# THE ANALYSIS AND DESIGN OF FOOTINGS

## A USER'S MANUAL

DEPARTMENT OF TRANSPORTATION
STATE OF GEORGIA

# THE ANALYSIS AND DESIGN
# OF MULTIPLE COLUMN PIERS FOR BRIDGES

VERSION IV

A FORTRAN COMPUTER PROGRAM

VOLUME I

## A USER'S MANUAL

Department of Transportation
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FORWARD

"The Analysis and Design of Footings" presented in this manual is a problem-oriented computer program which can be used effectively in the design of nearly all types of footings. This program is a combination of two previous programs for spread footings and pile footings. Actually the program is identical to the footing design module in "The Analysis and Design of Multiple Column Piers for Bridges" computer program. The footing design module was developed as a stand-alone program because there is a need for such a program to analysis/design isolated footings for signs or to analyze alternate designs.

The program is written in Fortran IV programming language and is compatible with most computers. The program is being processed on the Department's PDP-11/70 and VAX-11/780 computers.

This write-up is primarily a user's manual and does not include the method of solution, flow charts, or a program listing. However, since a copy of the source can be obtained by request, a program listing could then be obtained by listing or compiling the source. In addition, sinch the program is written in Fortran IV programming language and contains numerous comment statements which describe the program functions, the flow charts are not really essential in order to understand the procedure of the program solution. The reader is assumed to be familiar with the standard terminology of concrete design and such terms as moment, shear, stress, etc., are not defined in this manual.

This manual, then, explains in general terms the functions of the program and how the program can be used effectively in the design of footings.

Glenn H. Sikes
Atlanta, Georgia
February 14, 1983

## DISCLAIMER

Although this program has been subjected to many rigorous tests - all with excellent results - no warranty, expressed or implied, is made by the Georgia Department of Transportation as to the accuracy and functioning of the program; nor shall the fact of distribution constitute any such warranty, and no responsibility is assumed by the Georgia Department of Transportation in any connection therewith.

## REPRODUCTION AND DISTRIBUTION RESTRICTION

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# I. DESCRIPTION OF PROGRAM

"The Analysis and Design of Footing" is a problem-oriented computer program that can be used effectively in the design of foundations for bridge piers. The program can analyze (investigate) or design a spread or pile footing. In a design, service load requirements are used to determine the size (length and width), and the number of piles and spacing in the case of a pile footing. The thickness and reinforcement steel requirements are determined from service load or load factor. AASHTO Article 1.4.4(G) is not considered. In an investigation, the input footing size and pile arrangement are used to compute load effects without changing the size or pile arrangement.

In the case of a spread footing, the soil is assumed to resist no tension. The critical section for beam shear is at d from the face of the column, and at d/2 for peripheral shear. The critical section for moment is at the face of the column. In a design with width of the footing in the direction of the maximum moment ($M_T$ or $M_L$) will be incremented unless the width ratio is exceed, in which case the other side will be increment. Square footings can be obtained by using side ratios of 1.000.

In the design of a pile footing the specified minimum number of piles (4 is used if not specified) is used in a compact configuration (minimum spacing). If any pile is overstressed, either in compression or tension, the pile group is expanded by in crementing the pile spacing in the direction of the moment which causes the greatest pile load until the maximum pile spacing is reached or the piles are not overstressed. If the maximum spacing is reached in both direction and the piles are still overstressed, a pile is added and a compact arrangement selected. Then the whole process is repeated until an adequate arrangement has been found. The size of the footing is then determined by the pile arrangement and edge distance. The maximum number of piles is 25. Piles are assumed to be able to resist tension and the pile reactions are computed assuming each pile has an area of unity. After computing the section modulus of the pile group, the pile reactions are computed by the general stress equation. The critical section for beam shear and peripheral shear is at d/2 from the face of the column, and the critical section for moment is at the face of the column.

When computing the pile reactions or soil stress, the weight of the soil and footing is considered. However, when moment and shear in the footing are computed, the soil and footing weights are removed, i.e., they act opposite to the pile reaction or soil stress. Moments and shears in the footing are computed as average values; that is, the total moment and shear are found and divided by the portion of the footing width upon which each value acts.

The thickness of the footing is increased when the beam shear, peripheral shear, or moment capacities of the footing section are exceeded. The program designs the footing for the first load case and the uses this as a minimum design when considering the second load case. After designing for the second load case, the design is again used as a minimum design for the third load case. This procedure is continued until all load cases are processed. The final design will then be adequate for all load cases.

Each load case has its group designation (1 to 5) so that the program can provide for the overstress provisions of service load in the AASHTO Specifications. The input moments and shears are given at the top of the footing. However, when computing pile reactions, the moments are transferred to the bottom of the footing by using the shears and footing thickness.

A given footing size and pile arrangement can be analyzed (investigated) for the critical stresses and loads provided the piles (in the case of a pile footing) are arranged similar to the standard layouts shown on pages 2-x through 2-x. Symmentry about the longitudinal (L-L) and transverse (T-T) axes is a program requirement.

## II. PREPARING THE INPUT DATA

The input data required by the program is entered on a special input data form. Only one sheet is required to enter all the data needed ofr processing a problem. The form contains numerous headings and information to assist in entering the data. Note that the input form shows the implied position of the decimal póint. However, this position may be changed by inserting a decimal in the desired column. A negative value is denoted by placing a minus sign immediately preceding the first significant digit of the data field. In the following discussion of the input data refer to an input data form and the figures on pages 2-X through 2-X.

A. IDENTIFICATION (*B10 in col. 1-4)

The identification consists of one line of input data, containing the problem number (col. 5-8) and pertinent identifying remarks (col. 9-72). A unique problem number should be assigned to each footing analysis/design problem. This information will head the output data.

B. DESIGN DATA (1 in col. 1) One line of output provides the design data.

1. INVESTIGATION OF DESIGN (col. 2) Form: X (I or D)

   If the program is to investigate the footing, enter an I in this column. If not, enter D and the program will design the footing. Default is footing investigation.

2. DESIGN OPTION (col. 3) Form: X (S or L)

   If the design is to be Service Load, enter S in column 3. If not, enter L and the program will design by Load Factor. Blank or any other character defaults to Load Factor design.

3. MODULAR RATIO;n (col. 4-6) Form: XX.X

   Enter n, the modular ratio. The default is Es/Ec.

4. f'c (col. 7-11) Form: XX.XXX ksi

   Enter the 28-day concrete strength in these columns. The default is 3.0 ksi.

5. fy (col. 12-17) Form: XXX.XXX ksi

   Enter the steel yield stress in ksi in these columns. The default is 40.0 ksi.

6. fc (col. 18-22) Form: XX.XXX ksi

   Enter the allowable concrete stress (Service Load) in these columns. The default is 0.40 f'c ksi, and is used in Service Load design.

7. fs (col. 23-27) Form: XX.XXX ksi

   Enter the allowable steel stress in ksi in these columns. The default is 20.0 ksi and is used in Service Load design.

8. $W_{TS}$ (col. 28-31) Form: X.XXX kips per cubic ft.

   Use these columns to enter the unit weight of the soil imposed on the footings. There is no default.

9. ASP (col. 32-36) Form: XX.XXX ksf

Enter the allowable soil pressure in ksf in these columns. There is no default. A value must be given for a spread footing.

10. CL (col. 37-41) Form: XX.XXX inches

Enter reinforcement bar clearance from top of pile (pile footing) or bottom of footing (spread footing) to bottom layer of reinforcement in inches in these columns. One half of the bar diameter should not be included. The default is 3.0 inches.

11. $C_P$ (col. 42-26) Form: XX.XXX ft.

"$C_P$" is the distance from an exterior pile center line to the edge of the footing, and is required with a design problem only. The default is 1'-3".

12. P $S_{MIN}$ (col. 47-49) Form: X.XX feet.

Enter the minimum pile spacing in feet in these columns. The default is 2.5 feet.

13. PS $_{MAX}$ (col. 50-53) Form: XX.XX feet

Enter the maximum pile spacing in feet in these columns. The default is 5.0 feet.

14. $D_{PL}$ (col. 54-57) Form: X.XXX feet

Enter in this data field the length of pile embedment in the footing.

15. P1 $_{MAX}$ (col. 58-63) Form: XXX.XXX kips

This data field is for entering the maximum allowable load (compression) on the pile. A value is required for pile footings.

16. $P3_{MIN}$ (col. 64-69) Form: XXX.XXX kips

Enter the allowable uplift (tension) force per pile in this data field. A nagative value indicates uplift (tension) and a positive value is compression.

C. FOOTING DATA (2 in col. 1) One line of input provides the footing data.

1. SPREAD OR PILE (col. 2) Form: X ( S or P)

   If the program is to consider a spread footing, enter S in this data field. Otherwise, enter P, and the program will consider a pile footing.

2. NLC (col. 3-4) Form: XX

   Enter the number of load cases in this data field. At least one case must be used. The maximum number of load cases is 25.

3. B (col. 5-9) Form: XX.XXX feet

   "B" is the actual width of the footing in an analysis problem and is measured perpendicular to the longitudinal axis. "B" is the minimum width in a design problem, and is not required in a pile footing design.

4. D (col. 10-14) Form: XX.XXX feet

   Enter the width of the footing parallel to the longitudinal axis in this data field. This width is required in an analysis probelm, and a spread footing design (minimum).

5. T (col. 15-19) Form: XX.XXX feet

   "T" is the actual thickness of the footing in an analysis problem, and the minimum thickness in a design problem.

6. Bc (col. 20-24) Form: XX.XXX feet

   "Bc" is the width of the column or wall on top of the footing measured parallel to the transverse axis.

7. Dc (col. 25-29) Form: XX.XXX feet

   The width of the column or wall measured parallel to the longitudinal axis should be entered in this data field.

8. $H_s$ (col. 30-34) Form: XX.XXX feet

   The dimension $H_s$ is the height of the soil on top of the footing, i.e., overburden. This dimension may have a value of zero, or be left blank, i.e., soil not considered.

9. NP (col. 35-36) Form: XX piles (4-25)

Enter the number of piles in these card columns for an investigation problem or minimum number of piles for a design problem.

10. S (col. 37) Form: X (1 or 2 or Blank)

Enter a 1 in this column if the piles are to be expanded equally in both directions. Not used with a spread footing. Enter a 2 if the pile arrangement or spread footing is to be rotated 90 degrees, i.e., transverse and longitudinal effects interchanged.

11. $B_p$ (col. 38-42) Form: XX.XXX feet

The engineer will notice that the $B_p$ and $D_p$ dimensions are pile spacing parameters adapted to help illustrate the positioning of the piles based upon the number required. To enter this information correctly, he should refer to the pile layouts shown on pages 2-x to 2-x. $B_p$ is measured parallel to the footing B face and is required with an investigation only, i.e., not used within a design.

12. $D_p$ (col. 43-47) Form: XX.XXX feet

$D_p$ is the pile spacing dimension previously noted measured parallel to the footing D face. Required only with an investigation.

13. DB (col. 48-51) Form: X.XXX feet

The DB dimension is the amount by which the B width of the footing is incremented in a design problem. If a footing is being analyzed, this dimension should be given as zero, i.e., the width will not be altered. Used only with spread footings.

14. DD (col. 52-55) Form: X.XXX feet

The DD dimension is the amount by which the D width of the footing is incremented in a design problem. If an actual footing is being analyzed, this dimension should be given as zero, i.e., the width will not be altered. Use only with spread footings.

15. DT (col. 56-59) Form: X.XXX feet

The DT dimension is the amount by which the depth of the footing is incremented in a design problem. If a footing is being analyzed, this dimension should be given a value of zero, i.e., the depth will not be altered.

16. R B/D (col. 60-63) Form: X.XXX ratio

Enter in this data field the maximum allowable ratio of the B width to the D width. This ratio is used in the design process to keep the footing from becoming too narrow, i.e., strip footing. If a footing is being analyzed, assign this ratio a value of one (1.000). Do not use a value of zero or leave the field blank except with a pile footing.

In a design problem a value of one (1.000) can be used if the designer wishes the footing to be square. Otherwise, a value ranging from one (1.000) to two (2.000) is suggested. In any event, the sum of the R B/D ratio and the R D/B ratio should be equal to or greater than two (2.000).

17. R D/B (col. 64-67) Form: X.XXX ratio

Enter in this data field the maximum allowable ratio of the D width to the B width. This ratio is used in the design process to eliminate strip footings (very narrow). This ratio should be given a value of one (1.000) if a footing is be analyzed. In a design problem, a value of one (1.000) can be used if the designer wishes the footing to be square. Otherwise, a value ranging from one (1.000) to two (2.000) is suggested. Do not use a value of zero or leave the field blank except with a pile footing.

## LOAD CASES

The Load Case lines are used to enter load combinations to be used in analyzing/designing the footing. The digit three (3) in column one is for identification purposes only and of no significance to the designer.

1. GR (col. 2) Form: X (1-5)

Enter the AASHTO Group designation of the load case in this column. This allows the program to use the overstress provision in the service load design process. For example, the allowable stresses or pile loads are increased twenty-five percent for Group 3 loadings, etc.

2. LDID (col. 3-6) Form: XXXX

Enter the load case number of symbol in this data field. This data is given in the output for each design feature (maximum moment, maximum pile reaction, etc.). Therefore, the designer will know the controlling load cases for all design features. Numeric or alphabetic characters are acceptable.

## SERVICE LOADS

Because service loads are required in the analysis/design of footings, these loads should always be given. The loads should contain eht effects of live load, dead load, wind, etc. Impact is not normally included.

3. $P_S$ (col. 7-13) Form: XXXX.XXX kips

   Enter the load case reaction (P-load) in this data field. The load is assumed to act at the center fo the footing. The weight of the footing and overburden are not included in this load.

4. $MT_S$ (col. 14=20) Form: XXXX.XXX k-ft.

   Enter the load case moment about the transverse axis (T-T) in this data field. The moment is located at the top of the footing.

5. $VT_S$ (col. 21-26) Form: XXX.XXX kips

   Enter the load case shear at the top of the footing acting perpendicular to the transverse axis (T-T).

6. $ML_S$ (col. 27-33) Form: XXXX.XXX k-ft.

   "$ML_S$" is the load case moment about the longitudinal axis (L-L) and is given for the top of the footing (bottom of column).

7. $VL_S$ (col. 34 -39) Form: XXX.XXX kips

   "$VL_S$" is the load case shear at the top of the footing acting perpendicular to the longitudinal axis (L-L).

## FACTORED LOADS

If load factor is being used, then the factored loads are required in addition to the above service loads.

8. $P_F$ (col. 40-46) Form: XXXX.XXX kips

   Enter the load case reaction (P-load) in this data field. The load is assumed to act at the center of the footing. The weight of the footing and overburden are not included in this load.

9. $MT_F$ (col. 47-53) Form: XXXX.XXX k-ft.

   Enter the load case moment about the transverse axis (T-T) in this data field. The moment is located at the top of the footing.

10. $VT_F$ (col. 54-59) Form: XXX.XXX kips

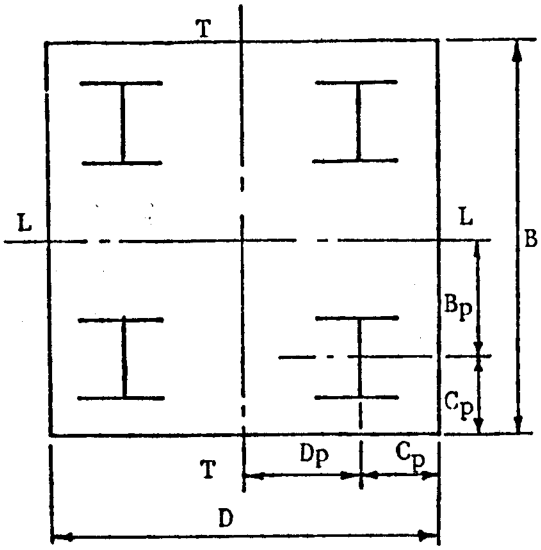
Enter the load case shear at the top of the footing acting perpendicular to the transverse axis (T-T).

11. $ML_F$ (col. 60-66) Form: XXXX.XXX k-ft.

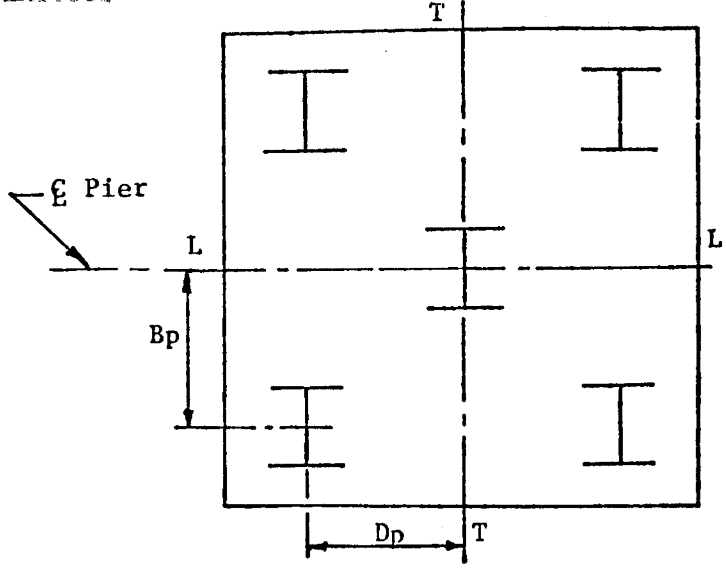
"$ML_F$" is the load case moment about the longitudinal axis (L-L) and is given for the top of the footing (bottom of column).

12. $VL_F$ (col. 67-72) Form: XXX.XXX kips

"$VL_F$" is the load case shear at the top of the footing acting perpendicular to the longitudinal axis (L-L).

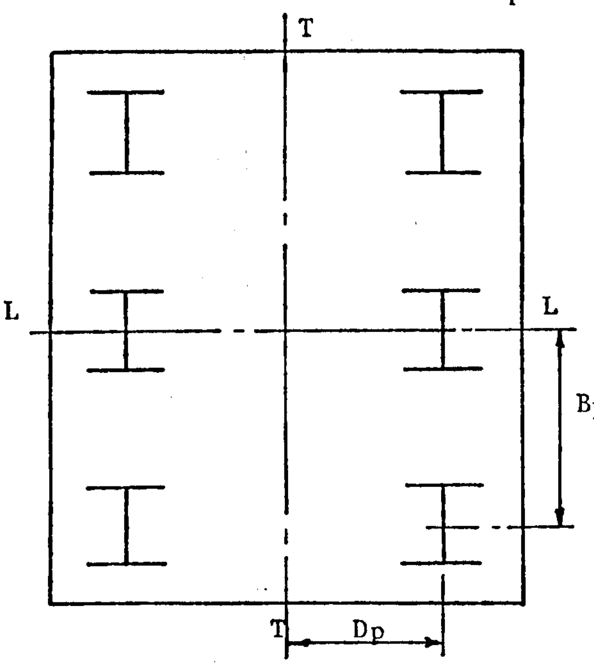



4 Piles




5 Piles

$C_p$= Edge Distance in input

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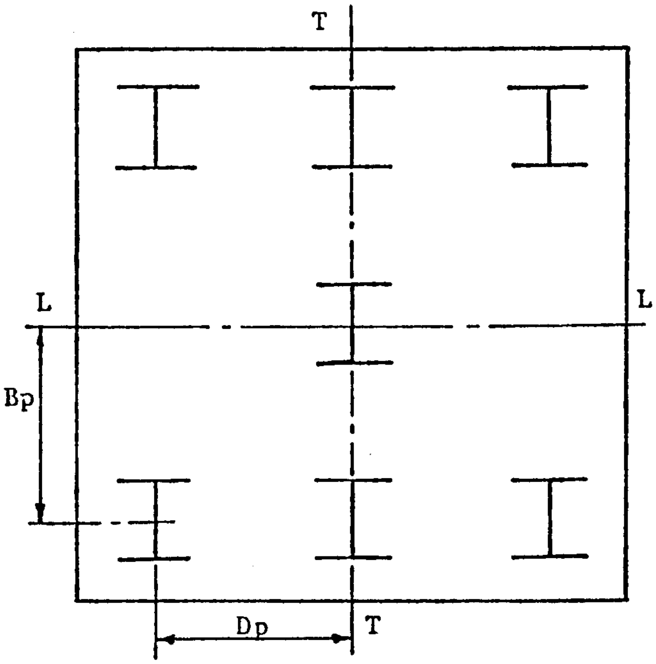


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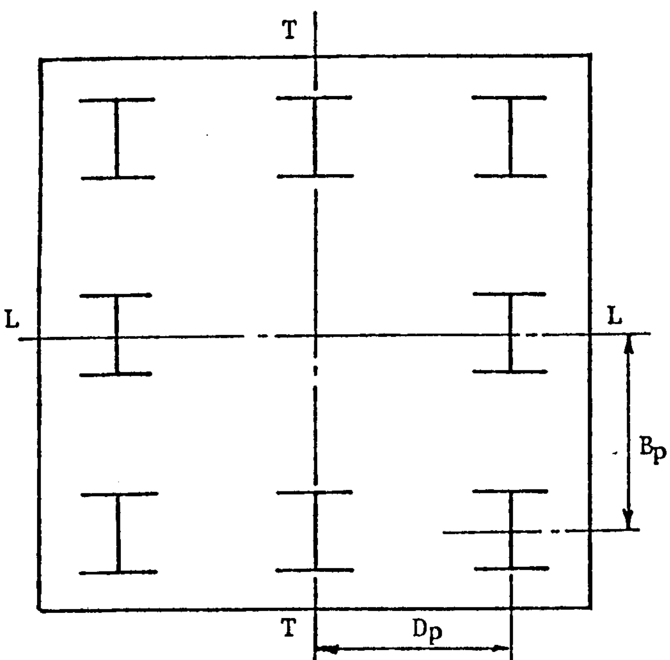


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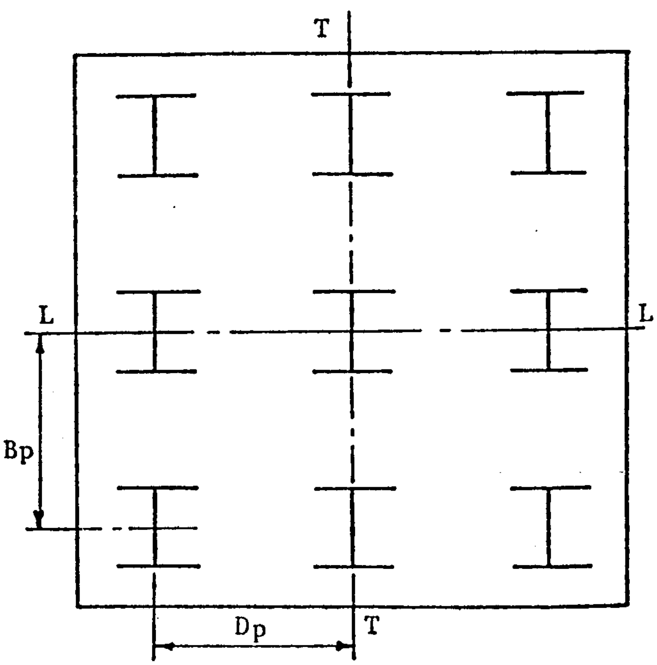
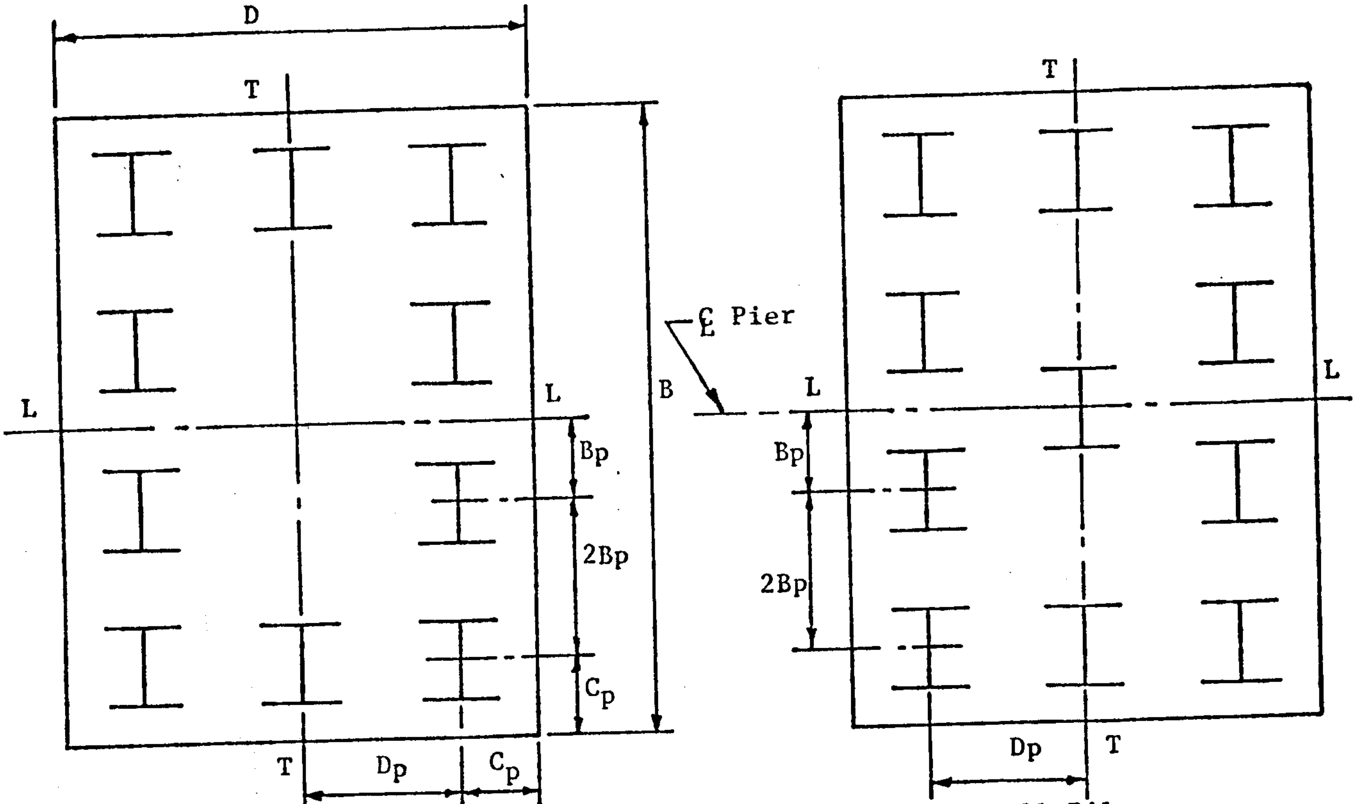



9 Piles

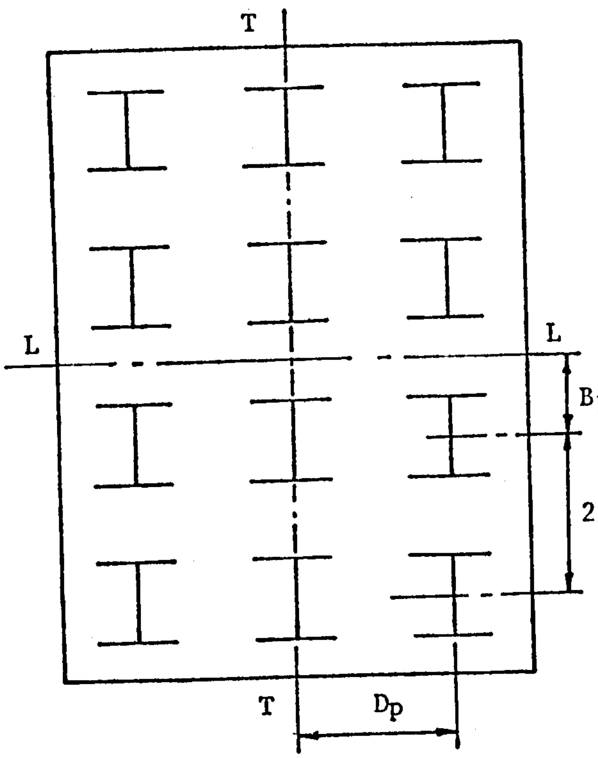
# PILE LAYOUTS




10 Piles

11 Piles

$C_p$ = Edge Distance in input

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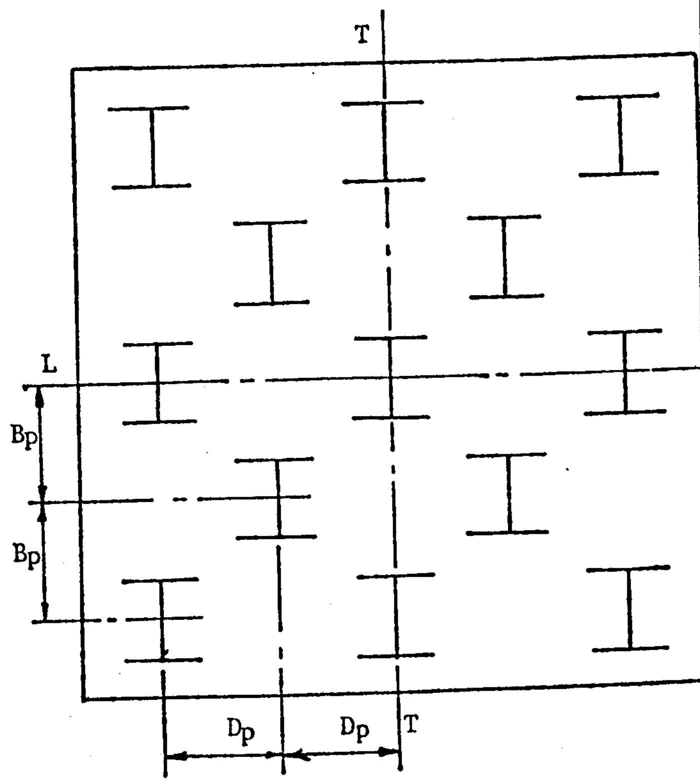
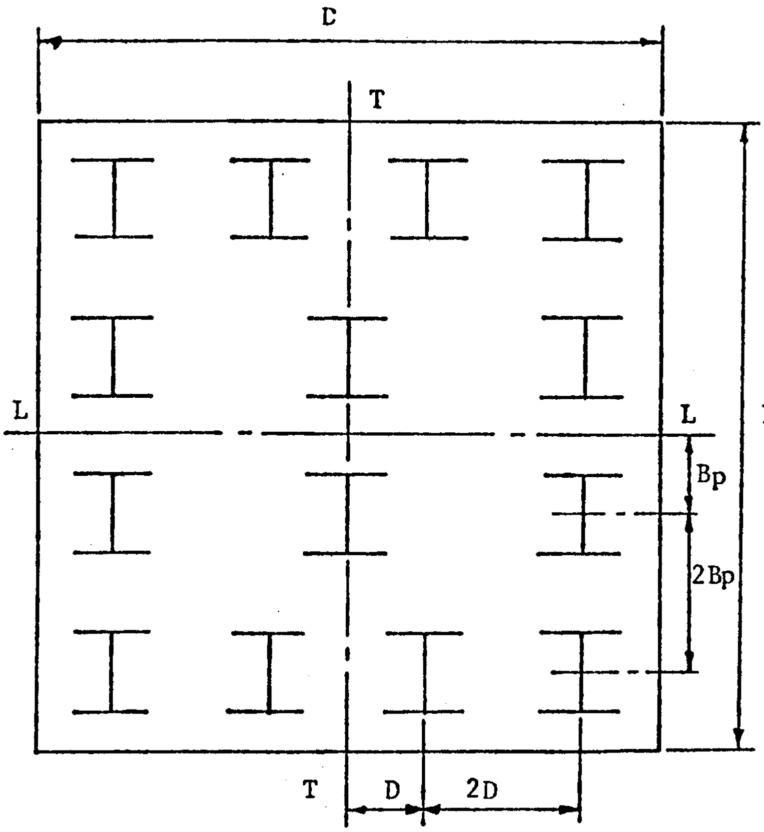



13 Piles

# PILE LAYOUTS

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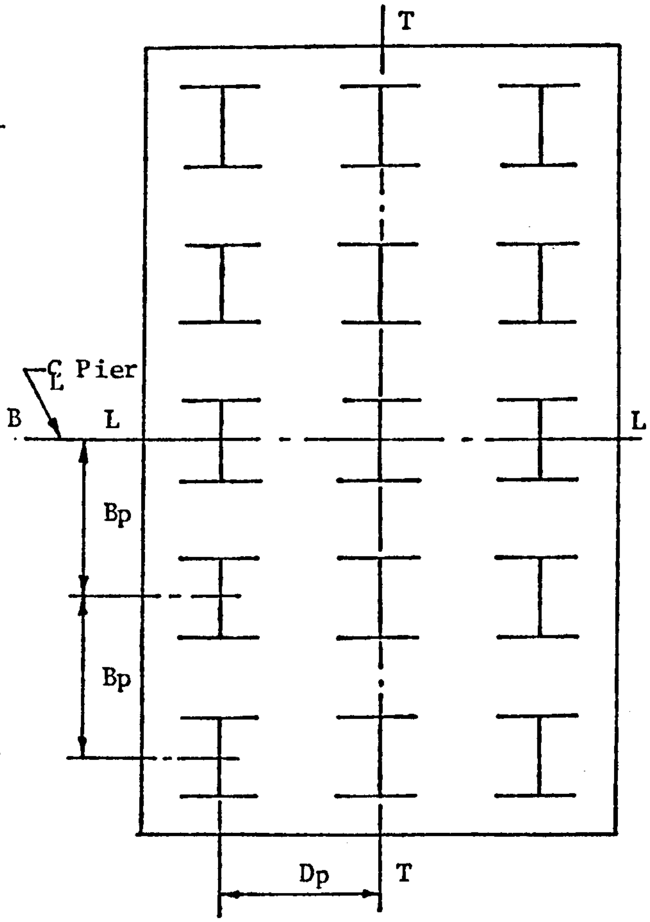


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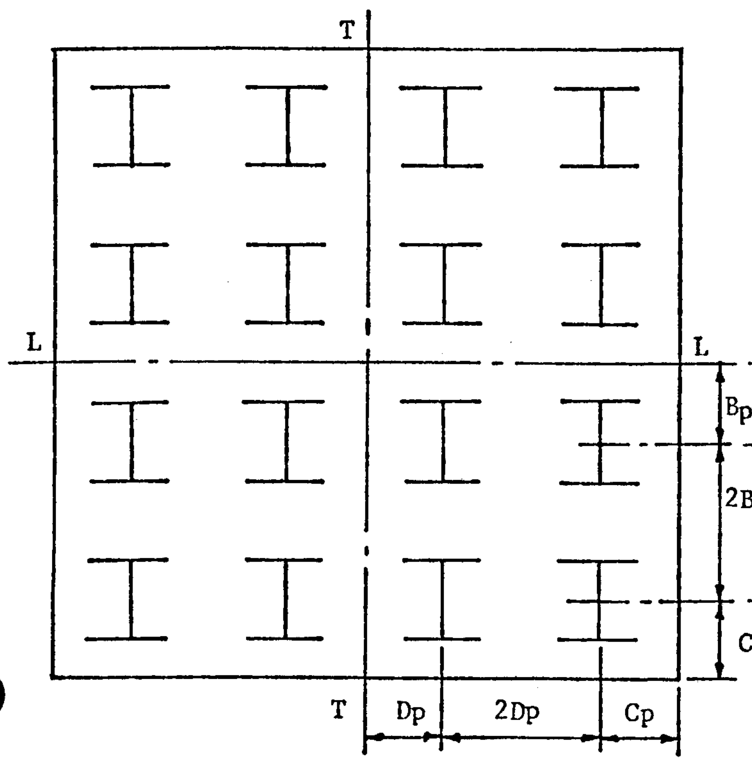
Cp= Edge Distance in input

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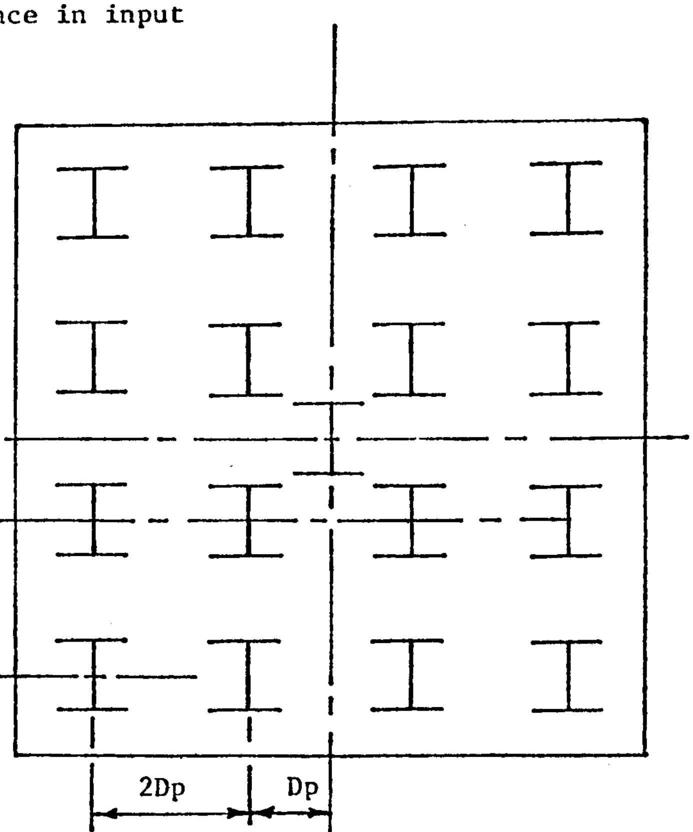
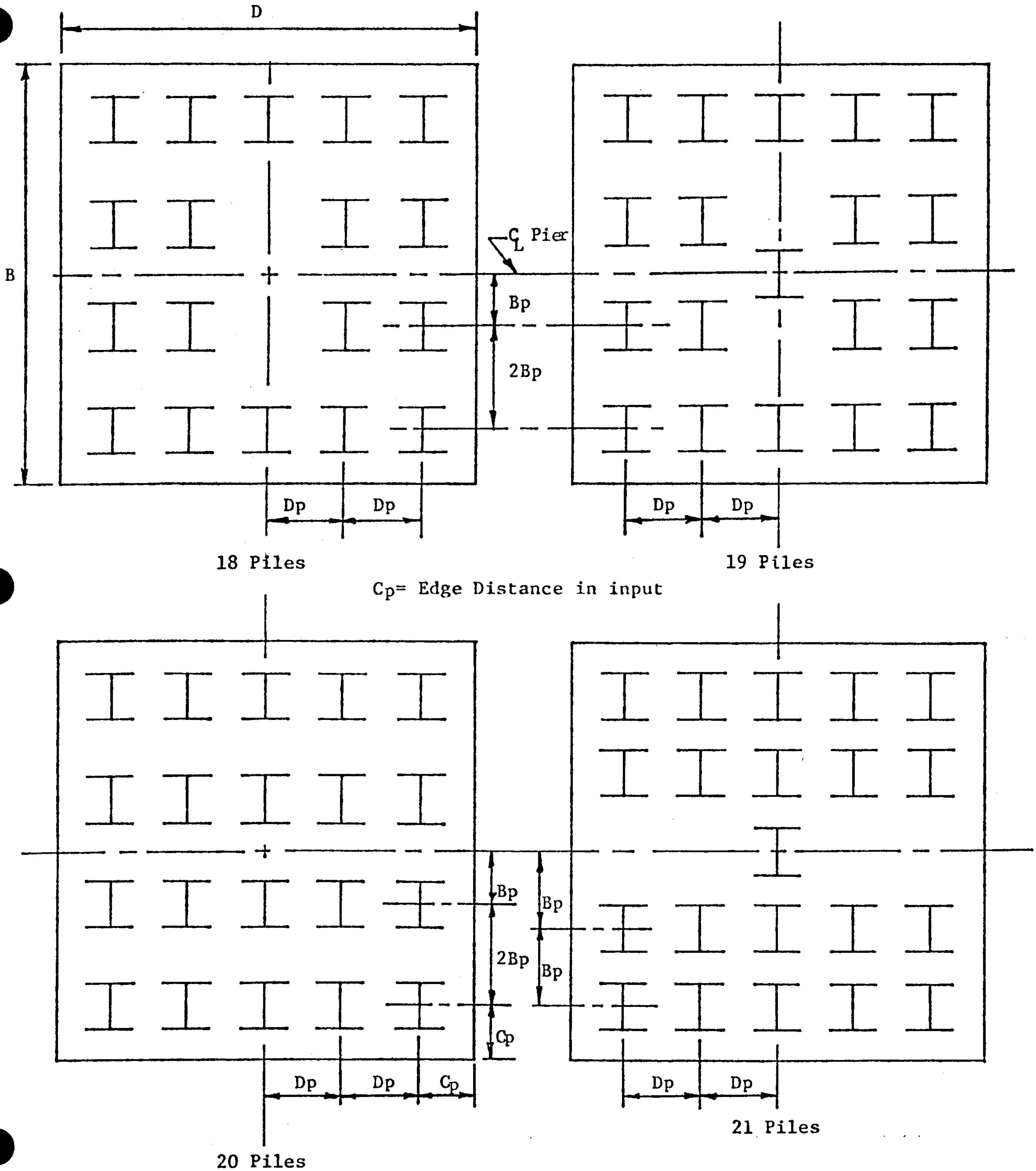
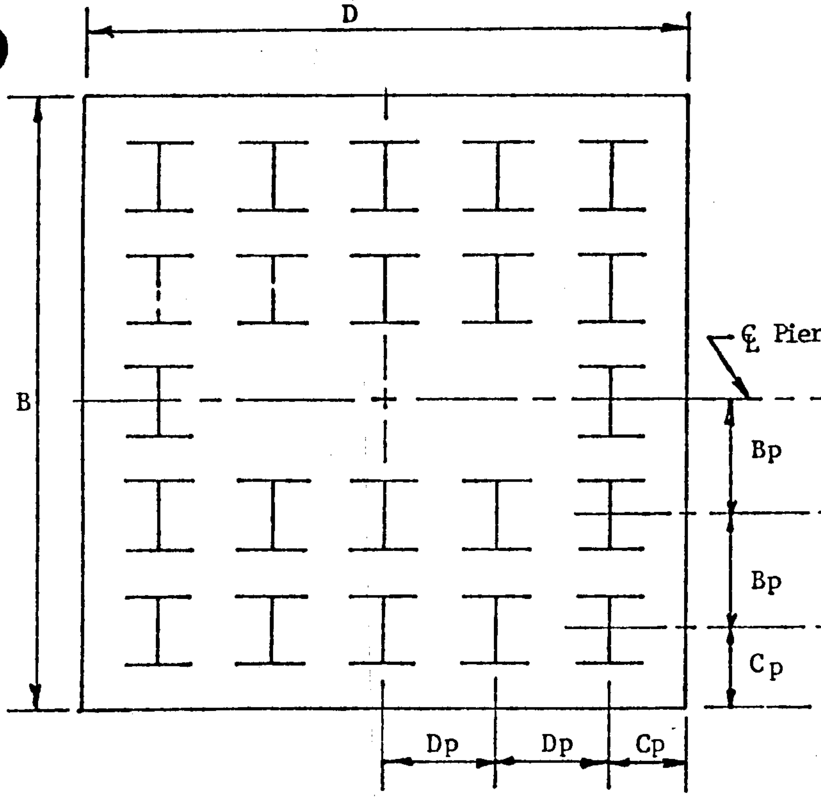



17 Piles

# PILE LAYOUTS



# PILE LAYOUTS

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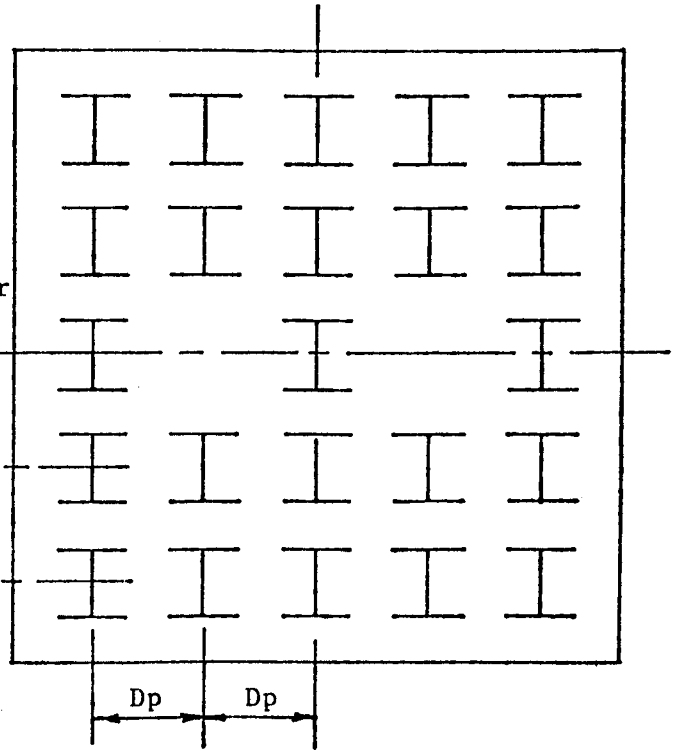


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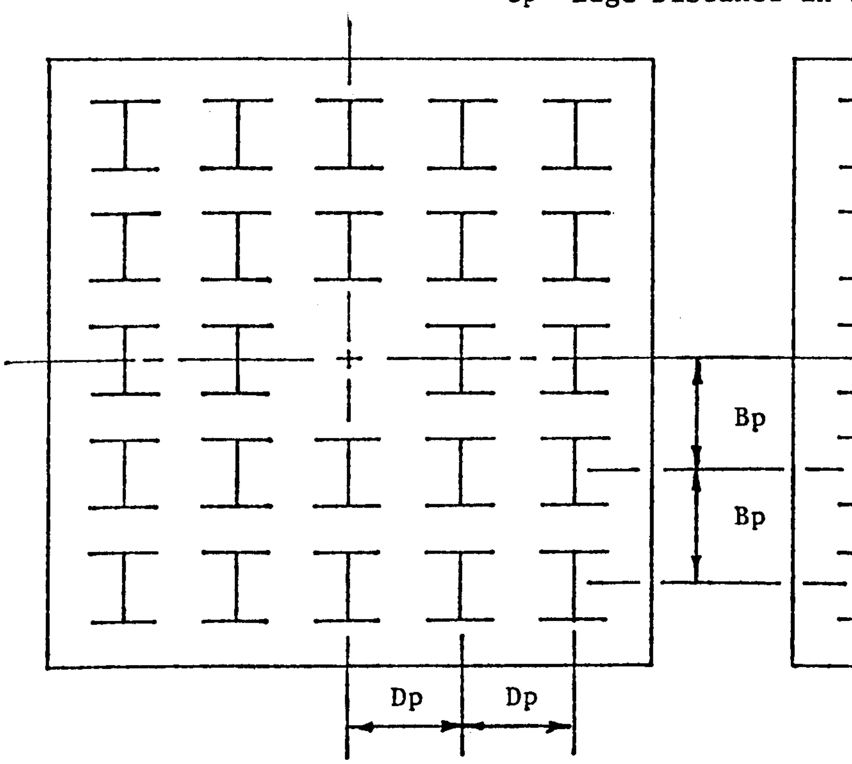


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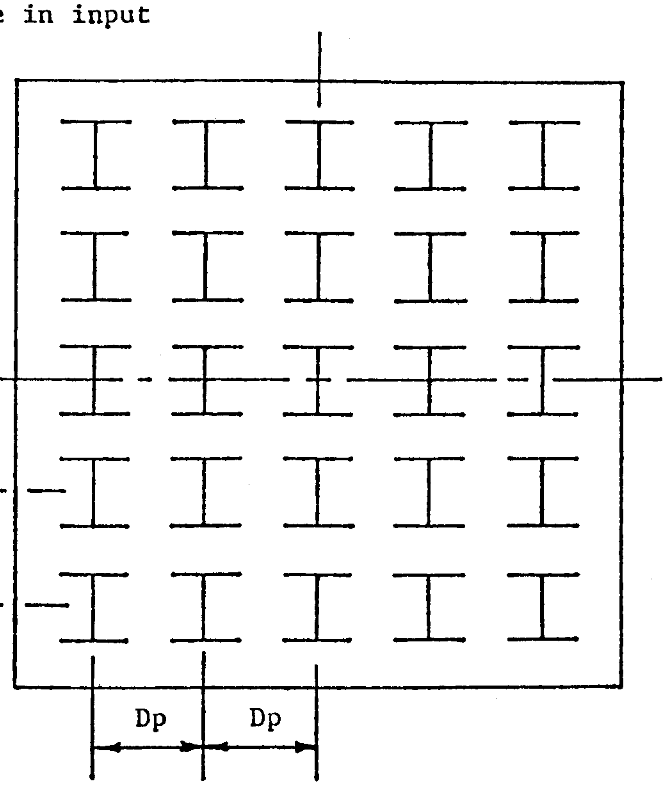


25 Piles

GA. DOT

BRIDGE OFFICE

# THE ANALYSIS/DESIGN OF FOOTINGS

FEB. 1983

## IDENTIFICATION DATA

| | PROB NO. | REMARKS, PROJECT NO., DATE, NAME, ETC. 72 |
|---|---|---|
| * B 1 0 | | |

## DESIGN DATA

| | K/D | S/L | N 6 | F'c 11 | FY 17 | Fc 22 | Fs 27 | WTs 31 | ASP 36 | CL 41 | CP 46 | PSMIN | PS MAX | DPL 57 | P1MAX 63 | P3MIN 69 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | | | | | | | | | |

## FOOTING DATA

| | S/D | NLC | B 9 | D 14 | T 19 | Bc 24 | Dc 29 | Hs 34 | NP | S | BP 42 | DP 47 | DB 51 | DD 55 | DT 59 | R B/D | R D/B 67 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | | | | | | | | | | | | | | | | | |

## LOAD DATA

| | GR | LDID 6 | Ps 13 | MTS 20 | VTS 26 | MLS 33 | VLS 39 | PF 46 | MTF 53 | VTF 59 | MLF 66 | VLF 72 |
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# III. THE OUTPUT DATA

The first page of the output data contains a listing of the input data. Sufficient headings are given in the listing so that the data are easily recognized. It is suggested that this listing be checked with the input data forms to guard against any data entry errors. In the discussion on the following pages, refer to an output listing of this program.

The second page contains the computed results as follows:

A. FOOTING DESIGN LOADS

The Footing Design Loads will contain seven maximum load cases used in the footing analysis/design process. These seven load cases produce:

1. The maximum soil stress or pile reaction (MAX.P1).

2. The maximum transverse moment in footing (MAX.MT).

3. The maximum transverse beam shear in footing (MAX.VT).

4. The maximum peripheral shear in footing (MAX.VP).

5. The maximum longititdinal moment in footing (MAX.ML).

6. The maximum longitudinal beam shear in footing (MAX.VL).

7. The maximum soil or pile uplift (MAX.P3).

The soil uplift has no structural meaning since the soil has no tension capacity, but it does give an indication that reinforcement steel may be needed in the top of the footing. The load effects for MAX.P1 and MAX.P3 will be Service Loads. The loads effects for the other five load cases will Service Load or Factored Loads depending on the design option.

1. G.

   The Group number of the load case is given in this column.

2. LDID.

   The load case identification for the controlling load case is given in this column.

3. P (kips)

This column contains the P-load on the footing from the column. The soil weight or footing weight is not included.

4. MT (kip-feet).

MT is moment at the top of the footing in the transverse direction.

5. VT (kips).

VT is the horizontal shear at the top of the footing in the transverse direction.

6. ML (Kip-feet).

The longitudinal moment at the top of the footing is given in this column.

7. VL (kips).

VL is the horizontal shear at the top of the footing in the longitudinal direction.

8. P4 (kips or kips/sq. ft. ).

P4 is the corner soil stress or pile reaction where MT causes tension and ML produces compression.

9. P3 (kips or kips/sq. ft.).

P3 is the corner soil stree or pile reaction where MT and ML cause tension.

10. P2 (kips or kips/sq. ft.).

P2 is the corner soil stress or pile reaction where MT causes compression and ML cuases tension.

11. P1.

P1 is the corner soil stress or pile reaction where MT and ML cause compression.

NOTE: P1, P2, P3, and P4 values contain the weight of the soil and footing.

12. MTF (kip-feet/foot).

MTF is the moment in the footing in the transverse or longitudinal direction at the face of the column per foot of footing width.

13. VBF (kips/foot).

VBF is the beam shear in the footing in the transverse or longitudinal direction at the critical section (d or d/2) from the face of the column per foot of footing width.

14. VPF (kips/foot).

VPF is the peripheral shear in the footing at the critical section (d/2) from the face of the column per foot of peripheral length.

NOTE: The weight of the soil and footing are considered when computing MTF, VBF, and VPF.

15. LOAD.

This column contains the identification of the maximum load case, i.e., maximum P1, moment, shear, etc.

A. FOOTING ANALYSIS/DESIGN RESULTS

The footing analysis/design results will consist of the footing size, bar reinforcement steel, and section capacities.

1. B (feet).

B is the footing width in the longitudinal direction. In a design problem this is the required width.

2. D (feet).

D is the footing width in the transverse direction. In a design problem this is the required width.

3. T (feet).

T is the thickness of the footing. In a design problem this is the required thickness.

4. P1/PA.

P1/PA is the ratio of the maximum corner soil stress (or pile reaction) to the allowable soil stress (or pile capacity).

5. AS (sq. inches).

AS is the required area of reinforcement steel per foot.

6. NO.

The total number of rebars is given in this column.

7. SIZE.

The standard bar designation of the selected bars is given in this column.

8. SPAC (inches)

The rebar spacing is given in this column.

9. PLACEMENT.

This column identifies the placement of the rebars. The top layer of bars is listed on the first line and the bottom layer of bars on the second line. The codes LONG and TRAN are listed to indicate the direction in which the rebars are to placed. TRAN bars corresponds to transverse moment and LONG bars corresponds to longitudinal moment. Note that the top or bottom bars may be in either direction (depends on magnitude of moment).

10. MT (kip-feet/foot).

MT is the moment capacity of the footing per foot of width considering the thickness and area of steel.

11. VB (kips/foot).

VB is the beam shear capacity of the footing per foot of width considering the thickness and steel placement.

12. VP (kips/foot).

VP is the peripheral shear capacity of the footing per foot of width considering the thickness and steel placement.

13. DS (inches).

DS is the distance from the top of the footing to the centerroid of the rebars.

14. FC (ksi).

FC is the concrete stress under the Service Load option. Under the Load Factor option, FC is shown as zero.

15. Number of Piles, Bp and Dp (feet).

If the footing has piles, the number of piles and pile placement data will be given on the next line of output. Refer to the pile layouts on pages 2-   through 2-   .

If a "S" code of 2 is used, the following message is printed:

****NOTE:  FOOTING SHOULD BE ROTATED 90 DEGREES.****

# IV. EXAMPLE PROBLEMS

Two examples are given here to illustrate the use of the program. The given data are given below and the coded input forms and output data are shown on subsequent pages. Finally a commentary on the computed results is given.

## A. EXAMPLE PROBLEM DATA

Example one is the design of a spread footing using load factor. Following are the input data:

Design Data: Use defaults and an allowable soil stress of 8.0 ksf.

Footing Data: Minimum footing size 5'-0" x 5'-0" x 2'-0", Column size 3'-0" x 3'-0", Soil height 2'-0", Increments for widths and thichness 0'-3", Maximum side ratios 1.5

LOADS

| GR. | LDID | PS | MTS | VTS | MLS | VLS | PF | MTF | VTF | MLF | VLF |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 1010 | 335.474 | 35.577 | 9.368 | 408.265 | 13.957 | 436.117 | 46.250 | 12.179 | 530.745 | 18.144 |
| 3 | 1001 | 315.964 | 88.271 | 15.828 | 408.265 | 13.957 | 410.753 | 114.752 | 20.577 | 530.745 | 18.144 |
| 5 | | 244.053 | 401.108 | 39.825 | 167.716 | 7.415 | 305.066 | 501.385 | 49.781 | 209.645 | 9.269 |

Example two is the analysis (investigation) of a pile footing using service loads. Following are the input data:

Design Data: Use defaults and pile load of 100.0 (to obtain ratio of actual to allowable)

Footing Data: Minimum footing size 6'-6" x 6'-6" x 3'-0", size of column 3'-0" x 3'-0", Soil height 2'-0", No. of piles 8, Pile spacing 2'-0" (see pile layouts), Use service loads of Example One.

## IDENTIFICATION DATA

| * | B | 1 | 0 | PROB NO. | REMARKS, PROJECT NO., DATE, NAME, ETC. 72 |
|---|---|---|---|---|---|
| * | B | 1 | 0 | EX.1 | EXAMPLE PROBLEM NO. 1 - DESIGN OF SPREAD FOOTING USING LOAD FACT OR. |

## DESIGN DATA

| | %S | N 6 | F'c 11 | FY 17 | Fc 22 | Fs 27 | WTs 31 | ASP 36 | CL 41 | CP 46 | PSMIN | PS MAX | DPL 57 | P1MAX 63 | P3MIN 69 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | DL | | | | | | | 8000 | | | | | | | |

## FOOTING DATA

| | %S | NLC | B 9 | D 14 | T 19 | Bc 24 | Dc 29 | Hs 34 | NP | S | BP 42 | DP 47 | DB 51 | DD 55 | DT 59 | R B/D | R D/B 67 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | S | 3 | 5000 | 5000 | 2000 | 3000 | 2000 | | | | | | 0250 | 0250 | 0250 | 1500 | 1500 |

## LOAD DATA

| | GR | LDID 6 | Ps 13 | MTS 20 | VTS 26 | MLS 33 | VLS 39 | PF 46 | MTF 53 | VTF 59 | MLF 66 | VLF 72 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 3 | 1010 | 335474 | 35577 | 9368 | 408265 | 13957 | 436117 | 46250 | 12179 | 530745 | 18144 |
| 3 | 3 | 1001 | 315964 | 88271 | 15828 | 408265 | 13957 | 410753 | 114752 | 20577 | 530745 | 18144 |
| 3 | 5 | | 244053 | 401108 | 39825 | 167716 | 7415 | 305066 | 501385 | 40781 | 209645 | 9269 |
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THE ANALYSIS AND DESIGN OF FOOTINGS

PROBLEM NO. EX.1 EXAMPLE PROBLEM NO. 1 - DESIGN OF SPREAD FOOTING USING LOAD FACTOR. 09-FEB-83

DESIGN DATA

| I/D | S/L | N | FPC | FY | FC | FS | WTS | ASP | CL | CP | PSMIN | PSMAX | DPL | P1 MAX | P3 MIN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| D | L | 9.2 | 3.000 | 40.000 | 1.200 | 20.000 | 0.110 | 8.000 | 3.000 | 1.250 | 2.50 | 5.00 | 1.000 | 0.000 | 0.000 |

FOOTING DATA

| S/P | NLC | B | D | T | BC | DC | HS | NP | S | BP | DP | DB | DD | DT | R B/D | R D/B |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 3 | 5.000 | 5.000 | 2.000 | 3.000 | 3.000 | 2.000 | 0 | 0 | 0.000 | 0.000 | 0.250 | 0.250 | 0.250 | 1.500 | 1.500 |

LOAD DATA

| GR. | LDID | PS | MTS | VTS | MLS | VLS | PF | MTF | VTF | MLF | VLF |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 1010 | 335.474 | 35.577 | 9.368 | 408.265 | 13.957 | 436.117 | 46.250 | 12.179 | 530.745 | 18.144 |
| 3 | 1001 | 315.964 | 88.271 | 15.828 | 408.265 | 13.957 | 410.753 | 114.752 | 20.577 | 530.745 | 18.144 |
| 5 | | 244.053 | 401.108 | 39.825 | 167.716 | 7.415 | 305.066 | 501.385 | 49.781 | 209.645 | 9.269 |

## FOOTING DESIGN LOADS

| G | LDID | P | MT | VT | ML | VL | P4 | P3 | P2 | P1 | MTF | VBF | VPF | LOAD |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | | 244.053 | 401.108 | 39.825 | 167.716 | 7.415 | -0.545 | -4.025 | 7.334 | 10.814 | 18.778 | 4.331 | 9.508 | MAX.P1 |
| 5 | | 305.066 | 501.385 | 49.781 | 209.645 | 9.269 | -0.971 | -5.430 | 9.076 | 13.535 | 23.628 | 5.457 | 11.965 | MAX.MT |
| 5 | | 305.066 | 501.385 | 49.781 | 209.645 | 9.269 | -0.971 | -5.430 | 9.076 | 13.535 | 23.628 | 5.457 | 11.965 | MAX.VT |
| 3 | 1010 | 436.117 | 46.250 | 12.179 | 530.745 | 18.144 | 9.750 | 1.115 | 2.584 | 11.220 | 15.783 | 3.363 | 16.413 | MAX.VP |
| 3 | 1010 | 436.117 | 46.250 | 12.179 | 530.745 | 18.144 | 9.750 | 1.115 | 2.584 | 11.220 | 58.785 | 17.465 | 16.413 | MAX.ML |
| 3 | 1010 | 436.117 | 46.250 | 12.179 | 530.745 | 18.144 | 9.750 | 1.115 | 2.584 | 11.220 | 58.785 | 17.465 | 16.413 | MAX.VL |
| 5 | | 244.053 | 401.108 | 39.825 | 167.716 | 7.415 | -0.545 | -4.025 | 7.334 | 10.814 | 18.778 | 4.331 | 9.508 | MAX.P3 |

## FOOTING ANALYSIS/DESIGN RESULTS

| FOOTING SIZE | | | | * BAR REINFORCEMENT STEEL | | | * | SECTION CAPACITIES | | | | * |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B | D | T | P1/PA | AS | NO.SIZE | SPAC. | PLACEMENT | MT. | VB | VP | DS | FC |
| 10.250 | 7.500 | 2.000 | 0.966 | 0.54 | 28 # 4 | @ 4.375 | TOP TRAN | 31.785 | 22.068 | 44.135 | 19.750 | 0.000 |
| | | | | 0.99 | 10 # 8 | @ 9.000 | BOT.LONG | 62.604 | 22.906 | 45.812 | 20.500 | 0.000 |

GA. DOT

BRIDGE OFFICE

# THE ANALYSIS/DESIGN OF FOOTINGS

FEB. 1983

## IDENTIFICATION DATA

| | PROB NO. | REMARKS, PROJECT NO., DATE, NAME, ETC. |
|---|---|---|
| *B10 | EX.2 | EXAMPLE PROBLEM NO. 2 - ANALYSIS OF PILE FOOTING USING SERVICE L |
| | | OADS. |

## DESIGN DATA

| | N | F'c | FY | Fc | Fs | WTs | ASP | CL | CP | PSMIN | PS MAX | DPL | P1MAX | P3MIN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 I S | | | | | | | | | | | | | 1000.00 | |

## FOOTING DATA

| | NLC | B | D | T | Bc | Dc | Hs | NP | S | BP | DP | DB | DD | DT | R B/D | R D/B |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 P | 3 | 65.00 | 65.00 | 30.00 | 30.00 | 30.00 | 20.00 | 8 | | 20.00 | 20.00 | | | | | |

## LOAD DATA

| GR | LDID | Ps | MTS | VTS | MLS | VLS | PF | MTF | VTF | MLF | VLF |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 33 | 1.01.0 | 3354.74 | 355.77 | 93.68 | 4082.65 | 139.57 | | | | | |
| 33 | 1.00.1 | 3159.64 | 882.71 | 158.28 | 4082.65 | 139.57 | | | | | |
| 35 | | 2440.53 | 4011.08 | 398.25 | 1677.16 | 74.15 | | | | | |
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THE ANALYSIS AND DESIGN OF FOOTINGS

PROBLEM NO. EX.2 EXAMPLE PROBLEM NO. 2 - ANALYSIS OF PILE FOOTING USING SERVICE LOADS. 09-FEB-83

DESIGN DATA

| I/D | S/L | N | FPC | FY | FC | FS | WTS | ASP | CL | CP | PSMIN | PSMAX | DPL | P1 MAX | P3 MIN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I | S | 9.2 | 3.000 | 40.000 | 1.200 | 20.000 | 0.110 | 0.000 | 3.000 | 1.250 | 2.50 | 5.00 | 1.000 | 100.000 | 0.000 |

FOOTING DATA

| S/P | NLC | B | D | T | BC | DC | HS | NP | S | BP | DP | DB | DD | DT | R B/D | R D/B |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P | 3 | 6.500 | 6.500 | 3.000 | 3.000 | 3.000 | 2.000 | 8 | 0 | 2.000 | 2.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

LOAD DATA

| GR. | LDID | PS | MTS | VTS | MLS | VLS | PF | MTF | VTF | MLF | VLF |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 1010 | 335.474 | 35.577 | 9.368 | 408.265 | 13.957 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 3 | 1001 | 315.964 | 88.271 | 15.828 | 408.265 | 13.957 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 5 | | 244.053 | 401.108 | 39.825 | 167.716 | 7.415 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

## FOOTING DESIGN LOADS

| G | LDID | P | MT | VT | ML | VL | P4 | P3 | P2 | P1 | MTF | VBF | VPF | LOAD |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 1001 | 315.964 | 88.271 | 15.828 | 408.265 | 13.957 | 68.985 | -6.038 | 16.588 | 91.611 | 11.725 | 0.000 | 0.000 | MAX.P1 |
| 5 | | 244.053 | 401.108 | 39.825 | 167.716 | 7.415 | 6.246 | -25.414 | 61.349 | 93.010 | 17.051 | 0.000 | 0.000 | MAX.MT |
| 3 | 1010 | 335.474 | 35.577 | 9.368 | 408.265 | 13.957 | 77.430 | 2.407 | 13.021 | 88.043 | 10.902 | 0.000 | 0.000 | MAX.VT |
| 3 | 1010 | 335.474 | 35.577 | 9.368 | 408.265 | 13.957 | 77.430 | 2.407 | 13.021 | 88.043 | 10.902 | 0.000 | 0.000 | MAX.VP |
| 3 | 1010 | 335.474 | 35.577 | 9.368 | 408.265 | 13.957 | 77.430 | 2.407 | 13.021 | 88.043 | 18.334 | 0.000 | 0.000 | MAX.ML |
| 3 | 1010 | 335.474 | 35.577 | 9.368 | 408.265 | 13.957 | 77.430 | 2.407 | 13.021 | 88.043 | 18.334 | 0.000 | 0.000 | MAX.VL |
| 5 | | 244.053 | 401.108 | 39.825 | 167.716 | 7.415 | 6.246 | -25.414 | 61.349 | 93.010 | 17.051 | 0.000 | 0.000 | MAX.P3 |

## FOOTING ANALYSIS/DESIGN RESULTS

| FOOTING SIZE | | | | * BAR REINFORCEMENT STEEL | | | * | SECTION CAPACITIES | | | | * |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B | D | T | P1/PA | AS | NO.SIZE | SPAC. | PLACEMENT | MT. | VB | VP | DS | FC |
| 6.500 | 6.500 | 3.000 | 0.733 | 0.38 | 13 # 4 @ | 6.000 | TOP TRAN | 17.895 | 15.805 | 29.947 | 20.250 | 0.563 |
| | | | | 0.45 | 15 # 4 @ | 5.125 | BOT.LONG | 18.832 | 16.195 | 30.686 | 20.750 | 0.542 |

NUMBER OF PILES = 8 BP = 2.000 DP = 2.000

## B. EXAMPLE PROBLEM COMMENTARY

The first page of each output contains a listing of the input data. Note that the default values used by the program are shown.

The resulting size of the spread footing in example one is 10'-3" x 7'-6". Note that there is "negative" stresses in the soil so there might be a need for top steel. This is left to the designer. The maximum corner stress is 10.814 ksf although there is a value of 13.535 shown. The latter value is from factored loads and does not pertain to soil stress.

In example two only service loads are considered. The maximum pile reaction is 91.611. With a allowable overstress the maximum ratio of actual to allowable pile load is 0.733. If the computed steel areas are present, the footing is adequate.

## V. ERROR MESSAGES

The program checks the validity of the input data to the extent possible and will list the following messages when an error is detected:

"DATA ERROR IN LINE I PROBLEM XXXX"

Where XXXX is the problem number defined in the Identification (first line) Data, and I is the line number where the error occured (digit in column one).

| LINE NO. | POSSIBLE CAUSE OF ERROR |
|---|---|
| 1. | Allowable soil pressure is zero for a spread footing.<br>Allowable pile capacity is zero for pile footing. |
| 2. | Number Load cases (NLC) less than one or greater than 25.<br>B and D dimensions are zero for a spread footing or for a pile footing investigation.<br>Thickness of footing (T) is zero.<br>R B/D or R D/B equals zero, or their sum less than 2.<br>DB and DD equal zero for spread footing design.<br>DT equals zero for a design problem.<br>Bp or Dp are zero for a pile footing investigation. |
| 3. | There are no data checks for this line. |

In addition, if the data is out of order, the following message is listed:

"DATA OUT OF ORDER LINE I PROBLEM XXXX"

Where I is the line number read but is not the correct line. The data should be entered in the order shown on the input form. Do not skip any lines except the unused load cases.

If the program runs into problems in the analysis/design process one of the following messates may appear:

"HAVING TROUBLE WITH FOOTING DESIGN"

The Service (PS, MTS, VTS, MLS, VLS) and Factored (PF, MTF, VTF, MLF, VLF) loads are listed for the load case the program was working with at that time. This is probably from having to increment the footing size too many times (100 is maximum). Begin with a larger footing or use larger increment of width. This message may be proceeded by message 7 and 8 below. The program proceeds to the next footing.

"SIDE RATIOS TOO RESTRICTING FOR FOOTING"

The program proceeds to the next footing.

"MAXIMUM NUMBER OF PILES EXCEEDED IN FOOTING"

Refer to 2 above.

"FOOTING IS BEING GOVERNED BY UPLIFT OF X"

Where X is the uplift value, Refer to 2 above.

"UNSTABLE LOAD CONDITION ON FOOTING"

This message will be given when the resultant P-load is off the footing (M/P is greater than or equal to one-half the footing width) and only occurs with an analysis of a spread footing.

After detecting an error the program will "flush" out the remainder of the problem and continue to the next one.