THE ANALYSIS AND DESIGN OF SPREAD FOOTINGS

A

Fortran IV-F

Computer Program

A USER'S MANUAL

Highway Division
Bridge Office

THE ANALYSIS AND DESIGN OF SPREAD FOOTINGS

COMPUTER PROGRAM

FORTRAN IV-F

BY

GLENN H. SIKES

HIGHWAY BRIDGE ENGINEER

A USER'S MANUAL

PRESENTED BY THE

Department of Transportation

BRIDGE OFFICE

R. L. CHAPMAN, JR.

STATE HIGHWAY BRIDGE ENGINEER

ATLANTA, GEORGIA

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FOREWORD

This program represents our first effort in the application of data processing to the analysis and design of spread footing foundations. As such, it probably would be more accurate to describe this work as research or, better still, experimentation. Although the program is in production and giving satisfactory results, there is no procedure or method incorporated in the program whereby the most economical design is always presented in the output. At present the designer is cautioned to scrutinize the design given in the output. An experienced designer can usually determine if an alternate design would be more economical and can then analyze that design using the program.

Actually the program was written as a routine and incorporated into "The Analysis and Design of Multiple Column Piers for Highway Bridges" computer program. That program has the capacity for spread footings but not pile footings. But since the spread footing routine can also be used for one-column piers (the "Pier Analysis" computer program does not have capacity for one column piers), it was written and tested so that it could also be used as a "stand-alone" program.

The program is written in Fortran IV F-level programming language. Running time requirements are insignificant. Core storage requirements are approximately 30^{k} and the only I/O devices required are a card reader and printer. The program was written and tested in 1969.

Glenn H. Sikes
July, 1972
Atlanta, Georgia

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I. METHOD OF SOLUTION

FOOTING SOIL STRESSES

After computing the footing properties, area and moments of inertia, the load cases are read and processed by the program. The processing of each load case involves computing the stresses caused by the load case using "uncracked" theory and, when there are tension stresses, "cracked" theory, i.e., no tension resisted by the soil.

Uncracked Section Analysis

The stresses for an uncracked section are computed by the following formula:

$$f = \frac{P'}{A} \pm \frac{Mx(Y)}{Ix} \pm \frac{My(X)}{Iy} = \text{footing corner stress.}$$

where:

$X = D/2$

$Y = B/2$

$Mx = M_L$ (input value) + V_L (T) = Moment at bottom of footing.

$My = M_T$ (input value) + V_T (T) = Moment at bottom of footing.

P' = P (input value) + weight soil and footing.

$A = B(D)$ = Area of footing.

$Ix = D\,(B)^3/12$ = Moment of inertia about L-L axis.

$Iy = B(D)^3/12$ = Moment of inertia about T-T axis.

Weight of footing = B(D)(T)(.150)

Weight of soil = $\left[B(D) - (Bc)(Dc)\right](Ws)(Hs)$

B, D and T are footing dimensions.

P, M_L, M_T, V_L, and V_T are input values of P-load, moment and shear.

Bc and Dc are input column dimensions.

Ws and Hs are input values of soil weight and height.

Cracked Section Analysis

However, if the footing has a tension stress, the stresses will be computed using cracked theory. This requires that the properties of the cracked section be computed. The position of the neutral axis is assumed from the previous uncracked or cracked analysis and the properties of the section are computed as shown on the following page.

The stresses are then computed using the general flexure formula:

$$f = \frac{P}{A} \pm \left[\frac{M_x' - M_y'\left(\frac{I_{xy}}{I_y}\right)}{I_x - \frac{I_{xy}^2}{I_y}}\right] Y' \pm \left[\frac{M_y' - M_x'\left(\frac{I_{xy}}{I_x}\right)}{I_y - \frac{I_{xy}^2}{I_x}}\right] X'$$

$$M_x' = M_x - P'(\bar{Y})$$

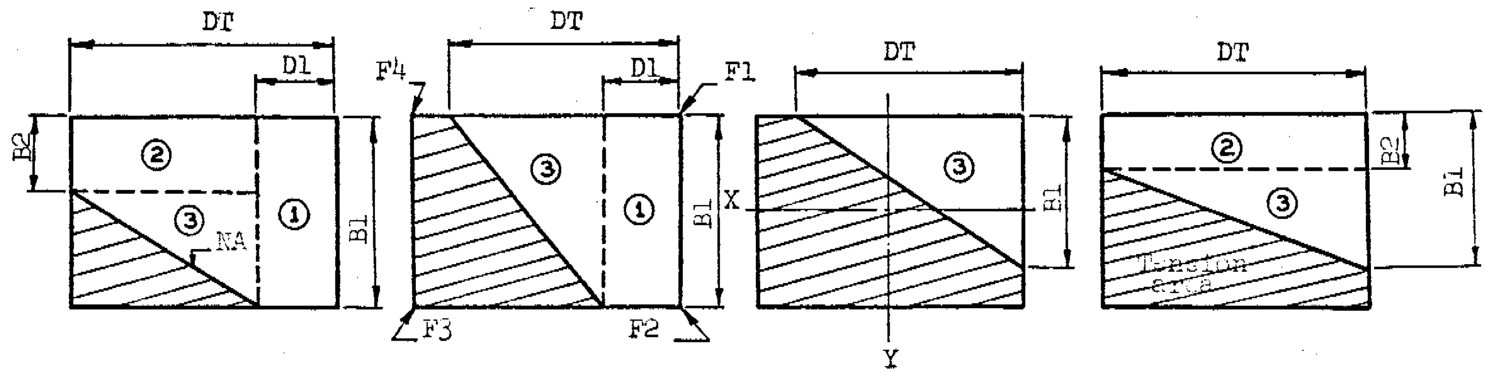
$$M_y' = M_y - P(\bar{X})$$

$$Y' = Y \pm \bar{Y}$$

$$X' = X \pm \bar{X}$$

The process of computing the location of the neutral axis, properties of the cracked section, and stresses is repeated until the stresses computed are the same as the previously computed stresses. Usually four or five iterations are required.

There are four possible locations of the neutral axis (line of zero stress):



D1=	$D\left[\frac{F2}{F2-F3}\right]$	$D\left[\frac{F2}{F2-F3}\right]$	0	0
DT=	D	$D\left[\frac{F1}{F1-F4}\right]$	$D\left[\frac{F1}{F1-F4}\right]$	D
B1=	B	B	$B\left[\frac{F1}{F1-F2}\right]$	$B\left[\frac{F1}{F1-F2}\right]$
B2=	$B\left[\frac{F4}{F4-F3}\right]$	0	0	$B\left[\frac{F4}{F4-F3}\right]$

D2 = DT-D1, D3 = D2, B3 = B1-B2

SECTION(n)	AREA (An)	X_n	Y_n
①	B1(D1)	(D-D1)/2	0
②	B2(D2)	[D-2(D1)-D2]/2	(B-B2)/2
③	B3(D3)/2	D/2-D1-D3/3	B/2-B2-B3/3

$$\bar{X} = \frac{\sum An(Xn)}{A}, \qquad \bar{Y} = \frac{\sum An(Yn)}{A} \qquad A = \sum An$$

$$Ix = \frac{A1(B1)^2+A2(B2)^2}{12} + \frac{A3(B3)^2}{18} + A2(Y2)^2+A3(Y3)^2 + \quad -A(\bar{X})^2$$

$$Iy = \frac{A1(D1)^2+A2(D2)^2}{12} + \frac{A3(D3)^2}{18} + A1(X1)^2+A2(X2)^2+A3(X3)^2 + \quad -A(\bar{Y})^2$$

$$Ixy = A2(X2)(Y2) - \frac{A3(D3)(B3)}{36} + A3(X3)(Y3) - A(\bar{X})(\bar{Y})$$

Design Procedure

If the maximum soil stress exceeds the allowable soil stress in a design problem, the footing width is incremented. The footing is incremented in the direction of the moment which causes the greatest soil stress. However, if the width ratio is exceeded or the increment is zero, the other width is incremented. In the case of a square footing both widths are increased. This continues until no load case will cause soil stresses greater than the allowable.

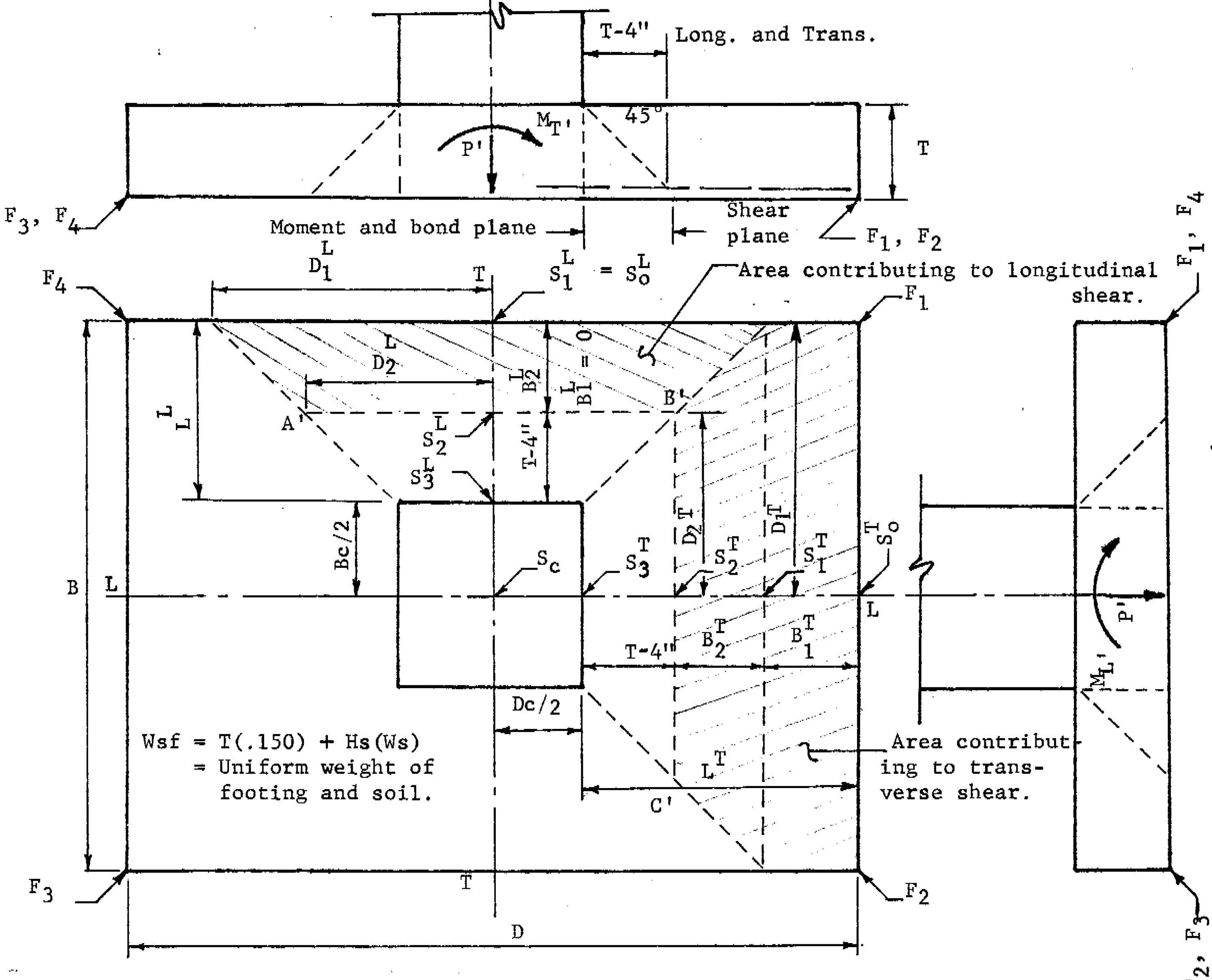
After computing the moment and shear in the footing (these are computed for each load case), the program computes the required area of steel, concrete compression stress, concrete diagonal tension shear stress and perimeter requirements. If the depth is inadequate in a design problem, the footing depth is incremented and the whole procedure repeated (computing P-load and moments at bottom of footing, soil stresses, moment and shear in footing, etc.) until the depth is adequate. The maximum values of soil stress, moment and shear in the footing, uplift, reinforcing steel, etc. are saved and listed in the output along with the footing size.

The moment and shear in the footing are computed as shown on the following page.

Computations for moment and shear in footing:

F_i = Corner soil pressures.

S_i^L and S_i^T = Soil pressures along center line of footing.



Diagonal Tension Shear per Foot:

$$V^T = \frac{\dfrac{\left[2\left[D_2^T(S_2^T) + D_1^T(S_1^T)\right] + D_1^T(S_2^T) + D_2^T(S_1^T)\right]B_2^T}{6} + \dfrac{D_1^T(S_o^T + S_1^T)B_1^T}{2} - \left[\dfrac{(D_1^T + D_2^T)B_2^T}{2} + D_1^T(B_1^T)\right] Wsf}{D_2^T}$$

= average transverse shear per foot on plane B'C'. V^L (longitudinal shear) computed similarly.

Bond Shear per Foot:

$$V_B^T = \left[\frac{(S_o^T + S_3^T)}{2} - Wsf\right] L^T$$ = transverse bond shear. V_B^L computed similarly.

Moment per Foot:

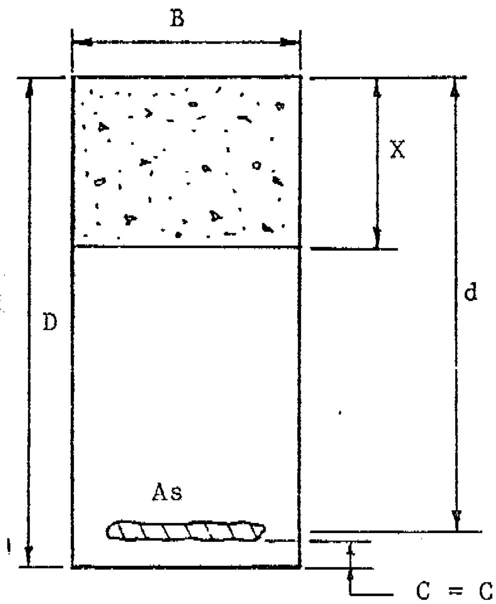
$$M^T = \left[\frac{S_3^T}{2} + \frac{(S_0^T - S_3^T)}{3} - \frac{Wsf}{2}\right](L^T)^2$$ = transverse moment. M^L computed similarly.

Following is the procedure used to solve for reinforcing steel and stresses:

Solve the two following equations simultaneously:
(assume d by assuming the bar size, i.e., D and C are known)

Equation 1 - Balance areas. $\frac{B}{2}(X)^2 = (d-X)(As)n$

Equation 2 - Find required As. $(d-\frac{X}{3})(As)fs = 12(M)$



C = Clearance (varies depending on layer of steel)

Eliminate As and solve for X.

$$\frac{12(M)}{(d-\frac{X}{3})fs} = \frac{\frac{B}{2}(X)^2}{(d-X)n}$$

$$\frac{B}{6}(fs)X^3 - \frac{B}{2}(fs)(d)X^2 - 12(M)(n)X + 12(M)(d)n = 0$$

Divide by $\frac{B}{6}(fs)$

$$X^3 - 3X^2 - \frac{72(M)n}{B(fs)}X + \frac{72(M)(d)n}{B(fs)} = 0$$

n = 10, B = 12 in., fs = 20.0 ksi.

M = kip-feet/foot, d = inches, X = inches

$F(x) = C_1X^3 + C_2X^2 + C_3X + C_4 = 0$; $C_1 = 1$, $C_2 = -3$, $C_3 = -3(M)$, $C_4 = 3(M)d$

Solve the equation F(x) by an iteration process using Newton's method for solving polynomial equations.

$D(x) = D_1X^2 + D_2X + D_3$ = derivative of F(x)

$D_1 = 3C_1$, $D_2 = 2C_2$, $D_3 = C_3$

Then: $X_{n+1} = X_n - \frac{F(Xn)}{D(Xn)}$ The first value of X is assumed to be $\frac{3}{8}$d.

This is solved by iteration until X is accurate to a hundredth of an inch. After X is found:

$$As = \frac{12(M)}{(d-\frac{X}{3})fs}$$

Stresses are computed as follows:

$fc = \frac{12(M)}{B(k)(j)(d)^2(\frac{1}{2})}$ = concrete stress, $k = \frac{X}{d}$, $j = 1 - \frac{k}{3}$

$fv = \frac{Vd}{B(j)(d)}$ = diagonal shear stress. Vd = diagonal tension shear, kips/ft.

$fb = \frac{Vb}{\Sigma o(j)(d)}$ = bond stress, Σo = actual perimeter. Vb = bond shear, kips/ft.

$\Sigma or = \frac{Vb}{fba(j)d}$ = required perimeter, fba = allowable bond stress.

Program Constants and Assumptions

1. Column is assumed to be symmetrically placed on the footing.

2. Concrete footing weighs 150 pounds per cubic foot.

3. Soil cannot resist tension.

4. Soil stresses are computed using moments, reactions at bottom of footing.

5. Weight of soil and footing is considered when computing soil stresses (additive) and moments and shears (substractive, i.e., acts opposite soil stress) in the footing.

6. Moment and shear on footing are computed as average values, i.e., total amount divided by appropriate width.

7. Clearance to footing reinforcement is assumed to be 3 inches.

8. When computing the required area of steel, the bottom row is assumed to be #8 bars (d = 12(T)-3.5 inches) and the row above is assumed to contain #6 bars (d = 12(T)-4.375 inches).

9. The critical planes for moment and shear are according to AASHO Specifications.

10. The reinforcement requirements are not altered if the footing width is greater than the column width plus twice the effective depth of the footing. See AASHO Art. 1.4.6 (F).

11. No compression reinforcement nor negative reinforcement in top of footing is considered by the program.

12. The allowable stresses are as follows:

    fs = 20,000 psi allowable reinforcing stress in tension.

    fc = 1,200 psi allowable concrete stress in compression.

    fv = 90 psi allowable concrete diagonal tension shear stress.

    fb = 350 psi allowable concrete bond stress (#6 bottom bar).

13. The modular ratio (n) is assumed to be ten (10).

14. Footing widths are incremented in the direction of the moment that causes the greatest soil stress.

15. When computing the diagonal tension shear, the critical plane is assumed to be T-4" from column face, i.e., effective depth.

II. PREPARING THE INPUT DATA

The input data for the Spread Footing Design and Analysis computer program is entered on a special input data form. This form is shown on page 12, and should be referred to during the following discussion. The data necessary to analyze or design a spread footing is defined on one or more sheets of the input form. Note that each sheet has provision for no more than one footing. Usually only one sheet is required to enter all the data needed for processing one footing. The form contains numerous headings and information to assist in entering the input data. Note that the input form shows the implied position of the decimal point. However, this position may be changed by inserting a decimal in the desired card column. A negative value is denoted by placing a minus sign immediately preceding the first significant digit of the data field. All input data will be listed as part of the output data. Comparison of the input form with the listed input data is recommended. Following is a discussion of the input data requirements.

A. IDENTIFICATION (* in c.c. 1).

The Identification consists of one line of input data per problem, i.e., additional lines are not allowed. The data in card columns 1 - 4 (*B08) is for program identification purposes and is of no significance to the engineer. Card columns 5-8 should be left blank since a unique Problem Number will be assigned to the problem from the log book of computer runs. The remaining portion of the line (c.c. 9-80) is used to enter the project number, county, date, name and any other pertinent remarks for identification purposes. The Identification must be the first line (card) of input data for each problem (one footing analysis or design). All the information given in the Identification will head the output listing.

B. FOOTING DATA (1 in c.c. 1)

The Footing Data consists of one line of input and is identified by the digit "1" in card column one.

1. NLC (c.c. 2,3) — Form: xx

Enter as NLC the number of load cases that are going to be defined in the input. At least one load case is required and the maximum is ninety-nine.

2. D (c.c. 4-7) — Form: xx.xx feet

This dimension is the width of the footing in an analysis problem (i.e., footing size remains constant) or the minimum footing width in a design problem (i.e., footing size can vary). It is the width that is parallel to the L-L or X-X axis.

3. B (c.c. 8-11) Form: xx.xx feet

Enter as "B" the width of the footing parallel to the T-T or Y-Y axis. This width is the actual width in an analysis problem and the minimum width is a design problem.

NOTE: When entering minimum widths (B and D) in a design problem, use reasonable widths, i.e., greater than column size.

4. T (c.c. 12-15) Form: xx.xx feet.

The actual or minimum thickness of the footing should be entered in this data field depending on the problem type, analysis or design.

5. ΔD (c.c. 16-20) Form: xx.xxx feet.

This dimension is the increment by which the footing width (D) is increased in a design problem. If the "D" width is not to be increased in a design problem, enter a value of zero or leave blank. If the problem is an analysis, enter zero or leave blank.

6. ΔB (c.c. 21-25) Form: xx.xxx feet.

This dimension is the increment by which the program increases "B" width in a design problem. If the "B" width is not to be increased in a design problem, enter a value of zero or leave this data field blank. A value of zero (or blank) is used if the problem is an analysis.

NOTE: If a square footing is desired in a design problem, ΔB must be given equal to ΔD and B must equal D.

7. ΔT (c.c. 26-30) Form: xx.xxx feet.

Enter in this data field the increment by which the program is to increase the footing thickness in a design problem. If this dimension is left blank or given a value of zero, the footing thickness will not change from the input value (T).

8. Dc (c.c. 31-35) Form: xx.xxx feet.

This dimension is the width of the column or wall parallel to the footing dimension "D".

9. Bc (c.c. 36-40)

"Bc" is the width of the column or wall parallel to the footing dimension "B".

NOTE: If the column is round, the dimensions (Bc and Dc) should be for an equivalent square column with the same area as the round column.

10. R^{B}/D (c.c. 41-44) Form: x.xxx ratio.

Enter in this data field the maximum allowable ratio of the footing width "B" to the footing width "D" for a design problem.

$B/D \leq R^{B}/_{D}$ is a design restraint in a design problem.

If a square footing (B = D) is desired in a design problem, enter a value of one (1.000) in this data field. In an analysis problem always give a value of one (1.000), i.e., actual value not required but zero unacceptable.

11. R^{D}/B (c.c. 45-48) Form: x.xxx ratio.

The maximum allowable ratio of the footing width "D" to the footing width "B" in a design problem should be entered in this data field.

$D/B \leq R^{D}/_{B}$ is a design restraint in a design problem.

If a square footing (B = D) is desired in a design problem, enter a value of one (1.000) in this data field. In an analysis problem always give a value of one (1.000), i.e., actual value not required but zero unacceptable.

NOTE: The purpose of the $R^{B}/_{D}$ and $R^{D}/_{B}$ ratios is to eliminate the possibility of obtaining a strip footing (2 x 20, for example) in a design problem.

C. LOAD CASES (2 in c.c. 1)

The Load Cases consist of a number of load combinations applied to the footing. Each Load Case will consist of a concentrated load, two moments about the axes of the footing and two shears at the top of the footing. Any number of Load Cases (1-99) may be defined. However, the input form only has capacity for nineteen Load Cases. Additional input sheets can be used to enter the remaining Load Cases, i.e., those over nineteen. Note that the Identification and Footing Data should not be defined on the additional sheets, i.e., this data has already been defined on the first sheet.

One Load Case is entered per line of the input form. The digit two (2) in card column one is for Load Case identification. The program does not have capacity for allowing overstress for the various group combinations specified by the AASHO Specifications. Therefore, the magnitudes of the Load Cases for groups with allowable overstress should be reduced appropriately. The designer should be aware that the Load Cases are the footing design loads, and that each case should contain the appropriate combination of dead load, live load, wind, etc. Note that if group loading combinations of moments, etc., are reduced, the results will not be exactly correct because the weight of the footing and soil is involved; close, but not exact. Another procedure would be to make a problem for each group (one for group I loads, one for group III loads, etc.) and then the soil weight can be modified. Then the largest footing from the runs can be analyzed in each run, etc.

1. ID (c.c. 2-5) Form: xxxx

Enter the Load Case number or symbol in this data field. This data is given in the output for each design feature (maximum moment, shear, etc.). Therefore, the designer will know the controlling Load Cases for all design features. Numeric or alphabetic characters are acceptable.

2. P (c.c. 6-12) Form: xxxx.xxx kips.

Enter the Load Case reaction in this data field, i.e., P-load. This load is assumed to act at the centroid of the footing. The weight of the footing and soil should not be included in this load, i.e., the program does that. The upward force of any buoyancy should be included in this load.

3. M_L (c.c. 13-19) Form: xxxx.xxx kip-feet.

The moment about the L-L axis (or X axis) is entered in this data field. This moment is assumed to be at the top of the footing.

4. M_T (c.c. 20-26) Form: xxxx.xxx kip-feet.

The moment about the T-T axis (or Y axis) is entered in this data field. This moment is assumed to be at the top of the footing.

5. V_L (c.c. 27-32) Form: xxx.xxx kips.

This data field is for entering the shear at the top of the footing acting perpendicular to the L-L axis (or X axis).

6. V_T (c.c. 33-38) Form: xxx.xxx kips.

Enter the shear at the top of the footing acting perpendicular to the T-T axis (or Y axis) in this data field.

NOTE: Moment and Shear Sign Convention.
The signs of the moment and shear should be such that the following is always true:

$$M_L + V_L(T) \geq 0$$

$$M_T + V_T(T) \geq 0$$

If either is not true reverse the sign of the moment and shear. In essence, the moments at the bottom of the footing must be zero or positive for the program to function properly. Reversing any signs in no way affects the validity of the solution since the footing is symmetrical.

SPREAD FOOTING DESIGN/ANALYSIS

IDENTIFICATION

PROG.	PROB. NO.	PROJECT NUMBER, COUNTY, DATE, NAME, REMARKS
*B11		

NLC = NUMBER OF LOAD CASES

FOOTING DATA

NLC	D	B	T	ΔD	ΔB	ΔT	Dc	Bc	RB/D	RD/B	S.B.C.	Hs	Ws
1													

LOAD CASES

	ID.	P	ML	MT	VL	VT
2						
2						
2						
2						
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2						
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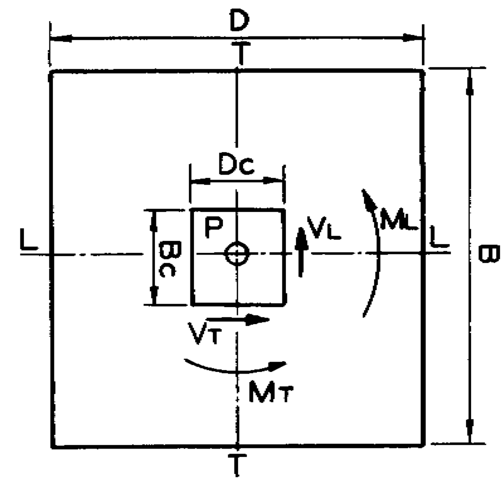
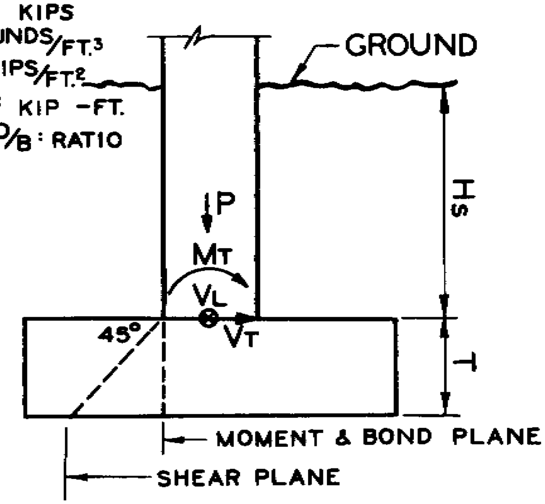


DIMENSIONS: FEET
P, VL, VT: KIPS
Ws: POUNDS/FT.^{3}
S.B.C.: KIPS/FT.^{2}
ML, MT: KIP-FT.
RB/D, RD/B: RATIO



III. OUTPUT DATA

The output data contains a listing of the input data. It is suggested that this listing be compared with the input form to check for any errors in key-punching, etc. The computed output data consists of the Footing Design Loads and Footing Design Data.

A. FOOTING DESIGN LOADS.

The Footing Design Loads contain eight critical load conditions as follows:

1. MAX. CORNER PRESSURE

   This load condition gives the maximum corner soil stress (all load cases entered in the input data are considered). The maximum value is given in the "F1" column.

2. MAX. FT. MOMENT - LONG.

   This load condition gives the maximum moment in the footing about the Dc column face. The maximum longitudinal footing moment is given in the "MT./FT." column and is the maximum from considering all load cases.

3. MAX. D. T. SHEAR - LONG.

   This load condition gives the maximum diagonal tension shear in the footing on a plane at a distance (T-4") from the Dc column face. The maximum footing shear value is given in the "V/FT." column and is computed by considering all load cases.

4. MAX. BOND SHEAR - LONG.

   This load condition gives the maximum shear in the footing about the Dc column face. The maximum shear is given in the "VB/FT." column and is the maximum from considering all load cases.

5. MAX. FT. MOMENT - TRAN.

   The maximum footing moment about the Bc column face from considering all load cases is given in the"MT./FT." column of this load condition.

6. MAX. D. T. SHEAR - TRAN.

   The maximum footing diagonal tension shear on a plane at a distance (T-4") from the Bc column face, considering all load cases, is given in the "V/FT." column of this load condition.

7. MAX. BOND SHEAR - TRAN.

   The maximum footing shear at the Bc column face, considering all load cases, is given in the "VB/FT." column of this load condition.

8. MAX. UPLIFT PRESSURE

This load condition gives the maximum corner uplift (tension) soil stress in the footing. Actually this is on ambiguous stress since the soil is assumed to be unable to resist tension. It is computed by extending the soil pressure plane to intersect footing corner 3. The purpose of this stress is to assist the designer in determining whether negative reinforcement in the top of the footing is required. This maximum uplift stress is given in the "F3" column. If the value is positive, there is no uplift, i.e., soil is in compression.

The following data is given for each load condition:

1. ID.

This column contains the identity of the load case that produced the critical value for the load condition.

2. F1, F2, F3, F4 Units: kips/sq. ft.

These columns contain the four corner soil stresses and include the weight of the footing and overburden.

Corner Soil Stress	M_T	M_L	
F1	C	C	Gives maximum soil stress.
F2	C	T	
F3	T	T	Gives minimum soil stress.
F4	T	C	

The above chart shows the type of stress (tension or compression) caused at the footing corners by the applied moments: M_T, M_L.

3. MT./FT. Units: kip-ft./ft.

This column contains the average moment in the footing (total moment divided by total width) at the column face for the load conditions.

4. V/FT. Units: kips/ft.

This column contains the average diagonal tension shear at a distance (T-4") from the column face for the load conditions.

5. V_B/FT. Units: kips/ft.

This column contains the average bond shear in the footing (total shear divided by total width) at the column face for the load conditions.

NOTE: The moment and shear in the footing are computed considering the weight of the overburden and footing, i.e., acts opposite soil stress.

B. FOOTING DESIGN DATA

Footing Size

The dimensions of the footing are given in feet. If the problem is an analysis, the dimensions are the input values. In a design problem, the size given is the size found by the program that prevents the allowable soil stress from being exceeded.

The following data is given for the transverse and longitudinal directions of the footing. Transverse stresses are caused by transverse moments and the reinforcing steel bars would be placed perpendicular to the transverse (T-T) axis. Similarly, the longitudinal stresses are caused by longitudinal moments and the reinforcing steel bars would be placed perpendicular to the longitudinal (L-L) axis.

1. AS — Units: sq. in/ft.

   "AS" is the area of steel required per foot for a maximum steel stress of 20.0 ksi.

2. JD — Units: inches.

   This dimension is the distance from the resultant compressive concrete force to the reinforcing steel tension force.

3. FS — Units: ksi.

   This value for the reinforcing steel stress should always be 20.0 ksi.

4. Fc — Units: ksi.

   This value is the maximum concrete stress; and, in a design problem this stress should not be greater than 1.200 ksi.

5. SO — Units: in./ft.

   This value is the perimeter required to prevent the bond stress from being exceeded.

6. VC — Units: ksi.

   This value is the maximum diagonal tension shear stress. In a design problem, this value should not be greater than 0.090 ksi.

IV. EXAMPLE PROBLEMS

Example Problem One:

Example problem one is test problem number 2 and is assigned a problem number of "T2". The problem consists of analyzing a 6'-0" square by 2'-6" thick footing with a 4'-0" square column for the following given load cases. No soil overburden is present.

Load Case	P	ML	MT	VL	VT
1	360.0	0.0	0.0	0.0	0.0
2	360.0	360.0	0.0	16.0	0.0
3	360.0	0.0	360.0	0.0	16.0
4	360.0	360.0	360.0	16.0	16.0

The input is shown on page 17 and the output is shown on page 18.

Example Problem Two:

Example problem two is test problem number 5 and is assigned a problem number of "54". The problem consists of designing a footing for an allowable soil pressure of 5 tons per square foot. Use a minimum footing size of 8'-0" x 6'-0" x 1'-0" and the column size is 3'-0" x 3'-0". The footing widths are to be incremented by 6 inches and the thickness by 3 inches. Also restrict each footing width to a maximum of 1.5 times the other width. No soil overburden is present. Following are the design loads:

Load Case	P	ML	MT	VL	VT
1	480.0	0.0	0.0	0.0	0.0
2	480.0	0.0	500.0	0.0	0.0
3	480.0	500.0	0.0	0.0	0.0
4	480.0	500.0	500.0	0.0	0.0

The input data is shown on page 19 and the output is shown on page 20.

SPREAD FOOTING DESIGN/ANALYSIS

IDENTIFICATION

	PROG.	PROB. NO.	PROJECT NUMBER, COUNTY, DATE, NAME, REMARKS
*	B 11	T2	TEST PROBLEM NO. 2

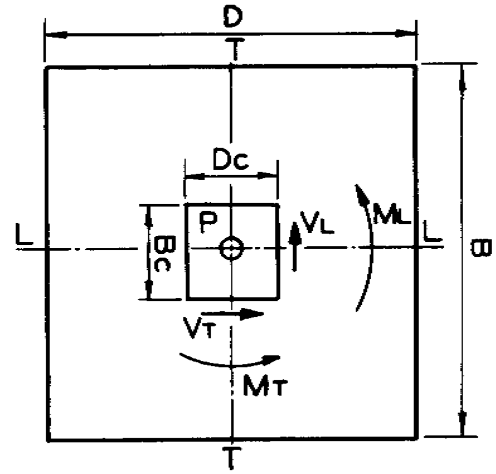
NLC = NUMBER OF LOAD CASES

FOOTING DATA

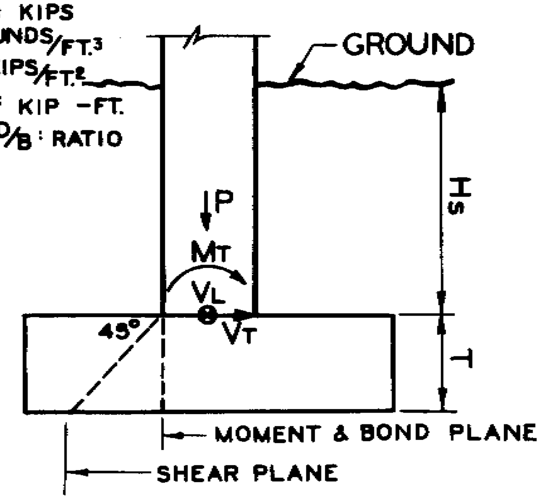
	NLC	D	B	T	ΔD	ΔB	ΔT	Dc	Bc	$R^B/_D$	$R^D/_B$	S.B.C.	Hs	Ws
1	4	6.00	6.00	2.50	.	.	.	4.000	4.000	.	.	.	.	

LOAD CASES

	ID.	P	ML	MT	VL	VT
2	1	360.000	0.0	0.0	0.0	0.0
2	2	360.000	360.000	0.0	16.000	0.0
2	3	360.000	0.0	360.000	0.0	16.000
2	4	360.000	360.000	360.000	16.000	16.000
2		.	.	.	.	.
2		.	.	.	.	.
2		.	.	.	.	.
2		.	.	.	.	.
2		.	.	.	.	.
2		.	.	.	.	.
2		.	.	.	.	.
2		.	.	.	.	.
2		.	.	.	.	.
2		.	.	.	.	.
2		.	.	.	.	.
2		.	.	.	.	.
2		.	.	.	.	.
2		.	.	.	.	.



DIMENSIONS: FEET
P, VL, VT : KIPS
Ws: POUNDS/FT.³
S.B.C.: KIPS/FT.²
ML, MT: KIP -FT.
$R^B/_D$, $R^D/_B$: RATIO



GEORGIA DEPARTMENT OF TRANSPORTATION

HIGHWAY DIVISION - BRIDGE DESIGN OFFICE

01AUG.72 THE ANALYSIS OR DESIGN OF SPREAD FOOTINGS PROB. NO. T2

TEST PROBLEM NO. 2

FOOTING DATA

NLC	D	B	T	DD	DB	DT	DC	BC	R B/D	R D/B	SBC	HS	WS
4	6.00	6.00	2.50	0.0	0.0	0.0	4.000	4.000	0.0	0.0	0.0	0.0	0.0

LOAD CASES

ID.	P	ML	MT	VL	VT
1	360.000	0.0	0.0	0.0	0.0
2	360.000	360.000	0.0	16.000	0.0
3	360.000	0.0	360.000	0.0	16.000
4	360.000	360.000	360.000	16.000	16.000

-18-

FOOTING DESIGN LOADS

LOAD CONDITION	ID.	F4	F3	F2	F1	MT./FT.	V/FT.	VB/FT.
MAX. CORNER PRESSURE	4	8.858	-19.343	8.858	37.060	10.509	0.0	20.234
MAX. FT. MOMENT-LONG.	4	8.858	-19.343	8.858	37.060	10.509	0.0	20.234
MAX. D.T. SHEAR-LONG.	1	10.375	10.375	10.375	10.375	5.000	0.0	10.000
MAX. BOND SHEAR-LONG.	4	8.858	-19.343	8.858	37.060	10.509	0.0	20.234
MAX. FT. MOMENT-TRAN.	4	8.858	-19.343	8.858	37.060	10.509	0.0	20.234
MAX. D.T. SHEAR-TRAN.	1	10.375	10.375	10.375	10.375	5.000	0.0	10.000
MAX. BOND SHEAR-TRAN.	4	8.858	-19.343	8.858	37.060	10.509	0.0	20.234
MAX. UPLIFT PRESSURE	4	8.858	-19.343	8.858	37.060	10.509	0.0	20.234

FOOTING DESIGN DATA

FOOTING SIZE			*	TRANSVERSE						*	LONGITUDINAL					
D	B	T	*	AS	JD	FS	FC	SO	VC	*	AS	JD	FS	FC	SO	VC
6.000	6.000	2.500		0.25	25.464	20.000	0.266	2.27	0.0		0.26	24.591	20.000	0.275	2.35	0.0

SPREAD FOOTING DESIGN/ANALYSIS

IDENTIFICATION

	PROG.	PROB. NO.	PROJECT NUMBER, COUNTY, DATE, NAME, REMARKS
*	B11	54	TEST PROBLEM NO. 5

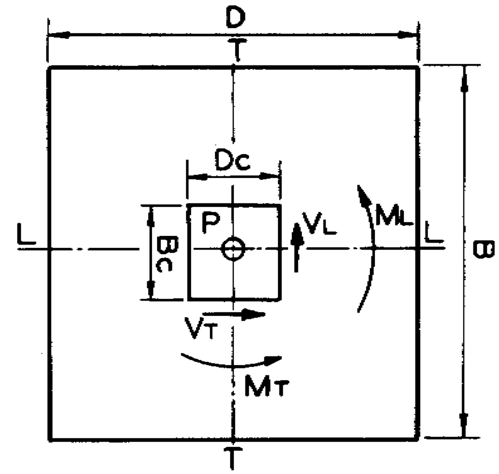
NLC = NUMBER OF LOAD CASES

FOOTING DATA

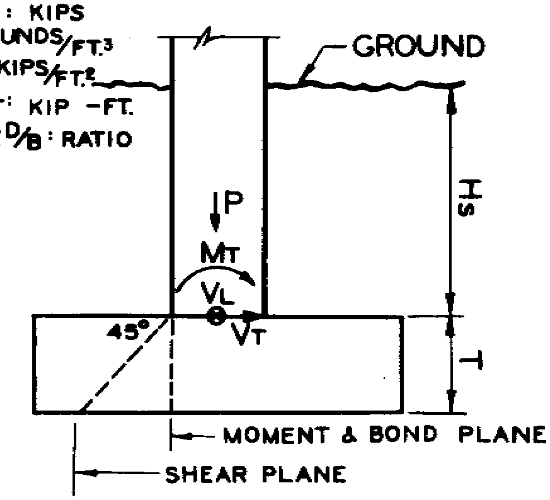
	NLC	D	B	T	ΔD	ΔB	ΔT	Dc	Bc	RB/D	RD/B	S.B.C.	Hs	Ws
1	4	8.00	6.00	1.00	0.500	0.500	0.250	3.000	3.000	1.500	1.500	10.000	0.0	0

LOAD CASES

	ID.	P	ML	MT	VL	VT
2	1	480.000	0.0	0.0	0.0	0.0
2	2	480.000	0.0	500.000	0.0	0.0
2	3	480.000	500.000	0.0	0.0	0.0
2	4	480.000	500.000	500.000	0.0	0.0
2						
2						
2						
2						
2						
2						
2						
2						
2						
2						
2						
2						
2						
2						
2						



DIMENSIONS: FEET
P, VL, VT : KIPS
Ws: POUNDS/FT.³
S.B.C.: KIPS/FT.²
ML, MT: KIP-FT.
RB/D, RD/B: RATIO



STATE HIGHWAY DEPARTMENT OF GEORGIA
BRIDGE DIVISION

GEORGIA DEPARTMENT OF TRANSPORTATION

HIGHWAY DIVISION - BRIDGE DESIGN OFFICE

01AUG.72 THE ANALYSIS OR DESIGN OF SPREAD FOOTINGS PROB. NO. 54

TEST PROBLEM NO. 5

FOOTING DATA

NLC	D	B	T	DD	DB	DT	DC	BC	R B/D	R D/B	SBC	HS	WS
4	8.00	6.00	1.00	0.500	0.500	0.250	3.000	3.000	1.500	1.500	10.000	0.0	0.0

LOAD CASES

ID.	P	ML	MT	VL	VT
1	480.000	0.0	0.0	0.0	0.0
2	480.000	0.0	500.000	0.0	0.0
3	480.000	500.000	0.0	0.0	0.0
4	480.000	500.000	500.000	0.0	0.0

FOOTING DESIGN LOADS

LOAD CONDITION	ID.	F4	F3	F2	F1	MT./FT.	V/FT.	VB/FT.
MAX. CORNER PRESSURE	4	4.948	-0.511	4.452	9.912	39.540	12.626	21.480
MAX. FT. MOMENT-LONG.	4	4.948	-0.511	4.452	9.912	39.540	12.626	21.480
MAX. D.T. SHEAR-LONG.	4	4.948	-0.511	4.452	9.912	39.540	12.626	21.480
MAX. BOND SHEAR-LONG.	4	4.948	-0.511	4.452	9.912	39.540	12.626	21.480
MAX. FT. MOMENT-TRAN.	4	4.948	-0.511	4.452	9.912	49.943	16.729	23.768
MAX. D.T. SHEAR-TRAN.	4	4.948	-0.511	4.452	9.912	49.943	16.729	23.768
MAX. BOND SHEAR-TRAN.	4	4.948	-0.511	4.452	9.912	49.943	16.729	23.768
MAX. UPLIFT PRESSURE	4	4.948	-0.511	4.452	9.912	39.540	12.626	21.480

FOOTING DESIGN DATA

FOOTING SIZE			*	TRANSVERSE						*	LONGITUDINAL					
D	B	T	*	AS	JD	FS	FC	SO	VC	*	AS	JD	FS	FC	SO	VC
11.000	10.000	2.250		1.40	21.390	20.000	0.738	3.17	0.065		1.14	20.730	20.000	0.671	2.96	0.051

V. ERROR MESSAGES

If the program finds an error in the input data, the following message is listed:

ERROR I PROB. NO. xxxx

Where I is the error number listed below and xxxx is the problem number given in the Identification card.

Error Number (I)	Cause of Error
1	First card of problem does not contain *B11 in card columns 1-4.
2	Second Card of problem does not contain the digit one in c.c. 1.
3	D, B, Dc or Bc equals zero.
4	Load case card does not contain the digit 2 in c.c. 1.
5	Program is in design loop. Review input data, especially the width ratio restrictions.
6	Resultant P-load is off the footing. Soil stresses cannot be computed. Increase size of footing if problem is a design.

VI. OPERATING PROCEDURE

The Spread Footing Design/Analysis computer program is written in Fortran IV, F level, programming language, and consists of approximately four hundred twenty-four program statements. This language was used primarily to obtain computer independency. In addition, the program is independent of any operating system. However, the program was compiled and tested, and is currently being run under IBM's Disk Operating System (DOS). The program has also been tested under IBM's OS.

No instructions will be given on the procedure used to compile the program since this would depend on the operating system. In any event, anyone familiar with data processing should be able to compile the program.

KEY-PUNCH INSTRUCTIONS

The input data will consist of one or more input sheets per problem with each line of the input data sheets representing a card. The numbers of the card columns are given in the headings of the various types of input lines for reference during and after punching. Note that the position of the decimal that is shown on the input form does not occupy a card column and should not be punched. However, on occasions a decimal will be entered in a card column and, in this instance, the decimal should be punched.

All blank data fields or card columns may be punched as zeros except in the alphabetic fields. These data fields are read as alphabetic characters and, therefore, a blank or zero would have a significant meaning. In general, the input data should be punched exactly as given on input data forms.

Only the lines that contain data entered by hand (data that is not a part of the green ink of the input data form) should be punched. The input data should be punched in the same sequence as given on the input data forms. That is, the key-punch operator should punch the input data in the same sequence that it is received. Any exception to this will be clearly noted on the input forms by the Engineer.

COMPUTER OPERATOR INSTRUCTIONS

No instructions on the manual operation of the computer will be given here. The computer operator is assumed to be fully versed on the computer operation. Primarily, this discussion will present the characteristics of the program which the computer operator is required to know in order to process the program.

The input data (cards) should be received from the key-punch section in the correct sequence, i.e., there should be no reason to rearrange the sequence of the input data cards. All input data to the program is from punched cards, and all output from the program is listed by the printer. No other I/O devices are used. The program has the ability to process one or several problems requiring only one EXECute Control Card with the first problem, i.e., the program automatically continues from one problem to another. The output form is automatically advanced by the program before printing the output data of each problem. The output data will consist of one or more sheets per problem. The running time required per problem will vary depending on the amount and type of input data with the average problem requiring approximately one-half minute. The input data cards should be entered in the card reader device in the following order (example shown for DOS):

1. / / JOB SPRDFOOT (Job Control Card)
2. / / EXEC SPRDFOOT (Execute Control Card)
3. Input data for all problems (input data cards)
4. /* (End of Data Control Card)
5. /& (End of Job Control Card)

After completing the processing of all problems, separate the output data of the various problems and return the output data along with the input data forms to the Engineer. The first lines of output of each problem will contain:

```
                GEORGIA DEPARTMENT OF TRANSPORTATION
              HIGHWAY DIVISION - BRIDGE DESIGN OFFICE
              THE ANALYSIS OR DESIGN OF SPREAD FOOTINGS     PROB. NO. XXXX
```

where XXXX is the Problem Number which is given in card columns 5-8 of the Identification card (first sheet of each problem). This will be of assistance when separating the output data of the various problems.

The program has a procedure for checking the validity of the input data, and will print an error message after detecting an error in the input data. The error message will be given in the list of the output data of the problem in error. After an error the rest of that problem's input data cards are read out and the program proceeds to the next problem. Actually, the only way the computer operator will know that an error has been detected is to observe the output data.

The procedure after an error message is to first, check the input data cards of the problem in error for key-punch errors, and second, check the sequence of the input data cards. If the input data cards are found to be punched correctly and in the proper sequence, return the output data with the error message and input data forms to the Engineer; if not, make the appropriate correction and rerun the problem from the beginning.

SPREAD FOOTING DESIGN/ANALYSIS

IDENTIFICATION

	PROG.	PROB. NO.	PROJECT NUMBER, COUNTY, DATE, NAME, REMARKS
*	B08	T1	TEST PROBLEM NO. 1

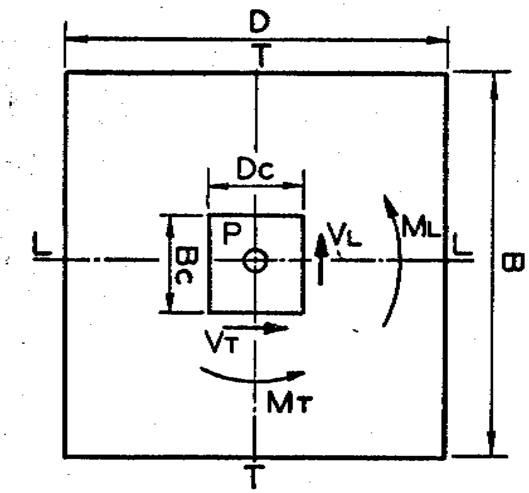
N_{LC} = NUMBER OF LOAD CASES

FOOTING DATA

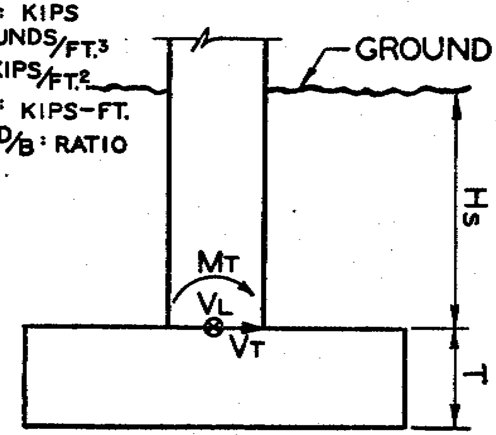
	N_{LC}	D	B	T	ΔD	ΔB	ΔT	Dc	Bc	$R^B/_D$	$R^D/_B$	S.B.C.	Hs	Ws
1	1	10.0	10.0	2.00	0.0	0.0	0.0	4.00	4.00	1.00	1.00	10.0	7.00	100

LOAD CASES

	ID.	P	M_L	M_T	V_L	V_T
2	1	50.0	0.0	0.0	0.0	0.0
2						
2						
2						
2						
2						
2						
2						
2						
2						
2						
2						
2						
2						
2						
2						
2						
2						



DIMENSIONS: FEET
P, V_L, V_T: KIPS
Ws: POUNDS/FT.^{3}
S.B.C.: KIPS/FT.^{2}
M_L, M_T: KIPS-FT.
$R^B/_D$, $R^D/_B$: RATIO



STATE HIGHWAY DEPARTMENT OF GEORGIA
BRIDGE DIVISION

SPREAD FOOTING DESIGN/ANALYSIS

IDENTIFICATION

PROG	PROB NO.	PROJECT NUMBER, COUNTY, DATE, NAME, REMARKS
* B08	T2	TEST PROBLEM NO. 2

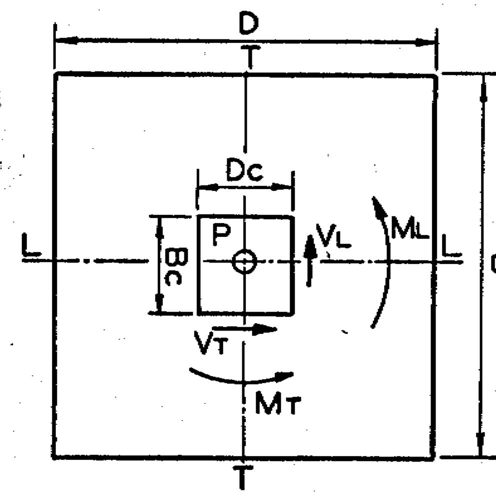
N_{LC} = NUMBER OF LOAD CASES

FOOTING DATA

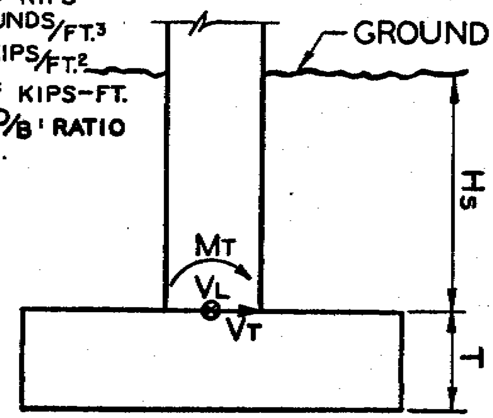
	N_{LC}	D	B	T	ΔD	ΔB	ΔT	Dc	Bc	$R^B/_D$	$R^D/_B$	S.B.C.	Hs	Ws
1	4	6.00	6.00	2.50	0.00	0.00	0.00	4.00	4.00	0.00	0.00	.	.	.

LOAD CASES

	ID.	P	M_L	M_T	V_L	V_T
2	1	360.00	.	.	.	.
2	2	360.00	360.00	.	16.00	.
2	3	360.00	.	360.00	.	16.00
2	4	360.00	360.00	360.00	16.00	16.00
2		.	.	.	.	.
2		.	.	.	.	.
2		.	.	.	.	.
2		.	.	.	.	.
2		.	.	.	.	.
2		.	.	.	.	.
2		.	.	.	.	.
2		.	.	.	.	.
2		.	.	.	.	.
2		.	.	.	.	.
2		.	.	.	.	.
2		.	.	.	.	.
2		.	.	.	.	.
2		.	.	.	.	.



DIMENSIONS: FEET
P, V_L, V_T: KIPS
Ws: POUNDS/FT.³
S.B.C.: KIPS/FT.²
M_L, M_T: KIPS-FT.
$R^B/_D$, $R^D/_B$: RATIO



SPREAD FOOTING DESIGN/ANALYSIS

IDENTIFICATION

	PROG.	PROB. NO.	PROJECT NUMBER, COUNTY, DATE, NAME, REMARKS
*	B08	T3	TEST PROBLEM NO. 3

N_{LC} = NUMBER OF LOAD CASES

FOOTING DATA

	N_{LC}	D	B	T	ΔD	ΔB	ΔT	Dc	Bc	$R^B/_D$	$R^D/_B$	S.B.C.	Hs	Ws
1	4	6.00	8.00	1.00	0.500	0.0	.250	3.0	3.0	1.50	5.0	10.0	.	.

LOAD CASES

	ID.	P	M_L	M_T	V_L	V_T
2	1	480.0	.	.	.	.
2	2	480.0	50.0	.	.	.
2	3	480.0	.	50.0	.	.
2	4	480.0	50.0	50.0	.	.
2		.	.	.	.	.
2		.	.	.	.	.
2		.	.	.	.	.
2		.	.	.	.	.
2		.	.	.	.	.
2		.	.	.	.	.
2		.	.	.	.	.
2		.	.	.	.	.
2		.	.	.	.	.
2		.	.	.	.	.
2		.	.	.	.	.
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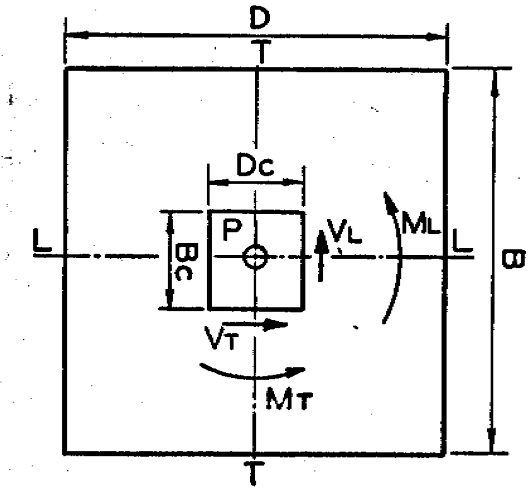
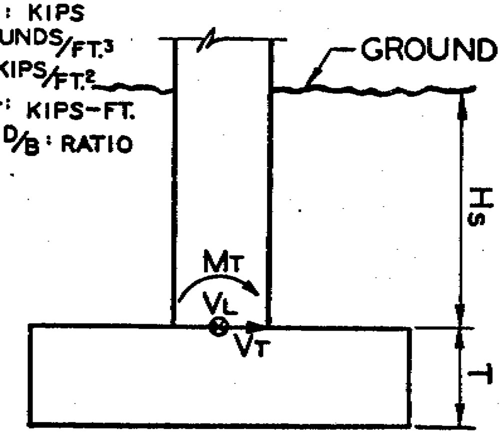
2		.	.	.	.	.
2		.	.	.	.	.
2		.	.	.	.	.



DIMENSIONS: FEET
P, V_L, V_T: KIPS
Ws: POUNDS/FT.³
S.B.C.: KIPS/FT.²
M_L, M_T: KIPS-FT.
$R^B/_D$, $R^D/_B$: RATIO



SPREAD FOOTING DESIGN/ANALYSIS

IDENTIFICATION

PROG.	PROB. NO.	PROJECT NUMBER, COUNTY, DATE, NAME, REMARKS
*B08	T4	TEST PROBLEM NO. 4

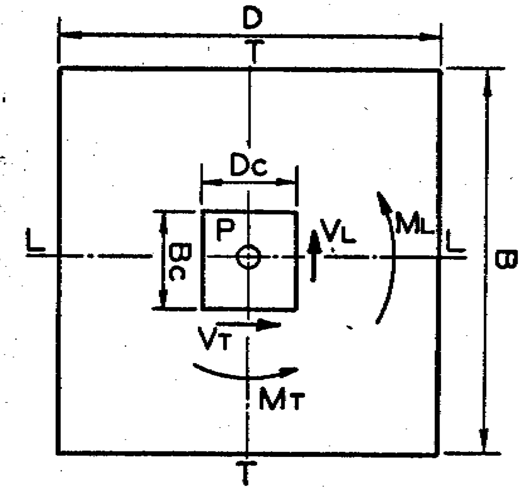
N_{LC} = NUMBER OF LOAD CASES

FOOTING DATA

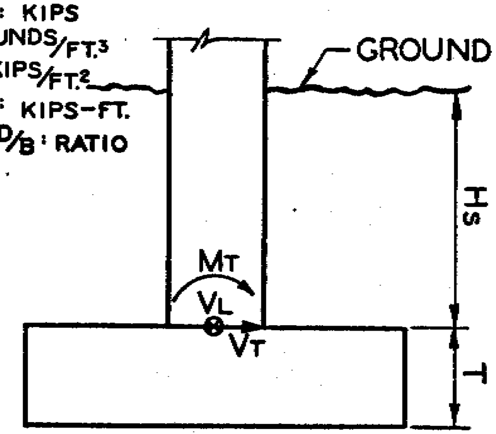
	N_{LC}	D	B	T	ΔD	ΔB	ΔT	Dc	Bc	$R^B/_D$	$R^D/_B$	S.B.C.	Hs	Ws
1	4	8.00	6.00	1.00	0.000	0.500	.250	3.000	3.000	5.000	1.500	10.000	.	

LOAD CASES

	ID.	P	ML	MT	VL	VT
2	1	480.00	.	.	.	.
2	2	480.00	.	50.00	.	.
2	3	480.00	50.00	.	.	.
2	4	480.00	50.00	50.00	.	.
2		.	.	.	.	.
2		.	.	.	.	.
2		.	.	.	.	.
2		.	.	.	.	.
2		.	.	.	.	.
2		.	.	.	.	.
2		.	.	.	.	.
2		.	.	.	.	.
2		.	.	.	.	.
2		.	.	.	.	.
2		.	.	.	.	.
2		.	.	.	.	.
2		.	.	.	.	.
2		.	.	.	.	.



DIMENSIONS: FEET
P, VL, VT: KIPS
Ws: POUNDS/FT.³
S.B.C.: KIPS/FT.²
ML, MT: KIPS-FT.
$R^B/_D$, $R^D/_B$: RATIO



JANUARY 21, 1970

SPREAD FOOTING DESIGN/ANALYSIS

STATE HIGHWAY DEPARTMENT OF GEORGIA
BRIDGE DIVISION

IDENTIFICATION

	PROG.	PROB NO.	PROJECT NUMBER, COUNTY, DATE, NAME, REMARKS
*	B08	T5	TEST PROBLEM NO. 5

NLC = NUMBER OF LOAD CASES

FOOTING DATA

	NLC	D	B	T	ΔD	ΔB	ΔT	Dc	Bc	RB/D	RD/B	S.B.C.	Hs	Ws
1	4	8.00	6.00	1.00	.0500	.500	.250	3.00	3.00	1.50	1.50	1.00	.	

LOAD CASES

	ID.	P	ML	MT	VL	VT
2	1	480.0	.	.	.	.
2	2	.	.	50.0	.	.
2	3	.	50.0	.	.	.
2	4	.	50.0	50.0	.	.
2		.	.	.	.	.
2		.	.	.	.	.
2		.	.	.	.	.
2		.	.	.	.	.
2		.	.	.	.	.
2		.	.	.	.	.
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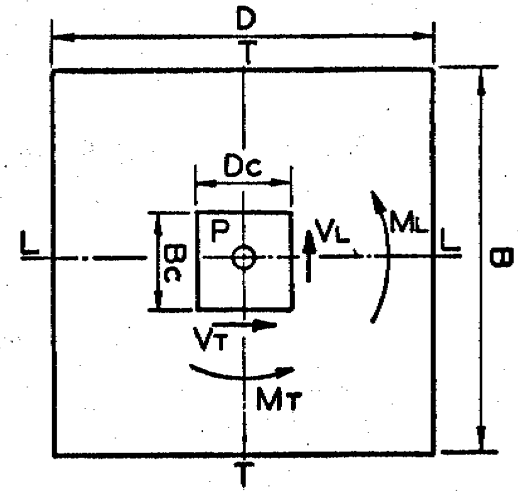
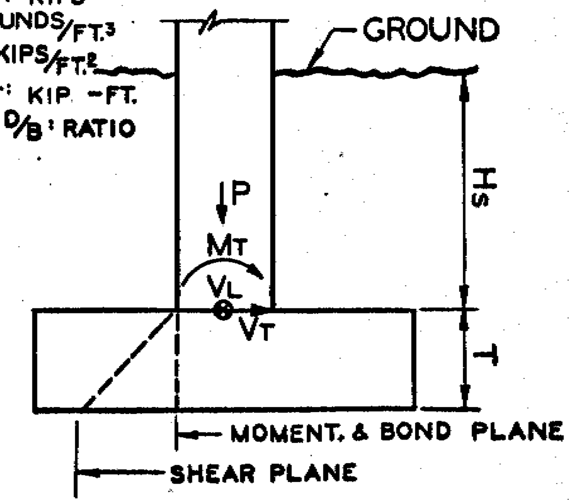


DIMENSIONS: FEET
P, VL, VT: KIPS
Ws: POUNDS/FT.^{3}
S.B.C.: KIPS/FT.^{2}
ML, MT: KIP-FT.
RB/D, RD/B: RATIO



SPREAD FOOTING DESIGN/ANALYSIS

IDENTIFICATION

PROG.	PROB NO.	PROJECT NUMBER, COUNTY, DATE, NAME, REMARKS
*B08	T6	TEST PROBLEM NO. 6

NLC = NUMBER OF LOAD CASES

FOOTING DATA

	NLC	D	B	T	ΔD	ΔB	ΔT	Dc	Bc	RB/D	RD/B	S.B.C.	Hs	Ws
1	4	6.00	8.00	1.00	.0500	.0500	.0250	3.00	3.00	1.500	1.500	10.	.	

LOAD CASES

	ID.	P	ML	MT	VL	VT
2	1	480.	.	.	.	.
2	2	.	50.	.	.	.
2	3	.	.	50.	.	.
2	4	.	50.	50.	.	.
2		.	.	.	.	.
2		.	.	.	.	.
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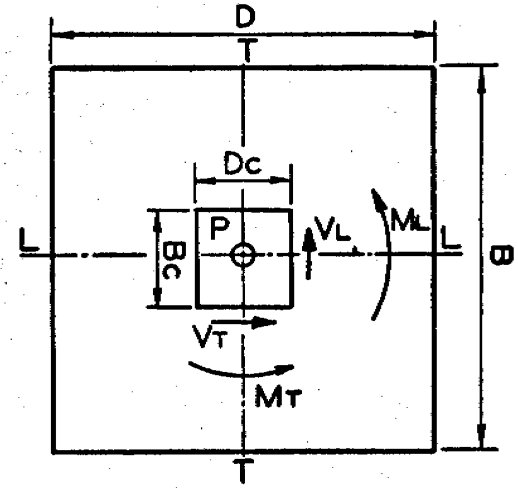
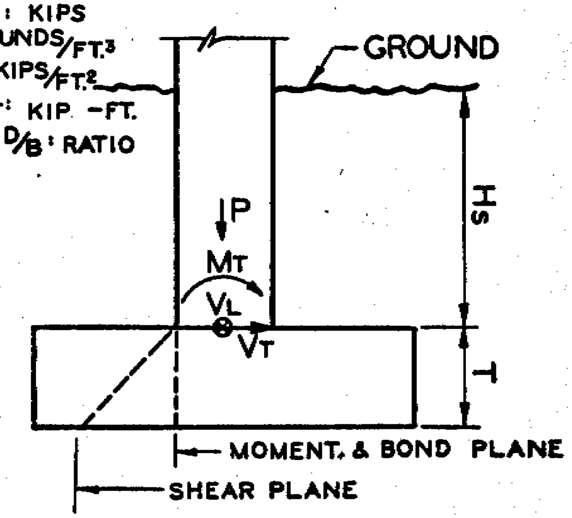


DIMENSIONS: FEET
P, VL, VT: KIPS
Ws: POUNDS/FT.³
S.B.C.: KIPS/FT.²
ML, MT: KIP-FT.
RB/D, RD/B: RATIO



SPREAD FOOTING DESIGN/ANALYSIS

IDENTIFICATION

	PROG.	PROB. NO.	PROJECT NUMBER, COUNTY, DATE, NAME, REMARKS
*	B08	T.T.	TEST PROBLEM No. - 7

NLC= NUMBER OF LOAD CASES

FOOTING DATA

	NLC	D	B	T	ΔD	ΔB	ΔT	Dc	Bc	RB/D	RD/B	S.B.C.	Hs	Ws
1	2	6.00	6.00	2.00	0.0	0.0	0.0	3.00	3.00	1.00	1.00	.	.	

LOAD CASES

	ID.	P	ML	MT	VL	VT
2	1	360.0	.	.	.	.
2	2	10.0	50.0	50.0	.	.
2		.	.	.	.	.
2		.	.	.	.	.
2		.	.	.	.	.
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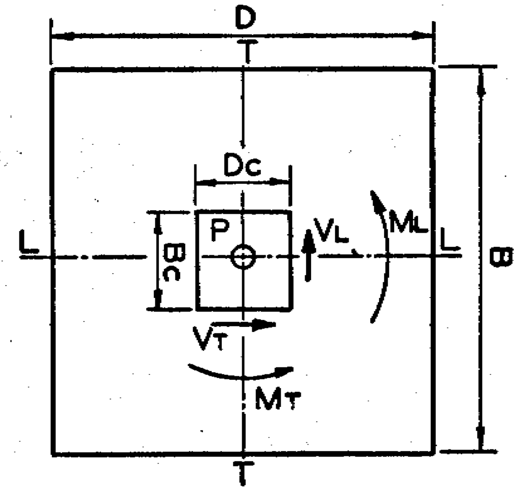
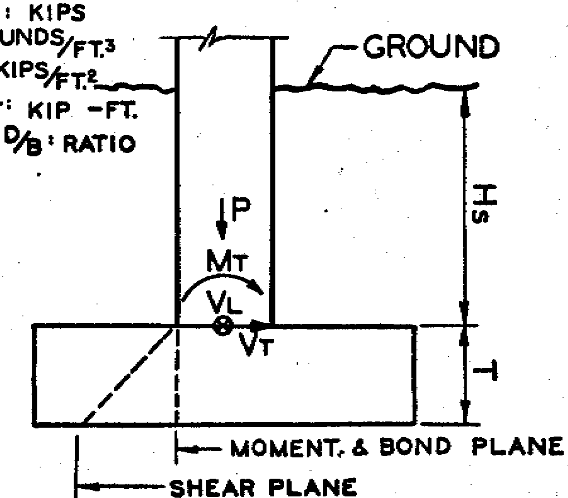


DIMENSIONS: FEET
P, VL, VT: KIPS
Ws: POUNDS/FT.³
S.B.C.: KIPS/FT.²
ML, MT: KIP-FT.
RB/D, RD/B: RATIO



10-1-69

SPREAD FOOTING DESIGN/ANALYSIS

360

IDENTIFICATION

1 PROG.	PROB. No. 9	PROJECT NUMBER, COUNTY, DATE, NAME, REMARKS 60
*B08		

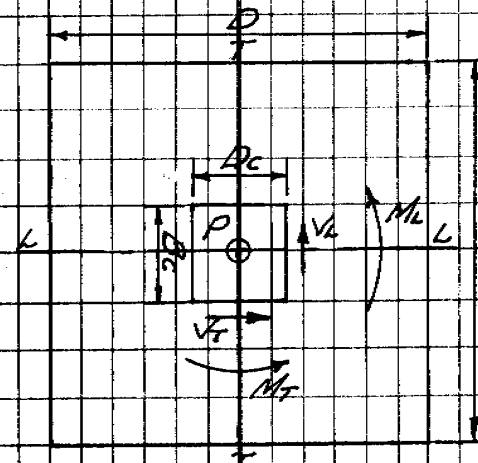
NLC = NUMBER OF LOAD CASES

FOOTING DATA

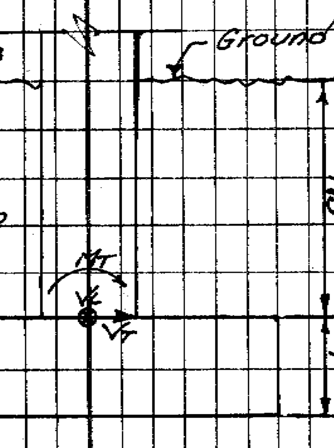
1 NLC 4	D 8	B 12	T 16	ΔD 21	ΔB 26	ΔT 31	Dc 36	Bc 41	$R^{B/D}$ 45	$R^{D/B}$ 49	S.B.C. 54	Hs 58	Ws 60
1													

LOAD CASES

1 2 ID. 6	P 13	ML 20	MT 27	VL 33	VT 39
2					



Dimensions: feet
P, VL, VT: kips
Ws: pounds/ft.³
S.B.C: kips/ft.²
ML, MT: kip-ft.
$R^{B/D}$, $R^{D/B}$: ratio



STATE HIGHWAY DEPARTMENT OF GEORGIA
BRIDGE DIVISION