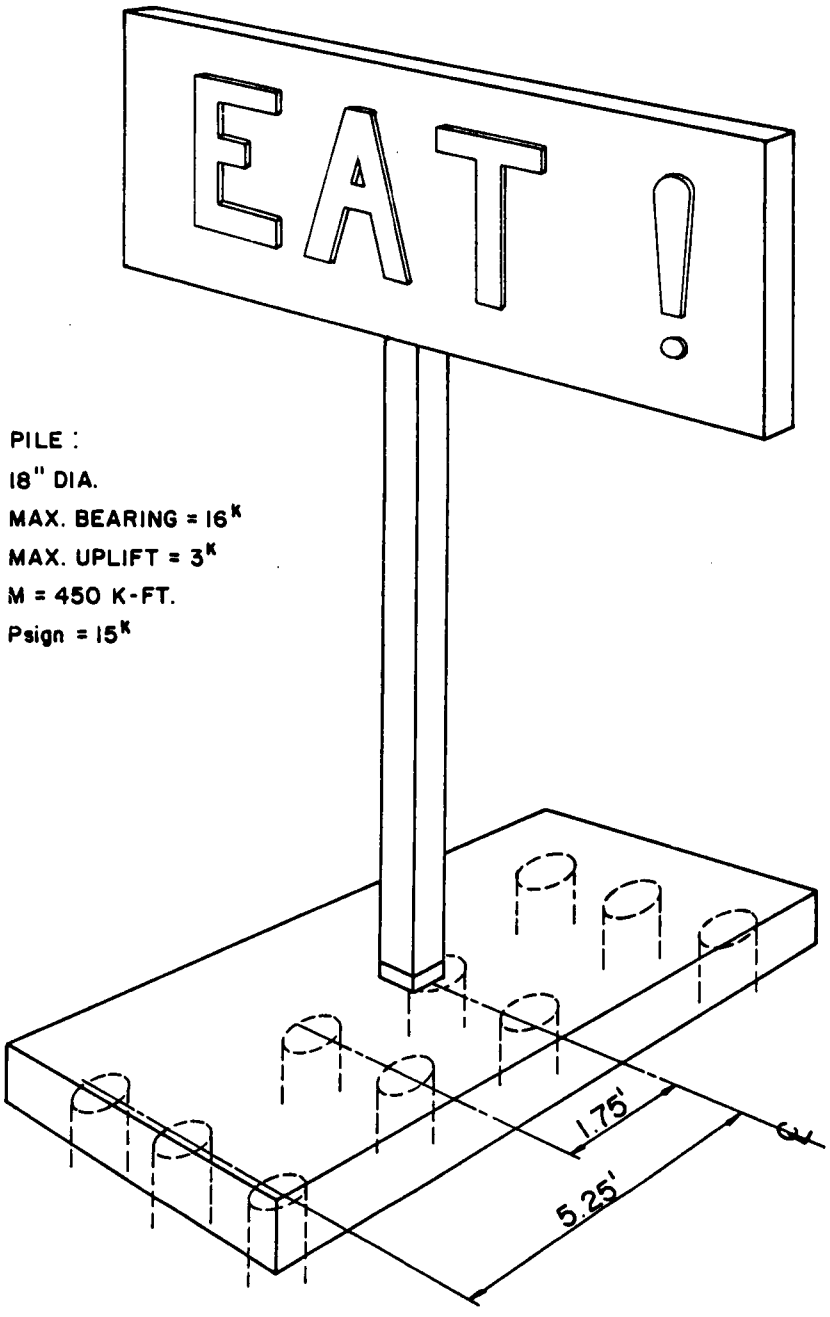


FIGURE 58

EXAMPLE 5-1
PILING ARRANGEMENT AND LOADS

uplift of 1.5 tons due to friction of the soil. As the user probably has very little feel for the foundation requirements, a crude assumption as to the arrangement required will be made for a start. Assume that a 16' x 10' x 2' thick footing acting as a pile cap will be required and that ten piles will be used.

The program begins with the screen prompt "IDENTIFICATION?". Input I-40 Snacks and press RETURN. The screen then displays "PILE DIAMETER?(FT)". Input 1.5 and press RETURN. The screen then displays "CONCRETE FOOTING LENGTH? (FT)". Input 16 and press RETURN. The screen displays "CONCRETE FOOTING WIDTH? (FT)". Input 10 and press RETURN.

The screen then displays "CONCRETE FOOTING DEPTH? (FT)". Input 2 and press RETURN. The screen then displays "NUMBER OF ROWS OF PILING?". Assuming ten piles put in four symmetrical rows of 3,2,2,3 input 4 and press RETURN. The screen next displays "ABS. VALUE OF DIST. FROM CL PILE ROW TO CL GROUP ROW 1 (FT)?". Referring to Figure 58, input 5.25 and press RETURN. The screen then displays the same request for piling Row 2. Referring to Figure 58, input 1.75 and press RETURN. The same request is then made for Row 3. As the absolute value of the distance is required, input 1.75 and press RETURN. Finally, the screen requests the same information for Row 4. Input 5.25 and press RETURN.

The screen then displays "NUMBER OF PILES IN ROW 1?". Input 3 and press RETURN. The same request is then made for Row 2. Input 2 and press RETURN. The program screen then requests this information for Row 3. Input 2 and press RETURN. And finally, it displays a request for the number of piles in Row 4. Input 3 and press RETURN.

The screen then displays "MOMENT? (K-FT)". Input 450 and press RETURN. The screen then displays "AXIAL LOAD EXCLUDING FOOTING WEIGHT? (KIPS)". Input 15 and press RETURN. The printer then displays the information previously input and gives a sketch of the pile pattern indicating the inertia of the pattern and the total axial load applied to the pattern including the footing weight.

In this example, the maximum uplift resulting from this arrangement is 6.89602 kips and the maximum bearing load is 19.496 kips. Referring to the information supplied in the assumed soil report, the uplift exceeds the 1.5 ton value, so this arrangement is unacceptable. The bearing load is over the recommended value as well.

The user can now determine that it would appear that a greater spreading of the pattern to increase the inertia would result in acceptable pile loading.

The next step in the iterative operation would be to make a second assumption as to the configuration of the piling. This second iteration is as shown in Figure 59. Results of evaluation of the second assumed piling

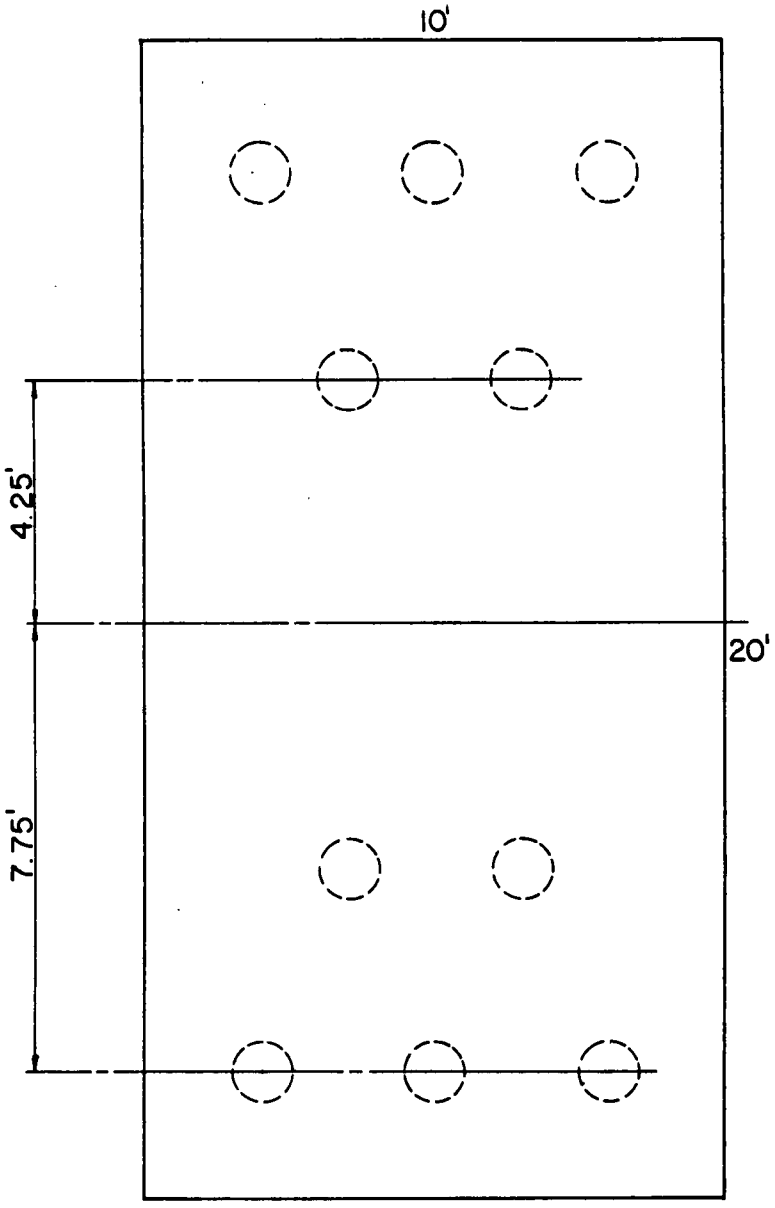


FIGURE 59

SECOND ITERATION PILING CONFIGURATION

configuration indicate a maximum uplift force of .535132 kips and a maximum bearing pressure of 15.5351 kips. These results are within the limits established by the assumed geotechnical engineer's report, so this is an acceptable pile pattern.

The user should be careful to evaluate the footing acting as a pile cap for ultimate moment capacity.

The tape resulting from the analysis of this foundation is shown in Figure 60.

Flow Chart

Figure 61 describes the chronological operation of the "PILEANA" program.

Program Copy

Figure 62 is a print-out of the "PILEANA" program. A wide margin is provided to allow the user to make notes, if desired.

```
I-40 SNACKS

TOTAL PILES= 10
PILE DIA.= 1.5  FT.
FOOTING: 16 X 10 X 2
TOTAL VERTICAL
LOAD= 63 KIPS
I-PATTERN= 316.375 FT^4

  o  o  o
  o  o
  o  o
  o  o  o

MAXIMUM UPLIFT
= 6.89602 KIPS +↑
MAXIMUM BEARING
= 19.496 KIPS ↓



SECOND ITERATION

TOTAL PILES= 10
PILE DIA.= 1.5  FT.
FOOTING: 20 X 10 X 2
TOTAL VERTICAL
LOAD= 75 KIPS
I-PATTERN= 766.999 FT^4

  o  o  o
  o  o
  o  o
  o  o  o

MAXIMUM UPLIFT
= .535132 KIPS +↑
MAXIMUM BEARING
= 15.5351 KIPS ↓
```

FIGURE 60

EXAMPLE 5-1
RESULTING PRINT-OUT TAPE

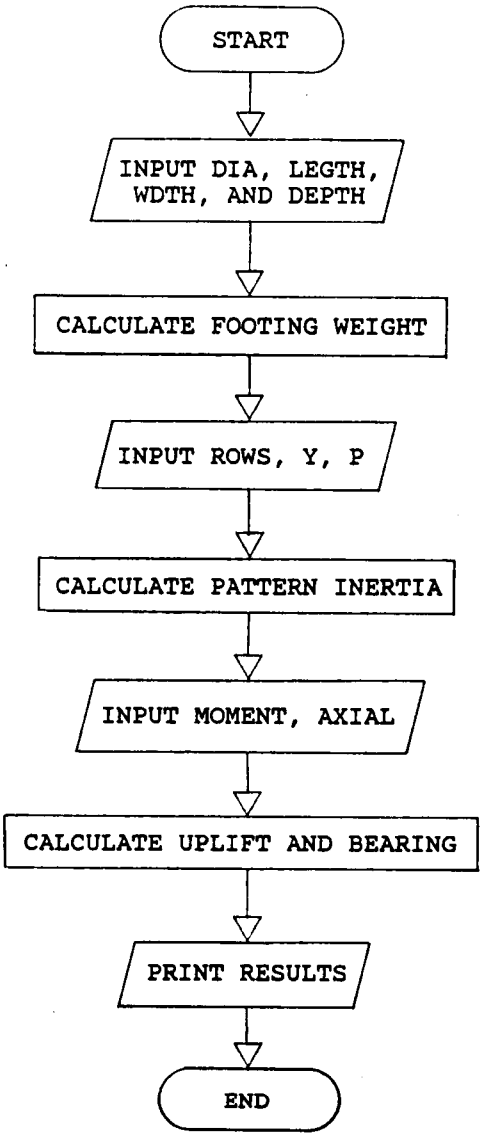


FIGURE 61

PILEANA PROGRAM FLOW-CHART

```
1 CLS
2 PRINT"IDENTIFICATION"
3 INPUT A$
4 CLS
5 PRINT"PILE DIAMETER?(F
T.)"
6 INPUT DIA
7 CLS
8 PRINT"CONCRETE FOOTING
"
9 PRINT"LENGTH? (FT)"
10 INPUT LEGTH
11 CLS
12 PRINT"CONCRETE FOOTIN
G"
13 PRINT"WIDTH? (FT)"
14 INPUT WDTH
15 CLS
16 PRINT"CONCRETE FOOTIN
G"
17 PRINT"DEPTH? (FT)"
18 INPUT DEPTH
19 CLS
20 WTFT=LEGTH*WDTH*DEPTH
*.15
21 PRINT"NUMBER OF ROWS"
22 PRINT"OF PILING?"
23 INPUT ROWS
24 CLS
25 DIM Y(10)
26 FOR J=1 TO ROWS
27 PRINT"ABS.VALUE OF DI
ST."
28 PRINT"FROM CL PILE RO
W TO"
29 PRINT"CL GROUP-ROW"J"
(FT)"
30 INPUT Y(J)
31 CLS
32 NEXT J
33 DIM P(10)
34 FOR J=1 TO ROWS
35 PRINT"NUMBER OF PILES
"
36 PRINT"IN ROW"J"?"
37 INPUT P(J)
38 CLS
39 NEXT J
40 IPILE=((3.1416)*(DIA^
4))/64
41 APILE=(3.1416)*((DIA/
2)^2)
42 FOR J=1 TO ROWS
43 IPAT=(P(J))*((IPILE)+
(APILE)*(Y(J)^2))
44 ITOT=ITOT+IPAT
45 NEXT J
46 PRINT"MOMENT? (K-FT)"
47 INPUT MOMENT
48 CLS
49 PRINT"AXIAL LOAD"
50 PRINT"EXCLUDING FOOTI
NG"
51 PRINT"WEIGHT? (KIPS)"
52 INPUT AXIAL
53 AX=AXIAL+WTFT
54 CLS
55 FOR J=1 TO ROWS
```

FIGURE 62

PILEANA PROGRAM PRINT-OUT

```
56 S=P(J)
57 PILESTOT=PILESTOT+S
58 NEXT J
59 BRG=(((MOMENT)*(Y(1))
)/ITOT)*(APILE)+((AX)/(P
ILESTOT))
60 UPL=(((MOMENT)*(Y(1))
)/ITOT)*(APILE)-((AX)/(P
ILESTOT))
61 LPRINT A$
62 LPRINT""
63 LPRINT"TOTAL PILES="P
ILESTOT
64 LPRINT"PILE DIA.="DIA
" FT."
65 LPRINT"FOOTING:"LEGTH
"X"WDTH"X"DEPTH
66 LPRINT"TOTAL VERTICAL
"
67 LPRINT"LOAD="AX"KIPS"
68 LPRINT"I-PATTERN="ITO
T"FT^4"
69 LPRINT""
70 FOR J=1 TO ROWS
71 FOR K=1 TO P(J)
72 LPRINT"  o";
73 NEXT K
74 LPRINT""
75 NEXT J
76 LPRINT""
77 LPRINT"MAXIMUM UPLIFT
"
78 LPRINT"="UPL"KIPS +↑"
79 LPRINT"MAXIMUM BEARIN
G"
80 LPRINT"="BRG"KIPS ↓"
81 LPRINT""
82 LPRINT""
83 LPRINT""
84 LPRINT""
85 CLS
86 FOR T=0 TO 31
87     FOR V=0 TO 119
88         PSET (V,T)
89     NEXT V
90 NEXT T
91 CLS
92 END
```

FIGURE 62 (Continued)

CHAPTER 6

PRECAST STRIPPING AND HANDLING DESIGN

Description of Program

The precast stripping and handling program is written specifically for analysis of uniform thickness precast members typically acting as wall panels. The program does not properly consider members with ledges and returns.

The program can best be used on a group of varying sized panels of a uniform thickness in which one standard reinforcing and release strength is desired for ease of fabrication. In this instance, the worst panels can be reviewed using this program using an assumed theoretical reinforcing and desired release strength. The program will analyze the panels for the number of pick-up points required to satisfy ultimate moment capacity requirements and keep the tensile stress below rupture levels. If the reinforcing and concrete strength combination are inadequate to prevent cracking, the program displays this information and the user may re-evaluate a different release strength or reinforcing combination.

The assumption made by the program is that precast members to be designed have an architectural appearance, where cracking is undesireable, thereby limiting the allowable tension to $5\sqrt{f'ci}$. The program is written to

comply with the PCI Design Handbook Precast and Prestressed Concrete, Edition 3, published by the Prestressed Concrete Institute.

Nomenclature

A	- Panel width.
ANCHU	- Ultimate anchor lift force.
ASX	- Area of the steel in the short direction.
ASY	- Desired reinforcing in the long direction.
B	- Panel length.
DY	- Depth of the reinforcing in the long direction.
DX	- Depth of the reinforcing in the short direction.
FCI	- Desired release strength.
FTLIMIT	- Limiting lfexural tension stress.
ISECTX	- Inertia of the section in the X direction.
ISECTY	- Inertia of the section in the Y direction.
LRY	- Moment resisting capacity in the long direction.
MRX	- Moment resisting capacity in the short direction.
RSX	- Effective moment resisting section for moment in the short direction.
RSY	- Effective moment resisting section for moment in the long direction.

W - Ultimate uniform load on the panel, including handling factors.

WS - Service uniform load on the panel including handling factors.

User Prompt Definitions

PANEL IDENTIFICATION

Input a description that identifies the panel or piece mark being analyzed.

LENGTH? (FT)

Input the length of the panel in feet.

WIDTH? (FT)

Input the width of the panel in feet.

MIN. THICKNESS? (IN)

Input the minimum thickness of the panel. If a reveal or false joint occurs in the panel face, the minimum thickness would be from the root of this reveal to the back face of the panel.

DESIRED REINFORCING (SQ. IN./FT) LONG DIR. T & B OR NET MID.

Input the desired reinforcing in square inches per foot that will occur either at the middle of the panel or at top and bottom. Note that if #3's at 12 are to be used top and bottom, the proper input at this point should be .11 rather than twice this value as might be assumed for steel top and bottom.

DEPTH OF REINF.? (IN)

Input the effective depth of the reinforcing in the long direction.

DESIRED REINFORCING (SQ. IN/FT) SHORT DIR. T & B OR NET MID.

Similar to above.

DEPTH OF REINF.? (IN)

Similar to above.

DESIRED RELEASE STRENGTH F'ci (PSI)

Input the desired release strength in units of psi.

NO. OF BAR LAYERS? 1=1 LAYER AT MIDDLE 2=1 LAYER T & B

Input whether the reinforcing just entered represents one layer of reinforcing at the middle of the panel or two layers of reinforcing, one being at the top of the panel and one being at the bottom of the panel.

ULT.UNIFORM LOAD ON PANEL INCLUDING HANDLING FACTORS? (KSF)

This is a request for the ultimate uniform load on the panel including handling factors. For example, if an eight inch panel is being considered, the uniform weight of this panel assuming concrete at 150 pounds per cubic foot is 100 pounds per square foot. Applying the ultimate load factor of 1.4 for dead load to this yields 140 pounds per square foot. Further applying a handling factor of 1.5 to this total yields 210 pounds per square foot. Converting this to KSF as requested, yields a value of .21, which would be the proper input in this case.

SERVICE UNIFORM LOAD INCLUDING HANDLING FACTORS? (KSF)

Similar to above with the exception that the ultimate factor is not applied. Proper input for the same example would be 100 times 1.5 divided by 1000 or .15.

Examples

Example 6-1

As this program is written to primarily make fabrication of the panels easiest for the producer, let us assume that the fabricator has been contacted and has indicated that his standard mix will easily attain 2000 psi strength overnight without accelerated heat curing. Further, let us assume that it is the fabricator's desire to have one layer of reinforcing at the middle of the panel as opposed to one layer top and bottom, even though the latter may be more effecient for control of cracking. Use of the program will be demonstrated based on this criteria.

The program begins with the screen displaying "PANEL IDENTIFICATION?". Referring to Figure 63, input MK-WP9 and press RETURN. The screen then displays "LENGTH? (FT)?". Input 16 and press RETURN. The screen then displays "WIDTH? (FT)?". Input 9 and press RETURN. The screen then displays "MIN. THICKNESS? (IN)?". As this panel has a reveal that is 3/4" deep into the face of the panel, the minimum thickness should be input as 7.25". This will be the panel section that will be used for analysis. Input 7.25 and press RETURN.

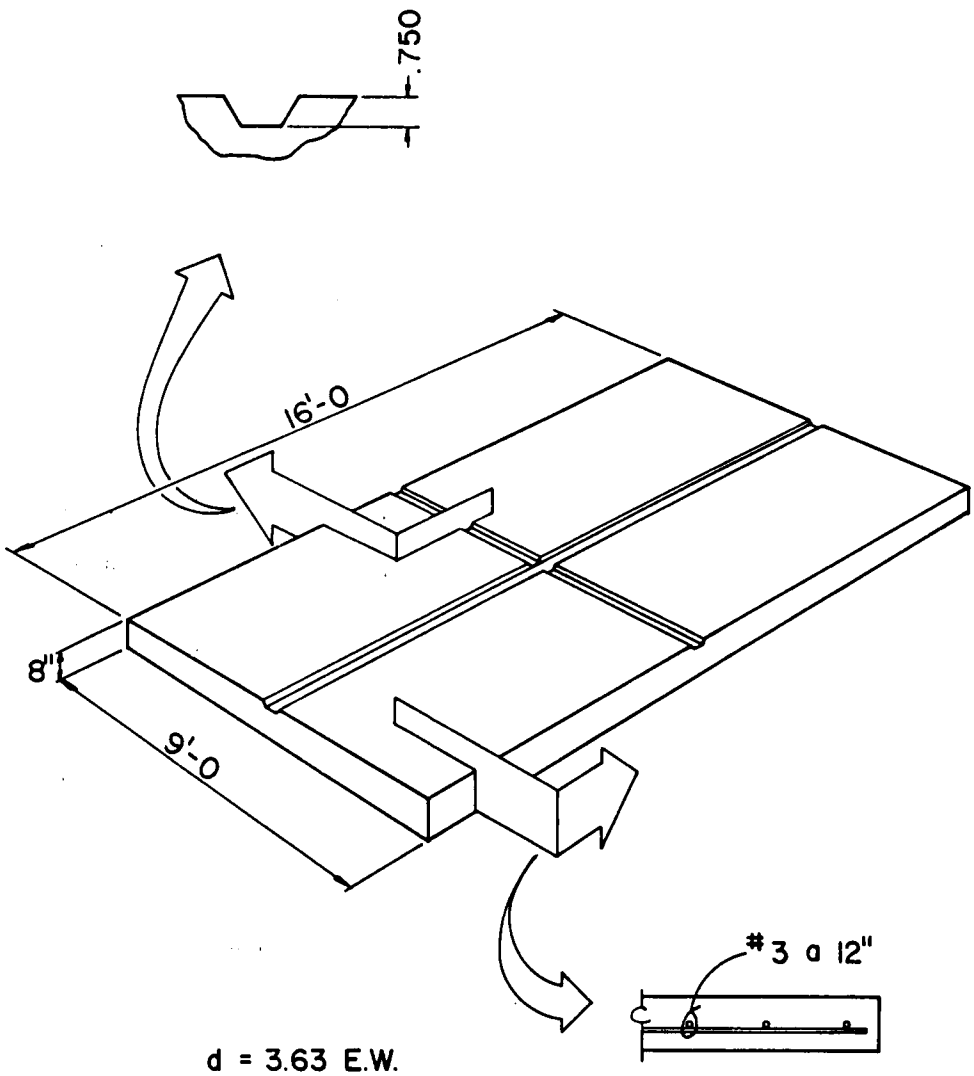


FIGURE 63

EXAMPLE 6-1
PANEL CONFIGURATION

The screen next displays "DESIRED REINFORCING (SQ.IN./FT)LONG DIR. T & B OR NET MID.?". This is a request to input the desired reinforcing that will run in the 16' direction. Assume that the fabricator has indicated to the designer that his preference for reinforcing is #3 bars at 12" centers as a minimum rather than using wire mesh. Input .11 and press RETURN. The screen then displays "DEPTH OF REINF.(IN)?". As the producer would like to have this at mid-depth and we have reduced the effective section to 7.25", input 3.63 for a dimension that represents half of 7.25 and press RETURN. The screen next displays "DESIRED REINFORCING (SQ.IN/FT) SHORT DIR. T & B OR NET MID.?". Input .11 and press RETURN. The screen then displays "DEPTH OF REINF.(IN)?". Input 3.63 and press RETURN.

The screen next displays "DESIRED RELEASE STRENGTH F'ci (PSI)?". As the fabricator feels that a release strength of 2000 psi can be attained, input 2000 and press RETURN. The screen next displays "NO. OF BAR LAYERS? 1=1 LAYER AT MIDDLE 2=1 LAYER T & B?". The reinforcing described represents an attempt to reinforce this panel with one layer of reinforcing at the middle. Input 1 and press RETURN.

The printer then displays the panel description and parameters, the initial release strength desired and a description of the reinforcing. It further indicates the moment resisting section width in the long and short directions as described in Figure 64 taken from the

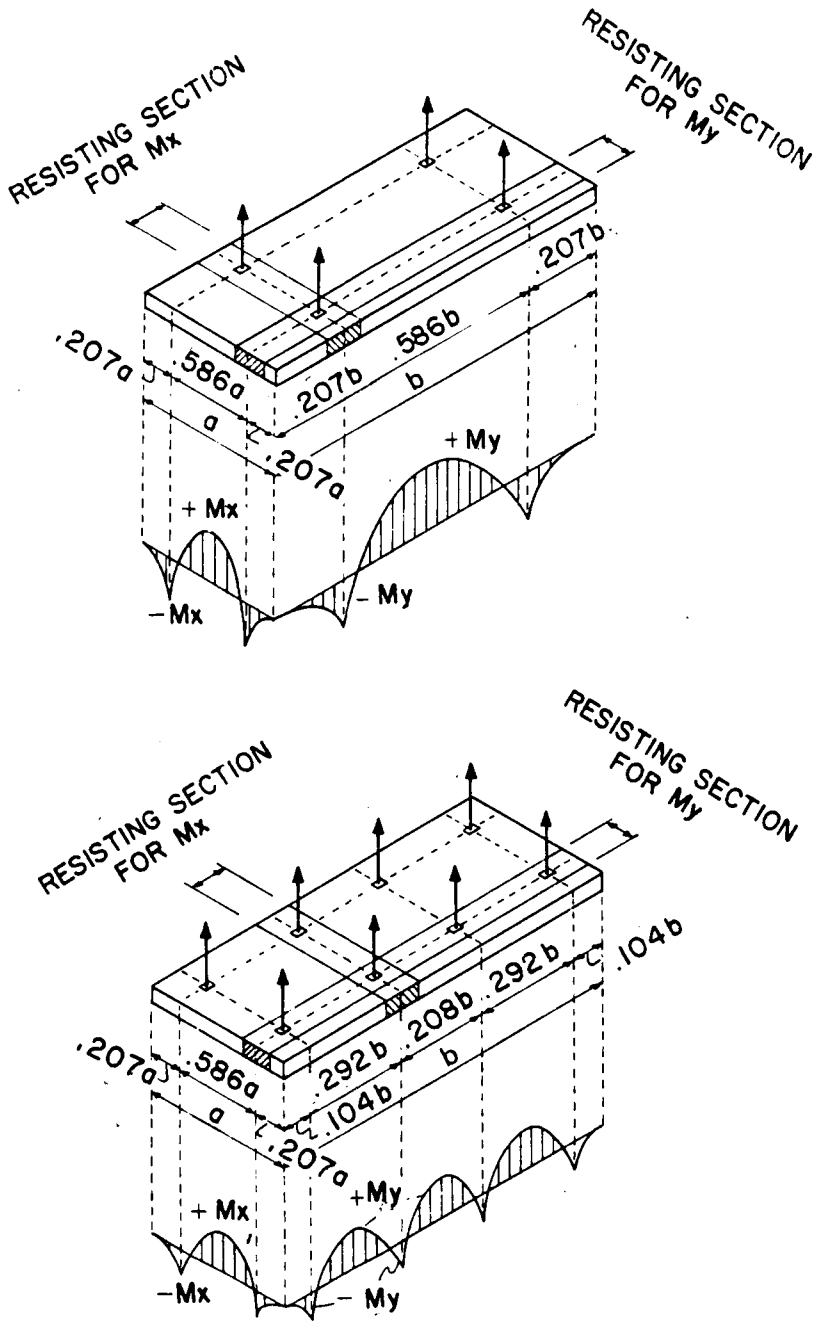


FIGURE 64

MOMENTS DEVELOPED IN PANELS STRIPPED FLAT

SOURCE: Prestressed Concrete Institute. PCI Design Handbook, Precast and Prestressed Concrete. Third Edition. Chicago, Illinois: Prestressed Concrete Institute, 1985.

PCI Design Handbook Precast and Prestressed Concrete, Edition 3, published by the Prestressed Concrete Institute.

The screen next displays "ULT. UNIFORM LOAD ON PANEL INCLUDING HANDLING FACTORS? (KSF)?". As the panel is nominally 8" thick, it can be seen that assuming a uniform concrete weight of 150 pounds per cubic foot, the uniform load on the panel due to its own dead weight is approximately 100 pounds per square foot. As this request is for ultimate load, applying a 1.4 dead load ultimate factor to this yields 140 pounds per square foot. Referring to Figure 65 developed using the above mentioned publication, let us assume that this panel will have an exposed aggregate face from sand blasting, is fluted with proper draft on the edges, and is in a smooth form with only a form oil bond breaker between the surface to be blasted and the form. This would indicate that a handling factor of 1.6 is appropriate. Multiplying 1.6 times the already attained 140 pounds per square foot yields 224 pounds per square feet as an ultimate load on the panel including handling factors. Converting this to KSF yields .224. Input .224 and press RETURN.

The screen next displays "SERVICE UNIFORM LOAD INCLUDING HANDLING FACTORS? (KSF)?". This is a request for the same information input previously excluding the 1.4 ultimate factor. This would be 100 times 1.6 divided by 1000, or .16 KSF. Input .16 and press RETURN.

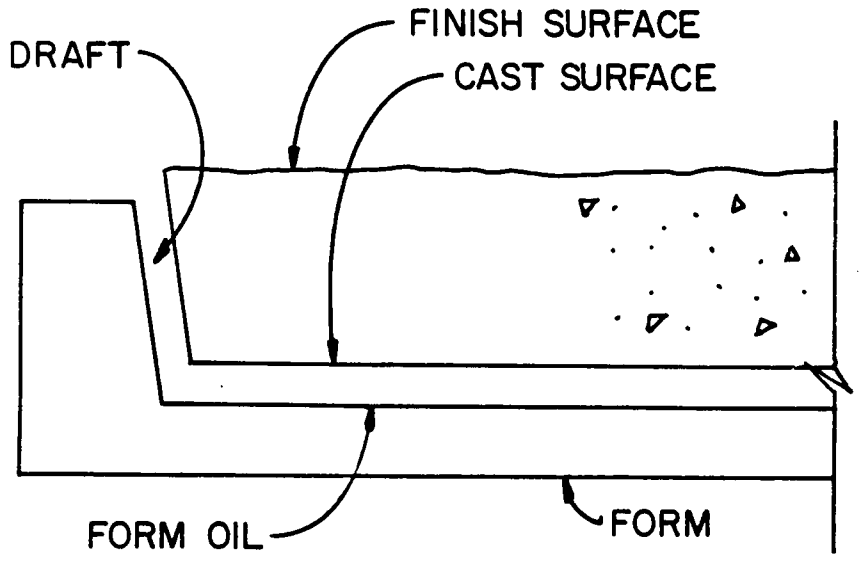


FIGURE 65

EQUIVALENT STATIC LOAD MULTIPLIER TO ACCOUNT FOR STRIPPING AND DYNAMIC FORCES

ADAPTED FROM: Prestressed Concrete Institute. PCI Design Handbook, Precast and Prestressed Concrete. Third Edition. Chicago, Illinois: Prestressed Concrete Institute, 1985.

The printer next displays the loading conditions just input. The screen prints "4 POINT PICK UP OKAY FOR ULT. CHECK SERVICE STRESS" which is an indication that the four point pick up is adequate to resist ultimate moments and that the next item to be checked is the service tension stress for the four point pick up. In this example, the tensile stress generated under service load including the handling factor was below the limiting stress and this information is displayed next by the printer. It should be noted that the limiting tensile stress to control cracking is $5\sqrt{f'ci}$ as recommended in the PCI Design Handbook Precast and Prestressed Concrete, Edition 3, published by the Prestressed Concrete Institute. In this instance, that value is 223.607 psi. It can be seen from the print-out that the service tension stress in the long and short directions is roughly half this value. So the reinforcing and release strengths assumed are acceptable. Further displayed on the printer is the ultimate anchor lift force that will occur at each pick up point of the panel so that the user may properly size a lifting device.

It should be noted that a smaller amount of reinforcing and/or a lower release strength could be checked and found acceptable. However, the analysis provided satisfies the criteria outlined by the fabricator.

Care should also be taken in considering reduction of the initial release strength as it may be adequate for

flexural compression but inadequate in terms of bond of the concrete to the tensile reinforcing at lower release strengths. A review of recommendations in the PCI Design Handbook Precast and Prestressed Concrete, Edition 3, published by the Prestressed Concrete Institute should be made by the user prior to assuming lower release strengths.

Figure 66 is a print-out of the tape resulting from this example.

Flow Chart

Figure 67 describes the chronological operation of the "PRECAST" program.

Program Copy

Figure 68 is a print-out of the "PRECAST" program. A wide margin is provided to allow the user to make notes, if desired.

```
MK-WP9
[redacted]

LENGTH= 16 FT.
WIDTH= 9 FT.
THICKNESS= 7.25 IN.

F'ci= 2000 PSI
REINFORCING: 1 LAYER(S)
LONG DIRECTION STEEL:
 .11 SQ. IN. @ d= 3.63 IN.
SHORT DIRECTION STEEL:
 .11 SQ. IN. @ d= 3.63 IN.
-------------------------------
NOTE: WITH 1 LAYER OF
      STEEL THE TENSIL
      STRESS IS COMPUTED
      BASED ON THE GROSS
      CONCRETE SECTION.
-------------------------------
LONG DIRECTION MOMENT
RESISTING SECTION
WIDTH= 54 IN.

SHORT DIRECTION MOMENT
RESISTING SECTION
WIDTH= 31.644 IN.

-------- LOADING --------

ULTIMATE UNIFORM LOAD ON
PANEL INCLUDING HANDLING
FACTORS= .224 KSF

SERVICE UNIFORM LOAD ON
PANEL INCLUDING HANDLING
FACTORS= .16 KSF
-------------------------------

FOUR POINT PICK-UP
[redacted]

MYu/STRIP= 5.52223 K-FT
STRIP CAP= 7.72549 K-FT
SERVICE TENS. (Y)=
 100.057 PSI
LIMIT= 223.607 PSI

MXu/STRIP= 3.10625 K-FT
STRIP CAP= 4.52714 K-FT
SERVICE TENS. (X)=
 96.0447 PSI
LIMIT= 223.607 PSI

ULT. ANCHOR LIFT FORCE
= 8.064 KIPS
```

FIGURE 66

EXAMPLE 6-1
PRINT-OUT TAPE

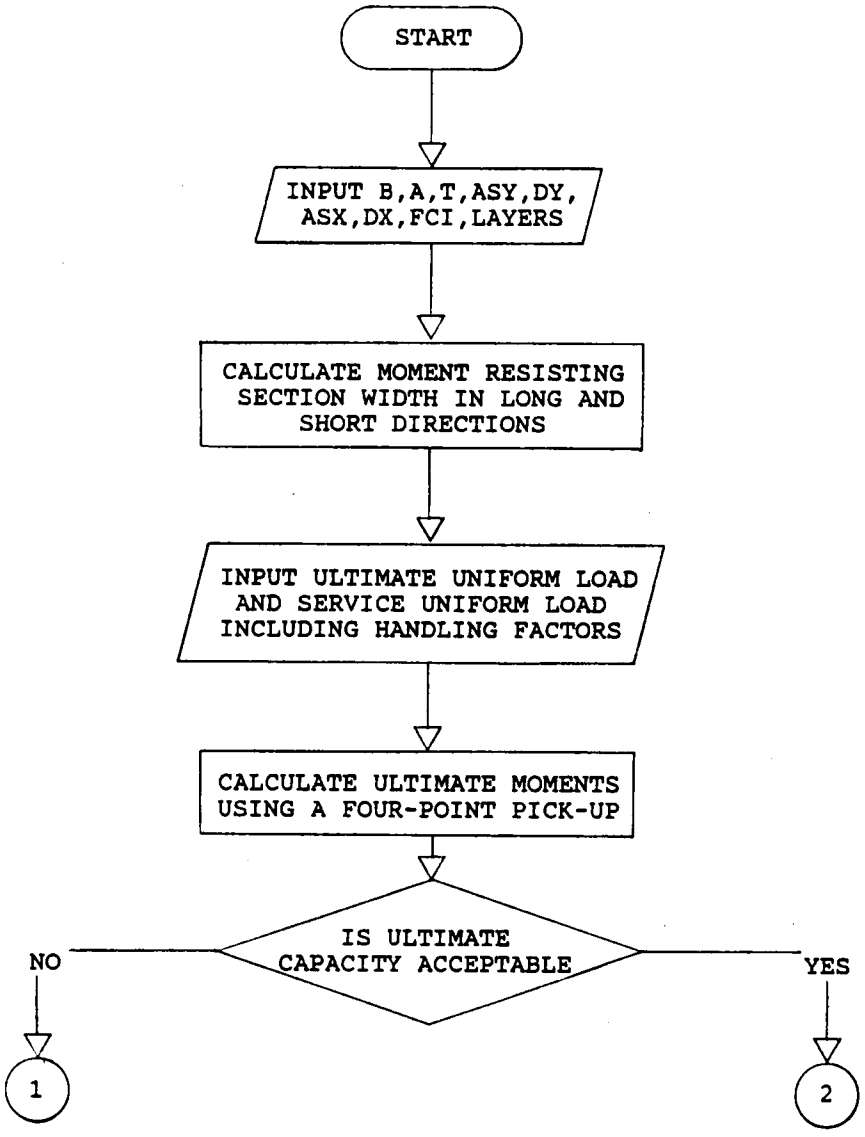


FIGURE 67

PRECAST PROGRAM FLOW CHART

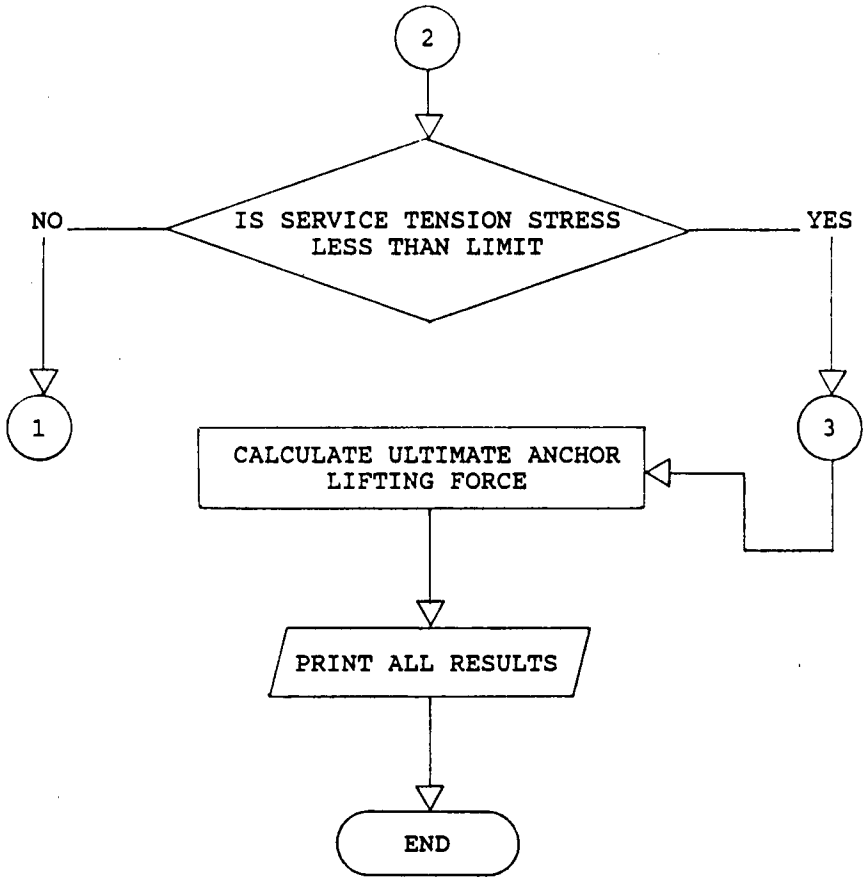


FIGURE 67 (Continued)

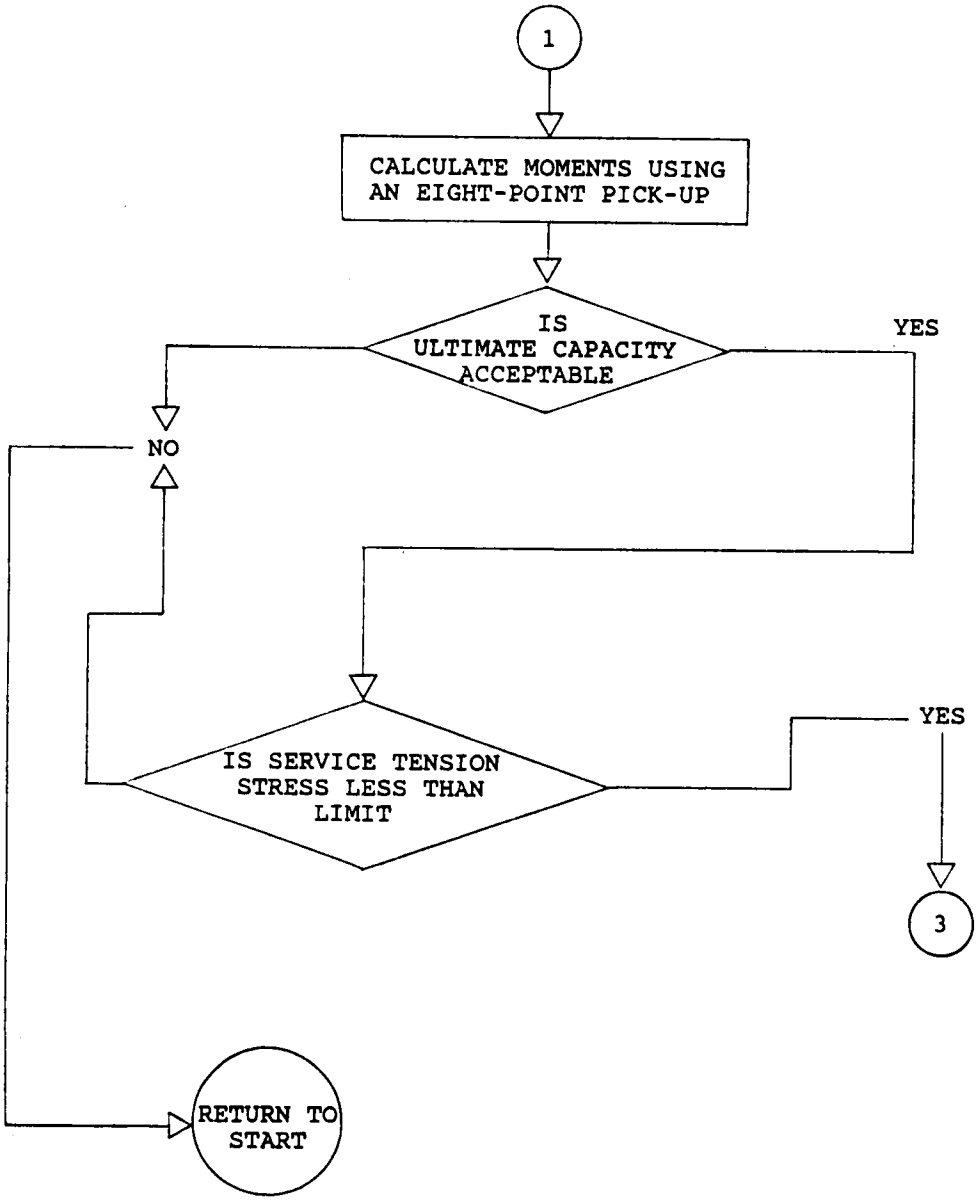


FIGURE 67 (Continued)

```
1 CLS
2 PRINT"PANEL IDENTIFICA
TION?"
3 INPUT A$
4 CLS
5 PRINT"LENGTH? (FT)"
6 INPUT B
7 CLS
8 PRINT"WIDTH? (FT)"
9 INPUT A
10 CLS
11 PRINT"MIN. THICKNESS?
(IN)"
12 INPUT T
13 CLS
14 PRINT"DESIRED REINFOR
CING"
15 PRINT"(SQ. IN./FT) LON
G"
16 PRINT"DIR. T&B OR NET
MID.?"
17 INPUT ASY
18 CLS
19 PRINT"DEPTH OF REINF.
(IN)"
20 INPUT DY
21 CLS
22 PRINT"DESIRED REINFOR
CING"
23 PRINT"(SQ. IN./FT) SHO
RT"
24 PRINT"DIR. T&B OR NET
MID.?"
25 INPUT ASX
26 CLS
27 PRINT"DEPTH OF REINF.
(IN)"
28 INPUT DX
29 CLS
30 PRINT"DESIRED RELEASE
"
31 PRINT"STRENGTH F'ci(P
SI)"
32 INPUT FCI
33 CLS
34 PRINT"NO. OF BAR LAYER
S?"
35 PRINT"1=1 LAYER @ MID
DLE"
36 PRINT"2=1 LAYER T & B
"
37 INPUT LAYERS
38 CLS
39 'RSY IS EFFECTIVE
40 'MOMENT RESISTING
41 'SECTION FOR MOMENT
42 'IN THE LONG (Y)
43 'DIRECTION
44 '
45 'RSX IS EFFECTIVE
46 'MOMENT RESISTING
47 'SECTION FOR MOMENT
48 'IN THE SHORT (X)
49 'DIRECTION
50 '
51 RSYA=10*T
52 RSYB=.293*B*12
53 RSYC=(A/2)*12
```

FIGURE 68

PRECAST PROGRAM PRINT-OUT

```
54 IF RSYA<RSYB THEN RSY
I=RSYA ELSE RSYI=RSYB
55 IF RSYC<RSYI THEN RSY
=RSYC ELSE RSY=RSYI
56 LPRINT A$
57 LPRINT"[redacted]
[redacted]"
58 LPRINT""
59 LPRINT"LENGTH="B"FT."
60 LPRINT"WIDTH="A"FT."
61 LPRINT"THICKNESS="T"I
N."
62 LPRINT""
63 LPRINT"F'ci="FCI"PSI"
64 LPRINT"REINFORCING:"L
AYERS"LAYER(S)"
65 LPRINT"LONG DIRECTION
 STEEL:"
66 LPRINT   ASY"SQ.IN.@
d="DY"IN."
67 LPRINT"SHORT DIRECTIO
N STEEL:"
68 LPRINT   ASX"SQ.IN.@
d="DX"IN."
69 LPRINT"----------
----------"
70 IF LAYERS=2 GOTO 77
71 LPRINT"NOTE: WITH 1 L
AYER OF"
72 LPRINT"      STEEL TH
E TENSIL"
73 LPRINT"      STRESS I
S COMPUTED"
74 LPRINT"      BASED ON
 THE GROSS"
75 LPRINT"      CONCRETE
 SECTION."
76 LPRINT"----------
----------"
77 LPRINT"LONG DIRECTION
 MOMENT"
78 LPRINT"RESISTING SECT
ION"
79 LPRINT"WIDTH="RSY"IN.
"
80 LPRINT""
81 RSXA=10*T
82 RSXB=(.293*A)*12
83 RSXC=(B/2)*12
84 IF RSXA<RSXB THEN RSX
I=RSXA ELSE RSXI=RSXB
85 IF RSXC<RSXI THEN RSX
C=RSX ELSE RSX=RSXI
86 LPRINT"SHORT DIRECTIO
N MOMENT"
87 LPRINT"RESISTING SECT
ION"
88 LPRINT"WIDTH="RSX"IN.
"
89 LPRINT""
90 CLS
91 PRINT"ULT.UNIFORM LOA
D"
92 PRINT"ON PANEL INCLUD
ING"
93 PRINT"HANDLING FACTOR
S(KSF)"
94 INPUT W
95 CLS
```

FIGURE 68 (Continued)

```
'96 PRINT"SERVICE UNIFORM
"
97 PRINT"LOAD INCLUDING"
98 PRINT"HANDLING FACTOR
S(KSF)"
99 INPUT WS
100 CLS
101 LPRINT"———— LOADI
NG ————"
102 LPRINT""
103 LPRINT"ULTIMATE UNIF
ORM LOAD ON"
104 LPRINT"PANEL INCLUDI
NG HANDLING"
105 LPRINT"FACTORS="W"KS
F"
106 LPRINT"
107 LPRINT"SERVICE UNIFO
RM LOAD ON"
108 LPRINT"PANEL INCLUDI
NG HANDLING"
109 LPRINT"FACTORS="WS"K
SF"
110 LPRINT"——————————
——————"
111 LPRINT""
112 MYPOS=(B^2)*A*(W)*.0
107
113 MYNEG=MYPOS
114 MXPOS=(A^2)*B*(W)*.0
107
115 MXNEG=MXPOS
116 '
117 'MRY=MOMENT RESIST.
118 'CAPACITY IN LONG
119 'DIRECTION
120 '
121 DB=((RSY/12)*ASY*600
00)/(.85*FCI*RSY)
122 MRY=(RSY/12)*.9*ASY*
60000*(DY-DB/2)
123 MRY=MRY/12000
124 'MRX=MOMENT RESIST.
125 'CAPACITY IN SHORT"
126 'DIRECTION"
127 DBX=((RSX/12)*ASX*60
000)/(.85*FCI*RSX)
128 MRX=(RSX/12)*.9*ASX*
60000*(DX-DBX/2)
129 MRX=MRX/12000
130 IF MYPOS>MRY GOTO 17
0
131 IF MXPOS>MRX GOTO 17
0
132 PRINT"4 POINT PICK-U
P"
133 PRINT"O.K.FOR ULT..C
HECK"
134 PRINT"SERVICE TENS."
135 BILL=BILL+1
136 IF BILL=125 GOTO 138
137 GOTO 135
138 CLS
139 SOUND 20,1
140 'CHECK TRANSFORMED
141 'SECTION FOR
142 'TENSIL STRESS
143 '
144 CLS
```

FIGURE 68 (Continued)

```
145 GOSUB 243
146 FOR JS = 1 TO 28
147 SOUND JS,1
148 NEXT JS
149 LPRINT"FOUR POINT PI
CK-UP"
150 LPRINT"
"
151 LPRINT""
152 LPRINT"MYU/STRIP="MY
POS"K-FT"
153 LPRINT"STRIP CAP="MR
Y"K-FT"
154 LPRINT"SERVICE TENS.
(Y)="FTY"PSI"
155 LPRINT"LIMIT="FTLIMI
T"PSI"
156 LPRINT""
157 LPRINT"MXU/STRIP="MX
POS"K-FT"
158 LPRINT"STRIP CAP="MR
X"K-FT"
159 LPRINT"SERVICE TENS.
(X)="FTX"PSI"
160 LPRINT"LIMIT="FTLIMI
T"PSI"
161 LPRINT""
162 ANCHU=(W*A*B)/4
163 LPRINT"ULT. ANCHOR LI
FT FORCE"
164 LPRINT"="ANCHU"KIPS"
165 LPRINT""
166 LPRINT""
167 LPRINT""
168 LPRINT""
169 END
170 'CHECK MOMENTS
171 'FOR 8 POINT
172 'PICK-UP
173 '
174 PRINT"4 POINT PICK-U
P"
175 PRINT"IS NO GOOD..TR
Y"
176 PRINT"8-POINT PICK-U
P"
177 JERK=JERK+1
178 IF JERK=150 GOTO 180
179 GOTO 177
180 SOUND 21,1
181 CLS
182 MYPOS=.0027*W*A*(B^2
)
183 MYNEG=MYPOS
184 MXPOS=.0054*W*B*(A^2
)
185 MXNEG=MXPOS
186 IF MYPOS>MRY GOTO 21
8
187 IF MXPOS>MRX GOTO 21
8
188 CLS
189 IF WS <> 0 GOTO 194
190 PRINT"SERVICE UNIFOR
M"
191 PRINT"LOAD INCLUDING
"
192 PRINT"HANDLING FACTO
RS(KSF)"
```

FIGURE 68 (Continued)

```
193 INPUT WS
194 CLS
195 GOSUB 275
196 FOR JS = 1 TO 28
197 SOUND JS,1
198 NEXT JS
199 LPRINT"8 POINT PICK-
UP"
200 LPRINT"▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒
▒▒"
201 LPRINT""
202 LPRINT"MYu/STRIP="MY
POS"K-FT"
203 LPRINT"STRIP CAP="MR
Y"K-FT"
204 LPRINT"SERVICE TENS.
(Y)="FTY"PSI"
205 LPRINT"LIMIT="FTLIMI
T"PSI"
206 LPRINT""
207 LPRINT"MXu/STRIP="MX
POS"K-FT"
208 LPRINT"STRIP CAP="MR
X"K-FT"
209 LPRINT"SERVICE TENS.
(X)="FTX"K-FT"
210 LPRINT"LIMIT="FTLIMI
T"PSI"
211 LPRINT""
212 ANCHU=(W*A*B)/8
213 LPRINT"ULT.ANCHOR LI
FT FORCE"
214 LPRINT"="ANCHU"KIPS"
215 LPRINT""
216 LPRINT""
217 END
218 LPRINT"DESIRED REINF
ORCING"
219 LPRINT"AND RELEASE S
TRENGTH"
220 LPRINT"ARE INADEQUAT
E"
221 LPRINT""
222 LPRINT"+My="MYPOS"K-
FT"
223 LPRINT"My CAP.="MRY"
K-FT"
224 LPRINT"+Mx="MXPOS"K-
FT"
225 LPRINT"Mx CAP.="MRX"
K-FT"
226 LPRINT"NOTE:-My=+My,
-Mx=+Mx"
227 LPRINT""
228 LPRINT"SERVICE TENS.
(Y)="FTY"PSI"
229 LPRINT"SERVICE TENS.
(X)="FTX"PSI"
230 LPRINT"LIMIT="FTLIMI
T"PSI"
231 LPRINT""
232 LPRINT"NOTE: 0 VALUE
S FOR SERV."
233 LPRINT"VALUES ABOVE
MEANS ULT."
234 LPRINT"CONDITIONS WE
RE NOT"
235 LPRINT"SATISFIED..SE
RVICE"
```

FIGURE 68 (Continued)

```
236 LPRINT"CONDITIONS WE
RE NOT"
237 LPRINT"CHECKED"
238 LPRINT""
239 LPRINT""
240 LPRINT""
241 LPRINT""
242 END
243 E=((FCI^.5)*33*1837)
/1000
244 IF LAYERS=2 GOTO 263
245 'IF 1 LAYER THEN
246 'EFFECT ON TRANS.
247 'SECTION IS SMALL
248 '
249 ISECT=(1/12)*RSY*(T^
3)
250 MYSERV=((B^2)*A*WS*.
0107)*12000
251 FTY=(MYSERV*(T/2))/I
SECT
252 FTLIMIT=(FCI^.5)*5
253 IF FTY>FTLIMIT GOTO
254 ELSE GOTO 256
254 SOUND 5,5
255 GOTO 170
256 ISECTX=(1/12)*RSX*(T
^3)
257 MXSERV=((A^2)*B*WS*.
0107)*12000
258 FTX=(MXSERV*(T/2))/I
SECTX
259 IF FTX>FTLIMIT GOTO
260 ELSE GOTO 262
260 SOUND 5,5
261 GOTO 170
262 RETURN
263 ITBARSY=(((T/2)-(T-D
Y))^2)*2*ASY*N*(RSY/12)
264 ISECTY=(1/12)*RSY*(T
^3)+ITBARSY
265 MYSERV=((B^2)*A*WS*.
0107)*12000
266 FTY=MYSERV*(T/2)/ISE
CTY
267 FTLIMIT=(FCI^.5)*5
268 IF FTY>FTLIMIT GOTO
170
269 ITBARSX=(((T/2)-(T-D
X))^2)*2*ASX*N*(RSX/12)
270 ISECTX=(1/12)*(RSX)*
(T^3)+IBARSX
271 MXSERV=((A^2)*B*WS*.
0107)*12000
272 FTX=MXSERV*(T/2)/ISE
CTX
273 IF FTX>FTLIMIT GOTO
170
274 RETURN
275 IF LAYERS <> 0 GOTO
281
276 E=((FCI^.5)*33*1837)
/1000
277 PRINT"NO. OF BAR LAYE
RS?"
278 PRINT"1=1 LAYER @ MI
DDLE"
279 PRINT"2=1 LAYER T &
B"
```

FIGURE 68 (Continued)

```
280 INPUT LAYERS
281 CLS
282 IF LAYERS=2 GOTO 301
283 'IF 1 LAYER THEN
284 'EFFECT ON TRANS.
285 'SECTION IS SMALL
286 '
287 ISECT=(1/12)*RSY*(T^
3)
288 MYSERV=((B^2)*A*WS*.
0027)*12000
289 FTY=(MYSERV*(T/2))/I
SECT
290 FTLIMIT=(FCI^.5)*5
291 IF FTY>FTLIMIT GOTO
292 ELSE GOTO 294
292 SOUND 5,5
293 GOTO 218
294 ISECTX=(1/12)*RSX*(T
^3)
295 MXSERV=((A^2)*B*WS*.
0054)*12000
296 FTX=(MXSERV*(T/2))/I
SECTX
297 IF FTX>FTLIMIT GOTO
298 ELSE GOTO 300
298 SOUND 5,5
299 GOTO 218
300 RETURN
301 ITBARSY=(((T/2)-(T-D
Y))^2)*2*ASY*N*(RSY/12)
302 ISECTY=(1/12)*RSY*(T
^3)+ITBARSY
303 MYSERV=((B^2)*A*WS*.
0027)*12000
304 FTY=MYSERV*(T/2)/ISE
CTY
305 FTLIMIT=(FCI^.5)*5
306 IF FTY>FTLIMIT GOTO
218
307 ITBARSX=(((T/2)-(T-D
X))^2)*2*ASX*N*(RSX/12)
308 ISECTX=(1/12)*(RSX)*
(T^3)+IBARSX
309 MXSERV=((A^2)*B*WS*.
0054)*12000
310 FTX=MXSERV*(T/2)/ISE
CTX
311 IF FTX>FTLIMIT GOTO
218
312 RETURN
```

FIGURE 68 (Continued)

CHAPTER 7

TWO-WAY PLATE SHEAR ANALYSIS

Description of Program

The two-way plate shear program performs the task of evaluating the shear stress that occurs around columns in a two-way flat plate slab system resulting from gravity loads and transfer of unbalanced moments from the slab system to the columns.

The program is written to comply with the Building Code Requirements for Reinforced Concrete (ACI 318-83), published by the American Concrete Institute.

The program allows the user to evaluate interior or end columns, including corner and edge columns. Figures for interpretation of proper input for the program were taken from Simplified Design Reinforced Concrete Buildings of Moderate Size and Height, published by the Portland Cement Association.

This operation was programed primarily because it is a time consuming process to evaluate the proper input and iterate for the various conditions that can occur. The program accurately calculates the maximum and allowable shear stresses and gives the user the option to provide a capital if required. If a capital is required around the columns, the program will re-evaluate the shear stresses based on this input.

The user is cautioned to have a thorough understanding of code requirements and two-way flat plate behavior before using this program.

Nomenclature

A - Critical perimeter dimension perpendicular to the axis of bending.

AC - Critical area.

B - Critical perimeter dimension parallel to the axis of bending.

C1 - Column dimension perpendicular to the axis of bending.

C2 - Column dimension parallel to the axis of bending.

D - Total thickness of the slab.

FC - The specified 28-day compressive strength of the concrete.

LAMT - λ , which is the factor for determining the portion of the unbalanced moment transferred by shear.

MU - Total unbalanced ultimate moment occurring at the section being analyzed.

POR - Portion of the unbalanced moment transferred by shear.

VU - Total ultimate shear occurring at the section being analyzed.

User Prompt Definitions

IDENTIFICATION

Input a brief description that appropriately identifies the analysis.

INPUT CONCRETE STRENGTH? (PSI)

Input the specified 28-day compressive strength of the concrete in units of PSI.

INPUT Vu? (KIPS)

Input the total ultimate shear acting at the section in units of KIPS.

INPUT UNBALANCED Mu? (K-FT)

Input the total unbalanced ultimate moment occurring at the section being analyzed in kip-feet.

INPUT C1? (IN)

Input the column dimension perpendicular to the axis of bending in inches.

INPUT C2? (IN)

Input the column dimension parallel to the axis of bending in inches.

INPUT d?

Input the total thickness of the slab being analyzed in inches.

INPUT 1.INT. COLUMN 2. END (A) 3. END (B) 4. CORNER COLUMN

Select the column condition being analyzed. Input the appropriate number.

DO YOU NEED TO ADD A CAPITAL? 1=YES 2=NO

If the shear stresses calculated exceed the allowable shear stress indicated, a capital is necessary. Input 1 to revise the section and input 2 if no revision is desired.

Examples

Example 7-1

Referring to Figure 69 the use of the program to analyze the shear stress at interior column location will be demonstrated. Figure 69 shows the layout of a two-way flat plate frame bay. From elastic and frame analysis, it was determined that the negative moment at the right end of Span 1 is -150 kip-feet and that the negative moment at the left of Span 2 is -60 kip-feet giving an unbalanced moment of 90 kip-feet transferred to the column at Joint B. Ultimate shear at the right end of Span 1 from the same analysis is 90 kips, while the ultimate shear at the left end of Span 2 is 75 kips for a total of 165 kips. Figure 70 shows the column orientation and slab configuration as well as the summary of the loads transferred at this joint.

The program begins with the screen display "SHEAR STRESS DUE TO Vu AND MOMENT TRANSFER". This heading will clear and the screen displays "IDENTIFICATION?". Input JOINT B and press RETURN. The screen next displays "INPUT CONCRETE STRENGTH? (PSI)". Input 4000 and press RETURN.

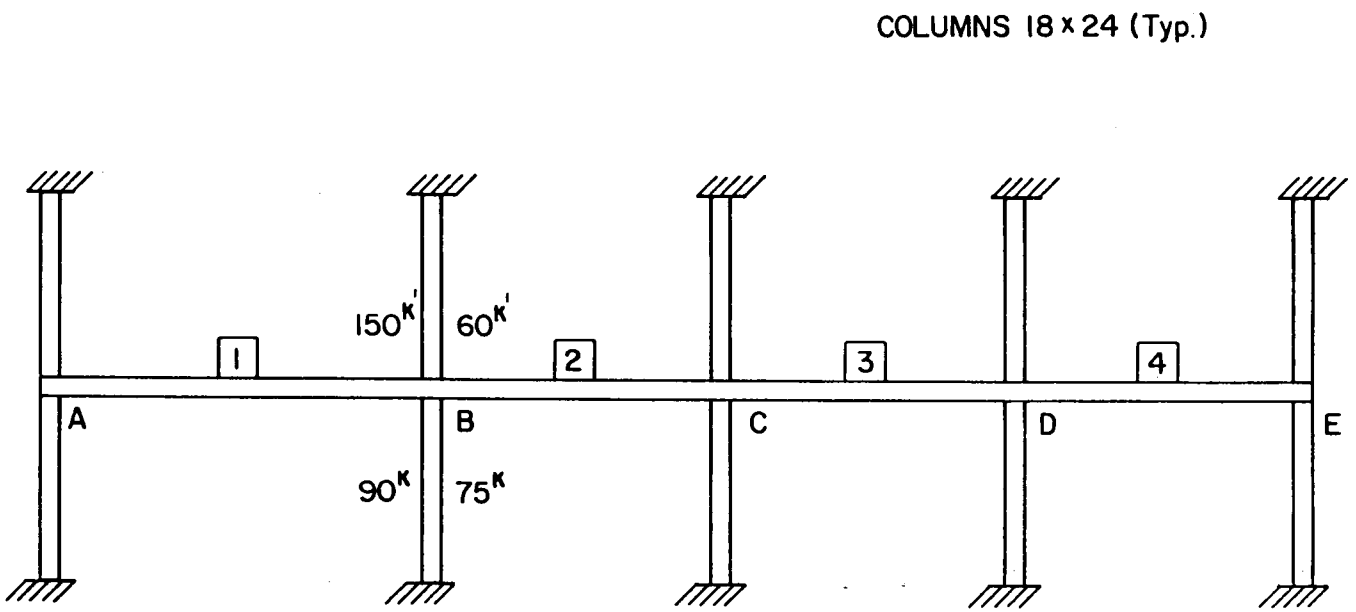
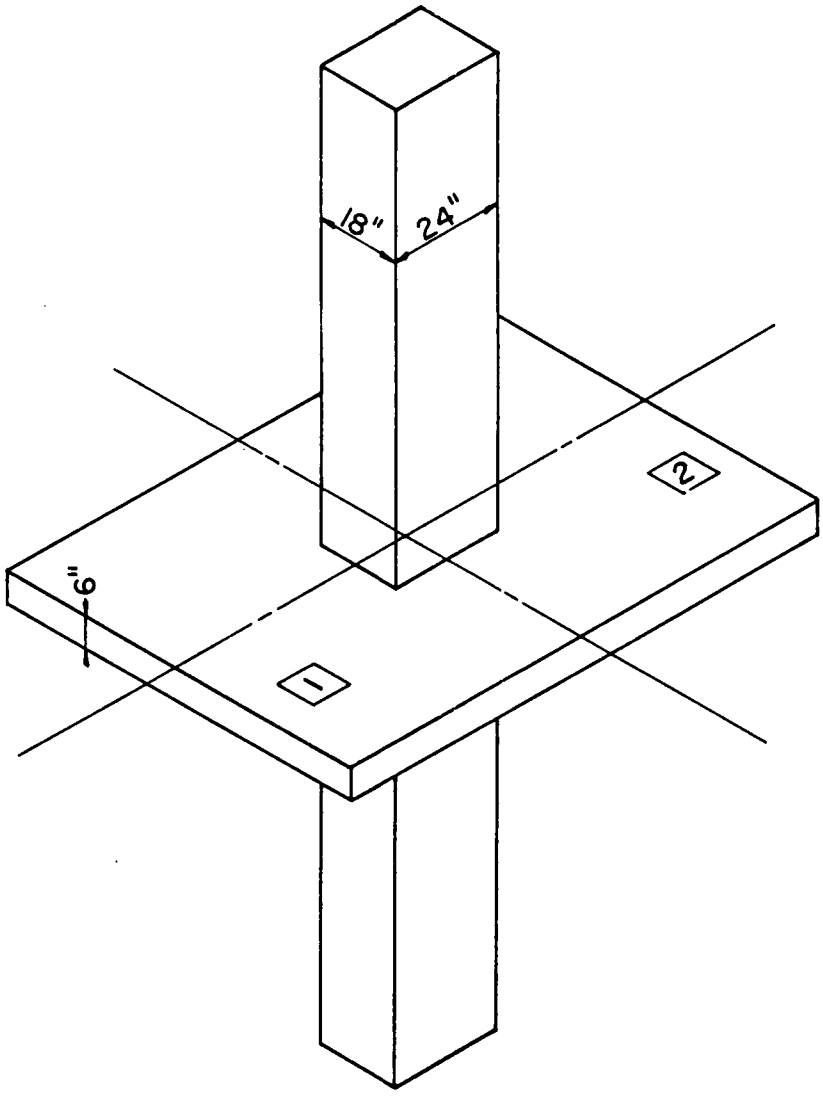


FIGURE 69

EXAMPLE 7-1
FRAME CONFIGURATION



f'c = 4000 PSI
Mu unbalanced = 90$^{k'}$
Vu = 165^{k}

FIGURE 70

EXAMPLE 7-1
LOAD SUMMARY AT JOINT B

The screen then displays "INPUT Vu? (KIPS)?". Input 165 and press RETURN.

The screen then displays "INPUT UNBALANCED Mu? (K-FT)?". Input 90 and press RETURN. The screen next displays "INPUT C1 (IN)?". Referring to Figure 71 which shows the definition of the following requested data for an interior column, C1 would be the column dimension perpendicular to the axis of bending, which in this case is 24". Input 24 and press RETURN. The screen next displays "INPUT C2 (IN)?". Input 18 and press RETURN. The screen then displays "INPUT d?". Input 6 and press RETURN to represent a 6" slab. The screen next displays "INPUT 1. INT. COLUMN 2. END (A) 3. END (B) 4. CORNER COLUMN?". As this is an interior column, input 1 and press RETURN.

The printer then displays the heading and the input data and indicates that the total maximum factored shear stress is 387.194 psi. The printer further displays that the allowable shear stress is 252.982 psi indicating that this condition is unacceptable without the addition of a column capital.

The screen then displays "DO YOU NEED TO ADD A CAPITAL? 1=YES 2=NO?". Input 1 and press RETURN. The screen then displays "INPUT C1 (IN)?". Referring to Figure 72, let us assume that it is desireable to try a column capital that has dimensions of 30" x 36" and a thickness below the slab of 12". Referring again to Figure 71 for an interior

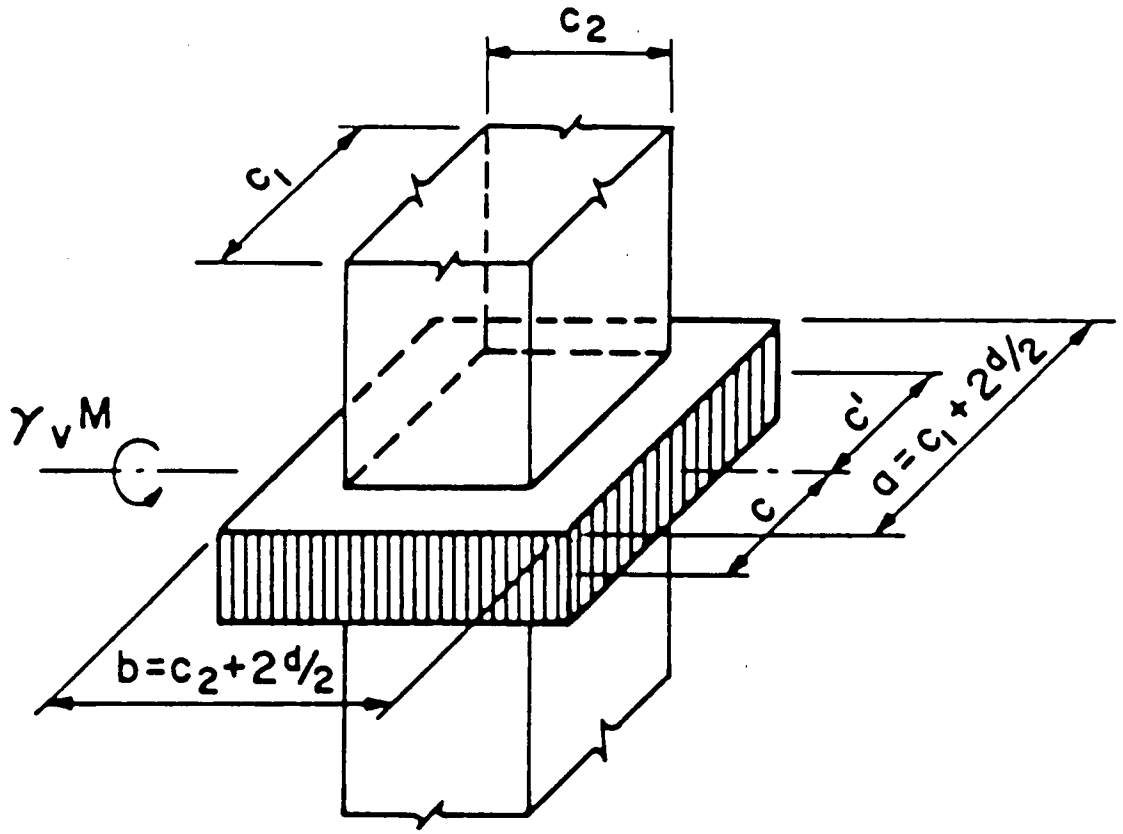


FIGURE 71

INTERIOR COLUMN CONFIGURATION

SOURCE: Neville, Gerald B., ed. Simplified Design, Reinforced Concrete Buildings of Moderate Size and Height. First Edition. Skokie, Illinois: Portland Cement Association, 1984.

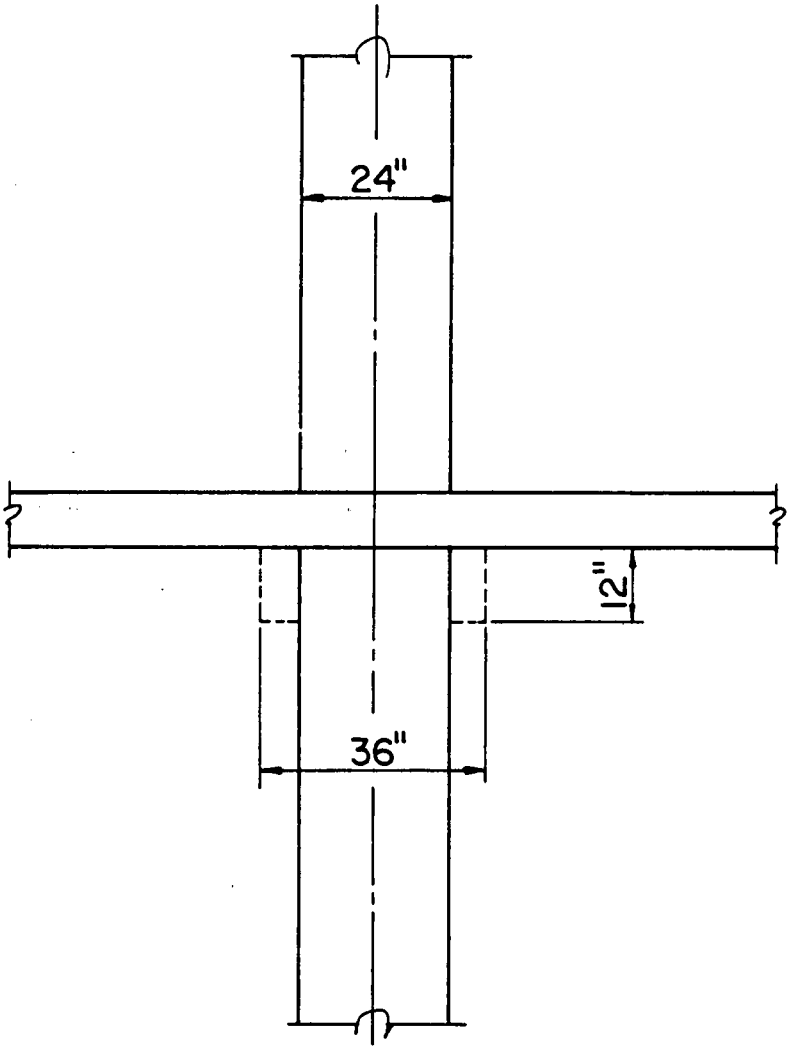


FIGURE 72

EXAMPLE 7-1
COLUMN CAPITAL

column, the value of C1 is now 36 to properly evaluate the shear stress using the capital.

Input 36 and press RETURN. The screen then displays "INPUT C2 (IN)?". Input 30 and press RETURN to identify the opposite face of the capital.

The screen next displays "INPUT d?". The depth of the slab for the added capital is still 6". The program is simply modeling a larger column. Input 6 and press RETURN.

The screen then displays "INPUT 1. INT. COLUMN 2. END (A) 3. END (B) 4. CORNER COLUMN?". Again, input 1 and press RETURN. The printer then displays the input data and indicates that the maximum total factored shear stress is 249.366 psi with the capital, which is less than the limit of 252.982 psi; therefore, this capital is satisfactory.

The screen again displays "DO YOU NEED TO ADD A CAPITAL? 1=YES 2=NO?". Input 2 and press RETURN. The program then returns to its beginning.

The print-out of the run of this example is as shown in Figure 73. Applications of this program to column conditions shown in Figures 74, 75 and 76 follows the same format as that described in Example 7-1.

Flow Chart

A chart showing the chronological operation of the "PLSHR" program is shown in Figure 77.

```
JOINT B

C1= 24 IN.
C2= 18 IN.
d= 6 IN.
Vu= 165 KIPS
UNBALANCED Mu= 90 K-FT
PORTION OF UNBALANCED
Mu TRANSFERED BY SHEAR
= 42.7051 % = 38.4346
K-FT
CRITICAL AREA (Ac)
= 648 SQ. IN.

TOTAL MAX. FACTORED
SHEAR STRESS
= 387.194 PSI
ALLOWABLE SHEAR STRESS
= 252.982 PSI
```

```
JOINT B

C1= 36 IN.
C2= 30 IN.
d= 6 IN.
Vu= 165 KIPS
UNBALANCED Mu= 90 K-FT
PORTION OF UNBALANCED
Mu TRANSFERED BY SHEAR
= 41.8632 % = 37.6769
K-FT
CRITICAL AREA (Ac)
= 936 SQ. IN.

TOTAL MAX. FACTORED
SHEAR STRESS
= 249.366 PSI
ALLOWABLE SHEAR STRESS
= 252.982 PSI
```

FIGURE 73

EXAMPLE 7-1
PRINT-OUT TAPE

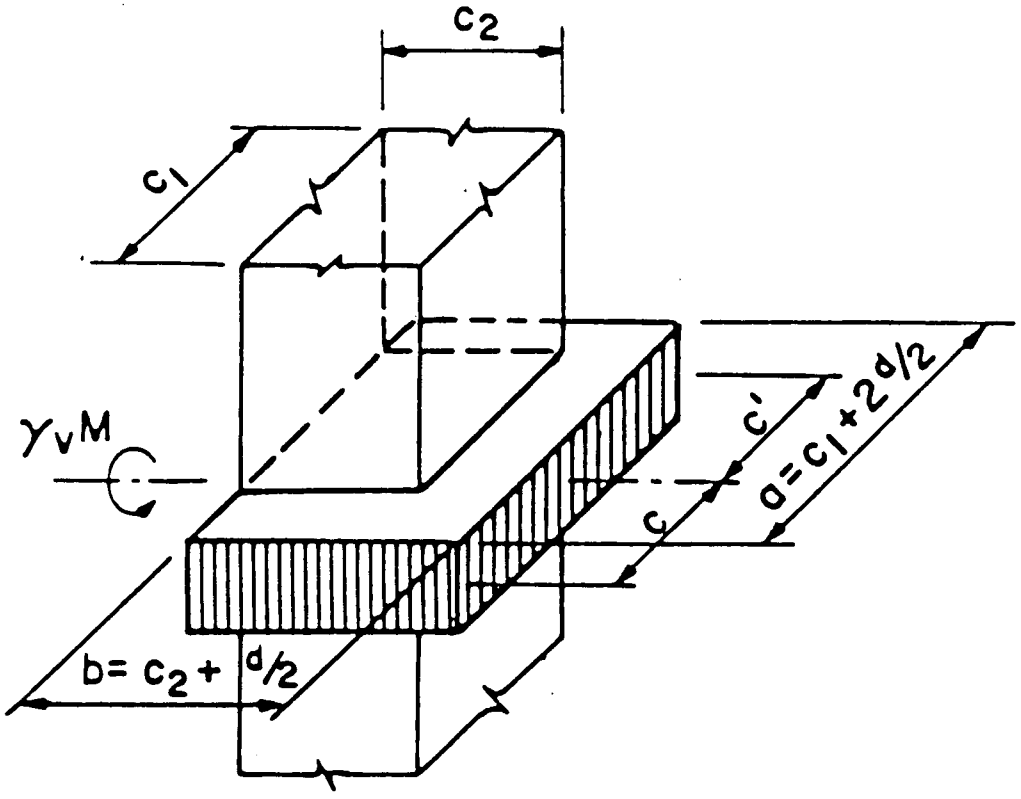


FIGURE 74

END A COLUMN CONFIGURATION

SOURCE: Neville, Gerald B., ed. Simplified Design, Reinforced Concrete Buildings of Moderate Size and Height. First Edition. Skokie, Illinois: Portland Cement Association, 1984.

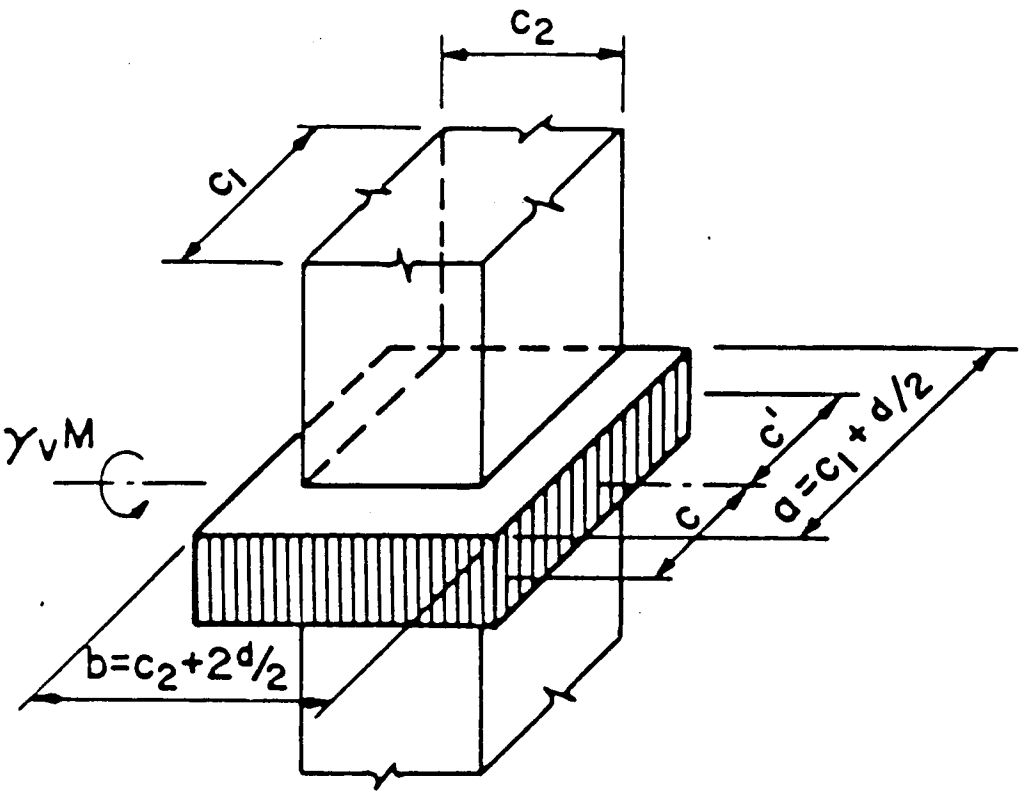


FIGURE 75

END B COLUMN CONFIGURATION

SOURCE: Neville, Gerald B., ed. Simplified Design, Reinforced Concrete Buildings of Moderate Size and Height. First Edition. Skokie, Illinois: Portland Cement Association, 1984.

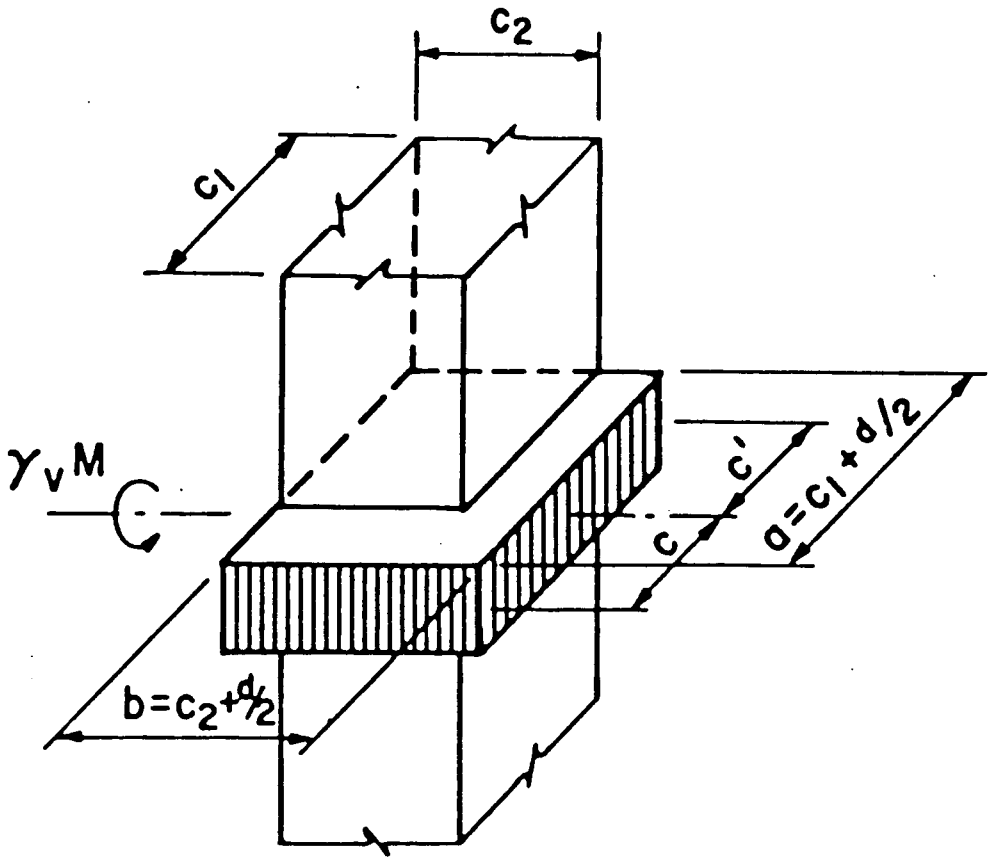


FIGURE 76

CORNER COLUMN CONFIGURATION

SOURCE: Neville, Gerald B., ed. Simplified Design, Reinforced Concrete Buildings of Moderate Size and Height. First Edition. Skokie, Illinois: Portland Cement Association, 1984.

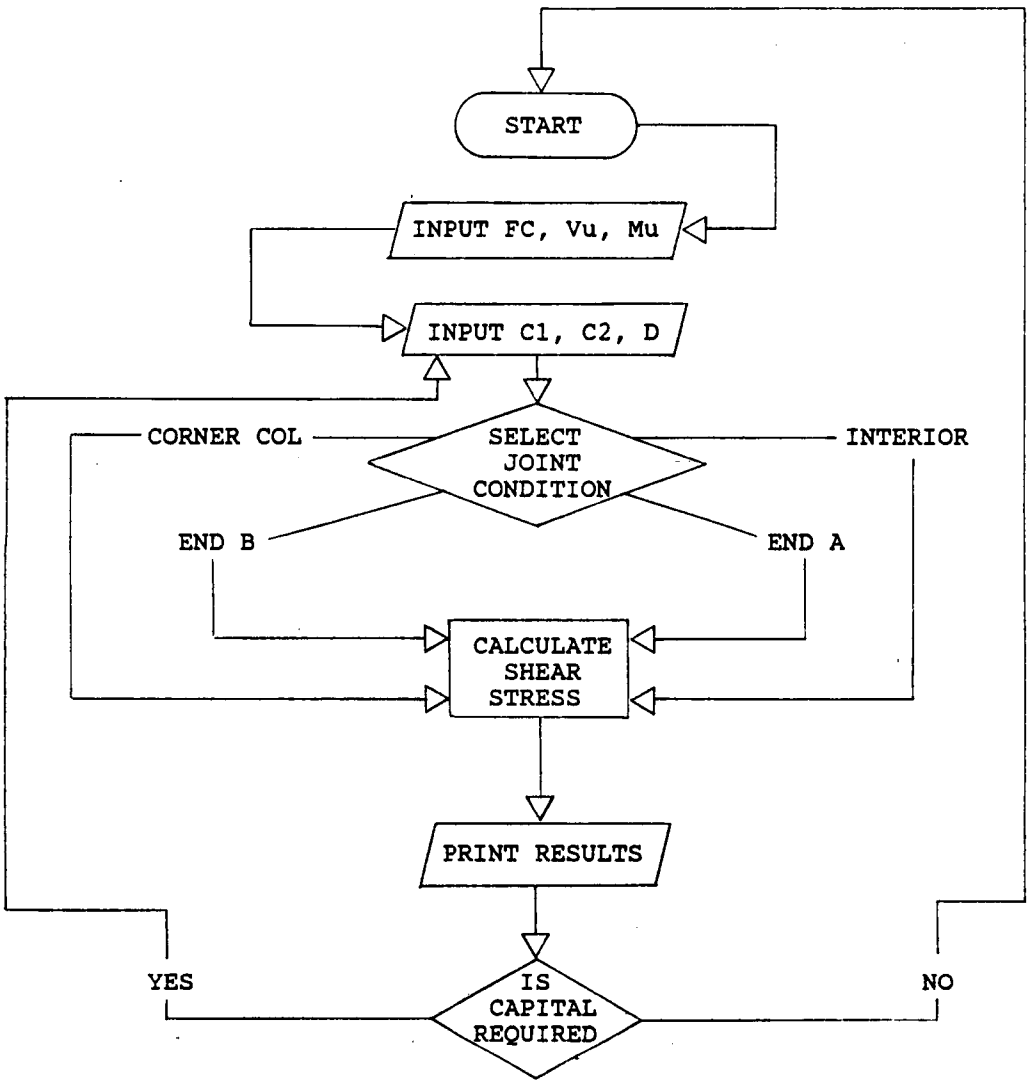


FIGURE 77

PLSHR PROGRAM FLOW CHART

Program Copy

A print-out of the "PLSHR" program is shown in Figure 78. A wide margin has been provided to allow the user to make notes, if desired.

```
1 CLS
2 PRINT"SHEAR STRESS DUE
"
3 PRINT"TO Vu AND MOMENT
"
4 PRINT"TRANSFER
5 N=N+1
6 IF N=200 THEN CLS ELSE
 GOTO 5
7 PRINT"IDENTIFICATION?"
8 INPUT A$
9 CLS
10 PRINT"INPUT CONCRETE"
11 PRINT"STRENGTH (PSI)"
12 INPUT FC
13 CLS
14 PRINT"INPUT Vu (KIPS)
"
15 INPUT VU
16 CLS
17 PRINT"INPUT UNBALANCE
D"
18 PRINT"Mu (K-FT)"
19 INPUT MU
20 CLS
21 PRINT"INPUT C1 (IN)"
22 INPUT C1
23 CLS
24 PRINT"INPUT C2 (IN)"
25 INPUT C2
26 CLS
27 PRINT"INPUT d"
28 INPUT D
29 CLS
30 LAMT=1-(1/(1+((2/3)*(
(C1+D)/(C2+D))^.5)))
31 PRINT"INPUT 1.INT.COL
UMN
32 PRINT"2.END (A) 3.END
 (B)"
33 PRINT"4.CORNER COLUMN
"
34 INPUT CHOICE
35 CLS
36 IF CHOICE=2 GOTO 45
37 IF CHOICE=3 GOTO 51
38 IF CHOICE=4 GOTO 59
39 A=C1+2*(D/2)
40 B=C2+2*(D/2)
41 AC=2*(A+B)*D
42 JOC=(A*D*(A+3*B)+D^3)
/3
43 GOSUB 67
44 GOTO 71
45 A= C1+2*(D/2)
46 B= C2+(D/2)
47 AC=(A+2*B)*D
48 JOC=(A*D*(A+6*B)+D^3)
/6
49 GOSUB 67
50 GOTO 71
51 A=C1+(D/2)
52 B=C2+2*(D/2)
53 AC=(2*A+B)*D
54 JOC=(2*A*D*(A+2*B)+D^
3*(2*A+B)/A)/6
55 JOCP=((2*A^2*D)*(A+2*
B)+D^3*(2*A+B))/6*(A+B)
```

FIGURE 78

PLSHR PROGRAM PRINT-OUT

```
56 IF JOC<JOCP THEN JOC=
JOC ELSE JOCP=JOC
57 GOSUB 67
58 GOTO 71
59 A=C1+(D/2)
60 B=C2+(D/2)
61 AC=(A+B)*D
62 JOC=(A*D*(A+4*B)+D^3*
(A+B)/A)/6
63 JOCP=(A^2*D*(A+4*B)+D
^3*(A+B))/6*(A+2*B)
64 IF JOC<JOCP THEN JOC=
JOC ELSE JOC=JOCP
65 GOSUB 67
66 GOTO 71
67 SHEARSTRESS=((VU*1000
/AC)+LAMT*MU*12000/(JOC)
)/.85
68 SOUND 1,5
69 SOUND 5,1
70 RETURN
71 LPRINT A$
72 LPRINT"
"
73 LPRINT""
74 LPRINT"C1="C1"IN.
75 LPRINT"C2="C2"IN.
76 LPRINT"d="D"IN.
77 LPRINT"Vu="VU"KIPS
78 LPRINT"UNBALANCED Mu=
"MU"K-FT"
79 LPRINT"PORTION OF UNB
ALANCED"
80 LPRINT"Mu TRANSFERED
BY SHEAR"
81 X=LAMT*100
82 POR=LAMT*MU
83 LPRINT"="X"% ="POR"K-
FT"
84 LPRINT"CRITICAL AREA
(Ac)"
85 LPRINT"="AC"SQ. IN."
86 LPRINT""
87 LPRINT"————————————
————————"
88 LPRINT"TOTAL MAX. FAC
TORED"
89 LPRINT"SHEAR STRESS
90 LPRINT"="SHEARSTRESS"
PSI"
91 OK=4*(FC^.5)
92 LPRINT"ALLOWABLE SHEA
R STRESS"
93 LPRINT"="OK"PSI"
94 LPRINT"————————————
————————"
95 LPRINT""
96 LPRINT""
97 LPRINT""
98 LPRINT""
99 PRINT"DO YOU NEED TO"
100 PRINT"ADD A CAPITOL?
"
101 PRINT"1=YES 2=NO"
102 INPUT REVISE
103 CLS
104 IF REVISE=1 GOTO 21
105 SOUND 1,21
106 SOUND 3,15
107 SOUND 24,3
108 SOUND 25,1
109 GOTO 7
```

FIGURE 78 (Continued)

CHAPTER 8

SECTION PROPERTIES

Description of Program

The Section Properties program calculates the inertia of any shape that can be modeled by rectangles or triangles The cross-sectional area of the section and the center of gravity is also calculated. Results are unitless as they are a function of the input.

The program, as written, has a limit of 150 element divisions that can be used to describe a total section. However, this can easily be redimensioned to larger values if necessary.

Nomenclature

AREA	- The cross-sectional area of an element.
AREATOT	- The total area of the section.
B	- The base of an element.
ERTIAX	- The inertia of an element about the X axis.
ERTIAY	- The inertia of an element about the Y axis.
ERTIAXTOT	- The total section inertia about the X axis.
ERTIAYTOT	- The total section inertia about the Y axis.
H	- The height of an element.
N	- The number of elements.
TRANSARMX	- The element area transfer arm.
TRANSARMY	- Similar to above.

X - The horizontal distance from the vertical base to the C.G. of an element.

XFROMBASE - The horizontal distance from the vertical base of an element to the section C.G.

Y - The vertical distance from the horizontal base to the C.G. of an element.

YFROMBASE - The vertical distance from the horizontal base of the section to the C.G.

User Prompt Definitions

IDENTIFICATION

Input a brief description identifying the section analyzed.

ENTER NUMBER OF ELEMENTS

Input the total number of rectangular and triangular elements necessary to model the section.

CHOOSE SHAPE: 1=RECTANGLE 2=TRIANGLE

For the element being considered, input the appropriate shape.

BASE, HEIGHT, HORIZONTAL C.G., VERTICAL C.G.

For the element being considered, input the element base, the element height, the horizontal distance from the vertical base to the C.G. and the vertical distance from the horizontal base to the C.G. in order, separating each input with a ",".

Examples

Example 8-1

Considering a standard 24" deep, 8' wide double tee, the use of the program will be demonstrated. Referring to Figure 79, the cross-section of a standard 24" 8 wide double tee is shown. The area and inertia about the X axis are as taken from the PCI Design Handbook Precast and Prestressed Concrete, Edition 3, as published by the Prestressed Concrete Institute. Figure 79 further illustrates the cross-section that will be modeled by rectangles and triangles.

The program begins with the screen displaying "IDENTIFICATION?". Input DT24X8. The screen then displays "ENTER NUMBER OF ELEMENTS?". Referring to Figure 79, the cross-section to be modeled has seven elements; three being rectangles and four being triangles. Input 7 and press RETURN.

The screen next displays "CHOOSE SHAPE: 1=RECTANGLE 2=TRIANGLE?". Following the numbering sequence shown in Figure 79, the first element would be the flange. Input 1 to represent a rectangle and press RETURN. The screen next displays "BASE, HEIGHT, HORIZONTAL C.G., VERTICAL C.G.?". Referring to Figure 79, the base dimension of Element 1 is 96". The height is 2". The horizontal distance to the C.G. from the horizontal base is half of 96 or 48" and the vertical distance from the vertical base to the C.G. of

$I_x = 20985\ IN^4$
$A = 401\ IN^2$

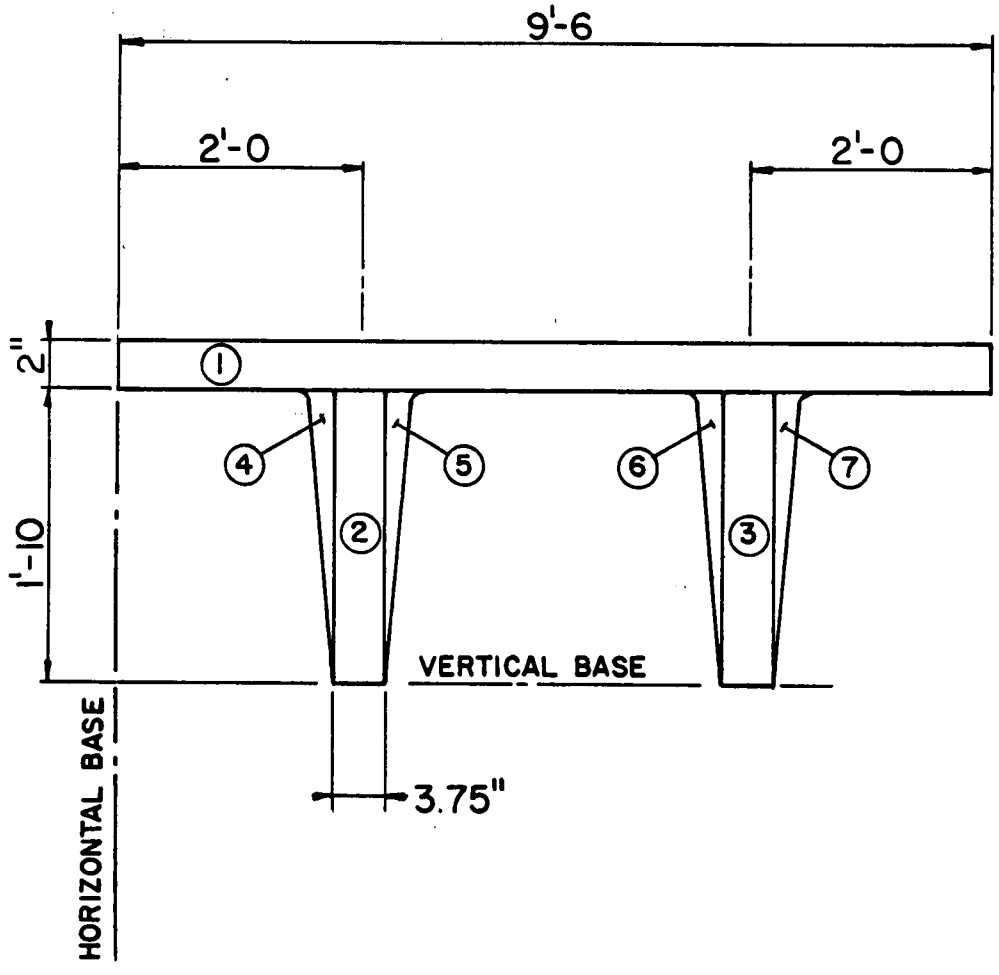


FIGURE 79

STANDARD 24" DOUBLE TEE
AND ELEMENTAL MODEL

Element 1 is 23". Therefore, input 96,2,48,23 and press RETURN, being certain to separate the data with a ",". The screen next displays "CHOOSE SHAPE: 1=RECTANGLE 2=TRIANGLE?". Considering Element 2, which is a rectangle, input 1 and press RETURN. The screen again displays "BASE, HEIGHT, HORIZONTAL C.G., VERTICAL C.G.?". This data for Element 2 would be input as 3.75,22,24,11. After input of this data, press RETURN.

The screen then displays "CHOOSE SHAPE: 1=RECTANGLE 2=TRIANGLE?". For Element 3, input 1 and press RETURN. The screen then displays "BASE, HEIGHT, HORIZONTAL C.G., VERTICAL C.G.?". This data for Element 3 would be entered 3.75,22,72,11. After this input, press RETURN.

The screen again displays "CHOOSE SHAPE: 1=RECTANGLE 2=TRIANGLE?". As Element 4 is now being considered, input 2 for a triangle and press RETURN. The screen then displays "BASE, HEIGHT, HORIZONTAL C.G., VERTICAL C.G.?". For understanding of this input, the user only need bear in mind that the reference for base and height of a triangle is the orientation of the element on the page. The base of all triangles is parallel to a horizontal line drawn through the section. The height of all triangles is parallel to a vertical line drawn through the section. For Element 4, the base is 1" and the height is 22". The distance from the horizontal base to the center of gravity of Element 4 is 21.7917" and the vertical distance from the vertical

baseline to the C.G. of Element 4 is 14.6667". Therefore, inputting the screen requested data for Element 4, input 1,22,21.7917,14.6667 and press RETURN. The screen again displays "CHOOSE SHAPE: 1=RECTANGLE 2=TRIANGLE?". This request for data continues until the seventh element has been input.

The printer then displays the base, height and horizontal and vertical distance from the base to element C.G. data just input for each element. It further gives the area, the inertia about the horizontal and vertical C.G.'s as well as the distance to these center of gravity points.

Figure 80 is a print-out of the tape resulting from this example. Comparison of this figure to the values shown in Figure 79 indicates that the program is accurate for modeling this cross-section.

Flow Chart

Figure 81 shows the chronological operation of the "SECTION" program.

Program Copy

Figure 82 shows a print-out of the "SECTION" program. A wide margin has been provided to allow the user to make notes, if desired.

DT24X8

7 ELEMENTS AS FOLLOWS

ELEMENT	BASE	HEIGHT	X	Y
1	96	2	48	23
2	3.75	22	24	11
3	3.75	22	72	11
4	1	22	21.7917	14.6667
5	1	22	26.2083	14.6667
6	1	22	69.7917	14.6667
7	1	22	74.2083	14.6667

AREA= 401
Ix= 20984.9
Iy= 268250
VERT. DIST. TO. C. G.
= 17.148
HORIZ. DIST TO. C. G.
= 48

FIGURE 80

EXAMPLE 8-1
PRINT-OUT TAPE

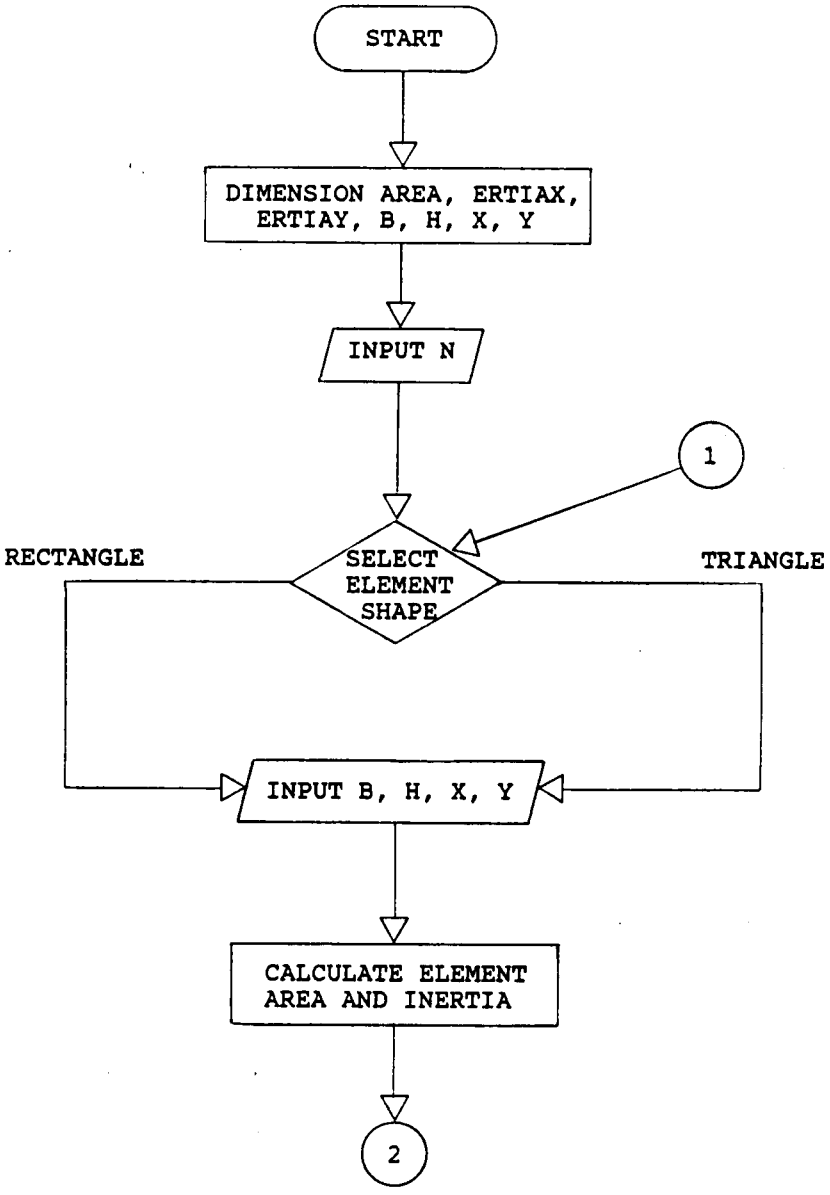


FIGURE 81

SECTION PROGRAM FLOW CHART

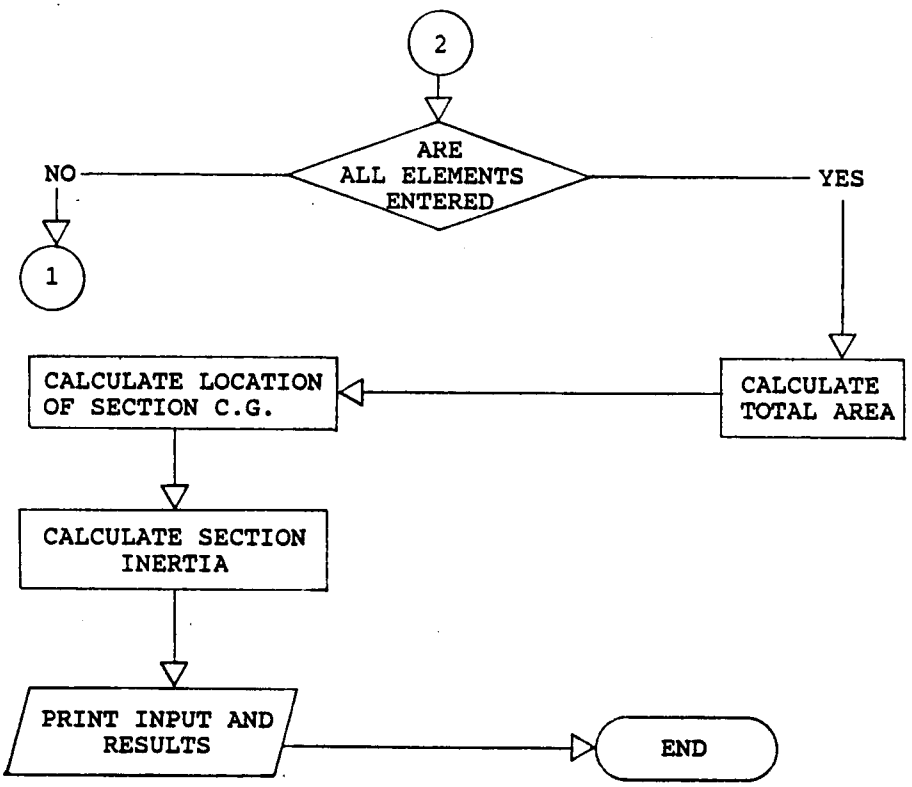


FIGURE 81 (Continued)

```
1 CLS
2 PRINT"IDENTIFICATION"
3 INPUT A$
4 CLS
5 DIM AREA(150)
6 DIM ERTIAX(150)
7 DIM ERTIAY(150)
8 DIM B(150)
9 DIM H(150)
10 DIM X(150)
11 DIM Y(150)
12 PRINT"ENTER NUMBER"
13 PRINT"OF ELEMENTS"
14 INPUT N
15 CLS
16 FOR I=1 TO N
17 PRINT"CHOOSE SHAPE:"
18 PRINT"1=RECTANGLE"
19 PRINT"2=TRIANGLE"
20 INPUT SHAPE
21 CLS
22 PRINT"BASE,HEIGHT,"
23 PRINT"HORIZONTAL C.G.
,"
24 PRINT"VERTICAL C.G."
25 INPUT B(I),H(I),X(I),
Y(I)
26 CLS
27 IF SHAPE=1 THEN AREA(
I)=B(I)*H(I) ELSE AREA(I
)=.5*B(I)*H(I)
28 IF SHAPE=1 THEN ERTIA
X(I)=(1/12)*B(I)*(H(I)^3
) ELSE ERTIAX(I)=(B(I)*(
H(I)^3))/36
29 IF SHAPE=1 THEN ERTIA
Y(I)=(1/12)*H(I)*(B(I)^3
) ELSE ERTIAY(I)=(H(I)*(
B(I)^3))/36
30 SOUND 20,1
31 NEXT I
32 FOR I=1 TO N
33 AREATOT=AREATOT + ARE
A(I)
34 AREAARMYTOT=AREAARMYT
OT + (AREA(I)*Y(I))
35 AREAARMXTOT=AREAARMXT
OT + (AREA(I)*X(I))
36 NEXT I
37 YFROMBASE=AREAARMYTOT
/AREATOT
38 XFROMBASE=AREAARMXTOT
/AREATOT
39 SOUND 2,10
40 FOR I=1 TO N
41 TRANSARMY=ABS(Y(I)-YF
ROMBASE)
42 TRANSARMX=ABS(X(I)-XF
ROMBASE)
43 ERTIAXTOT=ERTIAXTOT +
 (ERTIAX(I)+AREA(I)*(TRA
NSARMY^2))
44 ERTIAYTOT=ERTIAYTOT +
 (ERTIAY(I)+AREA(I)*(TRA
NSARMX^2))
45 NEXT I
46 LPRINT A$
47 LPRINT"[redacted]"
```

FIGURE 82

SECTION PROGRAM PRINT-OUT

```
48 LPRINT""
49 LPRINT N"ELEMENTS AS
FOLLOWS"
50 LPRINT"ELEMENT•BASE•H
EIGHT•X•Y"
51 LPRINT"———————————
——————————"
52 FOR I=1 TO N
53 LPRINT I"•"B(I)"•"H(I
)"•"X(I)"•"Y(I)
54 NEXT I
55 LPRINT"———————————
——————————"
56 LPRINT"AREA="AREATOT
57 LPRINT"Ix="ERTIAXTOT
58 LPRINT"Iy="ERTIAYTOT
59 LPRINT"VERT. DIST. TO. C
.G."
60 LPRINT"="YFROMBASE
61 LPRINT"HORIZ. DIST TO.
C.G."
62 LPRINT"="XFROMBASE
63 LPRINT"[redacted]
[redacted]"
64 SOUND 1,20
65 SOUND 25,2
66 CLS
67 LPRINT""
68 LPRINT""
69 LPRINT""
70 LPRINT""
71 PRINT"MITCHELL"
72 FOR X=0 TO 119
73 FOR Y=0 TO 15
74 IF POINT(X/2,Y/2)=1 T
HEN PSET (X,Y+10)
75 NEXT Y
76 NEXT X
77 FOR X=0 TO 119
78 FOR Y=0 TO 8
79 PRESET (X,Y)
80 NEXT Y
81 NEXT X
82 COPY
83 LPRINT""
84 LPRINT""
85 LPRINT""
86 LPRINT""
87 GOTO 87
```

FIGURE 82 (Continued)

CHAPTER 9

FRACTION ADDITION AND SUBTRACTION

Description of Program

The Fraction Addition and Subtraction program is a very useful tool for occasions when the structural engineer must verify shop drawing dimensions, architectural drawing dimensions or other occasions where fractional rather than decimal values are known.

The program takes dimensional input in feet, inches and fractions of an inch to a minimum of 32nds. The input is then converted to feet in decimal form and summed in a storage area. After all elements have been entered, the program then converts the total to whole feet and whole inches with a remaining decimal in units of inches. It then evaluates the decimal remainder against 32 possibilities, each representing 1/32 of an inch graduations in decimal form. When the appropriate decimal has been attained, the program assigns that fractional equivalent to the decimal and prints the total result.

Subtraction of a value is accomplished by inputting a negative sign in front of the input. For example, if 1'-10-1/2" is to be subtracted, a -1 would be input with the feet, 10 inches and numerator of the fraction. If 10-3/4" is to be subtracted, a -10 and a -3 would be input to designate subtraction. This subtracts the total value input

from the sum being collected in the storage area and results in a proper total. A print-out of the string of dimensions input is provided so the user may verify input.

Nomenclature

BOTENT - The sum of feet plus inches plus fractions of an inch in foot decimal form.

DEN - Denominator.

ENT - The number of string entries.

FRACFT - Fractional portion of feet.

FT - Feet.

IN - Inches.

INCALIN - Whole number of inches in the fractional portion of feet.

INFT - Inches in decimal form of feet.

NUM - Numerator.

TAL - Talley of all entries.

User Prompt Definitions

INPUT NO. ENTRIES

Input the total number of entries in this addition/subtraction operation. (Each entry may contain feet, inches and fractions of an inch.)

INPUT FT, IN, NUM, DEN

Input the entry, first inputting feet, then inches, then the numerator and denominator of the inch

fraction, separating all data by commas. (Portions having no input, example 10'-0-1/2" would have zero input, i.e. 10,0,1,2.

Examples

Example 9-1

Referring to Figure 83, the use of the program to add and subtract fractional entries will be demonstrated.

It is desired to determine the horizontal distance from Line AA to Point B; however, this information is not directly provided on documents being reviewed. The only way to ascertain this dimension is to add the string of dimensions from Line AA to Line BB and then subtract the dimensions shown from Line BB back to Point B.

The program begins with the screen prompt "INPUT NO. ENTRIES?". Referring to Figure 83, five entries will be added and two entries will be subtracted, so the total number of entries will be 7. Input 7 and press RETURN. The screen then displays "INPUT FT, IN, NUM, DEN?". Entries may be input in any order; however, for simplicity, work beginning at Line AA from left to right in the order shown in Figure 83. Input 11,1,3,32 representing 11'-1-3/32" with 3 being the numerator and 32 being the denominator of the fractional portion of the inch. When input is complete, press RETURN. The printer then displays this input and the screen then displays "INPUT FT,IN, NUM, DEN?". Referring to the entry designated as 2 on Figure 83, input 7,6,0,0. This

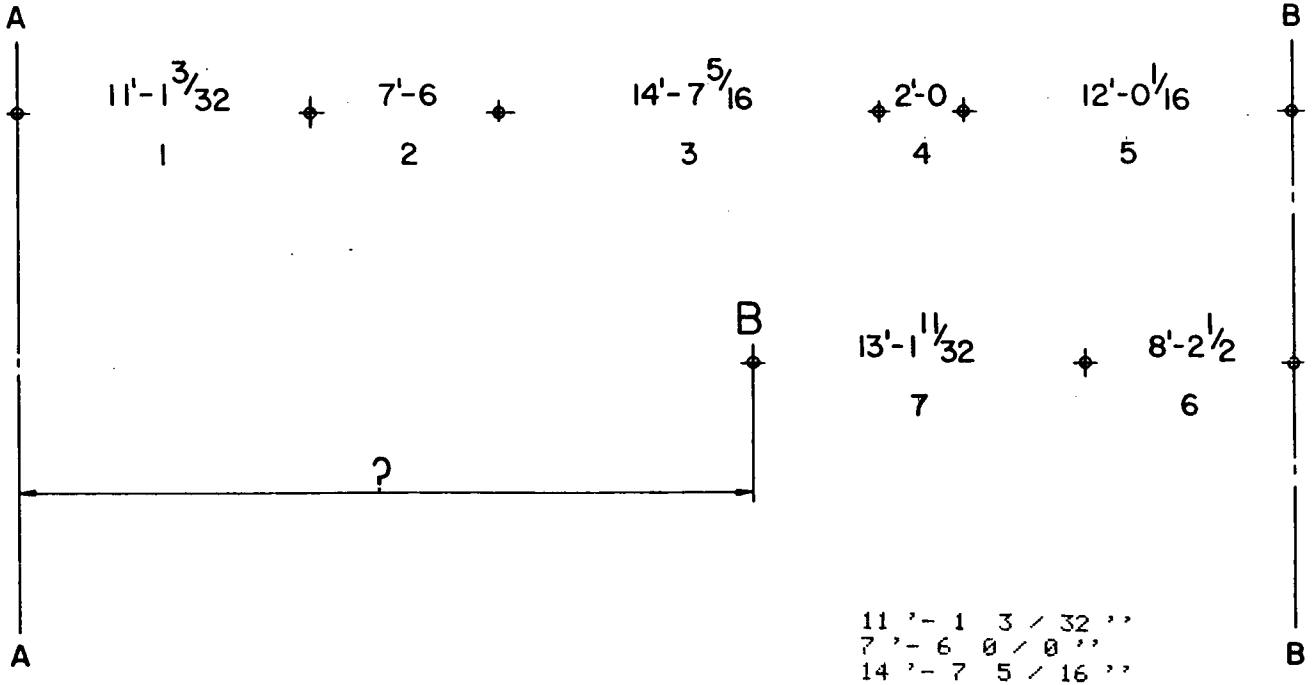


FIGURE 83

EXAMPLE 9-1
DIMENSION STRINGS AND RESULTING
PRINT-OUT TAPE

represents 7'-6" and no fractional portion of an inch. When this entry is made, press RETURN. The printer again displays this data. The screen again displays "INPUT FT,IN,NUM,DEN?". For Entry #3, input 14,7,5,16 representing 14'-7-5/16". When this input is made, press RETURN. This continues for Entries 4 and 5.

After entering the fifth dimension, the screen again displays "INPUT FT,IN,NUM,DEN?". This is the point at which we must now subtract the entries to attain the desired dimension. To subtract an entire entry, a negative sign must be placed in front of all portions except the denominator. To indicate subtraction of 8'-2-1/2", input -8,-2,-1,2 representing a negative 8'-2-1/2". The program takes the fractionally input entry and converts it to decimal feet form for summation in the storage area. After inputting the described data, press RETURN. At this point, the final entry is necessary, that being the subtraction of 13'-1-11/32". Input -13,-1,-11,32 and press RETURN. The printer then displays this string and gives the total of the adding and subtracting operation as 25'-10-5/8". Hand addition and subtraction of these numbers will verify this value.

The screen then displays "ADD NEW STRING? 1=YES". If a new string is desired, input 1 and press RETURN. The print-out resulting from this example is also shown in Figure 83.

Flow Chart

Figure 84 illustrates the chronological operation of the "ADD DIM" program.

Program Copy

Figure 85 is a print-out of the "ADD DIM" program. A wide margin has been provided to allow the user to make notes, if desired.

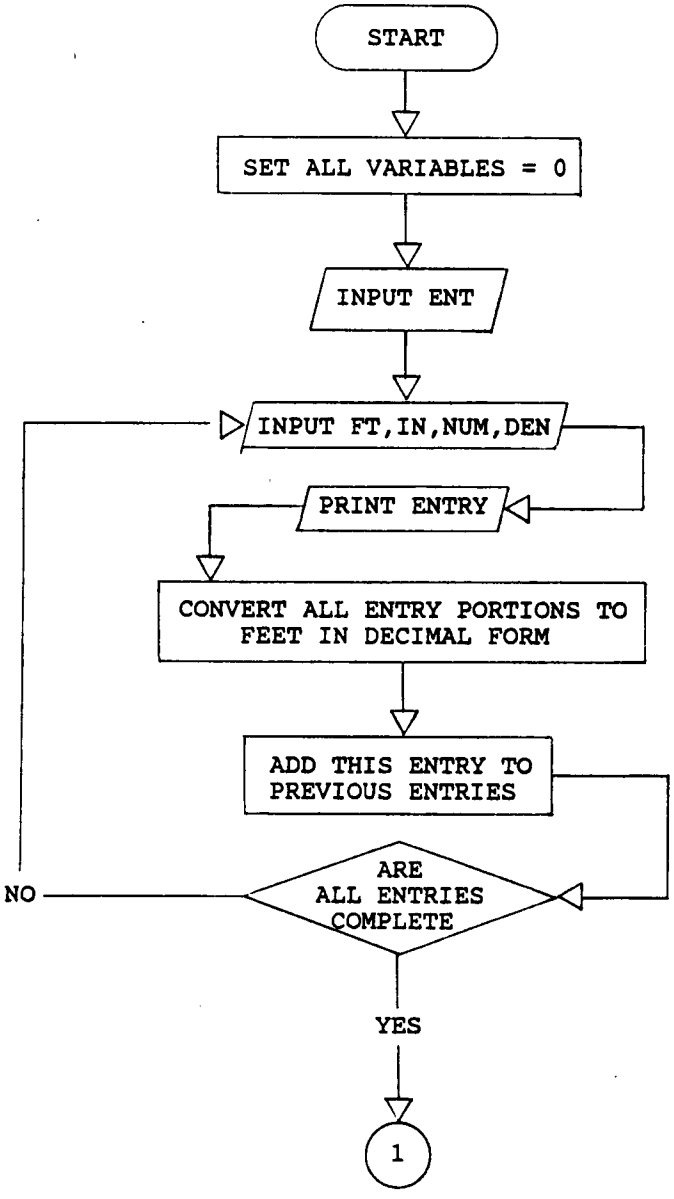


FIGURE 84

ADD DIM FLOW CHART

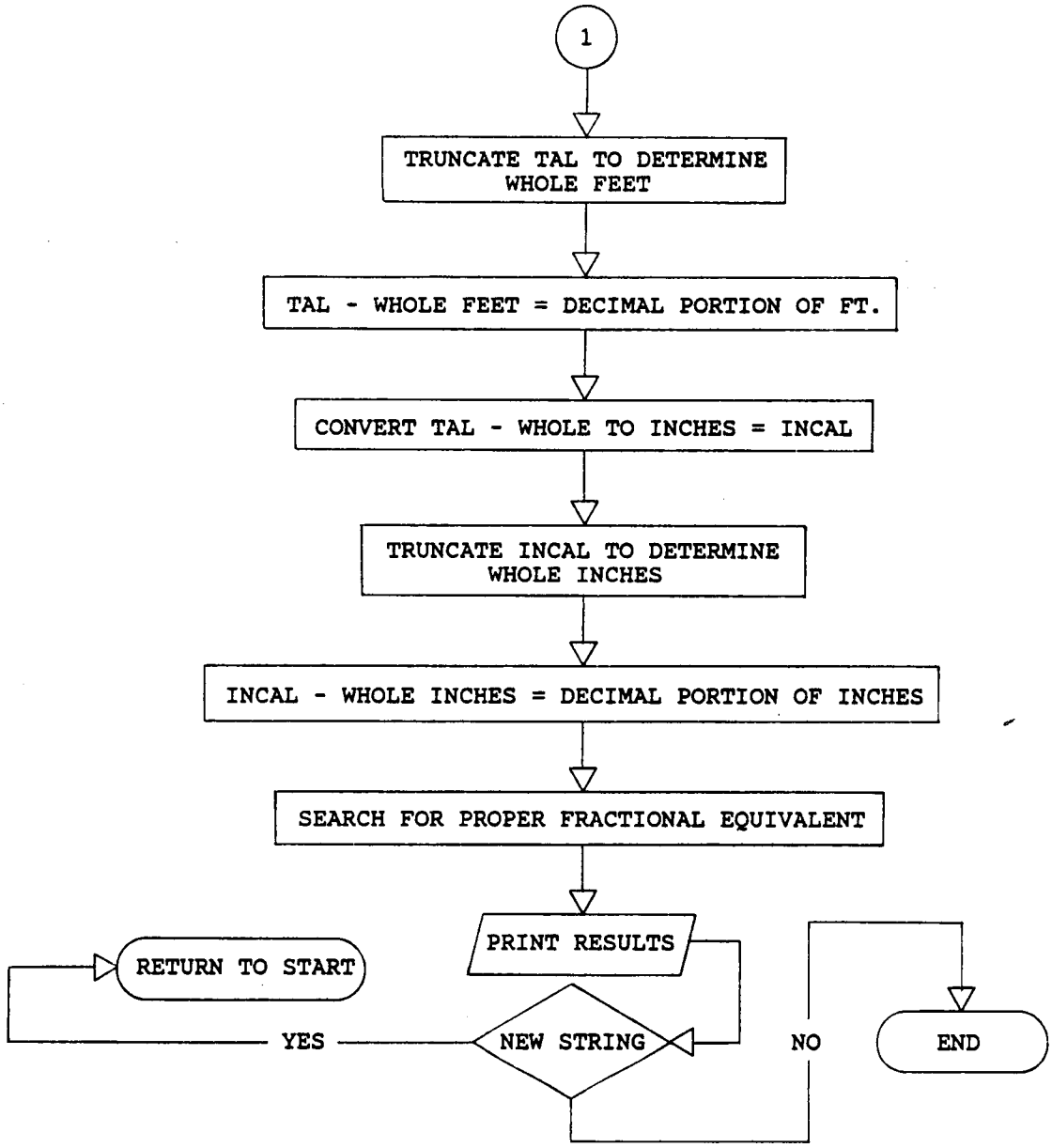


FIGURE 84 (Continued)

```
1 CLS
2 TAL=0
3 PRINT"INPUT NO.ENTRIES
"
4 INPUT ENT
5 MORE=0
6 CLS
7 J=0
8 FT=0
9 IN=0
10 NUM=0
11 DEN=0
12 BOTENT=0
13 FRAC=0
14 FRACFT=0
15 INFT=0
16 POP=0
17 INCHES=0
18 INCAL=0
19 INCALIN=0
20 FRACTION=0
21 F=0
22 PRINT"INPUT FT,IN,NUM
,DEN"
23 INPUT FT,IN,NUM,DEN
24 LPRINT FT"'-"IN NUM"/
"DEN"''"
25 J=J+1
26 IF DEN=0 THEN DEN=10
27 FRAC=NUM/DEN
28 FRACFT=FRAC/12
29 INFT=IN/12
30 BOTENT=FT+INFT+FRACFT
31 TAL=TAL+BOTENT
32 IF J=ENT GOTO 35 ELSE
 33
33 CLS
34 GOTO 8
35 POP=FIX(TAL)
36 INCHES=TAL-POP
37 INCAL=INCHES*12
38 INCALIN=FIX(INCAL)
39 FRACTION=INCAL-INCALI
N
40 F=FRACTION
41 IF F=0 THEN GOTO 78 E
LSE GOTO 42
42 IF (F<.001)*(F)0)THEN
 GOTO 78  ELSE GOTO 43
43 IF(F<.03225)*(F).0302
5) THEN GOTO 80 ELSE GOT
O 44
44 IF(F<.0635)*(F).0615)
THEN GOTO 82  ELSE GOTO
45
45 IF(F<.09475)*(F).0927
5)THEN GOTO 84 ELSE GOTO
 46
46 IF(F<.126)*(F).124)TH
EN GOTO 86   ELSE GOTO 4
7
47 IF(F<.15725)*(F).1552
5)THEN GOTO 88 ELSE GOTO
 48
48 IF(F<.1885)*(F).1865)
THEN GOTO 90  ELSE GOTO
49
```

FIGURE 85

ADD DIM PROGRAM PRINT-OUT

```
49 IF(F<.21975)*(F>.2177
5)THEN GOTO 92 ELSE GOTO
 50
50 IF(F<.251)*(F>.249)TH
EN GOTO 94  ELSE GOTO 51
51 IF(F<.28225)*(F>.2802
5)THEN GOTO 96 ELSE GOTO
 52
52 IF(F<.3135)*(F>.3115)
THEN GOTO 98  ELSE GOTO
53
53 IF(F<.34475)*(F>.3427
5)THEN GOTO 100 ELSE GOT
O 54
54 IF(F<.376)*(F>.374)TH
EN GOTO 102   ELSE GOTO
55
55 IF(F<.40725)*(F>.4052
5)THEN GOTO 104 ELSE GOT
O 56
56 IF(F<.4385)*(F>.4365)
THEN GOTO 106  ELSE GOTO
 57
57 IF(F<.46975)*(F>.4677
5)THEN GOTO 108 ELSE GOT
O 58
58 IF(F<.501)*(F>.499)TH
EN GOTO 110 ELSE GOTO 59
59 IF(F<.53225)*(F>.5302
5)THEN GOTO 112 ELSE GOT
O 60
60 IF(F<.5635)*(F>.5615)
THEN GOTO 114  ELSE GOTO
 61
61 IF(F<.59475)*(F>.5927
5)THEN GOTO 116 ELSE GOT
O 62
62 IF(F<.626)*(F>.624)TH
EN GOTO 118   ELSE GOTO
63
63 IF(F<.65725)*(F>.6552
5)THEN GOTO 120 ELSE GOT
O 64
64 IF(F<.6885)*(F>.6865)
THEN GOTO 122  ELSE GOTO
 65
65 IF(F< .71925)*(F>.717
25)THEN GOTO 124 ELSE GO
TO 66
66 IF(F<.751)*(F>.749)TH
EN GOTO 126  ELSE GOTO 6
7
67 IF(F<.78225)*(F>.7802
5)THEN GOTO 128 ELSE GOT
O 68
68 IF(F<.8135)*(F>.8115)
THEN GOTO 130  ELSE GOTO
 69
69 IF(F<.84475)*(F>.8427
5)THEN GOTO 132 ELSE GOT
O 70
70 IF(F<.876)*(F>.874)TH
EN GOTO 134   ELSE GOTO
71
71 IF(F<.90725)*(F>.9052
5)THEN GOTO 136 ELSE GOT
O 72
72 IF(F<.9385)*(F>.9365)
THEN GOTO 138  ELSE GOTO
 73
```

FIGURE 85 (Continued)

```
73 IF(F<.96975)*(F>.9677
5)THEN GOTO 140 ELSE GOT
O 74
74 IF F>.99  GOTO 143 EL
SE GOTO 75
75 CLS
76 PRINT"GOOD FOR 32ths
ONLY"
77 GOTO 158
78  LPRINT POP"'-" INCAL
IN"''"
79 GOTO 152
80  LPRINT POP"'-" INCAL
IN" 1/32''"
81 GOTO 152
82 LPRINT POP"'-" INCALI
N" 1/16''"
83 GOTO 152
84 LPRINT POP"'-" INCALI
N" 3/32''"
85 GOTO 152
86 LPRINT POP"'-" INCALI
N" 1/8''"
87 GOTO 152
88 LPRINT POP"'-" INCALI
N" 5/32''"
89 GOTO 152
90 LPRINT POP"'-" INCALI
N" 3/16''"
91 GOTO 152
92 LPRINT POP"'-" INCALI
N" 7/32''"
93 GOTO 152
94 LPRINT POP"'-" INCALI
N" 1/4''"
95 GOTO 152
96 LPRINT POP"'-" INCALI
N" 9/32''"
97 GOTO 152
98 LPRINT POP"'-" INCALI
N" 5/16''"
99 GOTO 152
100 LPRINT POP"'-" INCAL
IN" 11/32''"
101 GOTO 152
102 LPRINT POP"'-" INCAL
IN" 3/8''"
103 GOTO 152
104 LPRINT POP"'-" INCAL
IN" 13/32''"
105 GOTO 152
106 LPRINT POP"'-" INCAL
IN" 7/16''"
107 GOTO 152
108 LPRINT POP"'-" INCAL
IN" 15/32''"
109 GOTO 152
110 LPRINT POP"'-" INCAL
IN" 1/2''"
111 GOTO 152
112 LPRINT POP"'-" INCAL
IN" 17/32''"
113 GOTO 152
114 LPRINT POP"'-" INCAL
IN" 9/16''"
115 GOTO 152
116 LPRINT POP"'-" INCAL
IN" 19/32''"
117 GOTO 152
```

FIGURE 85 (Continued)

```
118 LPRINT POP"'-" INCAL
IN" 5/8''"
119 GOTO 152
120 LPRINT POP"'-" INCAL
IN" 21/32''"
121 GOTO 152
122 LPRINT POP"'-" INCAL
IN" 11/32''"
123 GOTO 152
124 LPRINT POP"'-" INCAL
IN" 23/32''"
125 GOTO 152
126 LPRINT POP"'-" INCAL
IN" 3/4''"
127 GOTO 152
128 LPRINT POP"'-" INCAL
IN" 25/32''"
129 GOTO 152
130 LPRINT POP"'-" INCAL
IN" 13/16''"
131 GOTO 152
132 LPRINT POP"'-" INCAL
IN" 27/32''"
133 GOTO 152
134 LPRINT POP"'-" INCAL
IN" 7/8''"
135 GOTO 152
136 LPRINT POP"'-" INCAL
IN" 29/32''"
137 GOTO 152
138  LPRINT POP"'-" INCA
LIN" 15/16''"
139 GOTO 152
140 LPRINT POP"'-" INCAL
IN" 31/32''"
141 GOTO 152
142 GOTO 147
143 INCALIN=INCALIN+1
144 IF INCALIN=12 GOTO 1
49
145 LPRINT POP"'-"INCALI
N"''"
146 GOTO 152
147 GOTO 157
148 GOTO 157
149 POP=POP+1
150 LPRINT POP"'-0''"
151 GOTO 152
152 LPRINT"[redacted]
[redacted]"
153 LPRINT""
154 LPRINT""
155 LPRINT""
156 LPRINT""
157 GOTO 158
158 PRINT"ADD NEW STRING
?"
159 PRINT"1=YES"
160 INPUT MORE
161 IF MORE=1 GOTO 1 ELS
E GOTO 162
162 CLS
163 PRINT"     END"
```

FIGURE 85 (Continued)

CHAPTER 10

SUMMARY AND CONCLUSIONS

The programs presented in this Thesis represent a broad portion of the work done on a daily basis by practicing Structural Engineers. This Thesis has by no means exhausted the problems encountered by design professionals, nor are the programs included capable of dealing with unusual or highly complex situations.

This Thesis was written to provide programming for a number of fundamental design and analysis applications for adaptation to micro computers with limited storage capability. The use of the programs as visualized by the writer is for typical structural configurations (i.e. single column footings, rectangular beams, etc.). Programming for unique situations would be lengthy and therefore, would be outside the scope of this paper.

Documentation of a problem and its solution and user-friendliness of the program were the primary criteria in designing program operation. A great deal of storage capacity is sacrificed in the programs in order to provide screen prompts that will make their use easier. Print-outs are easily incorporated into design calculations and contain all information pertinent to the problem considered.

In daily professional practice, the occurrence of problems allowing application of the programs included in this Thesis is inevitable. Their use by the writer has proven to be invaluable.

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LIST OF REFERENCES

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VITA

William Edd Mitchell, Jr., was born in Nashville, Tennessee on April 18, 1953. He attended elementary schools in Nashville and graduated from Hume Fogg Technical and Vocational High School in June 1971. The following September he entered Tennessee State University, and, in August 1974, he received a Bachelor of Science degree in Industrial Technology. In April 1975, he entered The University of Tennessee, Nashville, and began study toward a second Bachelor's degree. He was awarded a Bachelor of Science degree in Engineering in August 1979.

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The author is a Registered Professional Engineer in Tennessee, and he holds memberships in the Prestressed Concrete Institute and the American Society of Civil Engineers. Mr. Mitchell will continue to practice in the consulting field after graduation.