DISCLAIMER

Although each program has been tested by its contributor, no warranty, express or implied, is made by the contributor or COMMON, as to the accuracy and functioning of the program and related program material, nor shall the fact of distribution constitute any such warranty, and no responsibility is assumed by the contributor or COMMON, in connection therewith.

COMMON USERS GROUP PROGRAM REVIEW AND EVALUATION

(fill out in typewriter, ink or pencil)

Program No._____ Date_____

Program Name:_____

1. Does the abstract adequately describe what the program is and what it does? Yes____ No____
   Comment_____

2. Does the program do what the abstract says? Yes____ No____
   Comment_____

3. Is the description clear, understandable, and adequate? Yes____ No____
   Comment_____

4. Are the Operating Instructions understandable and in sufficient detail? Yes____ No____
   Comment_____
   Are the Sense Switch options adequately described (if applicable)? Yes____ No____
   Are the mnemonic labels identified or sufficiently understandable? Yes____ No____
   Comment_____

5. Does the source program compile satisfactorily (if applicable)? Yes____ No____
   Comment_____

6. Does the object program run satisfactorily? Yes____ No____
   Comment_____

7. Number of test cases run_____. Are any restrictions as to data, size, range, etc. covered adequately in description? Yes____ No____
   Comment_____

8. Does the Program meet the minimal standards of COMMON? Yes____ No____
   Comment_____

9. Were all necessary parts of the program received? Yes____ No____
   Comment_____

10. Please list on the back any suggestions to improve the usefulness of the program. These will be passed onto the author for his consideration.

Please return to:

Mr. Richard L. Pratt
Data Corporation
7500 Old Xenia Pike
Dayton 32, Ohio

Your Name _____
Company _____
_____
Address _____
_____
Users Group Code _____

THIS REVIEW FORM IS PART OF THE COMMON ORGANIZATION'S PROGRAM REVIEW AND EVALUATION PROCEDURE. NONMEMBERS ARE CORDIALLY INVITED TO PARTICIPATE IN THIS EVALUATION.

11/1/65

1620 Correction
9.2.016

April 10, 1964

"DTM Design System"

Cards 76-78 of the Alignment Design/Offsets object decks of this program are out of sort.

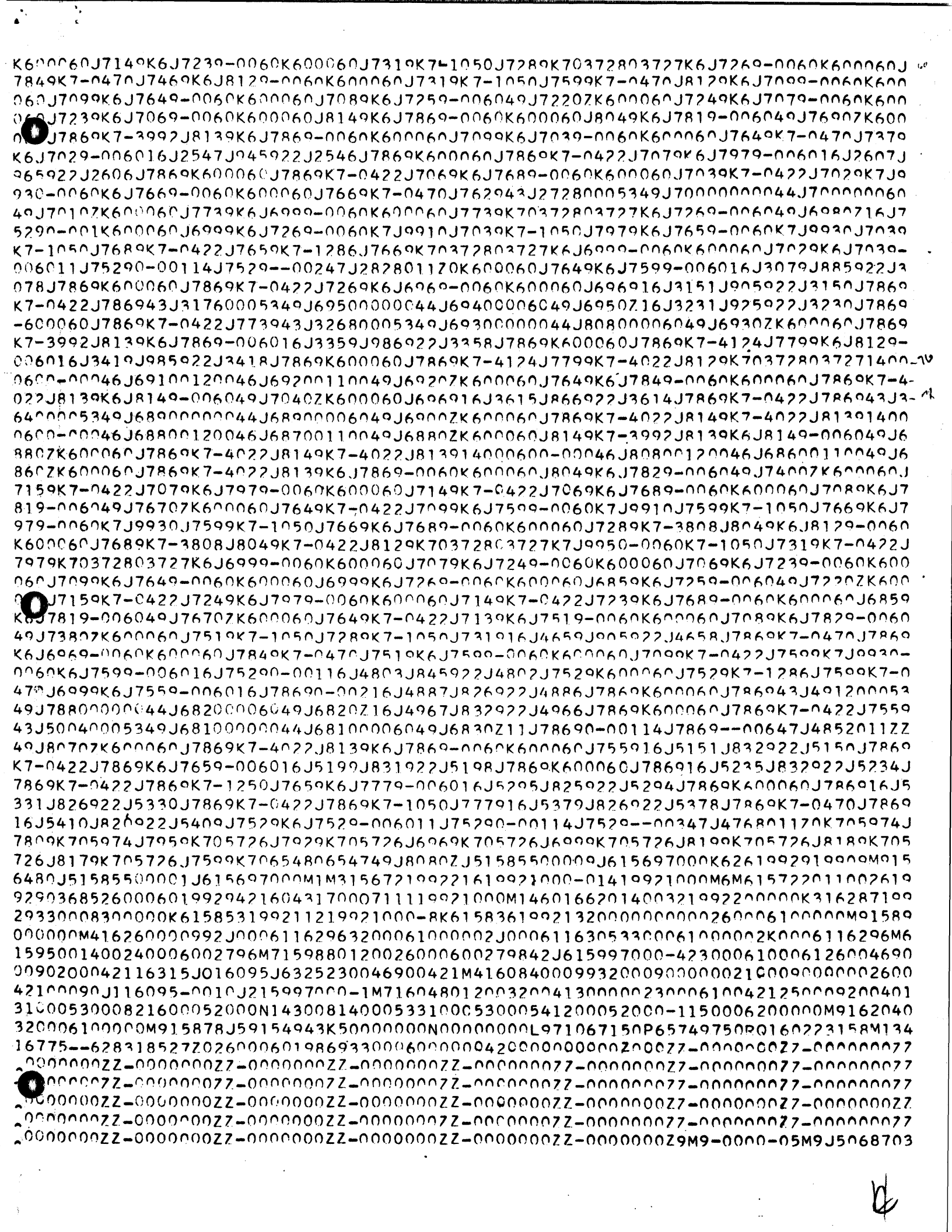
The decks have been replaced. The attached listing dated April 3, 1964 replaces the original listing.

Modifications or revisions to this program, as they occur, will be announced in the appropriate Catalog of Programs for the IBM Data Processing Systems. If such announcement indicates a change to the program decks or tapes, a complete new program, if needed, should be requested from the Program Distribution Center.

Compressed Object Decks Listing - Deck #6 - 1620-09.2.016

360746000500011000060000801400006J8410470000001100361986000500361994000500490750000000000000000000 000000000000000000000000000J704364J8169J704364J8159J704364J8449J704364J8439J704364J8429K600060J9659K7-3992J8139K6J8149-0060K600060J8139K6J8119-0060K600060J8139K6J8109-006049J8090ZK600060J8139K703728037Z7K6J8109-006049J8090ZK600060J8269K6J8319-0060K600060J8209K6J8259-0060K600060J8069K6J8109-0060K600060J8049K6J8059-0060J704612J8039J704612J8029J704364J801916J79990-00116-7875J842922-7874J7999J704612J799916-7911J837922-7910J7999J704612J799916-7947J842922-7946J7999K600060J7999K7-7020-0060K6J7979-0060K600060J7979K7-1050J816916-8026J832922-8025J8059K6J8059-006016-8067J837922-8066J7999K600060J7999K7-7020-0060K6J7979-0060K600060J7979K7-1050J815916-8146J826922-8145J8059K6J8059-0060K600060J8059K7-3992J8139K6J8059-006011J79990-00114J7999--00547-784001170K600060J7959K7-4022J8029140006000-00046J7930012000046J7940011000049J7940ZK600060J7929K7-0422J801943-834000005349J791000000044J7940000604 9J7940ZK600060J8109140006000-00046J7900012000046J7890011000049J8090ZK600060J8109140006000-00046J7880012000046J7890011000049J7890ZK600060J8029K6J7959-0060K600060J8019K6J7929-0060K600060J8309K6J8319-0060K600060J8249K6J8259-0060K600060J8119K6J7869-006016-8627J905922-8626J7869K600060J7869K6J7859-0060K600060J7839K6J7849-0060K600060J8139K6J7829-0060K600060J7809K6J7819-0060K600060J7959K7-4046J8049K6J8129-006016-8783J987922-8782J7869K600060J7869K7-4124J7799K6J7789-006016-8843J986922-8842J7869K600060J7869K7-4124J7799K7-3992J7789K7-4022J8129K703728037Z714000600-00046J7750012000046J7760011000049J7760ZK600060J792916-8983J866922-8982J7869K7-0422J786943-900800053 49J7740000004 4J7740000604 9J8080Z16-9063J925922-9062J7869K600060J7869K7-0422J773943-910000005349J7710000000044J7710000604 9J7720ZK600060J8029K6J7959-0060K600060J8119K7-3992J8139K6J8119-0060K600060J8119K7-4022J8139K6J7869-0060K600060J8139K6J7819-006016-9275J944922-9274J7869K600060J786916-9311J945922-9310J7869K7-0422J7869K6J7979-006016-9359J964922-9358J7869K600060J786916-9395J965922-9394J7869K7-0422J7869K6J7689-0060K600060J7979K7-3808J8049K6J8129-0060K600060J7689K7-3808J8049K7-0470J8129K7J9950-0060K6J7669-0060K600060J7639K6J7649-0060K600060J7669K7-0422J762943-957600053 49J7610000004 4J7600000604 9J7610ZK600060J7589K6J7599-0060K600060J7689 43-965600053 49J7560000004 4J7560000604 9J7570ZK600060J7589K703728037Z7K6J7599-0060K600060J7979K7-1286J7669K7J9870-0060K6J7689-0060K600060J7589K7-0422J7689K7J9870-0060K7-1286J7549K7J9950-0060K6J7559-0060K7J9930J7559K6J7649-006016J75290-001K7J9930J7649K7-0422J7559K703728037Z7K6J7519-0060K600060J7519K7-0422J750943-996400053 49J7490000004 4J7530000604 9J7490ZK600060J7649K7-0470J7519K6J7649-006011J75290-00114J7529--05047-986801170K600060J7599K7-1050J7649K7-1050J7549K6J7649-0060K600060J7979 43J0140000534 9J7470000004 4J7470000604 9J7480ZK600060J7469K7-0422J7649K6J7649-006049J7610ZK600060J7459K7-0470J7649K6J7649-006013J7819000-M32000095000001100099J033126J0299000099 26J0305000004 900000ZJ740J741J742J743J744K600060J7649K6J7839-0060K600060J7869K7-3992J8139K6J7869-0060K600060J8049K6J7309-006049J78707K600060J7649K7-0422J7849K6J7519-0060K600060J7519K7-0422J737943J0504000534 9J7360000000044J7350000604 9J7360ZK600060J7519K7-0470J7349K6J7519-006049J7380ZK600060J7519K7-0422J7349K6J7519-0060K600060J7829K7-4022J8049140006000-00046J7330012000046J7320011000049J7330ZK600060J7589K6J7319-0060K600060J7519 43J0732000534 9J7290000004 4J7290006049J7300ZK600060J7589K703728037Z7K6J7319-0060K600060J7519K7-1286J7549K6J7599-006016J0859J925922J0858J7869K600060J7869K6J7289-0060K7J9930J7599K6J7659-0060K7J9910J7599K7-1250J7659K7-1050J7289K7-1050J7319K6J7279-0060K600060J7849K7-0470J7379K6J7649-0060K600060J7279K6J7269-0060K600060J8139K6J7259-006016J1075J945922J1074J7869K600060J7869K6J7249-006016J1123J965922J1122J7869K600060J7869K6J7239-0060K7J9930J7649K7-1050J7269K7-0470J7249K6J7249-0060K7J9910J7649K7-1050J7269K7-0470J7239K6J7239-006013J7259000-M32000095000001100099J131926J1291000099 26J1297000004 900000007J718J719J720J721K600060J7249K6J7179-0060K600060J7239K6J7169-0060K600060J7319K7-1050J7469K7-0470J7849K6J7649-0060K600060J7289K6J7269-0060K600060J8049K6J7259-006049J7220ZK600060J7249K6J7159-0060K600060J7239K6J7149-0060K600060J7649K6J7139-0060K600060J7829K7-4022J8049140006000-00046J7110012000046J7320011000049J7120ZK600060J7929K7-0422J785943J1656000534 9J7710000000 44J7100000604 9J7710716J1711J885922J1710J7869K600060J7869K7-0422J7929K6J7269-0060K600060J7849K7-0470J7469K6J7099-0060K600060J7089K6J7259-0060K600060J7849K7-0470J7379K6J7649-006016J1867J945922J1866J7869K600060J7869K6J7249-006016J1915J965922J1914J7869K600060J7869K6J7239-006049J7220ZK600060J792916J1983J865922J1982J7869K7-0422J786943J2008000534 9J7760000000 44J7760000604 9J76907K600060J7929K7-0422J7859K7-1286J7289K6J7599-0060K600060J7159K6J7249-0060

April 3 1964



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* DTM DESIGN SYSTEM ** ALIGNMENT DESIGN / OFFSETS OUTPUT
*5 IBL BL STA CL STA OFFSET LEFT ELEV CL ELEV RIGHT ELEV SKEW

DECK KEY

Deck	1	Terrain Prep. Edit
Deck	2	Terrain Prep. Edit Object
Deck	3	Alignment Design Geometry
Deck	4	Alignment Design Geometry - Object
Deck	5	Alignment Design Offsets - Source
Deck	6	Alignment Design Object - Offsets
Deck	7	Roadway Design/Prep.
Deck	8	Roadway Design/Prep. -Object
Deck	9	Roadway Design/Template - Source
Deck	10	Roadway Design/Template - Object
Deck	11	Roadway Design/Volumes - Source
Deck	12	Roadway Design/Volume - Object
Deck	13	Classified Material - Prep.
Deck	14	Classified Material - Prep. - Object
Deck	15	Classified Material - Volumes - Source
Deck	16	Classified Material - Volumes - Object
Deck	17	Combined Plots - Source
Deck	18	Combined Plots - Object
Deck	19	Test Problem

1620 9.2.016 20K

RESEARCH REPORT R62-6

DEPARTMENT OF CIVIL ENGINEERING
CIVIL ENGINEERING SYSTEMS LABORATORY

DTM DESIGN SYSTEM
20K PROGRAM MANUAL

by

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Publication No. 157

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School of Engineering
Massachusetts Institute of Technology

ACKNOWLEDGEMENTS

The authors wish to gratefully acknowledge the research support provided by the Massachusetts Department of Public Works in cooperation with the U.S. Bureau of Public Roads. This support has made possible the research investigations on the use of the Digital Terrain Model System in highway location and design.

The authors also wish to acknowledge the early work on the D.T.M. System done by Professor C. L. Miller and R. A. Laflamme in 1958 and 1959. Many of the system concepts employed in the original version are still valid and have been used in this more advanced system. Credit is also due to Joseph H. Widmer and Thomas R. Plummer of Michael Baker, Jr., Inc. who contributed many ideas and suggestions during the initial stages of program development.

The programs in the system were written, debugged, and tested by many members of the staff of the Civil Engineering Systems Laboratory. Specifically, they are:

Terrain Preparation/Edit	C. L. Miller, E. E. Newman
Alignment Design/Geometry	P. O. Roberts
Alignment Design/Offsets	P. O. Roberts
Roadway Design/Preparation	N. W. Bryan, A. Villaveces
Roadway Design/Template	N. W. Bryan, J. A. Currie
Roadway Design/Volumes	W. A. Briggs, J. A. Currie
Classified Materials/Preparation	J. H. Suhrbier
Classified Materials/Volumes	J. A. Currie
Combined Plots	N. W. Bryan, P. O. Roberts
Flexible Format Subroutines	N. W. Bryan, A. Villaveces

This work has been done in the Civil Engineering Systems Laboratory, a research facility of the Civil Engineering Department at the Massachusetts Institute of Technology.

DIGITAL TERRAIN MODEL
DESIGN SYSTEM

20K PROGRAM MANUAL

INTRODUCTION

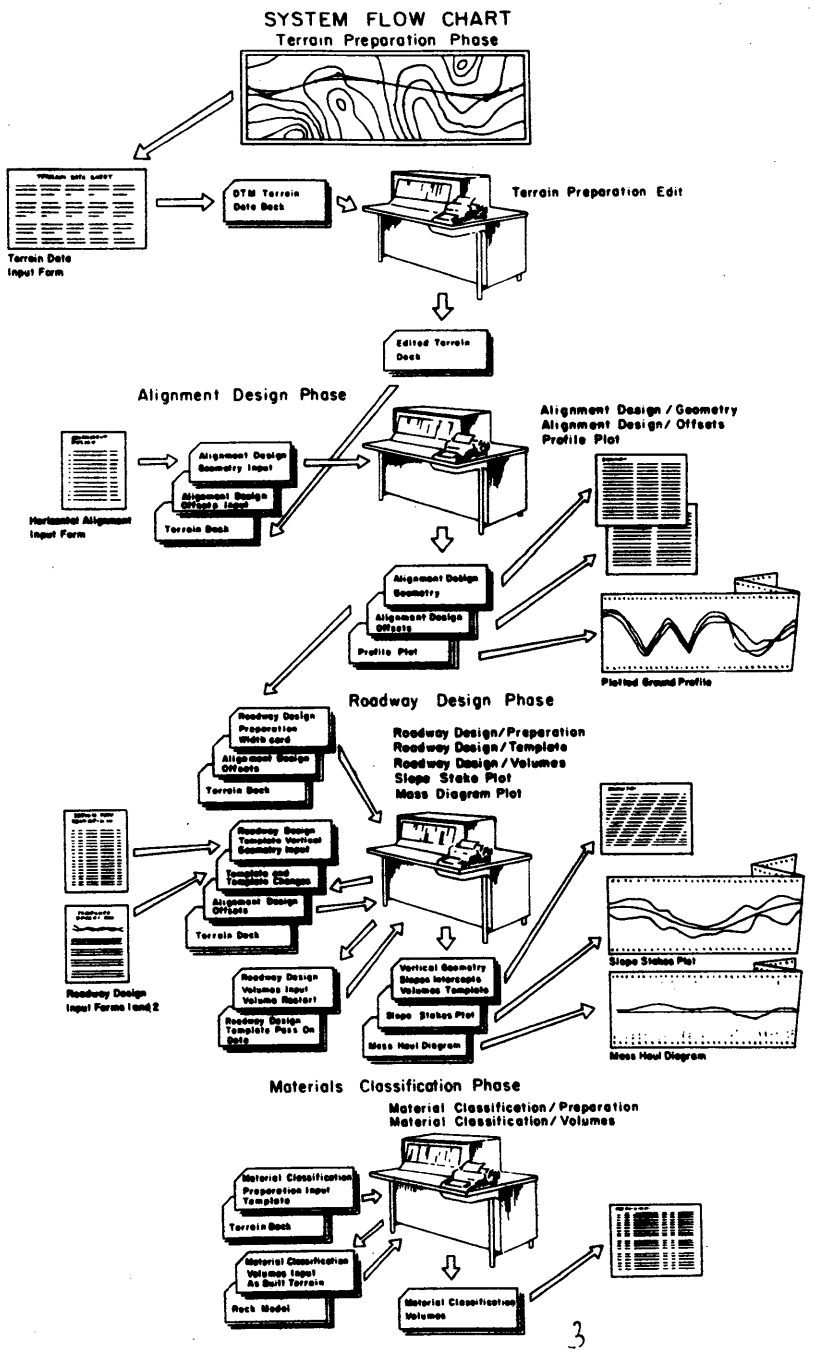
This manual describes a set of electronic computer programs for the final location and design of highways. This series of programs, known as the D.T.M. Design System, employs recently developed techniques of electronic computation and systems engineering in the very complex job of highway design. The programs making up the system have been integrated so that they supplement each other and closely parallel the design procedure followed by the highway engineer.

Since small line and grade changes are frequent even in the design stage of a project, the ability to make these changes easily is highly desirable. This is accomplished by the utilization within the system of curved baselines. Terrain data is taken on both sides of the baseline from either field notes or maps.

On some projects, exact final line and grade selection depends upon a rather careful quanitity determination. By defining the shape of the template using links, it can conform to almost any specified shape. At the same time, it retains flexibility. Templates can be automatically varied to fit new requirements as the computations progress. Bifurcated roadways and separated grades can also be handled.

Although the System itself is based on principles which apply to a wide variety of electronic computers, the programs described in this manual were written in FORTRAN for a 20K I.B.M. 1620 Data Processing System. The structure of the programs is dependent upon the memory size of the computer utilized.

SYSTEM FLOW CHART



PROGRAMS IN THE SYSTEM

The System can be divided logically into four separate phases: the Terrain Preparation Phase, the Alignment Design Phase, the Roadway Design Phase, and the Material Classification Phase. Each is described in more detail in the sections that follow. Each phase is implemented with one or more computer programs, as follows:

Terrain Preparation:
- Terrain Preparation/Edit

Alignment Design:
- Alignment Design/Geometry
- Alignment Design/Offset
- Profile Plot

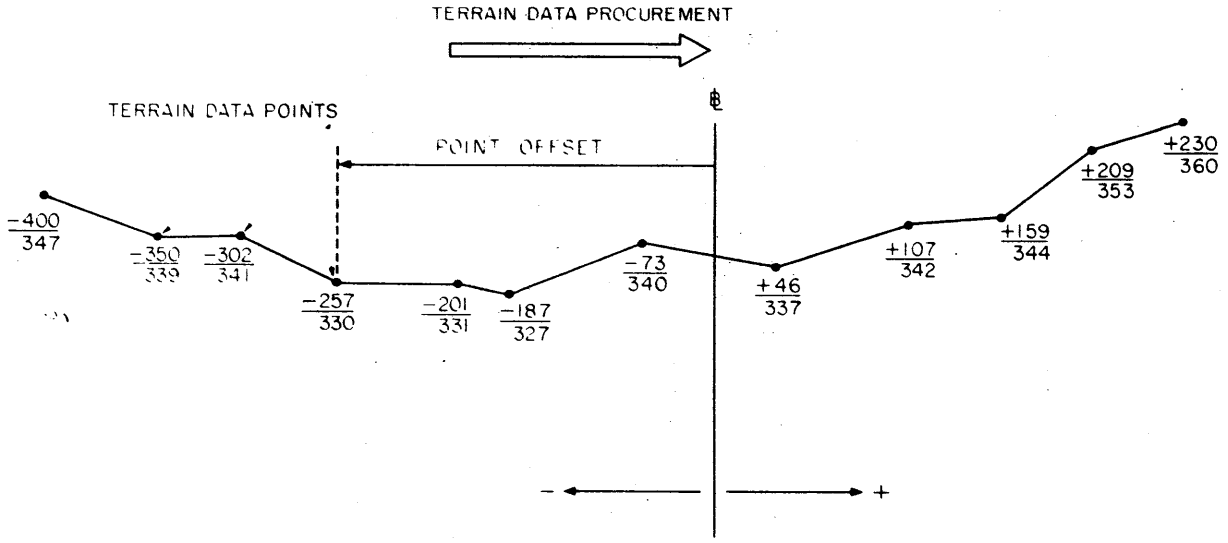
Roadway Design:
- Roadway Design/Preparation
- Roadway Design/Template
- Roadway Design/Volumes
- Slope Stakes and Mass Haul Plot

Materials Classification:
- Materials Classification/Preparation
- Materials Classification/Volumes

TERRAIN PREPARATION PHASE

Terrain data is defined relative to a baseline. The baseline is in turn defined using the state plane coordinates of each P.I. and one curve defining parameter. The terrain model is made up of discrete sample points taken along scan lines or cross sections. Within the band of interest, scan lines are spaced arbitrarily depending on the nature of the terrain and the accuracy requirements. Sample points are taken from left to right across each section. Each terrain point

DEFINITION OF MODEL



is referenced by giving its elevation and its offset distance from the baseline. Points to the left of the baseline are recorded with a negative sign. Points to the right are considered to have a positive offset.

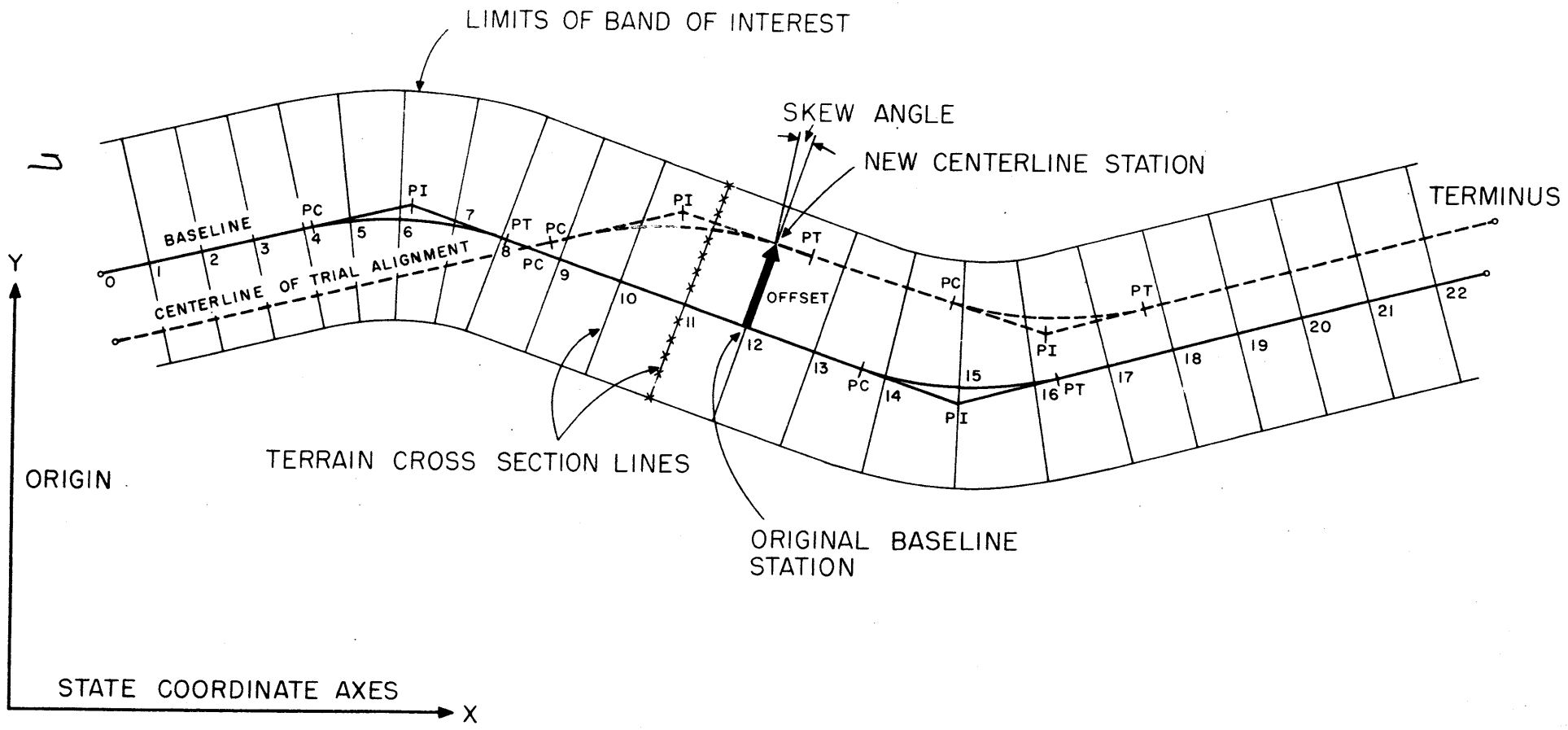
Terrain data may be taken directly from field notes or from topographic maps. After the terrain data has been punched into cards, the Terrain Preparation/Edit program is used to ascertain the accuracy of the data. Those points which do not conform to the logical requirements specified by the engineer are identified by the machine for hand checking.

ALIGNMENT DESIGN PHASE

The purpose of this phase is the calculation of the geometry of the highway centerline alignment and its relationship with the baseline to which the terrain data is referenced. Once this relation has been established at each cross section, the ground profile of the alignment can be interpolated from the terrain model. Both baselines and centerlines are defined by the state plane coordinates of each P.I. and one curve defining parameter given at each P.I. The Alignment Design/Geometry program will compute the geometry of the defined baselines and then proceed to compute the geometry of any number of desired centerline alignments. Geometry information for both alignments is left in memory to be used by the Alignment Design/Offsets program, which will compute the offset distances from the baseline to the centerline. It will then interpolate terrain data on each cross section to find the ground elevation along the centerline of the roadway and along two parallel alignments whose offset distance is specified by the engineer.

The Plot Profile program uses the output from this phase to plot

SYSTEM NOMENCLATURE



a ground profile under the centerline and the two offset lines. This profile will be used by the engineer to design the vertical alignment.

ROADWAY DESIGN PHASE

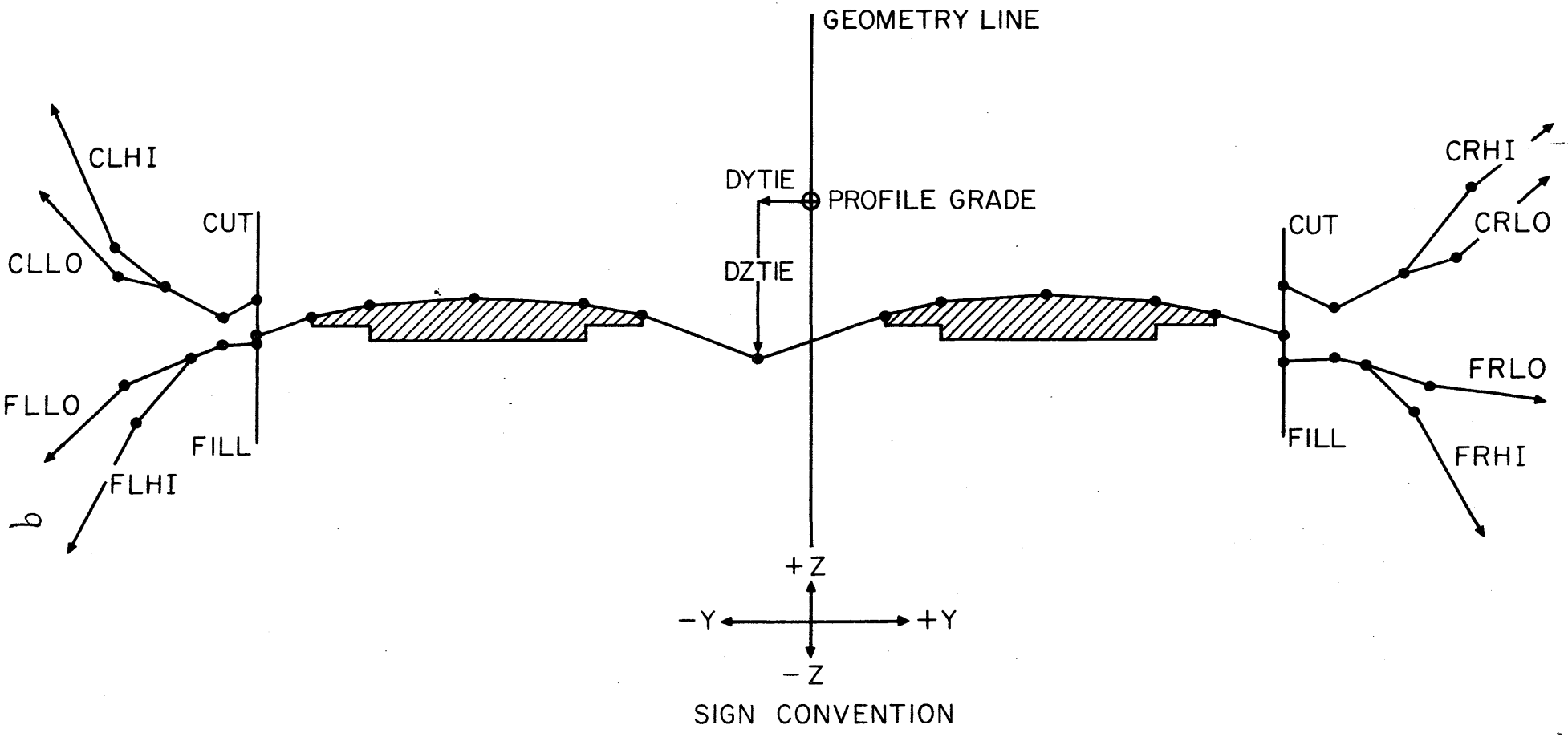
After the engineer has designed the vertical alignment and has delineated the template shape and its changes along the roadway, he may request additional information from the computer. This phase, which has been designated the Roadway Design Phase, includes the computation of vertical geometry and grades, template modifications, such as superelevation, slope intercepts, area, volumes, slope limits plots, and mass haul diagram.

Since trial alignments will ordinarily call for only part of the terrain information that is contained in the digitized band of interest, the Roadway Design/Preparation program can be used to reduce the width of the terrain data band to describe only the area adjacent to each trial alignment. Terrain and offsets cards from the Alignment Design Phase are also collated for use in subsequent passes.

The vertical geometry of the alignment is defined by giving the elevation and station number of each vertical P.I. and the length of each curve to be computed. The roadway template is defined by a series of links, each specified by a dy and a dz, starting at the middle and working both ways. The size of each link is written on an input form along with template changes and other template parameters. After this information has been punched into cards, it is entered into the Roadway Design/Template program which computes the vertical geometry of the trial alignment and the changes in the road template, where such changes occur.

Output from this program is entered directly into the Roadway Design/Volumes program which computes slope intercepts and earthwork

DEFINITION OF TEMPLATE



SIGN CONVENTION

volumes. Through the use of the Combined Plot program, card decks are obtained which can be listed to produce plots of the slope limits and mass haul diagram. The programs in this phase may be used individually without using the Alignment Design programs if the alignment is already fixed.

MATERIALS CLASSIFICATION PHASE

The Materials Classification Phase is included in the system to handle three special cases. The first of these is the case of overlapping slope stakes, where two separate roadways, paralleling each other, overlap slope limits. The second case is that where the roadway lies within rock and where some estimate of rock volume is necessary. A third use for the programs is the calculation of earthwork quantities in interchange areas. If none of these special cases occurs, it is unnecessary to use the programs.

If an overlapping-template situation exists, the first pass through the system is made with one of the roadways and the original terrain. The Materials Classification/Preparation program takes the Roadway Design/Volumes program output and original terrain and computes the "as-built" terrain. The Classified Materials/Volumes program takes this "as-built" terrain along with the rock template and computes the rock volume to be removed.

The determination of interchange volumes is accomplished using the following simple approach. First, the ramps are laid out and designed on a contour map. The Alignment Design and Roadway Design programs may be very useful during this phase. Next, the "as-built" contours for the entire interchange are established. Terrain information for an "as-built" terrain model is then stripped off using the original baseline. After editing, this "as-built" terrain is run with the original terrain model in the Materials Classification/Volumes program to produce cut and fill quantities for the entire interchange.

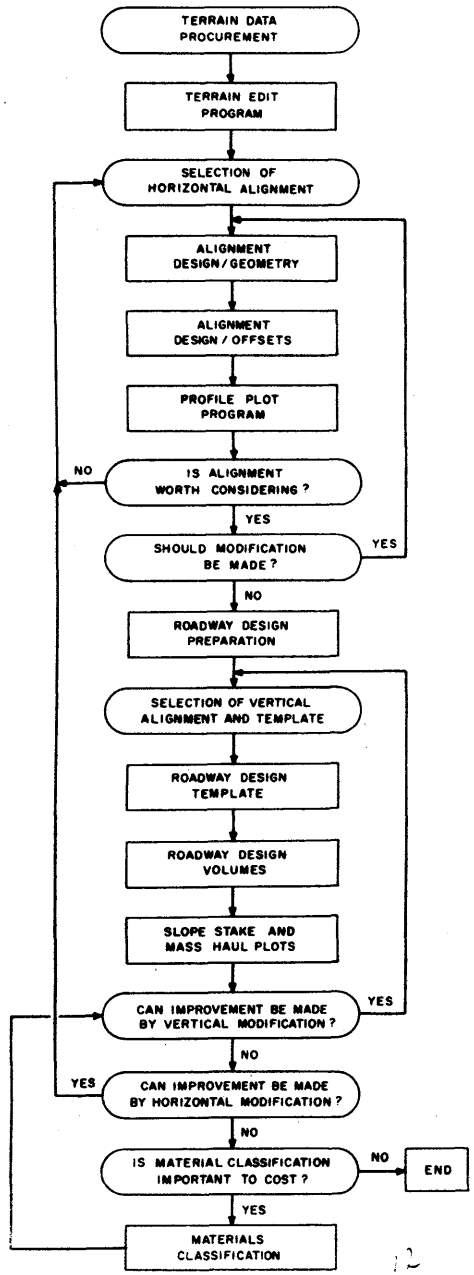
USING THE SYSTEM

The DTM Design System has been programmed primarily to handle the type of computations encountered during the Preliminary Engineering Design phase, although its use is certainly not limited to this phase. It is designed to be able to handle terrain models produced from either map or field data with equal ease. Terrain data, once digitized, may be used over and over for either small line shifts or for major line changes, whether in the initial location studies or in the final design computations. When a change becomes necessary, it can be easily and economically made.

DTM computations are done in phases. Each phase is closely integrated with the design activity of the engineer. For each of the phases, input sheets are completed by the designer and submitted to the computing center. The input information is punched directly into cards and fed to the computer along with the digital terrain model in the form of a deck of cards. After the answers have been received, they are printed with the input and returned to the designer for further engineering before the next phase in undertaken.

Many benefits are obtained as a result of a detailed DTM analysis during the early phases of a project. Right-of-way can be accurately and quickly estimated. Pipe and drainage requirements can be measured directly from machine made plots. The effect of side hill location is immediately apparent. Clearing and grubbing areas can be easily measured. Earthwork quantities are more easily balanced and optimized. In many instances remarkable savings can be realized because of the ability to try several alignments.

USING THE SYSTEM FOR HIGHWAY LOCATION



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TERRAIN PREPARATION/EDIT

Purpose

In the digitization of the band of interest, a large amount of terrain data is frequently recorded. The Terrain Preparation/Edit Program examines the logical reasonableness of the terrain described by the recorded data and prints a warning message when a doubtful situation is found to exist. The messages from the program will not merely point out those situations where a mistake was surely committed, but all those situations as uncommon in occurrence as to be worthy of checking against the original source of terrain data.

Description

At a cross section line, any terrain point is given two coordinates: an offset distance from the baseline (Y-coordinate), and an elevation (Z-coordinate). The criteria applied to determine the reasonableness of the terrain data are as follows:

a. The maximum allowable difference in the elevations of the first points of consecutive sections is five times the contour interval. Failure to meet this test may mean too large a spacing between cross sections, or a mistake made either in recording the elevation of one of the two compared points, or of all points at one of the two sections (see test f).

b. The horizontal distance between consecutive points on the same cross section must not exceed a specified allowable maximum. Failure to meet this test may mean involuntary skipping of too many contour lines.

c. At any cross section, the Y-coordinate of the terrain points must always be increasing and can never be zero. If the terrain data has been recorded in such a way that it fails to meet this test, it will not be acceptable to the programs in the System. It should be taken from left to right, from the largest negative to the largest positive.

13

d. The slope of the ground surface must not exceed a specified maximum. This check will supplement the horizontal distance difference and vertical distance difference tests and will warn the engineer in situations which may not have been detected by such tests.

e. High or low points should be defined by an interpolated offset and elevation. This check will essentially detect situations where the high or low points were missed and will help to eliminate many situations in which a recording mistake was made.

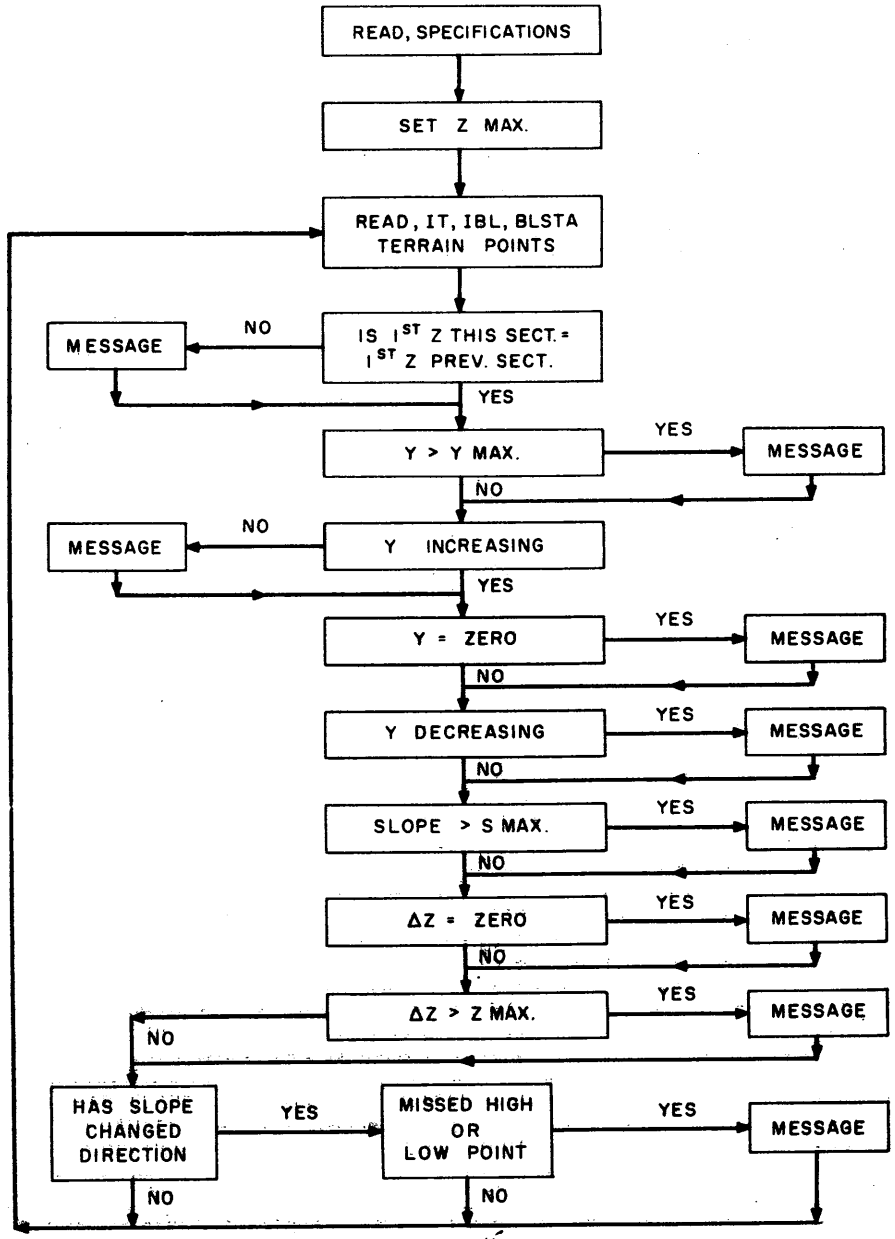
f. The difference in elevation between two consecutive points on the same cross section must not exceed five contour intervals. This check complements test (a) and will tell the engineer whether the mistake in elevation was made for a single point for for the entire section.

Program Operation

A specifications card containing the contour interval, the maximum allowable slope, and the maximum allowable horizontal distance between consecutive points is read in. These can be determined by the engineer for particular map and terrain conditions and will constitute the basis for the quantitative tests to be performed. A terrain cross section is now read in and checked according to the stated criteria.

The tests are performed sequentially; when one of them is not met, a warning message is printed out, indicating the doubtful situation just found, before performing the next test. When all the tests have been completed at a section, a new terrain cross section is read in and analyzed. The engineer should after each run check the warning messages against the source map and then test the corrected terrain data until all warning messages received correspond to acceptable terrain conditions.

MACRO FLOW DIAGRAM
TERRAIN PREPARATION/EDIT



TERRAIN PREPARATION/EDIT
OPERATING INSTRUCTIONS

Console Switches

1. PARITY - off, I/O CHECK - off, O FLOW - program
2. Sense Switches 1 not used
   2 not used
   3 not used
   4 not used

Typewriter

Not used

Loading Program

1. Clear memory 310000300002
2. INSTANT STOP, RESET, LOAD

Order of Input

1. Object Program Deck
2. Specification Card

   CI, SMAX, YMAX

   CI = Contour Interval SMAX = Maximum Slope % YMAX = Maximum Distance Between Points
3. Terrain Data Deck

   1, IBL, BLSTA, IY1, IZ1, IY2, IZ2, IY3, IZ3, IY4, IZ4, IY5, IZ5

Special Instructions

None

Restart Procedure

1. INSTANT STOP, RESET, INSERT 4908300
2. RELEASE, START

Sorting and Listing Instructions

List with 80 column straight list. The output messages are self-explanatory.


```
C     DTM DESIGN SYSTEM ** TERRAIN PREPARATION / EDIT ** 20K
C     C.L.MILLER + E.E.NEWMAN * * NOV. 27, 1961
C     CIVIL ENGINEERING SYSTEMS LABORATORY
      DIMENSION Y(50),Z(50),A(5),B(5),K(5),L(5)                          00001
C     INITIALIZATION ROUTINE
C     READ SPECIFICATION CARD
    1 FORMAT(F10.2,F10.2,F10.2)                                          00002
    2 READ 1,CI,SMAX,YMAX                                                00003
    4 FORMAT(46H DTM DESIGN SYSTEM ** TERRAIN PREPARATION / EDIT)        00004
      PUNCH 4                                                            00005
C     CI=CONTOUR INTERVAL, SMAX=MAX. SLOPE IN PERCENT
C     YMAX=MAX DISTANCE BETWEEN POINTS
      ZMAX=5.*CI                                                         00006
      PUNCH 1,CI,SMAX,YMAX                                               00007
C                 READ ROUTINE
C                 FORMAT FOR DATA CARDS
    9 FORMAT(I3,I3,F10.2,I6,I5,I6,I5,I6,I5,I6,I5,I6,I5)                  00008
C                 READ VERY FIRST CARD
  200 READ 9,I,J,X,K(1),L(1),K(2),L(2),K(3),L(3),K(4),L(4),K(5),L(5)     00009
      DO 60 I=1,5                                                        00010
      A(I)=K(I)                                                          00011
      B(I)=L(I)                                                          00012
   60 CONTINUE                                                           00013
  201 XB=-99999.                                                         00014
      ZONE=B(1)                                                          00015
  202 N=0                                                                00016
  203 I=1                                                                00017
  204 ANS1=ABSF(A(I))+ABSF(B(I))                                         00018
      IF(ANS1)206,206,205                                                00019
C     N IS NUMBER OF POINTS ON SECTION
  205 N=N+1                                                              00020
      Y(N)=A(I)                                                          00021
      Z(N)=B(I)                                                          00022
      I=I+1                                                              00023
      IF(I-5)204,204,206                                                 00024
  206 READ 9,I,M,XT,K(1),L(1),K(2),L(2),K(3),L(3),K(4),L(4),K(5),L(5)    00025
      DO 61 I=1,5                                                        00026
      A(I)=K(I)                                                          00027
      B(I)=L(I)                                                          00028
   61 CONTINUE                                                           00029
      IF(X-XT)207,203,207                                                00030
  207 IF(X-XB)208,208,209                                                00031
  208 PUNCH 20,J,X                                                       00032
   20 FORMAT(I3,F10.2,18H  X NOT INCREASING)                             00033
C     CHECKING ROUTINE
  209 ZB=(Z(2)-Z(1))                                                     00034
      ZTEST=(Z(1)-ZONE)                                                  00035
      ANS2=ABSF(ZTEST)-5.*CI                                             00036
       IF(ANS2)220,220,590                                               00037
  590 PUNCH 29,J,X,Y(1),ZTEST                                            00038
   29 FORMAT(I3,F10.2,F10.2,23H FIRST POINTS DIFFER BY F10.2, 5H FEET)   00039
  220 NC=N-1                                                             00040
  210 DO 999 I=1,NC                                                      00041
      YA=Y(I+1)-Y(I)                                                     00042
      ZA=Z(I+1)-Z(I)                                                     00043
      ANS3=ABSF(YA)-YMAX                                                 00044
      IF(ANS3)101,101,501                                                00045
  501 PUNCH 10,J,X,Y(I),YA                                               00046
   10 FORMAT(I3,F10.2,F10.2,32H DELTA Y EXCEEDS MAX, DELTA Y IS F10.2)   00047
```

```
      GO TO 106                                                          00048
101   IF(YA)503,502,105                                                  00049
502   PUNCH 11,J,X,Y(I)                                                  00050
 11   FORMAT(I3,F10.2,F10.2,16H DELTA Y IS ZERO)                         00051
      GO TO 106                                                          00052
503   PUNCH 12,J,X,Y(I),YA                                               00053
 12   FORMAT(I3,F10.2,F10.2,27H POINTS OVERLAP, DELTA Y IS F10.2)        00054
      GO TO 106                                                          00055
105   ANS4=ABSF((ZA*100.)/YA)                                            00056
      IF(ANS4-SMAX)106,106,504                                           00057
504   PUNCH 13,J,X,Y(I),YA,ZA                                            00058
 13   FORMAT(I3,F10.2,F10.2,19H SLOPE EXCEEDS MAX,F10.2,F10.2)           00059
106   ANS5=ABSF(ZA)-.01                                                  00060
      IF(ANS5)505,505,107                                                00061
505   PUNCH 14,J,X,Y(I)                                                  00062
 14   FORMAT(I3,F10.2,F10.2, 16H DELTA Z IS ZERO)                        00063
      GO TO 114                                                          00064
107   ANS6=ABSF(ZA)-ZMAX                                                 00065
      IF(ANS6)108,109,506                                                00066
506   PUNCH 15,J,X,Y(I),ZA                                               00067
 15   FORMAT(I3,F10.2,F10.2,34H  DELTA Z EXCEEDS 5XCI, DELTA Z IS F10.2) 00068
      GO TO 114                                                          00069
108   ANS7=ABSF(ZA)-CI                                                   00070
      IF(ANS7)109,109,509                                                00071
509   PUNCH 21,J,X,Y(I),ZA                                               00072
 21   FORMAT(I3,F10.2,F10.2,30H SKIPPED CONTOURS, DELTA Z IS F10.2)      00073
      GO TO 114                                                          00074
109   IF(ZB*ZA)110,114,114                                               00075
110   ANS8=ABSF(ZB)-CI                                                   00076
       IF(ANS8)111,112,112                                               00077
111   ANS9= ABSF(ZA)-CI                                                  00078
      IF(ANS9)114,114,112                                                00079
112   IF(ZB)507,114,508                                                  00080
507   PUNCH 16,J,X,Y(I)                                                  00081
 16   FORMAT(I3,F10.2,F10.2,30H  MISSED LOW POINT OR BAD DATA)           00082
550   PUNCH 17,Y(I-1),Z(I-1),Y(I),Z(I),Y(I+1),Z(I+1)                     00083
 17   FORMAT(F10.2,F10.2,F10.2,F10.2,F10.2,F10.2)                        00084
      GO TO 114                                                          00085
508   PUNCH 18,J,X,Y(I)                                                  00086
 18   FORMAT(I3,F10.2,F10.2,31H  MISSED HIGH POINT OR BAD DATA)          00087
      GO TO 550                                                          00088
114   ZB=ZA                                                              00089
999   CONTINUE                                                           00090
      XB=X                                                               00091
      X=XT                                                               00092
      ZONE=Z(1)                                                          00093
      IF(M-J)666,202,666                                                 00094
666   PUNCH 19,M,XT                                                      00095
 19   FORMAT(I3,F10.2,15H NEW JOB NUMBER)                                00096
      J=M                                                                00097
      GO TO 202                                                          00098
      END                                                                00099
```


ALIGNMENT DESIGN/GEOMETRY

Purpose

The major purpose of this program is the computation of the alignment geometry of a series of highway alignments defined by one or more baselines and centerlines. A table containing the geometry is then passed on to an offset computation program. It computes the centerline station number and distance between the baseline and the centerline at each cross section. This output is used by the rest of the system. The geometry of single alignments can also be computed.

Description

Two types of lines are designated by the engineer; baselines and centerlines. Each line is defined by giving the X and Y coordinates of each P.I. and one curve defining parameter (radius, tangent, degree of curvature, or external distance). The first line so defined is automatically the baseline; the second is the centerline.

Each line can be made up of one to several shorter segments each identified by a unique line number and defined by P.I.'s as described above. The end of each segment is indicated by an 888888.88 in the radius field. The end of the baseline is indicated by a 999999.99 in the radius field.

Each P.I. is given a 4 digit point number. The first 2 digits contain the line number on which the point appears. The last two digits are the identification number of the point. No particular order need be observed with regard to numbering the points, except that the line numbers must match for all points on the same line.

Stationing is initiated by placing the origin station number in

the radius field. With the exception of the first line an origin station number of exactly zero causes the program to use the terminus station of the previous line. Geometry can be computed on lines containing station equations by giving the line on each side of a station equation a different line number. The point of the equation is both the terminus of one line and the origin of the other.

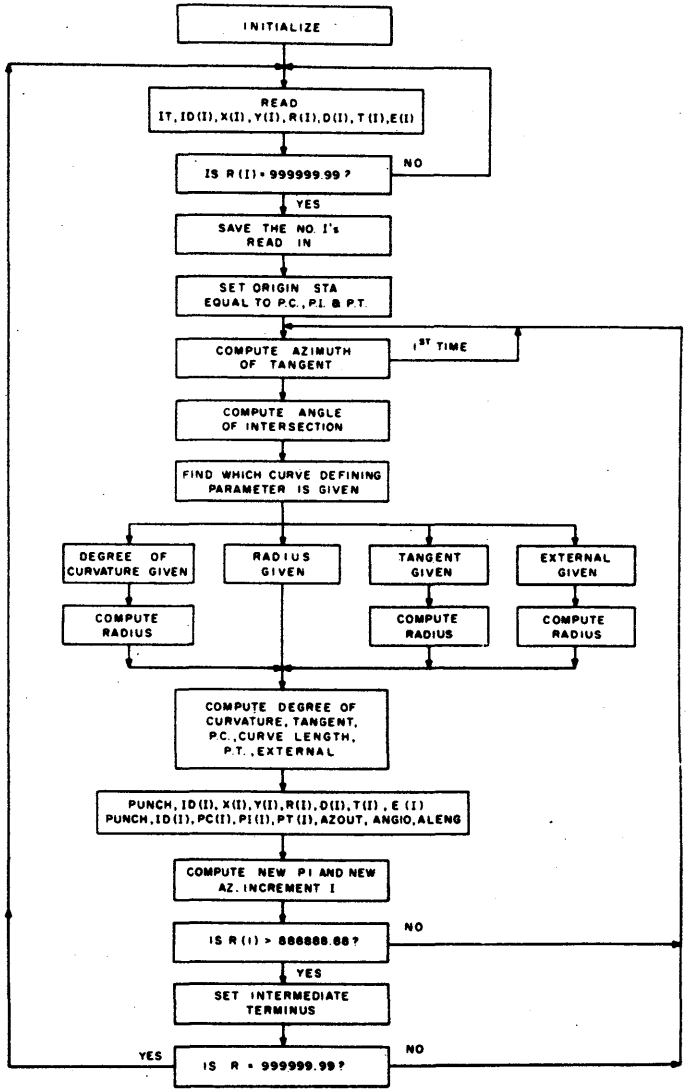
Program Operation

The program reads in the point number, the X coordinate, and the Y coordinate for each point and either the radius, degree of curvature, tangent, or external as a non-zero number to define each curve. (If all of the curve parameters are zero, the curve is treated as a zero-radius curve.)

As soon as the program senses a 999999.99 in the radius field of one of the input cards, the program stops reading and begins computation of the baseline alignment. The P.C., P.I., and P.T. station numbers for each curve are computed and output along with the radius, degree of curvature, tangent, external, X and Y coordinates and point number.

Control is then passed back to the input routine which initiates computations for the centerline alignment. If no center line computation is entered by the engineer, none is obtained. Computations for the centerline are performed in the same manner as those of the baseline. Output terminates the program.

MACRO FLOW DIAGRAM
ALIGNMENT DESIGN / GEOMETRY



ALIGNMENT DESIGN/GEOMETRY
OPERATING INSTRUCTIONS

Console Switches

1. PARITY - off, I/O CHECK - off, OFLOW - program
2. Sense Switches
   1 not used
   2 not used
   3 not used
   4 not used

Typewriter

Not used

Loading Program

1. Clear memory 310000300002
2. INSTANT STOP, RESET, LOAD

Order of Input

1. Program Deck
2. Up to 20 baseline and centerline input cards, with each line terminated by 999999.99 in the radius field.

Input List

3, IP, X, Y, RAD, DEG, TAN, EXT

Special Instructions

The geometry table computed by this program is retained in memory for use by the Alignment Design/Offset program. Therefore, a restart procedure should not be used unless a mistake has been made and it is necessary to start over or unless the offsets program is not to be run.

Restart Procedure

1. INSTANT STOP, RESET, INSERT 4907500
2. RELEASE, START

Sorting and Listing Instructions

No sorting is necessary. List with an 80 column 407 panel.

Output List

3, IP, X, Y, RAD, DEG, TAN, EXT

3, IP, PC, PI, PT, AZ, ANGI, CLENG


```
C     DTM DESIGN SYSTEM ** ALIGNMENT DESIGN / GEOMETRY ** 20 K
C     P.O. ROBERTS / AUG 18,1961
C     CIVIL ENGINEERING SYSTEMS LABORATORY
      DIMENSION ID (21),Y(20),X(20),R(20),PC(20),PI(20),PT(20),OFFD(3)      00001
      DIMENSION D(20),T(20),E(20)                                          00002
C     INITIALIZE
  100 I=0                                                                  00003
C     READ ROUTINE
      DO 262 N=1,2                                                         00004
      ID(21)=J                                                             00005
      DO 120 J=1,20                                                        00006
      I=I+1                                                                00007
      READ,IT,ID(I),X(I),Y(I),R(I),D(I),T(I),E(I)                          00008
      IF(R(I)-999999.98)120,140,140                                        00009
  120 CONTINUE                                                             00010
  140 I=I-J+1                                                              00011
  200 ISW1=1                                                               00012
      ISW3=1                                                               00013
      RI=R(I)                                                              00014
      PI(I)=RI                                                             00015
      PC(I)=RI                                                             00016
      PT(I)=RI                                                             00017
      C=0.0                                                                00018
      T(I)=0.                                                              00019
  201 ISW4=1                                                               00020
      GO TO 10                                                             00021
  206 IF(ISW1-2)248,210,210                                                00022
  248 ISW1=2                                                               00023
      ANGIO=0.0                                                            00026
      ALENG=0.0                                                            00025
      GO TO 232                                                            00026
  210 ANGI= AZ-AZO                                                         00027
  212 IF(ANGI-3.1415927) 211,211,214                                       00028
  211 ANGI=ANGI+6.2831854                                                  00029
      GO TO 212                                                            00030
  214 ANGI=ANGI-6.2831854                                                  00031
      IF(ANGI)208,209,209                                                  00032
  208 DS=-1.0000000                                                        00033
      GO TO 205                                                            00034
  209 DS=1.0000000                                                         00035
  205 ANG=ANGI/2.                                                          00036
C     FIND WHICH IS GIVEN
      IF(R(I))221,216,221                                                  00037
  216 IF(D(I))221,217,219                                                  00038
  217 IF(T(I))221,218,220                                                  00039
  218 IF(E(I))221,222,223                                                  00040
C     IF D IS GIVEN
  219 R(I)=5729.5780/D(I)                                                  00041
      GO TO 221                                                            00042
C     IF T IS GIVEN
  220 R(I)=T(I)*COS(ANG)/SIN(ANG)*DS                                       00043
      GO TO 221                                                            00044
C     IF E IS GIVEN
  223 R(I)=E(I)/(1./COS(ANG)-1.)                                           00045
      GO TO 221                                                            00046
C     IF NONE ARE GIVEN
  222 D(I)=0.0                                                             00047
      GO TO 215                                                            00048
  221 D(I)=5729.5780/R(I)                                                  00049
```

```
215   T(I)=R(I)*(SIN(ANG)/COS(ANG))*DS                                  00050
      PC(I)=PI(I)-T(I)                                                  00051
      ALENG=ANGI*R(I)*DS                                                00052
      PT(I)=PC(I)+ALENG                                                 00053
      E(I)=(1./COS(ANG)-1.)*R(I)                                        00054
      ANGIO=ANGI*57.295780                                              00055
232   AZOUT= AZ*57.295780                                               00056
      PUNCH,IT,ID(I),X(I),Y(I),R(I),D(I),T(I),E(I)                      00057
      PUNCH,IT,ID(I),PC(I),PI(I),PT(I),AZOUT,ANGIO,ALENG                00058
      PI(I+1)=PT(I)-T(I)+C                                              00059
      AZO=AZ                                                            00060
      I=I+1                                                             00061
240   IF(R(I)-888888.87)242,244,244                                     00062
242   CONTINUE                                                          00063
      GO TO 201                                                         00064
244   PC(I)=PI(I)                                                       00065
      PT(I)=PI(I)                                                       00066
      PUNCH,IT,ID(I),X(I),Y(I),R(I)                                     00067
      PUNCH,IT,ID(I),PC(I),PI(I),PT(I)                                  00068
260   IF(R(I)-999999.98)250,262,262                                     00069
262   CONTINUE                                                          00070
      PAUSE                                                             00071
      GO TO 100                                                         00072
250   I=I+1                                                             00073
      IF(R(I))200,252,200                                               00074
252   R(I)=PI(I-1)                                                      00075
      GO TO 200                                                         00076
C     AZIMUTH DISTANCE SUBROUTINE                                       00077
 10   A=X(I+1)-X(I)                                                     00078
      B=Y(I+1)-Y(I)                                                     00079
 11   C=SQR(A**2+B**2)                                                  00080
      IF(A)15,12,15                                                     00081
 12   IF(B)13,14,14                                                     00082
 13   AZ=3.1415927                                                      00083
      GO TO 18                                                          00084
 14   AZ=0.0                                                            00085
      GO TO 18                                                          00086
 15   ANG=ATN(B/A)                                                      00087
 16   IF(A)19,12,17                                                     00088
 17   AZ=1.5707964-ANG                                                  00089
      GO TO 18                                                          00090
 19   AZ=4.7123890-ANG                                                  00091
 18   GO TO (206,100),ISW4                                              00092
      END
```


ALIGNMENT DESIGN/OFFSETS

Purpose

The purpose of this program is the computation of the offset distance from a baseline to a centerline and the determination of the centerline station number of the intersection as well as the amount of skew in the cross section. Further, this program uses the computed offset distance and the terrain cross section to determine the elevation of the ground beneath the centerline for a left and right offset point. This information is later used by the plot profile program to plot a ground profile

Description

Computations can be performed with the centerline on either side of the baseline. An offset to the left is a negative offset; to the right, positive. Similarly, terrain points are recorded with offsets and elevations, 5 points to a card, from left to right using the sign convention above. Terrain multiplication factors are employed to control scaling of the terrain offsets and elevations. Widths up to 9999 feet to either side of the baseline may be used with a multiplication factor of 1.0.

Terrain cross sections contain both a baseline number and a baseline station. The baseline number is sequentially compared with the point numbers in the geometry table until the point numbers on both sides of the terrain cross section match. The baseline numbers given in the geometry table must therefore match those on the terrain cards.

Program Operation

The program uses the tables of IP, X, Y, R, P.C., P.I., P.T., which were left in the computer memory by the Alignment Design/Geometry program. The geometry computation must, therefore, immediately precede the

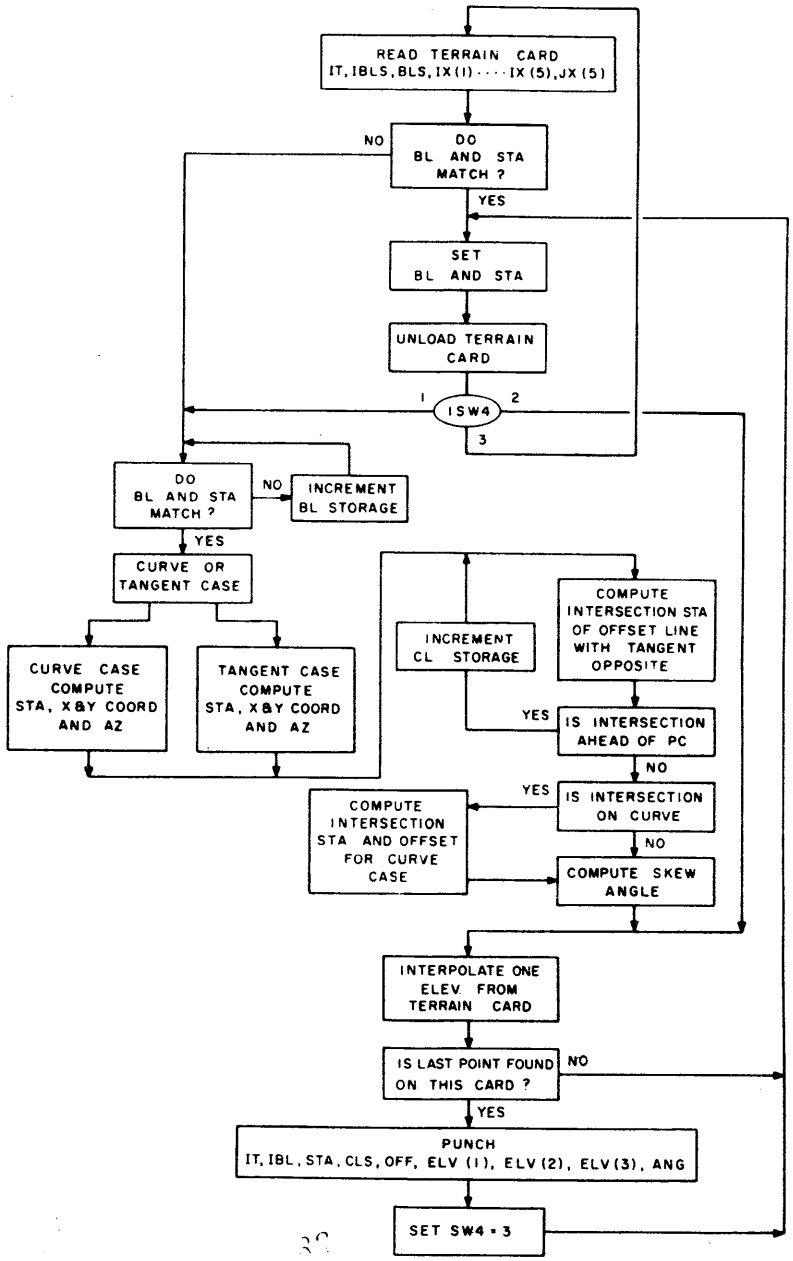
offset run.

The program reads in the first terrain card in order to get the baseline number and baseline station. The geometry table is searched to find where on the baseline this terrain section is. Once the point in front and behind are located, the logic of the program determines whether the cross section is on a tangent or a curve. Then, the coordinates on the baseline and a local normal are established. Control is then passed to the next routine.

The normal from the baseline is intersected with a tangent formed by two points on the centerline. Using the geometry table again, the station number of the intersection is compared with the P.C. and P.T. to determine whether the intersection is on tangent or curve or whether it falls beyond both. If the intersection is on curve, the offset and station are corrected before control is passed to the terrain interpolation routine.

Using the offset, the terrain points from the first card are interpolated to find the elevation. If the offset cannot be found on the first card, additional cards are read until the correct distance is found, or until the baseline changes. This procedure is repeated for each cross section on the baseline. Output consists of baseline number, baseline station, centerline station, offset, left offset elevation, centerline elevation, right offset elevation, and cosine of the skew angle.

MACRO FLOW DIAGRAM
ALIGNMENT DESIGN / OFFSETS



ALIGNMENT DESIGN/OFFSETS
OPERATING INSTRUCTIONS

Console Switches

1. PARITY - off, I/O CHECK - off, OFLOW - program
2. Sense Switches
   1 not used
   2 not used
   3 not used
   4 not used

Typewriter

Not used

Loading Program

1. DO NOT CLEAR memory
2. Must be loaded after Alignment Design/Geometry
3. RESET, LOAD

Order of Input

1. Program deck
2. Multiplication factor card

   FAC1, FAC2
3. Offset Card

   OFFL, OFFCL, OFFR
4. Terrain Deck

   1, IBL, BLSTA, IY1, IZ1, IY2, IZ2, IY3, IZ3, IY4, IZ4, IY5, IZ5
5. Final terrain section (one beyond end)

Special Instructions

The geometry table used by this program must be left in memory by the Alignment Design/Geometry program. Therefore, the memory cannot be cleared between runs, nor can other programs be run between them.

Restart Procedure

1. INSTANT STOP, RESET, INSERT 4907500
2. RELEASE START

Sorting and Listing Instructions

No sorting is necessary. List with an 80 column 407 panel.

Output List

5, IBL, BLSTA, CLSTA, OFF, ELEVL, ELEVC, ELEVR, SKEW


```
C     DTM DESIGN SYSTEM ** ALIGNMENT DESIGN / OFFSETS  ** 20 K
C     P.O. ROBERTS / OCT 2,1961
C     REVISION 1 POR  22 MARCH 62
C     CIVIL ENGINEERING SYSTEMS LABORATORY
      DIMENSION ID(21),Y(20),X(20),R(20),PC(20),PI(20),PT(20),OFFD(3)      00001
      DIMENSION JD(5),JE(5),D( 6),E( 6),ELV(3)                            00002
C     READ TERRAIN MULTIPLICATION FACTORS
      READ,FAC1,FAC2,OFFD(1),OFFD(2),OFFD(3)                              00003
      K=ID(21)+1                                                          00004
      J=1                                                                 00005
      ISW4=1                                                              00006
      GO TO 410                                                           00007
C     REENTRY POINT
  442 ISW4=-1                                                             00008
      GO TO 410                                                           00009
  401 D(1)=D(6)                                                           00010
      E(1)=E(6)                                                           00011
      ISW4=0                                                              00012
C     READ ONE TERRAIN CARD
C     FIVE PER CARD TERRAIN/ALL CARDS FULL
C     LAST CARD MUST CONTAIN ZEROS IN UNUSED WORDS
  410 N=2                                                                 00013
      READ,IT,IBLS,BLS                                                    00014
C     UNLOAD CARD
      DO 455 M=1,5                                                        00015
      READ,JD(M),JE(M)                                                    00016
  454 A=JD(M)                                                             00017
      D(N)=A*FAC1                                                         00018
      A=JE(M)                                                             00019
      E(N)=A*FAC2                                                         00020
  455 N=N+1                                                               00021
C     ARE WE TO A NEW CROSS SECTION
  430 IF(IBL-IBLS)460,431,460                                             00022
  431 IF(STA-BLS)460,450,460                                              00023
  450 IF(ISW4)410,700,470                                                 00024
  460 IF(ISW4)470,705,470                                                 00025
  470 IBL=IBLS                                                            00026
      STA=BLS                                                             00027
      D(1)=D(2)                                                           00028
      E(1)=E(2)                                                           00029
C     COMPUTE COORDINATES ON BASELINE
  500 I=J                                                                 00030
      PCI=PC(I)                                                           00031
      AZO=AZB                                                             00032
      ISW3=1                                                              00033
      ISW2=5                                                              00034
C     CHECK FOR MATCHING BASELINES
      IF(IBL*2-(ID(I-1)/100+ID(I)/100))510,515,510                        00035
  515 IF(STA-PT(I-1))442,520,520                                          00036
  520 IF(R(I)-888888.88)525,530,530                                       00037
C     GO TO GEOM 1
C     GEOMETRY SUBROUTINE
  509 IBL=IBLS                                                            00038
  510 J=J+1                                                               00039
      I=J-1                                                               00040
      ISW2=1                                                              00041
C     GO TO AZ DIS 1
C     AZIMUTH DISTANCE SUBROUTINE
   10 A=X(I+1)-X(I)                                                       00042
```

```
      B=Y(I+1)-Y(I)                                                    00043
 11   C=SQR(A**2+B**2)                                                 00044
      AZ=0.0                                                           00045
      IF(C-.00001)18,18,12                                             00046
   12 ANG=1.0                                                          00047
      IF(B)3,4,4                                                       00048
    3 ANG=-1.0                                                         00049
    4 B=ABSF(A/C)                                                      00050
      P=SQR(ABSF(1.0-B)/2.)                                            00051
      AZ=SINF(P)                                                       00052
      DO 14 L=1,50                                                     00053
      ANGI=P-SINF(AZ)                                                  00054
      IF(ANGI-.1E-05)15,15,14                                          00055
   14 AZ=AZ+ANGI                                                       00056
 15   AZ=(ANG*AZ)*2.                                                   00057
      IF(A)17,16,16                                                    00058
   16 AZ=1.5707964-AZ                                                  00059
      GO TO 18                                                         00060
   17 AZ=4.7123890+AZ                                                  00061
   18 GO TO (207,605,660,685,210),ISW2                                 00062
  207 AZB=AZ                                                           00063
      I=I+1                                                            00064
      ISW1=2                                                           00065
      GO TO 500                                                        00066
 210  ANGI= AZ-AZO                                                     00067
C     ADJUST ANGLES TO LESS THAN 180 DEGREES
 212  IF(ANGI-3.1415927) 211,211,214                                   00068
 211  ANGI=ANGI+6.2831854                                              00069
      GO TO 212                                                        00070
 214  ANGI=ANGI-6.2831854                                              00071
      IF(ISW3-2)204,204,690                                            00072
C     COMPUTE SIGN OF DEFLECTION ANGLE
 204  DS=1.0                                                           00073
      IF(ANGI)208,205,205                                              00074
 208  DS=-1.0                                                          00075
 205  ANG=ANGI/2.                                                      00076
C     COMPUTE CURVE TANGENT
      RI=R(I)                                                          00077
      TANG=RI*(SIN(ANG)/COS(ANG))*DS                                   00078
      AZ=AZO+3.1415927                                                 00079
C     FIND COORDINATES OF PC
      DIS=TANG                                                         00080
      ISW5=1                                                           00081
      XI=X(I)                                                          00082
      YI=Y(I)                                                          00083
C     GO TO COORD 1
C     COMPUTE COORDINATES SUBROUTINE
 20   XI=XI+DIS*SIN(AZ)                                                00084
      YI=YI+DIS*COS(AZ)                                                00085
      GO TO (216,217,540,680),ISW5                                     00086
 216  PCX=XI                                                           00087
      PCY=YI                                                           00088
C     FIND COORDINATES OF CIRCLE CENTER
      AZ=AZO+DS*1.5707964                                              00089
      DIS=RI                                                           00090
      ISW5=2                                                           00091
      GO TO 20                                                         00092
C     GO TO COORD 2
 217  XO=XI                                                            00093
```



```
      YO=YI                                                            00094
      PCAZ=AZ                                                          00095
      IF(ISW3-2)550,655,690                                            00096
 525  IF(STA-PCI)530,530,545                                           00097
C     TANGENT CASE
 530  DIS=PI(I)-STA                                                    00098
      AZMIT=AZO+1.5707964                                              00099
      ISW5=3                                                           00100
      AZ=AZO+3.1415927                                                 00101
      XI=X(I)                                                          00102
      YI=Y(I)                                                          00103
      GO TO 20                                                         00104
C     GO TO COORD 3
 545  IF(STA-PT(I))10,510,510                                          00105
C     CURVE CASE
 550  ANG=(STA-PCI)/RI                                                 00106
      XI=XO                                                            00107
      YI=YO                                                            00108
      DIS=DS*(-RI)                                                     00109
      AZMIT=AZO+1.5707964+DS*ANG                                       00110
      AZ=AZMIT                                                         00111
      ISW5=3                                                           00112
      GO TO 20                                                         00113
C     STORE BASELINE COORDINATES
 540  CORDX=XI                                                         00114
      CORDY=YI                                                         00115
C     COMPUTE INTERSECTION ON CENTERLINE
 600  I=K                                                              00116
 601  ISW2=2                                                           00117
      GO TO 10                                                         00118
C     GO TO AZ DIS 2
 605  I=I+1                                                            00119
      AZ1=AZMIT                                                        00120
      AZ2=AZ+3.1415927                                                 00121
      A=X(I)-CORDX                                                     00122
      B=Y(I)-CORDY                                                     00123
      C=SIN(AZ1-AZ2)                                                   00124
      IF(C+.00001)632,638,638                                          00125
  638 OFF=888888.88                                                    00126
      DIS=-888888.88                                                   00127
      GO TO 610                                                        00128
C     COMPUTE OFFSET FROM BL TO CL AND DISTANCE FROM PI
 632  DO 636 L=1,2                                                     00129
      DIS=OFF                                                          00130
      OFF=(A*COS(AZ1)-B*SIN(AZ1))/C                                    00131
 636  AZ1=AZ2                                                          00132
 610  ANG=AZ                                                           00133
      CLS=PI(I)-DIS                                                    00134
C     IS INTERSECTION BEYOND THE PC
      IF(CLS-PC(I))625,625,640                                         00135
C     IS ALIGNMENT FINISHED
  640 IF(R(I)-888888.88)642,642,442                                    00136
 641  I=I+1                                                            00137
 642  IF(ID(I)/100-ID(I+1)/100)641,645,641                             00138
 645  AZO=AZ                                                           00139
      K=I-1                                                            00140
      GO TO 601                                                        00141
C     IS ALIGNMENT BEYOND THE PREVIOUS PT
 625  IF(CLS-PT(I-1))628,626,626                                       00142
```

```
 626   IF(I-K-1)698,698,697                                              00143
 697   K=K+1                                                             00144
       GO TO 698                                                         00145
 628   IF(I-K-1)650,442,650                                              00146
C      INTERSECTION ON CURVE
 650   I=I-1                                                             00147
       ISW3=2                                                            00148
       GO TO 210                                                         00149
C      GO TO LAST PART OF GEOM 2
 655   A=XO-CORDX                                                        00150
       B=YO-CORDY                                                        00151
       ISW2=3                                                            00152
       GO TO 11                                                          00153
C      GO TO LAST PART OF AZ DIS 3
C      COMPUTE CURVE OFFSET
 660   ANG=AZ-AZMIT                                                      00154
       A=C*COS(ANG)                                                      00155
       B=C*SIN(ANG)                                                      00156
       OFF=A-DS*SQR(RI**2-B**2)                                          00157
C      GET COORDINATES OF INTERSECTION POINT
       XI=CORDX                                                          00158
       YI=CORDY                                                          00159
       AZ=AZMIT                                                          00160
       DIS=OFF                                                           00161
       ISW5=4                                                            00162
       GO TO 20                                                          00163
C      GO TO COORD 4
C      GET AZIMUTH OF RADIUS
 680   A=XO-XI                                                           00164
       B=YO-YI                                                           00165
       ISW2=4                                                            00166
       GO TO 11                                                          00167
C      GO TO AZ DIS 4
C      COMPUTE ANGLE SUBTENDED
 685   ANGI=AZ-PCAZ                                                      00168
       ISW3=3                                                            00169
       GO TO 212                                                         00170
C      GO TO GEOM 3
C      COMPUTE CLS AND LOCAL AZIMUTH FOR CURVE INTERSECTION
 690   CLS=PC(I)+ANGI*RI*DS                                              00171
       ANG=AZO+ANGI                                                      00172
 698   ANG =SIN(AZMIT-ANG)                                               00173
C      INTERPOLATE GROUND ELEVATIONS
       DO 704 L=1,3                                                      00174
       P=OFF+(OFFD(L)/ANG)                                               00175
 700   DO 701 I=2,6                                                      00176
       IF(E(I))702,705,702                                               00177
 702   IF(D(I)-P)701,703,703                                             00178
 701   CONTINUE                                                          00179
       GO TO 401                                                         00180
C      INTERPOLATE ELEVATION OF ONE POINT
 703   I=I-1                                                             00181
 704   ELV(L)=E(I)+(P-D(I))/(D(I+1)-D(I))*(E(I+1)-E(I))                  00182
 705   PUNCH, 5,IBL,STA,CLS,OFF,ELV(1),ELV(2),ELV(3),ANG                 00183
       GO TO 442                                                         00184
       END                                                               00185
```


ROADWAY DESIGN/PREPARATION

Purpose

The purpose of this program is to produce a reduced terrain deck containing information which is relevant only to the particular alignment being run, rather than to the whole band of interest. This narrowed band of interest is defined by offset widths to the right and to the left of the centerline. All terrain information within this specified band is punched into a reduced terrain deck and also automatically collated with the offsets.

Description

The offset distances that define the narrow band of interest generally depend upon the configuration of the terrain and should be determined by the engineer for each specific alignment. Because of memory-size restrictions, the other programs in the Roadway Design Phase cannot accept more than twenty-four terrain points at each cross section. The Roadway Design/Preparation Program uses a sense switch to cause a pause whenever more than twenty-four terrain points are found within the narrowed band of interest. Also, it is possible to control the input so that the maximum available storage will not be exceeded.

Program Operation

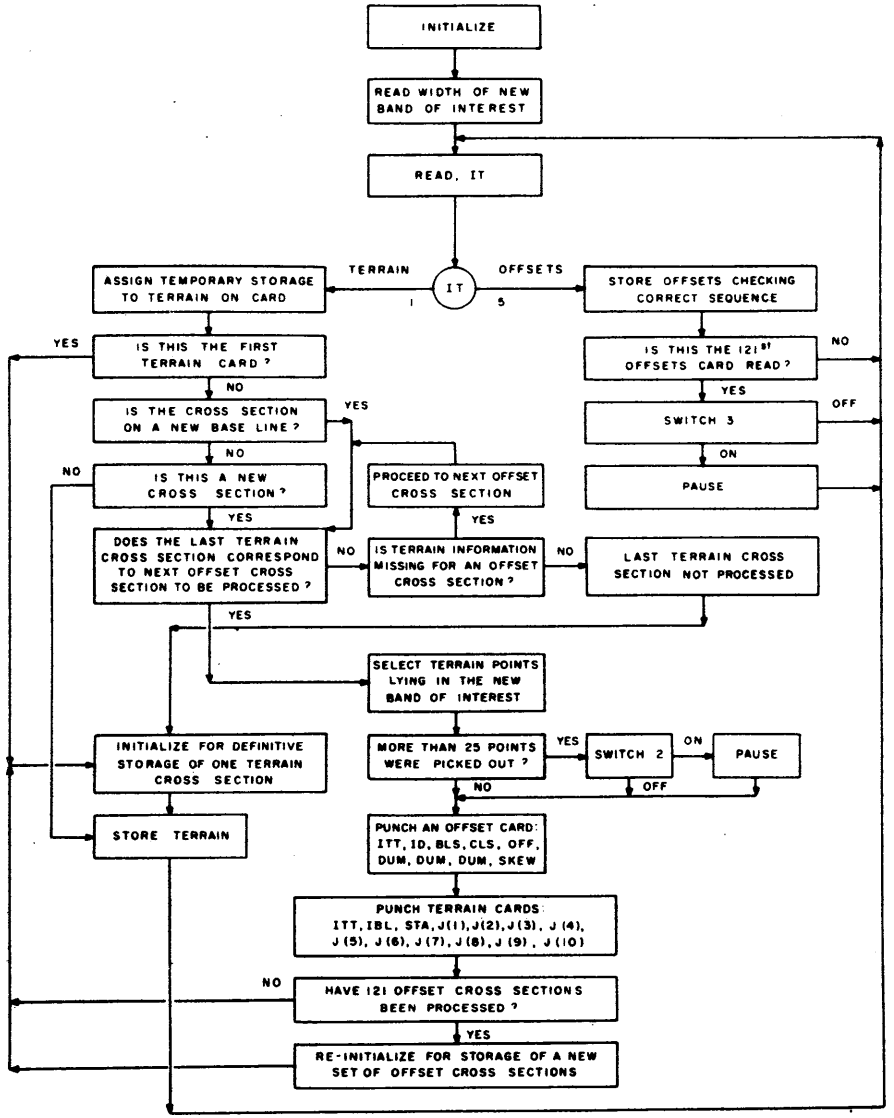
The program initializes control constants and immediately reads in a card in which the offsets from the centerline to the limits of the new band of interest (WIDL, WIDR) are specified. The remainder of the input consists of the terrain deck and of offset cards produced by the Alignment Design/Offset Program. This input can be collated or not. The only restriction is that the offsets card corresponding to any cross

section must be read in before the last terrain card for the same cross section.

The program reads in a card from the input deck and determines whether it is an offset card or a terrain card. If it is an offset card, it is immediately stored, and the program decides whether storage space is still available to read in an additional offset card. When 121 cards have been read in, it will interrogate sense switch 3. If it is on, the program will pause, allowing the terrain information to be input; if it is off, the program will read in as many offset cards as there are in the read hopper.

When the first terrain card is read in, it will be immediately stored; any other terrain card will be assigned to temporary storage and then examined to see if it corresponds to the same cross section as the one read before it; if it corresponds to a new section, the previous section is processed: the limits of the narrowed band of interest are computed, and those points lying within it are punched. If at any section more than twenty-four points are found within the specified band, the program will interrogate sense switch 2. If it is on, the computer will pause, allowing the operator to determine the section at which this condition occurs. If it is off, normal processing will continue. An offset card is also produced which contains only that information which is going to be used by the Roadway Design programs. Only those sections for which both terrain and offsets were input are processed. Any section for which only offset or only terrain were input is neglected. A maximum of sixty-eight terrain points can be read in at each cross section. The last section is not normally processed; therefore, terrain information should be given up to one cross section beyond the last one desired.

MACRO FLOW DIAGRAM
ROADWAY DESIGN / PREPARATION



ROADWAY DESIGN/PREPARATION
OPERATING INSTRUCTIONS

Console Switches

1. PARITY - off, I/O CHECK - off, OFLOW - program
2. Sense Switches
   1 not used
   2 On: Counts Terrain Points; Pause >25
   3 On: Counts Offset Cards; Pause > 121
   4 not used

Typewriter

Not used

Loading Program

1. Clear Memory 310000300002
2. INSTANT STOP, RESET, LOAD

Order of Input

1. Program Deck
2. Band of Interest Definition Card
   WIDL, WIDR
3. Offset Deck (up to 121 cards)
   5, ID, BLS, CLS, OFF, DUM, DUM, DUM, SKEW
4. Terrain Deck (up to 151 cards)
   IT, IBLS, BLSTA, IY1, IZ1, IY2, IZ2, IY3, IZ3, IY4, IZ4, IY5, IZ5

Restart Procedure

Start again from the very beginning with the first offset card equal to the station of starting.

1. INSTANT STOP, RESET, INSERT 4907500
2. RELEASE, START

Sorting and Listing Instructions

Cards having a 5 in card column 2 are offset cards; those having a 1 are narrowed terrain cards. Sorting and listing is usually unnecessary. These cards can be entered directly into the Roadway Design/Template Program.

Output List

Collated Offsets and Narrowed Terrain Deck

Offsets
5, ID, BLS, CLS, OFF, DUM, DUM, DUM, SKEW

Terrain
1, IBLS, BLSTA, IY1, IZ1, IY2, IZ2, IY3, IZ3, IY4, IZ4, IY5, IZ5


```
C     DTM DESIGN SYSTEM ** ROADWAY DESIGN / PREPARATION ** 20 K
C     N.W. BRYAN    ** A. VILLAVECES    **  10/25/61
C     CIVIL ENGINEERING SYSTEMS LABORATORY
C     CORRECTION 2 * A. VILLAVECES ** JAN 11/62
C     CORRECTION 1  * A. VILLAVECES* 12/13/61
C     SWITCH 3 ON COUNTS OFFSET CARDS
C     SWITCH 2 ON COUNTS TERRAIN OUTPUT CARDS
      DIMENSION JD(5),JE(5),JY(68),JZ(68),J(10),ID(121),BLS(121)          00001
      DIMENSION CLS(121),SKEW(121),OFF(121)                               00002
C     INITIALIZE
      K=1                                                                 00003
      K2=121                                                              00004
      K3=-1                                                               00005
      K0=1                                                                00006
      ISW1=1                                                              00007
      ISW2=1                                                              00008
      DUM=0.                                                              00009
C     GENERAL READ
      READ,WIDL,WIDR                                                      00010
    1 READ,IT                                                             00011
      IF(IT-1)2,30,2                                                      00012
C     STORE OFFSETS
    2 READ,ID(K),BLS(K),CLS(K),OFF(K),DUMM,DUMM,DUMM,SKEW(K)              00013
      IF(K3)100,100,34                                                    00014
   34 IF(CLS(K)-CLS(K3))1,1,100                                           00015
  100 K3=K                                                                00016
      K=K+1                                                               00017
      IF(K-K2)1,3,3                                                       00018
    3 IF(SENSE SWITCH 3)4,5                                               00019
    4 PAUSE                                                               00020
    5 K=1                                                                 00021
      GO TO 1                                                             00022
C     NARROW TERRAIN WIDTH
   30 READ,IBLS,BLSTA                                                     00023
      DO 31 M=1,5                                                         00024
   31 READ,JD(M),JE(M)                                                    00025
      IF(ISW1-1)24,21,24                                                  00026
   24 IF(IBL-IBLS)6,25,6                                                  00027
   25 IF(STA-BLSTA)6,37,6                                                 00028
    6 K4=K0+1                                                             00029
      IF(STA-BLS(K0))36,11,36                                             00030
   36 IF(STA-BLS(K4))21,33,21                                             00031
   33 K0=K0+1                                                             00032
      IF(K0-K2+1)6,8,8                                                    00033
    8 IF(SENSE SWITCH 3)9,10                                              00034
    9 PAUSE                                                               00035
   10 ISW2=2                                                              00036
   11 NPP=NP-1                                                            00037
      YWIDL=OFF(K0)+WIDL                                                  00038
      YWIDR=OFF(K0)+WIDR                                                  00039
      JWIDL=YWIDL                                                         00040
      JWIDR=YWIDR                                                         00041
      K1=1                                                                00042
      DO 14 I=2,NPP                                                       00043
      IF(JY(I)-JWIDL)14,12,12                                             00044
   12 IF(JY(I-1)-JWIDR)13,13,16                                           00045
   13 JY(K1)=JY(I-1)                                                      00046
      JZ(K1)=JZ(I-1)                                                      00047
      K1=K1+1                                                             00048
```

```
 14 CONTINUE                                                                    00049
 16 JY(K1)=JY(I-1)                                                              00050
    JZ(K1)=JZ(I-1)                                                              00051
    NTP=K1+1                                                                    00052
    PUNCH COLLATED DECK
    IF(SENSE SWITCH2)51,52                                                      00053
 51 IF(K1-25)52,52,50                                                           00054
 50 PAUSE                                                                       00055
 52 PUNCH,5,ID(K0),BLS(K0),CLS(K0),OFF(K0),DUM,DUM,DUM,SKEW(K0)                 00056
    DO 26 I=NTP,68                                                              00057
    JY(I)=0                                                                     00058
 26 JZ(I)=0                                                                     00059
    DO 28 I=1,K1,5                                                              00060
    IJ=I                                                                        00061
    DO 29 M=1,10,2                                                              00062
    J(M)=JY(IJ)                                                                 00063
    J(M+1)=JZ(IJ)                                                               00064
 29 IJ=IJ+1                                                                     00065
 28 PUNCH,1,IBL,STA,J(1),J(2),J(3),J(4),J(5),J(6),J(7),J(8),J(9),J(10)          00066
    IF(ISW2-1)21,21,40                                                          00067
 40 K0=1                                                                        00068
    ISW2=1                                                                      00069
 21 NP=1                                                                        00070
 37 STA=BLSTA                                                                   00071
    IBL=IBLS                                                                    00072
    DO 23 M=1,5                                                                 00073
    IF(JE(M))22,27,22                                                           00074
 22 JY(NP)=JD(M)                                                                00075
    JZ(NP)=JE(M)                                                                00076
 23 NP=NP+1                                                                     00077
 27 ISW1=2                                                                      00078
    GO TO 1                                                                     00079
    END                                                                         00080
```


ROADWAY DESIGN/TEMPLATE

Purpose

The Roadway Design/Template program computes the vertical geometry, the profile grade, and the shape of the template at each station of the alignment. These cards are then used for the volume computations performed in the Roadway Design/Volumes program.

Description

The vertical alignment is defined by giving the station, elevation, and curve length at each V.P.I. This information is used by the program to compute grades, V.P.C., V.P.T., and elevations of V.P.C. and V.P.T. for each curve.

The template is made up of a series of links which can be shaped to conform to almost any roadway. Each link is defined by giving its dy and dz dimensions. Negative dy's are associated with links to the left of the centerline. Positive dy's apply to the right. Negative dz's are given to those links which slope down. The template is defined starting at the middle and working to each side. The template is connected to the profile grade by a final link defined by a DYTIE and a DZTIE.

The way in which the template is defined allows parts of it to be changed without disturbing the rest. If, for instance, the link in the template representing the median were redefined by changing the dy and dz to make them larger, the other template parts would be merely pushed out. Template change cards are used to modify the template specified at the beginning of the run. Changes require that the station numbers be given at the section where the change begins to occur and at the section where it is completed. The change is applied linearly between the beginning and ending stations.

Since the offset distance must be known before the template can be applied, it must be given for each cross section. This information

was produced in the Alignment Design/Offsets program and is passed on in the form of offset cards. The Roadway Design/Template program places the information from these cards in a table which can hold 20 cards. It is not necessary for each offset to be in the table because the values used by the program are interpolated between those given in the table. This feature makes it possible for the Roadway Design programs to be used without being preceded by the Alignment Design program. This is sometimes desirable where only one roadway is being evaluated. In this case, one offset card at the beginning and another at the end are all that is necessary. Parallel roadways can also be handled in this manner. The Roadway Design programs can therefore be used as conventional earthwork programs.

Offset cards may either be collated with the terrain as occurs when the Roadway Design/Preparation program is used, or they may be placed in with twenty offset cards and twenty terrain section, twenty offsets, twenty terrain, and so forth. The template may be changed at any time by merely inserting a new set of template cards in the terrain deck.

Program Operation

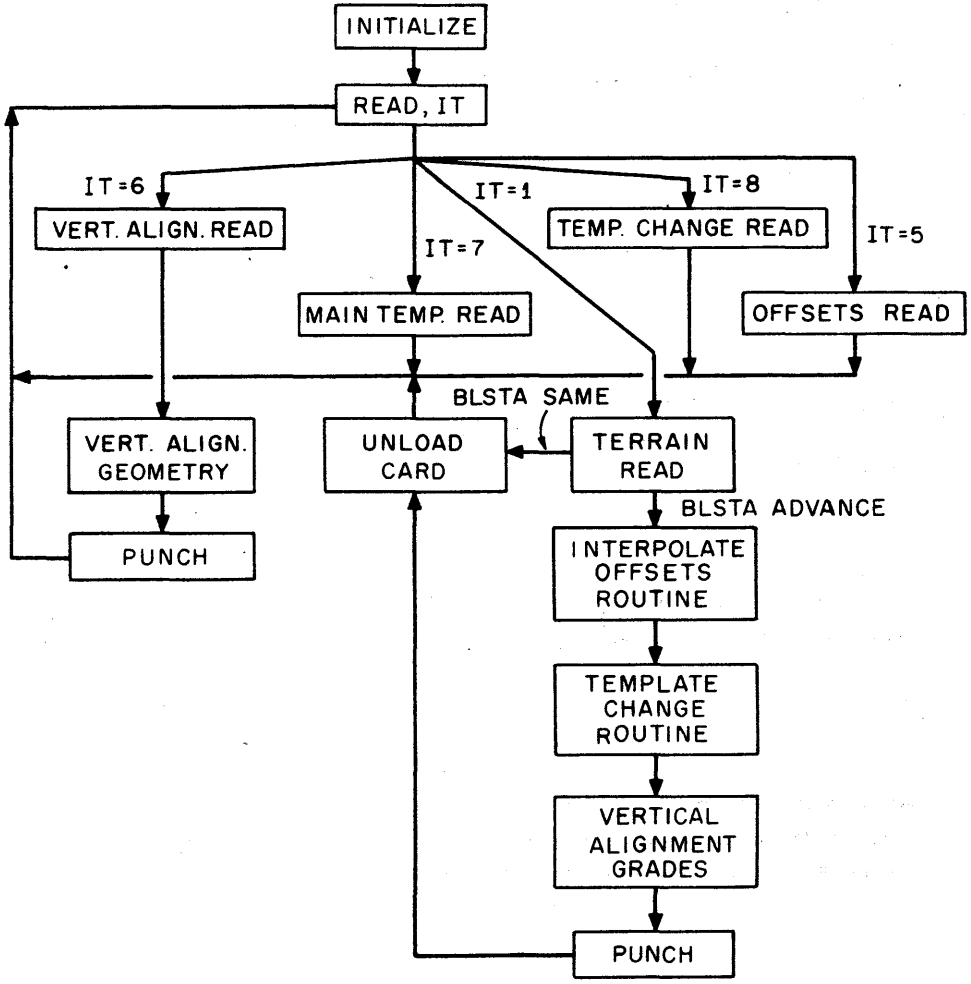
After read-in, the program computes the P.C. and P.T. centerline station numbers, their elevation, and the grades of the road before and after each curve. The templates are then computed by interpolation at those stations where the cross section of the road is changing. This template is output as pass-on information for the first section and for those stations where the template is different from the previous station's template.

If terrain information is given at a section for which no corresponding offset data exists, the program interpolates the offset, the centerline station number, and the skew angle corresponding to this section.

The output deck is all used as input to the Roadway Design/Volumes program, except those cards having an identification number (IT) of 10. These cards are to be found at the first of the output deck and contain vertical geometry output.

MACRO FLOW DIAGRAM

ROADWAY DESIGN / TEMPLATE



ROADWAY DESIGN/TEMPLATE
OPERATING INSTRUCTIONS

Console Switches

1. PARITY - off, I/O CHECK - off, OFLOW - program
2. Sense Switches 1 not used
   2 not used
   3 not used
   4 not used

Typewriter

Not used

Loading Program

1. Clear memory 310000300002
2. INSTANT STOP, RESET, LOAD

Order of Input

1. Program Deck
2. Terrain Factors Card
   FAC1, FAC2
3. Vertical Geometry (up to 20 cards)
   6, IDENT, SVPI, ZVPI, CLENG
4. Additional Parameters (2 cards)
   9, CL1, CL2, CCL, DYTIE, DZTIE, CCR, CR2, CR1
   9, FL1, FL2, FCL, FMUL, CMUL, FCR, FR2, FR1
5. Template Links (7 cards)
   7, DY(M), DZ(M), DY(M+1), DZ(M+1), DY(M+2), DZ(M+2), DY(M+3), DZ(M+3)
6. Template Changes (up to 10 cards)
   8, IP(J), START(J), END(J), WIDTH(J), HEIGHT(J)
7. * Offsets (up to 20 cards)
   5, ID(K), BLS(K), CLS(K), OFF(K), YS, YS, YS, SKEW(K)
8. * Terrain (up to 20 matching stations)
   IT, IBLS, BLSTA, IY(1), IZ(1), IY(2), IZ(2), IY(3), IZ(3), IY(4), IZ(4), IY(5), IZ(5)

* Output from the Roadway Design/Preparation program may be used instead of collated Offset and Terrain cards.

Special Instructions

Output from this program (with the exception of the geometry output) is used directly as input to the Roadway Design/Volumes program.

Restart Procedure

To start a new run, branch to 07500. For a mistake, branch to general read 7728.

Sorting and Listing Instructions

Vertical Geometry output is easily recognized by a card type of 10. List with 80 column panel. The rest of the output is pass-on information to the Roadway Design/Volumes and is not usually listed.

Output List

1. Vertical Geometry Output
   10, SVPC, ZVPC, SVPIN, ZVPIN, SVPT, ZVPT, CLENG
   10, GA
2. Collated Pass-on Deck
   1, STA, CLSTA, HOFF, VOFF, SKEWA, NTP, ISW
   2, Y(1), Z(1), Y(1+1), Z(1+1), Y(1+2), Z(1+2).....Y(NTP), Z(NTP)
   3, DY(1), DZ(1), DY(1+1), DZ(1+1).....DY(28), DZ(28)

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```
C     DTM DESIGN SYSTEM ** ROADWAY DESIGN / TEMPLATE ** 20 K
C     N.W. BRYAN ** JULY 21,1961
C     REVISION NO. 3 ** JAC ** 26 MARCH 61
C     REVISION NO. 2 ** POR ** 3 NOV 61
C     REVISION NO. 1 ** JAC ** SEPTEMBER 1961
      DIMENSION SVPI(20),ZVPI(20),CLENG(20),DY(28),DZ(28)                    00001
      DIMENSION ID(20),BLS(20),CLS(20),OFF(20)                               00002
      DIMENSION SKEW(20),IP(10),START(10),END(10),WIDTH(10),HEIGT(10)        00003
C     INITIALIZE
      READ,FAC1,FAC2                                                         00004
      ISW4=-1                                                                00005
      ISW3=0                                                                 00006
      J=0                                                                    00007
      K=1                                                                    00008
      KO=1                                                                   00009
      M=1                                                                    00010
      N=1                                                                    00011
      ISW2=1                                                                 00012
C     GENERAL READ
  140 READ,IT                                                                00013
      GO TO(160,140,140,140,150,100,110,130,220),IT                          00014
C     VERTICAL ALIGNMENT READ IT=6
  100 READ,IDENT                                                             00015
      DO 101 I=N,60,20                                                       00016
      READ,SVPI(I)                                                           00017
      IF(SVPI(I)-999999.98)101,3000,3000                                     00018
  101 CONTINUE                                                               00019
      N=N+1                                                                  00020
      GO TO 140                                                              00021
C     VERTICAL ALIGNMENT**PART 1
 3000 ISW1=1                                                                 00022
      N=1                                                                    00023
 3001 ZVPIN=ZVPI(N)                                                          00024
      SVPIN=SVPI(N)                                                          00025
      DIMENSION Y(25)                                                        00026
      YS=ZVPI(N+1)-ZVPIN                                                     00027
      Y1=SVPI(N+1)-SVPIN                                                     00028
      DIMENSION Z(25)                                                        00029
      S=YS/Y1                                                                00030
      Y2=CLENG(N)/2.                                                         00031
      SVPC=SVPIN-Y2                                                          00032
 3004 ZVPC=ZVPIN-GB*Y2                                                       00033
      SVPT=SVPIN+Y2                                                          00034
      ZVPT=ZVPIN+S*Y2                                                        00035
      IF(ISW1-2)3002,4003,4008                                               00036
 3002 IF(N-1)3005,3005,3003                                                  00037
 3003 PUNCH,10,SVPC,ZVPC,SVPIN,ZVPIN,SVPT,ZVPT,CLENG(N)                      00038
 3005 PUNCH,10,S                                                             00039
      N=N+1                                                                  00040
      GB=S                                                                   00041
      IF(CLENG(N)-999999.98)3001,140,140                                     00042
C     READ ATT TABLE
  220 READ,DY(2),DY(1),DY(5),DY(13),DY(14),DY(8),DY(12),DY(11)               00043
      READ,IT,DY(4),DY(3),DY(6),DY(15),DY(16),DY(7),DY(10),DY(9)             00044
      PUNCH,1                                                                00045
      DO 221 I=1,16                                                          00046
  221 PUNCH,DY(I)                                                            00047
      GO TO 140                                                              00048
C     MAIN TEMPLATE READ IT=7
```

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```
  110 DO 111 I=1,4                                                    00049
      READ,DY(M),DZ(M)                                                00050
  111 M=M+1                                                           00051
      GO TO 140                                                       00052
C     READ TEMPLATE CHANGE  TABLE IT=8
  130 J=J+1                                                           00053
      READ,IP(J)                                                      00054
      DO 131 I=J,40,10                                                00055
  131 READ,START(I)                                                   00056
      GO TO 140                                                       00057
C     OFFSETS READ IT=5
  150 READ,ID(K),BLS(K),CLS(K),OFF(K),YS,YS,YS,SKEW(K)                00058
      IF(K-1)152,152,153                                              00059
  153 IF(CLS(K)-CLS(K-1))140,140,152                                  00060
  152 K=K+1                                                           00061
      IF(K-20)140,140,151                                             00062
  151 K=1                                                             00063
      GO TO 140                                                       00064
C     INTERPOLATION ROUTINE
   30 YS=(S2-S)/(S2-S1)                                               00065
      YS=Y2-YS*(Y2-Y1)                                                00066
      GO TO(186,187,188,208,209),ISW3                                 00067
C     TERRAIN READ  IT=1
  160 READ,IBLS,BLSTA                                                 00068
      IF(ISW3-1)170,161,161                                           00069
  161 IF(IBL-IBLS)163,162,163                                         00070
  162 IF(STA-BLSTA)163,171,163                                        00071
  163 NTP=NTP-1                                                       00072
  175 K3=K0+1                                                         00073
      IF(K3-20)164,164,176                                            00074
  176 K3=1                                                            00075
  164 IF(IBL-ID(K0))169,165,169                                       00076
  165 IF(STA-BLS(K0))170,185,167                                      00077
  167 IF(IBL-ID(K3))169,168,169                                       00078
  168 IF(STA-BLS(K3))185,169,169                                      00079
  169 K0=K0+1                                                         00080
      IF(K0-20)175,166,166                                            00081
  166 K0=1                                                            00082
      GO TO 175                                                       00083
  170 NTP=1                                                           00084
  171 IBL=IBLS                                                        00085
      STA=BLSTA                                                       00086
      DO 173 M=1,5                                                    00087
      READ,JY,JZ                                                      00088
      YS=JY                                                           00089
      Y(NTP)=YS*FAC1                                                  00090
      YS=JZ                                                           00091
      Z(NTP)=YS*FAC2                                                  00092
      IF(Z(NTP))172,173,172                                           00093
  172 NTP=NTP+1                                                       00094
  173 CONTINUE                                                        00095
      ISW3=1                                                          00096
      M=1                                                             00097
      GO TO 140                                                       00098
C     INTERPOLATE OFFSETS ROUTINE
  185 S=STA                                                           00099
      S1=BLS(K0)                                                      00100
      S2=BLS(K3)                                                      00101
      Y1=CLS(K0)                                                      00102
```

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```
      Y2=CLS(K3)                                                      00103
      GO TO 30                                                        00104
  186 CLSTA=YS                                                        00105
      Y1=OFF(K0)                                                      00106
      Y2=OFF(K3)                                                      00107
      ISW3=2                                                          00108
      GO TO 30                                                        00109
  187 HOFF=YS                                                         00110
      Y1=SKEW(K0)                                                     00111
      Y2=SKEW(K3)                                                     00112
      ISW3=3                                                          00113
      GO TO 30                                                        00114
  188 SKEWA=YS                                                        00115
C     TEMPLATE CHANGE ROUTINE
      IF(J)200,4010,200                                               00116
  200 DO 210 IT=1,J                                                   00117
      VOFF=END(IT)                                                    00118
      J1=IP(IT)                                                       00119
      IF(CLSTA-START(IT))210,207,206                                  00120
  206 IF(CLSTA-VOFF)207,207,216                                       00121
  216 IF(VOFF)217,210,217                                             00122
  207 ISW4=1                                                          00123
      S1=START(IT)                                                    00124
      S2=VOFF                                                         00125
      S=CLSTA                                                         00126
      Y2=WIDTH(IT)                                                    00127
      Y1=DY(J1)                                                       00128
      ISW3=4                                                          00129
      GO TO 30                                                        00130
  217 DY(J1)=WIDTH(IT)                                                00131
      DZ(J1)=HEIGT(IT)                                                00132
      END(IT)=0                                                       00133
      ISW4=1                                                          00134
      GO TO 210                                                       00135
  208 DY(J1)=YS                                                       00136
      Y2=HEIGT(IT)                                                    00137
      Y1=DZ(J1)                                                       00138
      ISW3=5                                                          00139
      GO TO 30                                                        00140
  209 DZ(J1)=YS                                                       00141
  210 CONTINUE                                                        00142
C     VERTICAL ALIGNMENT**PART 2
 4010 IF(ISW2-2)4001,4002,4011                                        00143
 4001 N=1                                                             00144
      GB=0                                                            00145
 4002 ISW1=2                                                          00146
      ISW2=2                                                          00147
      GO TO 3001                                                      00148
 4003 IF(CLSTA-SVPT)4006,4004,4004                                    00149
 4004 N=N+1                                                           00150
      GB=S                                                            00151
      IF(CLENG(N)-999999.98)3001,4005,4005                            00152
 4005 ISW2=3                                                          00153
      ZVPIN=ZVPI(N)                                                   00154
 4011 Y2=SVPI(N)-CLSTA                                                00155
      IF(Y2)140,4007,4007                                             00156
 4006 YS=CLSTA-SVPC                                                   00157
      IF(YS)4011,4011,4009                                            00158
 4007 ISW1=3                                                          00159
```

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```
      GO TO 3004                                                        00160
 4008 VOFF=ZVPC                                                         00161
      GO TO 211                                                         00162
 4009 YS=YS*YS                                                          00163
      Y1=(S-GB)/(2.*CLENG(N))                                           00164
      Y2=GB*(CLSTA-SVPC)                                                00165
      VOFF=ZVPC+YS*Y1+Y2                                                00166
C     GENERAL PUNCH
  211 PUNCH,2,IBL,STA,CLSTA,HOFF,VOFF,SKEWA,NTP,ISW4                    00167
      M=NTP+1                                                           00168
      DO 215 I=M,27                                                     00169
      Y(I)=0                                                            00170
  215 Z(I)=0                                                            00171
      PUNCH,3                                                           00172
      DO 212 I=1,NTP,3                                                  00173
  212 PUNCH,Y(I),Z(I),Y(I+1),Z(I+1),Y(I+2),Z(I+2)                       00174
      IF(ISW4-1)213,213,170                                             00175
  213 DO 214 I=1,28,2                                                   00176
  214 PUNCH,DY(I),DZ(I),DY(I+1),DZ(I+1)                                 00177
      ISW4=2                                                            00178
      GO TO 170                                                         00179
      END                                                               00180
```


ROADWAY DESIGN/VOLUMES

Purpose

The purpose of the Roadway Design/Volumes program is the computation of earthwork volumes demanded by a particular alignment. It reads and stores the template definitions and template parameters passed on from the Roadway Design/Template program and will at each cross section apply the specified design criteria in order to determine the final template to be used. Areas, volumes, and slope intercepts are then computed and output.

Description

The Roadway Design/Volumes program has been designed to accept as input the output from the Roadway Design/Template program. The only additional input needed are initial volumes if they are to be other than zero. If initial values of the accumulated cut and fill are not desired, then no input other than the Roadway Design/Template is required.

For cases of overlapping slope stakes or for instances where classified materials are to be evaluated, the ability to punch the "as-built" template has been incorporated. The template data is prepared for further use in the Materials Classification/Preparation program.

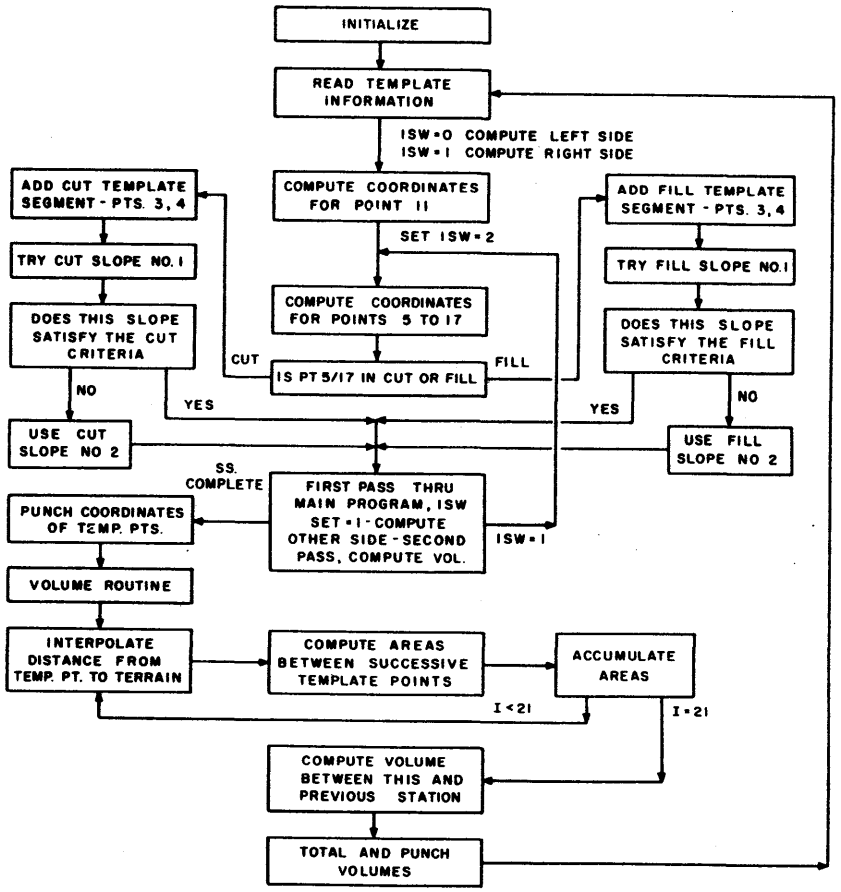
Program Operation

The program first reads the template parameters passed on from the Roadway Design/Template program. The template parameters consist of two cut slopes, two fill slopes, the cut criteria and the fill criteria for both the right and the left sides, a cut and fill multiplication factor, and the horizontal and vertical dimensions which tie the profile grade line to the centerline of the roadway template.

Next, a card is read giving the baseline station number, the centerline station number of that section, the horizontal offset of the centerline from the baseline, the profile elevation, the skew angle, and a number which tells the program whether or not there is a new template to be read at that section. Terrain information for that cross section is read next, the coordinates for points 5 to 17 in the template are then computed, and it is determined at both right and left whether the road is in cut or fill at those points. Next, the low fill or cut slope is tried, and the intersection points of the slopes and terrain are computed. If the cut or fill criterion is exceeded, the high slope is selected and the intercept computed. If the selected slope is parallel to the ground surface at the section or if any of the intersection is not found within the range for which terrain information is given, the program will set the intersection as occurring at the last given terrain point. This is done in order to permit the program to continue the computations without interruption. (Although no messages will be given out if this happens, the error will be easily detected in the slope-stakes plot.) The program then computes the end area and the volume between succeeding stations. The computed volumes can be swelled or shrunk by use of the fill and cut multiplication factors: FMUL, CMUL.

The output consists of two types of cards: slopes cards and volumes cards. The slopes card, with identification number IT=11, contains the baseline station number, the centerline station number, grade, the slope type selected on the left, the slope coordinate at the left of the centerline, the offset of the centerline, the slope stake coordinate at the right, and the slope type selected on the right. A slope type of 3 indicates cut; 4, fill. The volumes card, with identification number IT=12, contains the baseline station number, the centerline station number, the volume in cut computed at that cross section, the volume in fill computed at that station, the accumulated volume in cut in the alignment, the accumulated volume in fill in the alignment, and the haul at that station.

MACRO FLOW DIAGRAM
ROADWAY DESIGN/VOLUMES



ROADWAY DESIGN/VOLUMES
OPERATING INSTRUCTIONS

Console Switches

1. PARITY - off, I/O CHECK - off, OFLOW - program
2. Sense Switches 1 On - punches template cards
   2 not used
   3 not used
   4 not used

Typewriter

Not used

Loading Program

1. Clear memory 310000300002
2. INSTANT STOP, RESET, LOAD

Order of Input

1. Program Deck
2. Volumes restart (if used, branch to 7508)
   12, BLSTA, SA, CUTV, FILLV, CUMC, CUMF, HAUL
3. Pass-on deck from Roadway Design/Template program (less Vertical Alignment Output, IT=10)

Special Instructions

The pass-on data consists of all the output cards from the Roadway Design/Template program, except those which have an identification number of 10. These cards are on the top of the deck and need only be slipped off before entering the Roadway Design/Volumes program.

Restart Procedure

If the program is stopped by mistake, machine failure, etc., take the last volume card IT=12, punched by the program, and use it as a volume restart card. Branch to 07508 and follow the volume restart card with the normal input for this station. This procedure assumes that the memory has not been disturbed.

Sorting and Listing Instructions

Sort on CC2 and 3 to place in three stacks. List each with an 80 column panel.

Output List

1. Slope Card
   11, ID, BLSTA, SA, VOFF, NL, YH(1), YH(11), YH(21), NR
2. Volumes Card
   12, BLSTA, SA, CUTV, FILLV, CUMC, CUMF, HAUL
3. Template Cards (21 points)
   2, BLSTA, YH(1), ZH(1)
   :
   2, BLSTA, YH(21),ZH(21)


```
C     DTM DESIGN SYSTEM ** ROADWAY DESIGN / VOLUMES ** 20 K
C     W.A. BRIGGS/SLOPE STAKES ** J.A. CURRIE/VOLUMES ** JULY 21,1961
C     REVISION NO. 3 ** JAC ** 26 MARCH 61
C     REVISION NO. 2 ** JAC ** AUGUST 1961
C     REVISION NO. 1 ** JAC ** JULY 1961
      DIMENSION Y(27),Z(27),YH(21),ZH(21),DY(28),DZ(28),ATT(12)                00001
C     INPUT ROUTINES - NOT PART OF SUBPROGRAM
      GO TO 83                                                                 00002
      READ,IT,BLSTA,SB,CUTV,FILLV,CUMC,CUMF,HAUL                               00003
   83 READ,IT                                                                  00004
      IF(IT-2)82,80,84                                                         00005
   82 DO 81 I=1,12                                                             00006
   81 READ,ATT(I)                                                              00007
      READ,DYTIE,DZTIE,FMUL,CMUL                                               00008
      GO TO 83                                                                 00009
   80 READ,ID,BLSTA,SA,HOFF,HAUL,SKEWA,NTP,NSW                                 00010
      I=0                                                                      00011
      GO TO 83                                                                 00012
   84 DO 85  ISW=1,NTP,3                                                       00013
      DO 86 J=1,3                                                              00014
      I=I+1                                                                    00015
   86 READ,Y(I),Z(I)                                                           00016
   85 CONTINUE                                                                 00017
      DO 90 I=1,28                                                             00018
      IF(NSW-1)87,90,89                                                        00019
   87 SB=SA                                                                    00020
   90 READ,DY(I),DZ(I)                                                         00021
C     BEGIN SLOPE STAKE LOCATION SUBPROGRAM
C     COMPUTE COORDINATES FOR POINT 11
   89 YH(11)=HOFF+DYTIE/SKEWA                                                  00022
      ZH(11)=HAUL+DZTIE                                                    1   00023
      NSW=NTP-1                                                                00024
C     COMPUTE COORDINATES FOR POINTS 5 THROUGH 18
      M=14                                                                     00025
      I=10                                                                     00026
      JJ=1                                                                     00027
      NHP=1                                                                    00028
      DO 1201 ISW=0,1                                                          00029
      IKE=0                                                                    00030
      DO 10 K=1,6                                                              00031
    5 L=I+JJ                                                                   00032
      YH(I)=YH(L)+DY(M)/SKEWA                                                  00033
      ZH(I)=ZH(L)+DZ(M)                                                        00034
      IF(IKE-1)9,131,141                                                       00035
    9 I=I-JJ                                                                   00036
   10 M=M-JJ                                                                   00037
C     TEST POINT 5, K INCR. BY 1 IF 5 IS IN FILL
      K=1                                                                      00038
      I=5+12*ISW                                                               00039
C     TEST POINT SUBROUTINE, INCR. K BY 1 IF  POINT IS IN FILL
 1100 DO 1135 J=1,NSW                                                          00040
      IKE=-1                                                                   00041
      IF((YH(I)-Y(J))*(YH(I)-Y(J+1)))800,800,1135                              00042
 1120 T1=ZH(I)-Z(J)-T1                                                         00043
      IF(T1)1130,1125,1125                                                     00044
 1125 K=K+1                                                                    00045
 1130 GO TO (125,126,140,140,175,1000,1000,175,205,1000,1000,205),K            00046
C     POINT NOT IN TERRAIN, SET NSW TO NTP AND  EXIT
 1135 CONTINUE                                                                 00047
```

```
      GO TO 83                                                          00048
C     INTERSECT LINES I,I+1 AND J,J+1 STORE INTERCEPT IN YH(1),ZH(1)
C     K=6,7,10, OR 11
 1000 J=NSW*ISW+1                                                       00049
      DO 1015 IKE=1,NSW                                                 00050
      L=J+JJ                                                            00051
      NTP=I+JJ                                                          00052
      YJ=Y(J)                                                           00053
      A1=Y(L)-YJ                                                        00054
      A2=YH(NTP)-YH(I)                                                  00055
      ZJ=Z(J)                                                           00056
      DA=Z(L)-ZJ                                                        00057
      DB=ZH(NTP)-ZH(I)                                                  00058
      XA=A1*DB                                                          00059
      XB=A2*DA                                                          00060
      T1=(ZH(I)-ZJ)*A1*A2                                               00061
      YH(NHP)=(T1+YJ*XB-YH(I)*XA)/(XB-XA)                               00062
      YHN=YH(NHP)                                                       00063
      ZH(NHP)=ZJ+(YHN-YJ)*DA/A1                                         00064
      IF((YHN-YJ)*(YHN-Y(L)))1020,1020,1015                             00065
 1015 J=J+JJ                                                            00066
 1020 IF(I-NHP)220,220,170                                              00067
C     ADD CUT OR FILL TEMPLATE SEGMENTS, PTS. 3 AND 4
C     TEST POINT 3, INCR. K BY 1 IF IN FILL
C     K=1 OR 2
  125 M=6+17*ISW                                                        00068
      GO TO 129                                                         00069
  126 M=8+13*ISW                                                        00070
  129 I=NHP+3*JJ                                                        00071
      DO 130 NTP=1,2                                                    00072
      IKE=1                                                             00073
      GO TO 5                                                           00074
  131 I=I-JJ                                                            00075
  130 M=M-JJ                                                            00076
      I=I+JJ                                                            00077
      K=3                                                               00078
      GO TO 1100                                                        00079
C     USING SLOPE SET 1 THEN 2 , COMPUTE COORDINATES OF POINT 2 -THE
C       SLOPE  BROKEN-BACK POINT
C     K=3 OR 4
  140 NL=NR                                                             00080
      NR=K                                                              00081
      JSW=(K*K)/4                                                       00082
      I=NHP+JJ                                                          00083
      DO 245 KSW=1,2                                                    00084
      M=29*ISW+JSW*JJ                                                   00085
      IKE=2                                                             00086
      GO TO 5                                                           00087
  141 K=JSW+KSW+2                                                       00088
      GO TO 1100                                                        00089
C     TERRAIN INTERCEPT BETWEEN POINTS 2 AND 3, SET 1 AND 2 TO
C       INTERCEPT AND CONTINUE
  170 YH(I)=YH(NHP)                                                     00090
      ZH(I)=ZH(NHP)                                                     00091
      GO TO 220                                                         00092
C     NO INTERCEPT BETWEEN PTS. 2 AND 3, COMPUTE FICTITIOUS POINT
C       ON SLOPE AND TEST THAT POINT FOR CUT OR FILL
C     K=5 OR 8
  175 IF(ISW)176,176,177                                                00093
```



```
  176 M=JSW                                                             00094
      GO TO 174                                                         00095
  177 IF(JSW-2)178,178,179                                              00096
  178 M=10+KSW                                                          00097
      GO TO 174                                                         00098
  179 M=8+KSW                                                           00099
  174 NTP=NSW*ISW+1                                                     00100
      I=NHP                                                             00101
      CUTA=4-JSW-KSW                                                    00102
      L=I+JJ                                                            00103
      ZH(I)=ZH(L)+(CUTA*(YH(L)-Y(NTP))/ATT(M))*SKEWA                    00104
      YH(I)=Y(NTP)                                                      00105
      K=JSW+KSW+6                                                       00106
      GO TO 1100                                                        00107
C     IF SLOPE DOES NOT INTERSECT TERRAIN, SET LAST TEMPLATE POINT
C           TO SAME COORDINATES AS LAST TERRAIN POINT.
C     K=9 OR 12
  205 I=NHP                                                             00108
      NTP=NSW*ISW+1                                                     00109
      YH(I)=Y(NTP)                                                      00110
      ZH(I)=Z(NTP)                                                      00111
C     IF THIS IS THE SECOND SLOPE SET, DONT TEST CUT OR FILL CRITERIA
  220 IF(KSW-1)225,225,1200                                             00112
C     TEST SLOPES AGAINST CUT OR FILL CRITERIA
  225 K=4+5*ISW+JJ*(JSW+1)/2                                            00113
      JS=I+2*JJ                                                         00114
      IF(CUTA*(ZH(I)-ZH(JS))-ATT(K))1200,1200,240                       00115
C     TRY SECOND SLOPE SET
  240 I=NHP+JJ                                                          00116
  245 JSW=JSW-1                                                         00117
 1200 JJ=-JJ                                                            00118
      NHP=21                                                            00119
      I=12                                                              00120
 1201 M=15                                                              00121
C     EARTHWORK AREA AND VOLUME SUBPROGRAM
      FILLA=0                                                           00122
      CUTA=0                                                            00123
      I=1                                                               00124
      J=0                                                               00125
      IKE=0                                                             00126
  301 J=J+1                                                             00127
      IF(Y(J)-YH(I))301,500,302                                         00128
  302 I=I-1                                                             00129
      J=J-1                                                             00130
  303 I=I+1                                                             00131
  800 T1=(Z(J+1)-Z(J))*(YH(I)-Y(J))/(Y(J+1)-Y(J))                       00132
      IF(IKE)1120,801,801                                               00133
  500 T1=0                                                              00134
  801 DA=Z(J)-ZH(I)+T1                                                  00135
      XA=YH(I)                                                          00136
      IF(IKE)304,304,307                                                00137
  304 IKE=1                                                             00138
  305 DB=DA                                                             00139
      XB=XA                                                             00140
      IF(YH(I+1)-Y(J+1))303,504,306                                     00141
  306 J=J+1                                                             00142
      DA=Z(J)-((ZH(I+1)-ZH(I))*(Y(J)-YH(I)))/(YH(I+1)-YH(I))-ZH(I)      00143
      GO TO 506                                                         00144
  504 J=J+1                                                             00145
```

```
      I=I+1                                                              00146
      DA=Z(J)-ZH(I)                                                      00147
  506 XA=Y(J)                                                            00148
  307 W=0.5*(XA-XB)                                                      00149
      IF(DA*DB)309,308,308                                               00150
  308 A1=W*(DA+DB)                                                       00151
      GO TO 313                                                          00152
  309 W=W/(DA-DB)                                                        00153
      A1=-DB*DB*W                                                        00154
      T1=DA*DA*W                                                         00155
      IF(T1)311,313,312                                                  00156
  311 FILLA=FILLA+T1                                                     00157
      GO TO 313                                                          00158
  312 CUTA=CUTA+T1                                                       00159
  313 IF(A1)314,315,315                                                  00160
  314 FILLA=FILLA+A1                                                     00161
      GO TO 317                                                          00162
  315 CUTA=CUTA+A1                                                       00163
  317 IF(I-21)305,320,320                                                00164
  320 A1=(SA-SB)/54.                                                     00165
      CUTV=(CUTA*SKEWA+BCUTA*SKEWB)*A1                                   00166
      FILLV=(FILLA*SKEWA+BFILA*SKEWB)*A1                                 00167
      CUMC=CUMC+CUTV*CMUL                                                00168
      CUMF=CUMF+FILLV*FMUL                                               00169
      PUNCH,11,ID,BLSTA,SA,HAUL,NL,YH(1),YH(11),YH(21),NR                00170
      HAUL=CUMC+CUMF                                                     00171
      PUNCH,12,BLSTA,SA,CUTV,FILLV,CUMC,CUMF,HAUL                        00172
      SB=SA                                                              00173
      SKEWB=SKEWA                                                        00174
      BCUTA=CUTA                                                         00175
      BFILA=FILLA                                                        00176
      IF(SENSE SWITCH 1)321,83                                           00177
  321 DO 323 I=1,21                                                      00178
  323 PUNCH,2,BLSTA,YH(I),ZH(I)                                          00179
      GO TO 83                                                           00180
      END                                                                00181
```


Purpose

The Materials Classification/Preparation program is intended to prepare the input terrain data for the Materials Classification/Volumes program or to prepare template data as terrain for further use in the system.

Description

As it is presently written, three cases are covered. The first of these is the overlapping slope stake case. This is where there are two separate roadways paralleling each other and the templates of these two roads are overlapping. The first pass through the DTM Design System would be with template No. 1 and the original terrain. The associated cut and fill volumes are computed. The Materials Classification/Preparation program takes the original terrain and template No. 1 and computes the new "as-built" terrain as shown by the dotted line in Figure 1. The earthwork volume programs are then rerun with template No. 2 and the new converted terrain. This procedure is necessary so that the volume corresponding to region A in Figure 1 will not be computed twice.

The second case for which data is prepared is where the template lies completely within rock (Figure 2). The first pass through the System is made with the original earth terrain and the desired roadway template. The total volume of material to be removed is calculated on this pass. The Materials Classification/Preparation program computes the "as-built" terrain as shown by the dotted line in Figure 2. This terrain and the rock line (which is denoted by 2's in Figure 2 and which is input as the new template) is then used as input for the Materials Classification/Volumes program. If the cut factor is set equal to zero, the resulting volumes will be the quantity of rock that has to be removed.

The Materials Classification/Preparation program can also be used for calculating quantities in interchanges. The main line quantities are evaluated in the normal manner and the main line template is obtained. The template

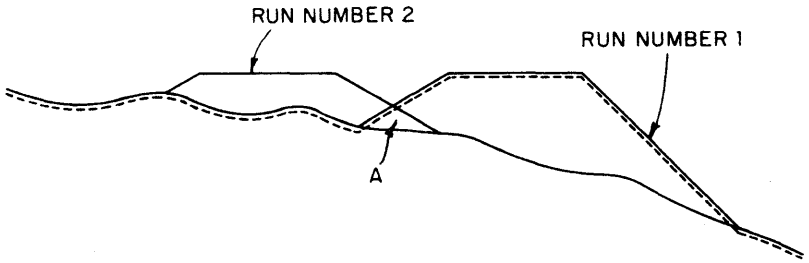


FIG. 1 OVERLAPPING SLOPE STAKES

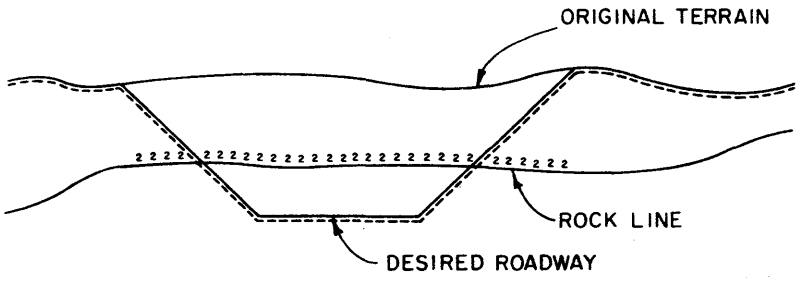


FIG. 2 ROCK MODEL

and original ground are used in the Materials Classification/Preparation program to obtain main line terrain. After the interchange ramps have been laid out, contoured terrain data is taken across this "as-built" surface. This "as-built" terrain and the main line terrain are run in the Materials Classification/Volumes program to obtain interchange quantities. Note that this method obtains ramp quantities exclusive of the main line quantities.

Program Operation

The program is capable of handling the terrain and the resulting templates from as many baseline stations as may be desired by the operator. However, at any one station there should not be more than 24 terrain points. As in the other DTM Design System programs, the template is designed to be described by 21 points.

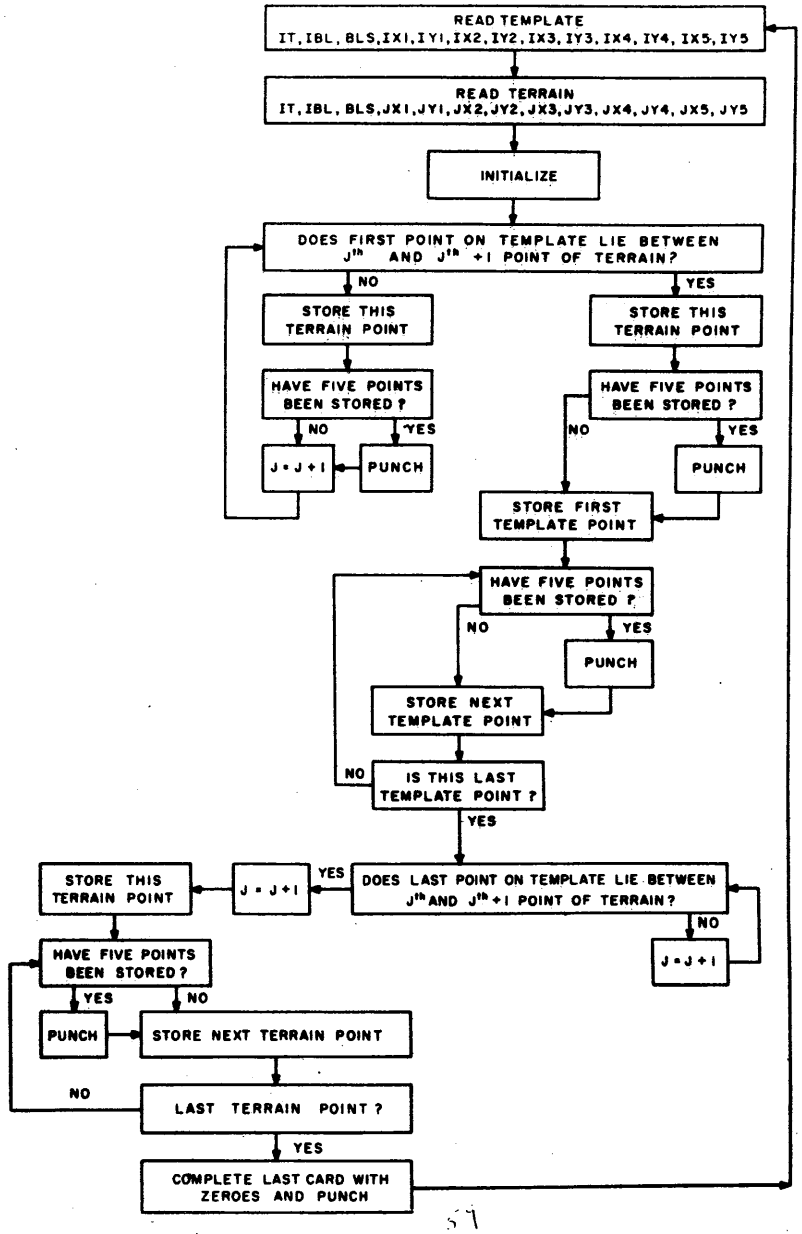
At each baseline station, at least one terrain point should be equal to or outside the extreme template points; that is, the defined template must be completely within the given terrain.

The input template data is the output from the Roadway Design/Volumes program and will be in one point per card, floating point form.

The input terrain data is from the original terrain deck used in the rest of the system and will be in five points per card, fixed point form. Two constants (FAC1 and FAC2) can be read in so that the location of the decimal point can be controlled, if so desired.

Output is five points per card in fixed point form and includes, in addition to the converted terrain points, and IT and ID number and the baseline station.

MACRO FLOW DIAGRAM
CLASSIFIED MATERIALS / PREPARATION



MATERIALS CLASSIFICATION/PREPARATION
OPERATING INSTRUCTIONS

Console Switches

1. PARITY - off, I/O CHECK - off, OFLOW - program
2. Sense Switches
   1 not used
   2 not used
   3 not used
   4 not used

Typewriter

Not used

Loading Program

1. Clear memory 310000300002
2. INSTANT STOP, RESET, LOAD

Order of Input

1. Program Deck
2. Terrain Factor Card
   FAC1, FAC2
3. Template Cards from Roadway Design/Volumes (21 cards)
   2, BLSTA, YH(1), ZH(1)
4. Terrain Cards (for 1 section)
   1, IBL, BLSTA, IY1, IZ1, IY2, IZ2, IY3, IZ3, IY4, IZ4, IY5, IZ5
5. Repeat 3 and 4 until complete
6. End of Run Card, IT=2

Special Instructions

Input data must be collated before entering the program. Place terrain for each station after every 21st template card. The terrain for the last station may be discarded if no matching template is present.

Restart Procedure

1. INSTANT STOP, RESET, INSERT 4907500
2. RELEASE, START

Sorting and Listing Instructions

No sorting necessary. List on an 80 column panel.

Output List

Terrain Card
IT, ID, BLSTA, IY1, IZ1, IY2, IZ2, IY3, IZ3, IY4, IZ4, IY5, IZ5


```
      DTM DESIGN SYSTEM ** MATERIALS CLASSIFICATION / PREPARATION ** 20 K
      J.H. SUHRBIER ** OCT.26,1961
     REVISION NO. 2 ** J.H. SUHRBIER ** MARCH, 1962
     REVISION NO. 1 ** J.H. SUHRBIER ** DECEMBER, 1961
      DIMENSION YH(21),ZH(21),A(5),B(5),Y(25),Z(25),L(5),LZ(5)          00001
      READ,FAC1,FAC2                                                   00002
      READ,IT                                                          00003
    1 READ, BLSTA, YH(1), ZH(1)                                        00004
      DO 101 I=2,21                                                    00005
  101 READ, IT, BLSTA, YH(I), ZH(I)                                    00006
      NTP=1                                                            00007
    2 READ,IT                                                          00008
      IF(IT-2) 3,33,33                                                 00009
    3 READ,ID,BLSTA                                                    00010
      DO 32 M=1,5                                                      00011
      READ,JY,JZ                                                       00012
      T1=JY                                                            00013
      Y(NTP)=T1*FAC1                                                   00014
      T1=JZ                                                            00015
      Z(NTP)=T1*FAC2                                                   00016
      IF(Z(NTP)) 31,32,31                                              00017
   31 NTP=NTP+1                                                        00018
   32 CONTINUE                                                         00019
      GO TO 2                                                          00020
   33 NTP=NTP-1                                                        00021
      J=1                                                              00022
      K=1                                                              00023
      I=1                                                              00024
      M=0                                                              00025
      M1=1                                                             00026
      N=0                                                              00027
    4 IF(J-NTP) 6,8,20                                                 00028
    6 IF((YH(I)-Y(J))*(YH(I)-Y(J+1)))11,11,7                           00029
    7 IF (M)8,8,10                                                     00030
    8 A(K)=Y(J)                                                        00031
      B(K)=Z(J)                                                        00032
      IF(K-5) 9,15,15                                                  00033
    9 K=K+1                                                            00034
   10 J=J+1                                                            00035
      GO TO 4                                                          00036
   11 N=1                                                              00037
      IF(M) 12,12,19                                                   00038
   12 A(K)=Y(J)                                                        00039
      B(K)=Z(J)                                                        00040
      IF(K-5) 121,15,15                                                00041
  121 K=K+1                                                            00042
   13 M1=0                                                             00043
      A(K)=YH(I)                                                       00044
      B(K)=ZH(I)                                                       00045
      IF(I-21)14,18,18                                                 00046
   14 IF(K-5) 16,15,15                                                 00047
   15 IT=1                                                             00048
      K=1                                                              00049
      DO 152 K=1,5                                                     00050
      T1=A(K)/FAC1                                                     00051
      L(K)=T1                                                          00052
      T1=B(K)/FAC2                                                     00053
      LZ(K)=T1                                                         00054
  152 CONTINUE                                                         00055
```

```
PUNCH,IT,ID,BLSTA,L(1),LZ(1),L(2),LZ(2),L(3),LZ(3),L(4),LZ(4),L(5),LZ(5)   00056
      K=0                                                                  00057
      IF(J-NTP) 151,1,1                                                    00058
  151 IF(N) 9,9,16                                                         00059
   16 K=K+1                                                                00060
      I=I+1                                                                00061
      IF(M1) 162,162,163                                                   00062
  162 IF(I-21) 13,13,161                                                   00063
  161 I=21                                                                 00064
      GO TO 4                                                              00065
  163 I=1                                                                  00066
      GO TO 162                                                            00067
   18 M=1                                                                  00068
      IF(K-5)  181,15,15                                                   00069
  181 K=K+1                                                                00070
      GO TO 4                                                              00071
   19 J=J+1                                                                00072
      M=0                                                                  00073
      N=0                                                                  00074
      GO TO 8                                                              00075
   20 A(K)=0                                                               00076
      B(K)=0                                                               00077
      IF(K-5) 21,15,15                                                     00078
   21 K=K+1                                                                00079
      GO TO 20                                                             00080
      END                                                                  00081
```


MATERIALS CLASSIFICATION/VOLUMES

Purpose

The purpose of this program is to compute the volume of material between two surfaces: "as-built" terrain and original terrain. Both terrains are defined by offsets from a baseline and elevations above sea level. The two terrains are collated before running. The resultant volumes can be those of a borrow pit, a stock pile, or classified materials on a roadway.

Description

Terrain data taken over the original ground is given a card type 1. Terrain data defining the "as-built" terrain has a card type of 2. After both type 1 and type 2 terrain have been read in and stored in memory, the edge points of the type 2 terrain are interrogated to determine whether they are in cut or fill. Vertical slopes are then applied to the edge points and intersections with the terrain are computed. The area of the cross section and volumes are then computed and output. This program can be used for two special purposes, overlapping slope stakes and classified materials quantity computations, as well as the more general application to the computation of borrow pits, stock piles, and "as-built" quantities. such as interchanges.

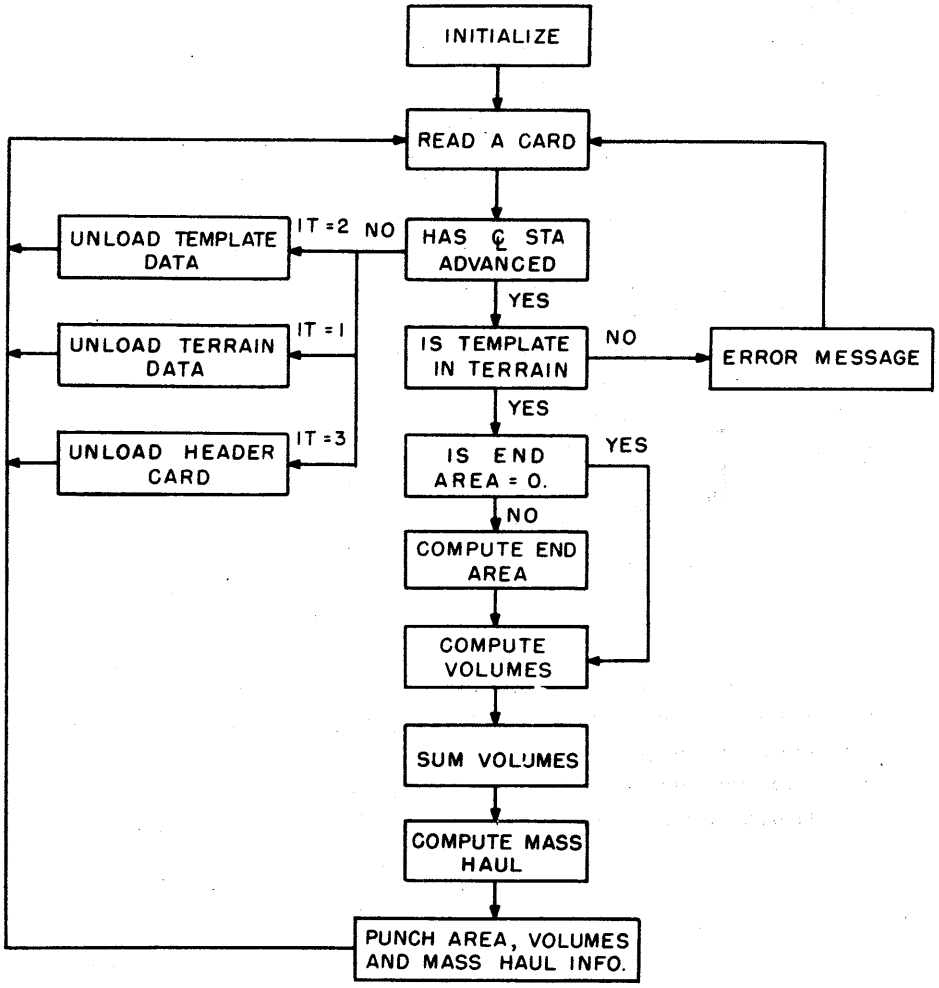
The program has the facility to modify the 5/card fixed point terrain by multiplication factors and the cut and fill volumes by cut and fill multiplication factors. Header cards are not used. A volume restart card with the same format as the volumes output card may be used to initialize the volumes. Volumes are computed using baseline station numbers.

Operation

Input to the Classified Materials/Volumes program is arranged so that an initial volumes card may be either read or not, depending upon the requirements of the user. Control is then transferred to a read statement which reads the template or terrain cards. Card type is sensed in order to distinguish the different cards being read. When the station number changes, the computations are begun. If the template is not in terrain, an error message is printed out, and control is returned to the general read statement.

The template and terrain are stored as two tables in memory. Areas are computed between each. Template edge points are projected vertically upward or downward to intersect the terrain. Volumes are computed by the average end area method. No correction is made for curved alignment or center of gravity. Computations are completed when the program punches the areas volumes and mass haul information.

MACRO FLOW DIAGRAM
MATERIALS CLASSIFICATION / VOLUMES



MATERIALS CLASSIFICATION/VOLUMES
OPERATING INSTRUCTIONS

Console Switches

1. PARITY - off, I/O CHECK - off, OFLOW - program
2. Sense Switches
   1 not used
   2 not used
   3 not used
   4 not used

Typewriter

Not used

Loading Program

1. Clear memory 310000300002
2. INSTANT STOP, RESET, LOAD

Order of Input

1. Program Deck
2. Terrain Factor Card
   FAC1, FAC2
3. Template Factor Card
   FAC3, FAC4
4. Volume Multiplication Card
   CMUL, FMUL
5. Volume Initialization (if used, branch to 7508)
   ID, BLSTA, CUTV, FILLV, CUMC, CUMF, HAUL
6. Collated Template and Terrain Cards
   2, ID, BLSTA, IY1, IZ1, IY2, IZ2, IY3, IZ3, IY4, IZ4, IY5, IZ5
   (up to 50 points on any one template)
   1, ID, BLSTA, IY1, IZ1, IY2, IZ2, IY3, IZ3, IY4, IZ4, IY5, IZ5
   (up to 100 points on any one terrain)

Special Instructions

FAC1, FAC2, FAC3, and FAC4 govern the location of the decimal point on the horizontal and vertical input for the terrain and template respectively. Terrain data may be produced by the Materials Classification/Preparation program.

Restart Procedure

1. INSTANT STOP, RESET, INSERT 4907508
2. RELEASE, START

Sorting and Listing Instructions

No sorting required. List with an 80 column panel.

Output List

ID, BLSTA, CUTV, FILLV, CUMC, CUMF, HAUL
ID, BLSTA, CUTA, FILLA


```
C     DTM DESIGN SYSTEM ** CLASSIFIED MATERIALS/VOLUMES ** 20 K
C     J.A. CURRIE ** MAY 15,1961
C     REVISION NO. 2 ** JAC ** 12-19-61
C     REVISION NO. 1 ** JAC ** 11-30-61
      DIMENSION YH(50),ZH(50),Y(100),Z(100),YA(4),ZA(4)                 00001
C     INITIALIZE
      GO TO 5                                                           00002
      READ,JOB,SB,CUTV,FILLV,CUMC,CUMF,HAUL                             00003
      GO TO 9                                                           00004
    5 JOB=0                                                             00005
    9 READ,FAC1,FAC2,FAC3,FAC4,CMUL,FMUL                                00006
      KSW=-1                                                            00007
      DELS=0                                                            00008
      OFF=0                                                             00009
      HIH=0                                                             00010
      SKEWB=1.0                                                         00011
      SKEWA=1.0                                                         00012
      BCUTA=0                                                           00013
      BFILA=0                                                           00014
      IDA=JOB                                                           00015
      ISW=0                                                             00016
    8 SA=0                                                              00017
      NHP=1                                                             00018
      NTP=1                                                             00019
      NSW=0                                                             00020
      JSW=0                                                             00021
   10 J=5                                                               00022
      IF(SENSE SWITCH 3)11,39                                           00023
   11 READ,IT,ID,S,SKEWA                                                00024
   39 READ,IT,ID,S                                                      00025
      IF(IDA)17,16,17                                                   00026
   17 IF(ID-IDA)16,16,14                                                00027
   16 IF(IT-2)18,20,22                                                  00028
C     TERRAIN READ SUBROUTINE  IT=1
   18 J=1                                                               00029
   28 IF(S-SA)32,30,32                                                  00030
   32 IF(SENSE SWITCH 2)218,37                                          00031
   30 SA=S                                                              00032
      IDA=ID                                                            00033
      DO 215 M=1,5                                                      00034
      READ,JY,JZ                                                        00035
      T1=JY                                                             00036
      Y(NTP)=T1*FAC1                                                    00037
      T1=JZ                                                             00038
      Z(NTP)=T1*FAC2                                                    00039
      IF(Z(NTP))214,215,214                                             00040
  214 NTP=NTP+1                                                         00041
  215 CONTINUE                                                          00042
      IF(Y(1)+Z(1))409,408,409                                          00043
  408 NTPX=NTP                                                          00044
      GO TO 410                                                         00045
  409 NTPX=NTP-1                                                        00046
  410 M=1                                                               00047
      ISW=1                                                             00048
      KSW=KSW+1                                                         00049
      GO TO 10                                                          00050
C     TEMPLATE READ SUBROUTINE IT=2
   20 J=2                                                               00051
      IF(KSW)26,24,7                                                    00052
```

```
      7 IF(SA)14,21,24                                                  00053
     24 IF(S-SA)40,26,25                                                00054
     25 IF(SENSE SWITCH 1)218,29                                        00055
     29 IF(ISW)38,38,218                                                00056
     21 SB=SA                                                           00057
     26 SA=S                                                            00058
        IDA=ID                                                          00059
    116 DO 110 M=1,5                                                    00060
        READ,JY,JZ                                                      00061
        T1=JY                                                           00062
        YH(NHP)=T1*FAC3                                                 00063
        T1=JZ                                                           00064
        ZH(NHP)=T1*FAC4                                                 00065
        IF(ZH(NHP))117,110,117                                          00066
    117 NHP=NHP+1                                                       00067
    110 CONTINUE                                                        00068
        IF(YH(1)+ZH(1))407,406,407                                      00069
    406 NHPX=NHP                                                        00070
        GO TO 119                                                       00071
    407 NHPX=NHP-1                                                      00072
    119 M=1                                                             00073
        ISW=0                                                           00074
        IF(KSW)6,10,10                                                  00075
      6 SB=SA                                                           00076
        GO TO 10                                                        00077
C       HEADER CARD  IT=3
     22 J=3                                                             00078
        IF(S-SA)14,34,36                                                00079
     34 READ,CMUL,FMUL,DELS,OFF,HIH                                     00080
        ISW=0                                                           00081
        GO TO 10                                                        00082
C       CHECK FOR TEMPLATE NOT IN TERRAIN
     36 JSW=1                                                           00083
        GO TO 218                                                       00084
     37 IF(ISW)38,38,33                                                 00085
     33 NSW=1                                                           00086
        GO TO 219                                                       00087
    217 NSW=2                                                           00088
    218 J=4                                                             00089
    219  IF(YH(1)-Y(1))14,220,220                                       00090
    220 IF(Y(NTPX)-YH(NHPX))14,222,222                                  00091
C       CHECK FOR ZERO END AREA
    222 IF(ZH(1))300,224,300                                            00092
    224 FILLA=0                                                         00093
        CUTA=0                                                          00094
        GO TO 320                                                       00095
C       ERROR MESSAGE
     40 IF(ISW)14,38,217                                                00096
     13 J=2                                                             00097
     14 IF(J-4)12,38,12                                                 00098
     12 PUNCH,J,ID,S                                                    00099
        IF(J-4)8,26,10                                                  00100
     38 PUNCH,J,IDA,SA                                                  00101
        NHP=1                                                           00102
        NTP=1                                                           00103
        GO TO 26                                                        00104
C       COMPUTATION ROUTINE
    300 FILLA=0                                                         00105
        CUTA=0                                                          00106
```



```
        I=1                                                             00107
        J=0                                                             00108
        IKE=0                                                           00109
    301 J=J+1                                                           00110
        IF(Y(J)-YH(I))301,500,302                                       00111
    302 I=I-1                                                           00112
        J=J-1                                                           00113
    303 I=I+1                                                           00114
        DA=Z(J)+((Z(J+1)-Z(J))*(YH(I)-Y(J)))/(Y(J+1)-Y(J))-ZH(I)        00115
        GO TO 502                                                       00116
    500 DA=Z(J)-ZH(I)                                                   00117
    502 XA=YH(I)                                                        00118
        IF(IKE)304,304,307                                              00119
    304 IKE=1                                                           00120
    305 DB=DA                                                           00121
        XB=XA                                                           00122
        IF(YH(I+1)-Y(J+1))303,504,306                                   00123
    306 J=J+1                                                           00124
        DA=Z(J)-((ZH(I+1)-ZH(I))*(Y(J)-YH(I)))/(YH(I+1)-YH(I))-ZH(I)    00125
        GO TO 506                                                       00126
    504 J=J+1                                                           00127
        I=I+1                                                           00128
        DA=Z(J)-ZH(I)                                                   00129
    506 XA=Y(J)                                                         00130
    307 IF(DA*DB)309,308,308                                            00131
    308 A1=0.5*(DA+DB)*(XA-XB)                                          00132
        GO TO 313                                                       00133
    309 W=(XA-XB)/(2.*(DA-DB))                                          00134
        A1=-DB*DB*W                                                     00135
        A2=DA*DA*W                                                      00136
    310 IF(A2)311,313,312                                               00137
    311 FILLA=FILLA+A2                                                  00138
        GO TO 313                                                       00139
    312 CUTA=CUTA+A2                                                    00140
    313 IF(A1)314,315,315                                               00141
    314 FILLA=FILLA+A1                                                  00142
        GO TO 317                                                       00143
    315 CUTA=CUTA+A1                                                    00144
    317 IF(I-NHPX)305,320,320                                           00145
    320 DIST=SA-SB                                                      00146
        J=4                                                             00147
        IF(SA-SB)14,323,321                                             00148
    321 CUTV=((CUTA)*(SKEWA)+(BCUTA)*(SKEWB))*(DIST)/54.                00149
        FILLV=((FILLA)*(SKEWA)+(BFILA)*(SKEWB))*(DIST)/54.              00150
        CUMC=CUMC+CUTV*CMUL                                             00151
        CUMF=CUMF+FILLV*FMUL                                            00152
        HAUL=CUMC+CUMF                                                  00153
        PUNCH,IDA,SA,CUTV,FILLV,CUMC,CUMF,HAUL                          00154
    323 PUNCH,IDA,SA,CUTA,FILLA                                         00155
        IF(DELS)326,328,326                                             00156
    326 PRINT,SA                                                        00157
        SA=SA+DELS                                                      00158
        PRINT,SA                                                        00159
    328 SB=SA                                                           00160
        BCUTA=CUTA                                                      00161
        BFILA=FILLA                                                     00162
        SKEWA=SKEWB                                                     00163
        NHP=1                                                           00164
        NTP=1                                                           00165
```

```
    J=1                                                          00166
    IF(NSW-1)325,14,13                                           00167
325 IF(JSW)14,324,34                                             00168
324 IF(SENSE SWITCH 1)26,600                                     00169
 600 IF(SENSE SWITCH 2)30,610                                    00170
 610 GO TO 26                                                    00171
    END                                                          00172
```


COMBINED PLOT PROGRAM

Purpose

The purpose of this program is po produce cards which when listed on the 407 Accounting Machine will produce plots of the ground profile, the slope stakes, or the mass-haul diagram, depending on the input.

Description

This program deck contains programs for plotting the ground profile, the slope stakes, and the mass-haul diagram. The appropriate program is selected by means of console switches and by the card type of the input cards.

All of the programs use the same plotting routine, which is actually a modified Fortran Output Subroutine. The output for each line of the plot is contained on two cards. The first card of the two card dequence is identified by a 1 in card column 1.

The plots can be produced to any desired scales. Scale input consists of horizontal and vertical scales and datum elevation. Any reasonable datum will work because the plot will shift by 7 inches if the 10-inch limits of the plot are exceeded. Exaggerated horizontal or vertical scales can be obtained if desired.

Profile Plot

Input to the profile plot is the offset cards (IT=5) from the Alignment Design/Offsets program. The centerline station and three interpolated elevations are used in the production of the plot cards. On the plot, an L designates the elevation of the left offset, an R the right offset, and a C the centerline. In cases where the R or C do not appear, they are the same as the L.

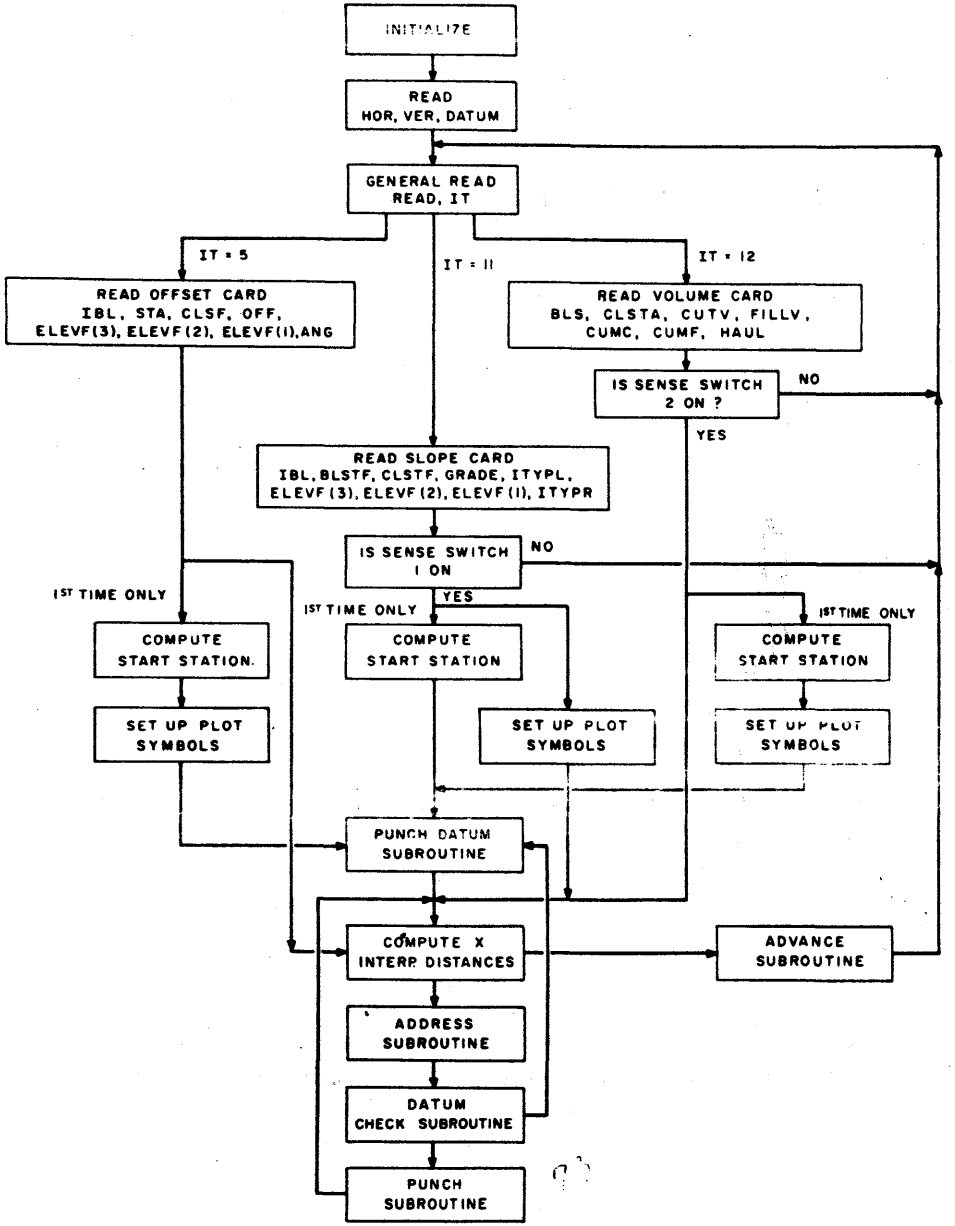
Slope Stakes Plot

The slope stakes plot is produced from the slope cards output from the Roadway Design/Volumes program. A "." designates the centerline; a "C" or an "F" delineates the edge of a cut or fill slope. In cases where the baseline is not a straight line, the plot is merely a graphical indication of the distance from the baseline and the relation between the centerline and the slope limits.

Mass-Haul Plot

The mass-haul plot is made from the volume output of the Roadway Design/Volumes program. The engineer should attempt to scale the plot so that it will be unnecessary for a shift to occur. Points above the zero cut-fill line are marked with a C; points below are marked with an F.

MACRO FLOW DIAGRAM
COMBINED PLOT PROGRAM



COMBINED PLOT PROGRAM
OPERATING INSTRUCTIONS

Console Switches

1. PARITY - off, I/O CHECK - off, OFLOW - program
2. Sense Switches
   1 On - Slope Stakes Plot
   2 On - Mass Diagram Plot
   3 not used
   4 not used

Typewriter

Not used

Loading Program

1. Clear Memory 310000300002
2. INSTANT STOP, RESET, LOAD

Order of Input

1. Scales Card: HOR, VER, DATUM
2. Input cards
   1. Plot Profile - Offset cards
      5, IBL, BLSTA, CLSTA, OFF, ELEVL, ELEVC, ELEVR, SKEW
   2. Plot Slope Stakes - Slope cards
      11, IBL, BLSTF, CLSTF, GRADE, ITYPL, OFF(3), OFF(2), OFF(1), ITYPR
   3. Plot Mass Diagram - Volume cards
      12, BLS, CLSTA, CUTV, FILLV, CUMC, CUMF, HAUL

Special Instructions

For input to the Plot Slope Stakes and Plot Mass Diagram, the type 11 and type 12 cards may be either separated or intermixed. The plots are controlled by sense switches.

Restart Procedure

1. To run a new plot

   INSTANT STOP, RESET, INSERT 4907500, RELEASE,START

2. To restart an existing plot

   INSTANT STOP, RESET, INSERT 4907500, RELEASE,START

Sorting and Listing Instructions

No sorting is required. List with the specially wired 407 DTM Design System Plot Panel.


```
C     DTM DESIGN SYSTEM ** COMBINED PLOTS/PROFILE/SLOPE STAKES/MASS HAUL ** 20K
C     N.W.BRYAN,P.O.ROBERTS 12 NOV 61
C     CORRECTION 2 * ALVARO VILLAVECES  ** MARCH 1962
C     CIVIL ENGINEERING SYSTEMS LABORATORY
      DIMENSION ELEVF(3),ELEVB(3),ICD(3),IADD(3),ISMB(3)                  00001
C     INITIALIZE
 7500 M=3                                                                 00002
      N=3                                                                 00003
      ISW1=1                                                              00004
      ISW2=1                                                              00005
      ISW3=1                                                              00006
      ISW4=1                                                              00007
      ISW5=1                                                              00008
C     READ SCALES AND DATUM
      READ,HOR,VER,DATUM                                                  00009
C     COMPUTE SCALES
      HORI=HOR/2.                                                         00010
      VERI=VER/10.                                                        00011
      SHIFT=VER*7.                                                        00012
C     GENERAL READ
  100 READ,IT                                                             00013
      IF(IT-11)101,600,601                                                00014
C     PROFILE PLOT
C     READ OFFSETS AND ELEVATIONS
  101 READ,IBL,STA,CLSF,OFF,ELEVF(3),ELEVF(2),ELEVF(1),ANG                00015
      IF(ISW1-1)400,200,400                                               00016
C     ADVANCE SUBR.
  200 CLSTB=CLSTF                                                         00017
      CLSB=CLSF                                                           00018
      DO 201 I=1,M                                                        00019
  201 ELEVB(I)=ELEVF(I)                                                   00020
      IF(ISW2-2)202,100,100                                               00021
  202 ISMB(1)=59                                                          00022
      ISMB(2)=43                                                          00023
      ISMB(3)=53                                                          00024
      ISW1=2                                                              00025
      ISW2=2                                                              00026
      ISTAR=CLSF/HORI                                                     00027
      START=ISTAR                                                         00028
      CLS=(START*HORI)+HORI                                               00029
C     PUNCH DATUM SUBR.
    1 DAT=-ABS(DATUM)                                                     00030
      PUNCH,DAT                                                           00031
      IF(ISW3-2)100,702,401                                               00032
C     COMPUTE X INTERP. DISTANCES
  400 XN=CLSF-CLSB                                                        00033
      DX=CLS-CLSB                                                         00034
      IF(DX-XN)401,401,200                                                00035
C     ADDRESS SUBR.
  401 DO 411 J=1,M                                                        00036
      YN=ELEVF(J)-ELEVB(J)                                                00037
      DZ=DX*(YN/XN)                                                       00038
      ELZ=ELEVB(J)+DZ                                                     00039
      IF(ISW4-1)1002,4,1002                                               00040
    4 ADDZ=ELZ-DATUM                                                      00041
      IADDZ=(ADDZ/VERI)                                                   00042
      IADD(J)=7311+IADDZ*2                                                00043
      IF(J-2)403,402,3                                                    00044
  402 IF(ISW5-1)412,412,900                                               00045
```

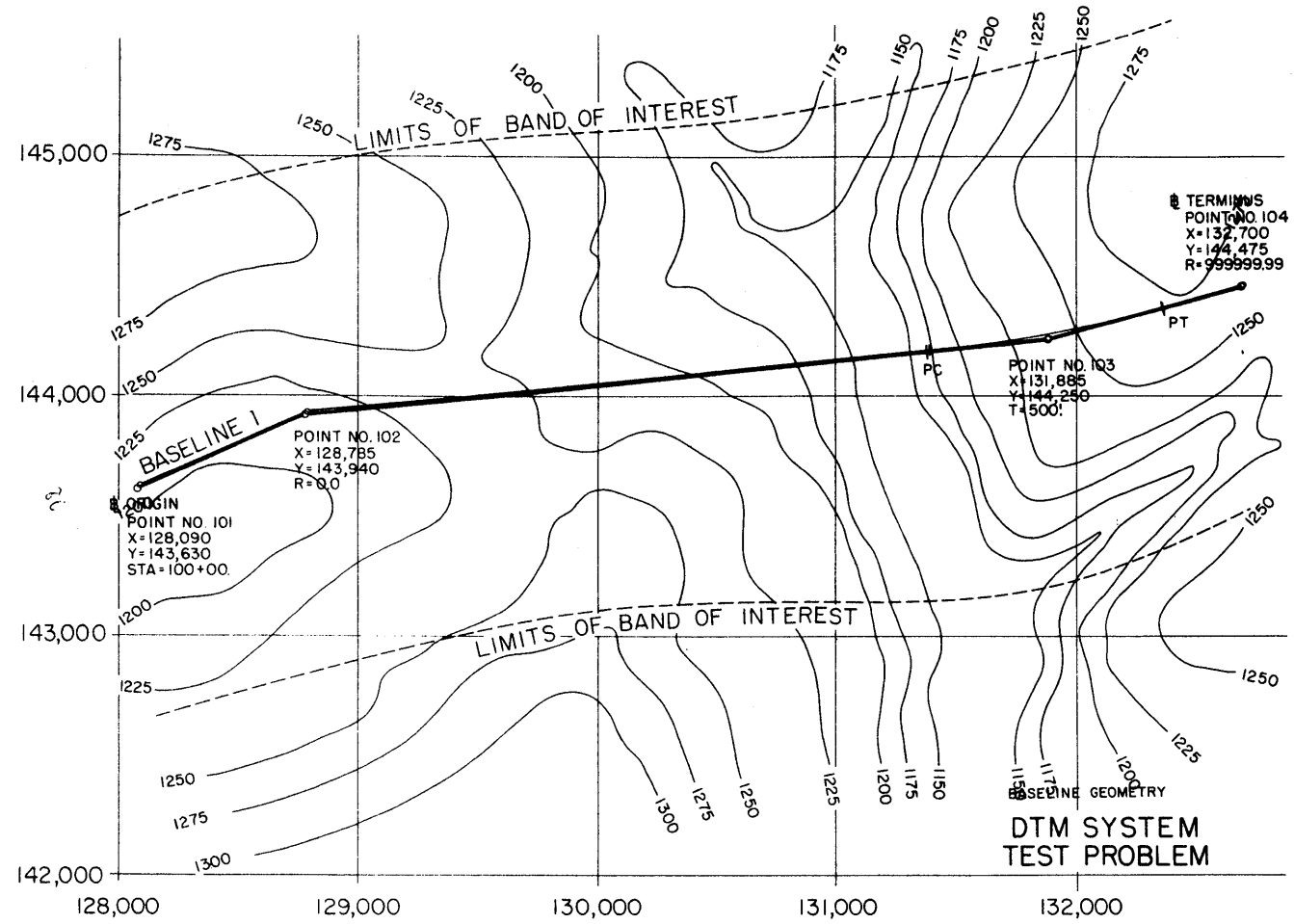
```
  402 IF(ISW5-1)412,412,900                                          00045
  412 IEL=-ELZ                                                       00046
      GO TO 403                                                      00047
C     DATUM CHECK SUBR.
 0003 ITE=IADD(3)-IADD(1)                                            00048
      SP=ITE                                                         00049
      IF(ABS(SP)-210.)403,2,2                                        00050
 0002 STOP                                                           00051
  403 ISW3=3                                                         00052
      IF(IADD(J)-7331)407,407,404                                    00053
  404 IF(IADD(J)-7541)405,409,409                                    00054
  405 IF(IADD(J)-7429)406,406,410                                    00055
  406 ICD(J)=1                                                       00056
      GO TO 411                                                      00057
  407 DATUM=DATUM-SHIFT                                              00058
      GO TO 1                                                        00059
  409 DATUM=DATUM+SHIFT                                              00060
      GO TO 1                                                        00061
  410 ICD(J)=2                                                       00062
      IADD(J)=IADD(J)-120                                            00063
  411 CONTINUE                                                       00064
C     PUNCH SUBR.
  504 PUNCH,CLS                                                      00065
      DO 501 I=1,N                                                   00066
      IF(ICD(I)-1)501,500,501                                        00067
  500 PUNCH,ISMB(I),ICD(I),IADD(I)                                   00068
  501 CONTINUE                                                       00069
      DO 503 I=1,N                                                   00070
      IF(ICD(I)-2)503,502,503                                        00071
  502  PUNCH,ISMB(I),ICD(I),IADD(I)                                  00072
  503 CONTINUE                                                       00073
  510 PUNCH,IEL                                                      00074
      CLS=CLS+HORI                                                   00075
      GO TO 400                                                      00076
C     SLOPE STAKE PLOT
  600 READ,IBL,BLSTF,CLSTF,GRADE,ITYPL,ELEVF(3),ELEVF(2),ELEVF(1),ITYPR  00077
      DO 602 I=1,3                                                   00078
  602 ELEVF(I)=-ELEVF(I)                                             00079
      IF(SENSE SWITCH 1)610,100                                      00080
  610 CLSF=BLSTF                                                     00081
      IF(ISW1-1)620,620,600                                          00082
  620 ISTAR=CLSF/HORI                                                00083
      START=ISTAR                                                    00084
      CLS=(START*HORI)+HORI                                          00085
  700 ISW1=2                                                         00086
      ISW3=2                                                         00087
      GO TO 1                                                        00088
  702 ISW2=2                                                         00089
      GO TO 200                                                      00090
  703 ISW2=3                                                         00091
C     DETERMINE PLOTTING SYMBOLS
  800 IF(ITYPR-3)802,801,802                                         00092
  801 ISMB(1)=43                                                     00093
      GO TO 803                                                      00094
  802 ISMB(1)=46                                                     00095
  803 IF(ITYPL-3)805,804,805                                         00096
  804 ISMB(3)=43                                                     00097
      GO TO 806                                                      00098
  805 ISMB(3)=46                                                     00099
```

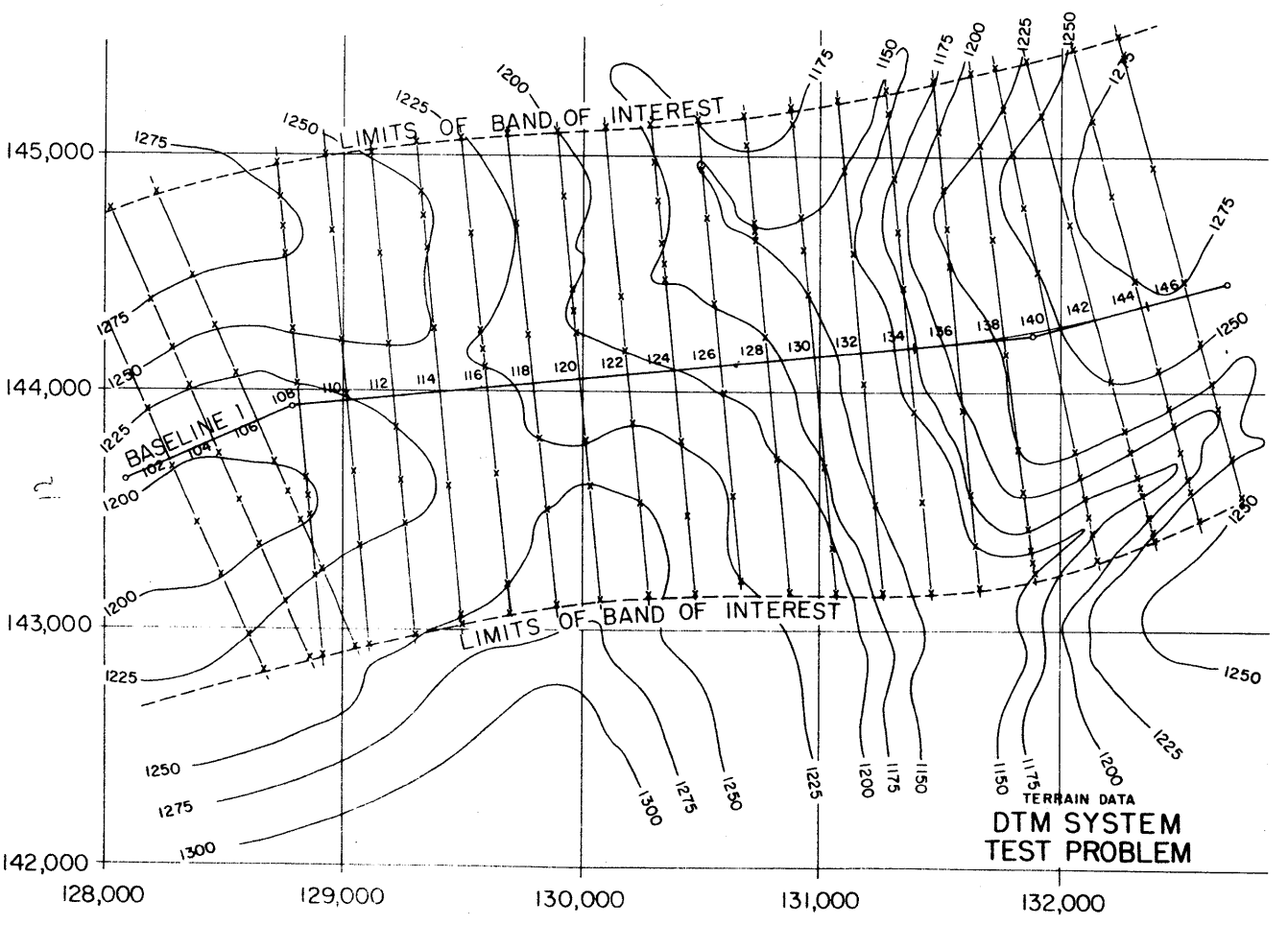


```
  806 ISMB(2)=03                                                     00100
      ISW5=2                                                         00101
C     INTERPOLATE CLSTA
      GO TO 400                                                      00102
  900 CLSTA=CLSTB+SQR(DX*DX+DZ*DZ)                                   00103
      IEL=-CLSTA                                                     00104
      GO TO 403                                                      00105
C     MASS HAUL PLOT
  601 READ,BLS,CLSTA,CUTV,FILLV,CUMC,CUMF,HAUL                       00106
      IF(SENSE SWITCH 2)1000,100                                     00107
 1000 CLSTF=BLS                                                      00108
      CLSF=CLSTA                                                     00109
      ELEVF(1)=HAUL                                                  00110
      IF(ISW1-1)400,1001,400                                         00111
 1001 ISTAR=CLSF/HORI                                                00112
      START=ISTAR                                                    00113
      CLS=HORI*(START+1.)                                            00114
      ISW2=2                                                         00115
      ISW4=2                                                         00116
      ISMB(2)=44                                                     00117
      M=1                                                            00118
 1060 IDATU=10.*DATUM                                                00119
      IDAT=7311+IDATU*2                                              00120
      IF(IDAT-7331)1051,1051,1052                                    00121
 1051 IDAT=7333                                                      00122
      GO TO 1053                                                     00123
 1052 IF(IDAT-7541)1053,1053,1054                                    00124
 1054 IDAT=7541                                                      00125
 1053 IADD(2)=IDAT                                                   00126
      IF(DATUM-6.)1003,1004,1004                                     00127
 1003 ICD(2)=1                                                       00128
      GO TO 1005                                                     00129
 1004 IADD(2)=IADD(2)-120                                            00130
      ICD(2)=2                                                       00131
 1005 IF(ISW1-1)400,1070,400                                         00132
 1070 VERI=VERI*1000.                                                00133
      ISW1=2                                                         00134
      GO TO 200                                                      00135
 1002 IADDI=(ELZ/VERI)                                               00136
      IADD(1)=IDAT+IADDI*2                                           00137
      SP=IDAT-IADD(1)                                                00138
      IF(ABS(SP)-210.)1020,1020,2                                    00139
 1020 IF(IADD(1)-7331)1006,1007,1007                                 00140
 1007 IF(IADD(1)-7541)1008,1008,1009                                 00141
 1008 IF(IADD(1)-IDAT)1010,1010,1011                                 00142
 1006 DATUM=DATUM+1.                                                 00143
      GO TO 1060                                                     00144
 1009 DATUM=DATUM-1.                                                 00145
      GO TO 1060                                                     00146
 1010 ISMB(1)=46                                                     00147
      GO TO 1012                                                     00148
 1011 ISMB(1)=43                                                     00149
 1012 IF(IADD(1)-7429)1013,1013,1014                                 00150
 1013 ICD(1)=1                                                       00151
      GO TO 1015                                                     00152
 1014 ICD(1)=2                                                       00153
      IADD(1)=IADD(1)-120                                            00154
 1015 PUNCH,CLS                                                      00155
      DO 1016 J=1,2                                                  00156
```

```
      IF(ICD(J)-1)1016,1017,1016                                        00157
1017  PUNCH,ISMB(J),ICD(J),IADD(J)                                      00158
1016  CONTINUE                                                          00159
      DO 1019 J=1,2                                                     00160
      IF(ICD(J)-2)1019,1018,1019                                        00161
1018  PUNCH,ISMB(J),ICD(J),IADD(J)                                      00162
1019  CONTINUE                                                          00163
      IEL=-ABSF(ELZ)/1000.                                              00164
      GO TO 510                                                         00165
      END                                                               00166
```

APPENDIX 1
TEST PROBLEM


LIMITS OF BAND OF INTEREST
LIMITS OF BAND OF INTEREST
BASELINE 1
POINT NO. 101
X=128,090
Y=143,630
STA=100+00.
POINT NO. 102
X=128,785
Y=143,940
R=0.0
POINT NO. 103
X=131,885
Y=144,250
T=500.
TERMINUS
POINT NO. 104
X=132,700
Y=144,475
R=999999.99
PC
PT
BASELINE GEOMETRY
DTM SYSTEM
TEST PROBLEM
145,000
144,000
143,000
142,000
128,000
129,000
130,000
131,000
132,000


LIMITS OF BAND OF INTEREST
LIMITS OF BAND OF INTEREST
BASELINE 1
TERRAIN DATA
DTM SYSTEM
TEST PROBLEM
145,000
144,000
143,000
142,000
128,000
129,000
130,000
131,000
132,000

DTM
TERRAIN DATA INPUT FORM

PROJECT DTM TEST PROB
PAGE 1 of 2
DATE 3/21/62
RECORDED BY POR & THS

CARD TYPE | IT (1–2) | 01 |

BASELINE NUMBER | IBL (4–6) | 001 |

BLSTA (8–16)	± (18)	DIST (19–22)	ELEV (24–27)	± (29)	DIST (30–33)	ELEV (35–38)	± (40)	DIST (41–44)	ELEV (46–49)	± (51)	DIST (52–55)	ELEV (57–60)	± (62)	DIST (63–66)	ELEV (68–71)
10200	-	640	1275	-	390	1250	-	230	1225	+	[illegible]	1200	+	300	1180
10200	+	550	1200	+	930	1225	+	1000	1232		0	0		0	0
10400	-	1075	1295	-	650	1275	-	415	1250	-	250	1225	+	75	1200
10400	+	280	1185	+	490	1200	+	760	1225	+	1025	1240		0	0
10600	-	1060	1290	-	670	1275	-	440	1250	-	210	1225	+	200	1200
10600	+	335	1195	+	465	1200	+	700	1225	+	1000	1240		0	0
10800	-	1025	1265	-	880	1275	-	760	1280	-	645	1275	-	310	1250
10800	-	90	1225	+	310	1200	+	400	1198	+	470	1200	+	730	1225
10800	+	1080	1240		0	0		0	0		0	0		0	0
11000	-	1040	1260	-	720	1270	-	350	1250	-	20	1225	+	310	1210
11000	+	640	1225	+	1050	1245		0	0		0	0		0	0
11200	-	1020	1250	-	610	1260	-	210	1250	+	140	1225	+	370	1220
11200	+	550	1225	+	1030	1250		0	0		0	0		0	0
11400	-	1050	1235	-	850	1250	-	750	1252	-	270	1248	+	410	1230
11400	+	960	1250	+	1000	1255		0	0		0	0		0	0
11600	-	1050	1225	-	760	1237	-	240	1225	-	160	1220	-	80	1225
11600	+	375	1240	+	850	1250	+	980	1260		0	0		0	0
11800	-	1060	1217	-	675	1223	-	200	1217	+	240	1225	+	550	1250
11800	+	960	1267		0	0		0	0		0	0		0	0
12000	-	1060	1200	-	780	1210	-	380	1200	-	290	1197	-	200	1200
12000	+	270	1225	+	460	1250	+	960	1270		0	0		0	0
12200	-	1050	1185	-	340	1180	-	100	1200	+	220	1225	+	560	1250
12200	+	960	1260		0	0		0	0		0	0		0	0
12400	-	1050	1170	-	900	1175	-	780	1180	-	530	1175	-	450	1170
12400	-	200	1175	-	10	1200	+	320	1225	+	640	1230	+	980	1235

NOTE: All terrain cards must be complete. Finish last card of each section with zero distances and elevations.

DTM
TERRAIN DATA INPUT FORM

PROJECT DTM TEST PROB.
PAGE 2 of 2
DATE 3/21/62
RECORDED BY JHS & PGR

CARD TYPE | IT (1–2) | 01 |

BASELINE NUMBER | IBL (4–6) | 001 |

BLSTA (8–16)	± (18)	DIST (19–22)	ELEV (24–27)	± (29)	DIST (30–33)	ELEV (35–38)	± (40)	DIST (41–44)	ELEV (46–49)	± (51)	DIST (52–55)	ELEV (57–60)	± (62)	DIST (63–66)	ELEV (68–71)
12600	-	1040	1175	-	830	1150	-	620	1159	-	260	1175		130	1200
12600		570	1220		930	1225		990	1230		0	0		0	0
12800	-	1050	1185	-	900	1175	-	590	1150	-	550	1140	-	520	1150
12800	-	100	1175		430	1200		1000	1220		0	0		0	0
13000	-	1060	1180	-	990	1175	-	590	1150	-	450	1145	-	270	1150
13000		470	1175		830	1200		1030	1205		0	0		0	0
13200	-	1070	1160	-	800	1150	-	410	1149		130	1140		660	1150
13200		1050	1170		0	0		0	0		0	0		0	0
13400	-	1100	1147	-	1000	1150	-	730	1175	-	490	1190	-	250	1175
13400		290	1150		670	1137		1060	1140		0	0		0	0
13600	-	1130	1175	-	920	1200	-	660	1225	-	490	1230	-	320	1225
13600		300	1200		660	1175		880	1150		1060	1140		0	0
13800	-	1130	1210	-	830	1225	-	410	1232		90	1229		500	1225
13800		670	1200		830	1175		930	1150		980	1148		1020	1150
14000	-	1130	1217	-	950	1225	-	760	1250	-	530	1255	-	230	1250
14000		540	1225		650	1200		750	1175		830	1155		900	1175
14000		1020	1190		0	0		0	0		0	0		0	0
14200	-	1140	1230	-	910	1250	-	400	1273		280	1250		500	1225
14200		600	1200		710	1175		750	1170		790	1175		890	1200
14200		950	1225		970	1230		0	0		0	0		0	0
14400	-	1130	1257	-	850	1275	-	490	1285	-	110	1275		290	1250
14400		460	1225		520	1200		650	1182		760	1200		820	1225
14400		950	1235		0	0		0	0		0	0		0	0
14600	-	1130	1267	-	1050	1275	-	560	1290	-	50	1275		220	1250
14600		400	1225		520	1205		740	1225		900	1245		0	0

NOTE: All terrain cards must be complete. Finish last card of each section with zero distances and elevations.

DTM
PROJECT INPUT FORM

ENGINEER J. H. SUHRBIER
DATE MARCH 21, 1962
PROJECT DTM TEST PROBLEM JOB NO. 8431
SECTION Test 1 LENGTH .75 mi
SOURCE MAPS DTM SYSTEM TEST PROBLEM

TERRAIN PREPARATION PHASE

CONTOUR INTERVAL	MAXIMUM SLOPE %	MAXIMUM DISTANCE BETWEEN TERRAIN
25.0	50.0	800.0

INPUT TO TERRAIN PREPARATION/EDIT PROGRAM

OVERALL SYSTEM INPUT

HORIZONTAL MULT. FACTOR	VERTICAL MULT. FACTOR
1.0	1.0

INPUT TO:
ALIGNMENT DESIGN /OFFSETS PROGRAM
ROADWAY DESIGN/ TEMPLATE PROGRAM
MATERIALS CLASSIFICATION/PREPARATION PROGRAM
MATERIALS CLASSIFICATION/VOLUMES PROGRAM

NOTE: UNLESS THESE FACTORS ARE 1.0 RELATED CRITERIA MUST BE ADJUSTED ACCORDINGLY

ALIGNMENT DESIGN PHASE

LEFT OFFSET	℄ OFFSET	RIGHT OFFSET
-34.0	0.0	34.0

INPUT TO ALIGNMENT DESIGN/OFFSETS PROGRAM

NOTE: OFFSETS ARE MINUS TO LEFT OF CENTERLINE

HORIZONTAL SCALE FT/IN	VERTICAL SCALE FT/IN	DATUM ELEVATION FT
200.0	30.0	1000.0

INPUT TO COMBINED PLOT PROGRAM (PROFILE)

ROADWAY DESIGN PHASE

WIDTH TO LEFT	WIDTH TO RIGHT
-1100.0	1100.0

INPUT TO ROADWAY DESIGN/PREPARATION PROGRAM

NOTE: WIDTHS ARE MINUS TO LEFT OF CENTERLINE

HORIZONTAL SCALE FT/IN	OFFSET SCALE FT/IN	DATUM OFFSET FT
200.0	200.0	-1500.0

INPUT TO COMBINED PLOT PROGRAM (SLOPES STAKES)

NOTE: HORIZONTAL AND OFFSET SCALES SHOULD BE CONSISTENTLY THE SAME ON ALL PLOTS

HORIZONTAL SCALE FT/IN.	VOLUMES SCALE 1000 CU.YDS./IN.	ZERO LOCATION IN
200.0	50.0	4.0

INPUT TO COMBINED PLOT PROGRAM (MASS HAUL DIAGRAM)

NOTE: "ZERO LOCATION" IS THE DISTANCE FROM THE LEFT MARGIN TO THE ZERO CUT-FILL LINE OF THE DIAGRAM

MATERIALS CLASSIFICATION

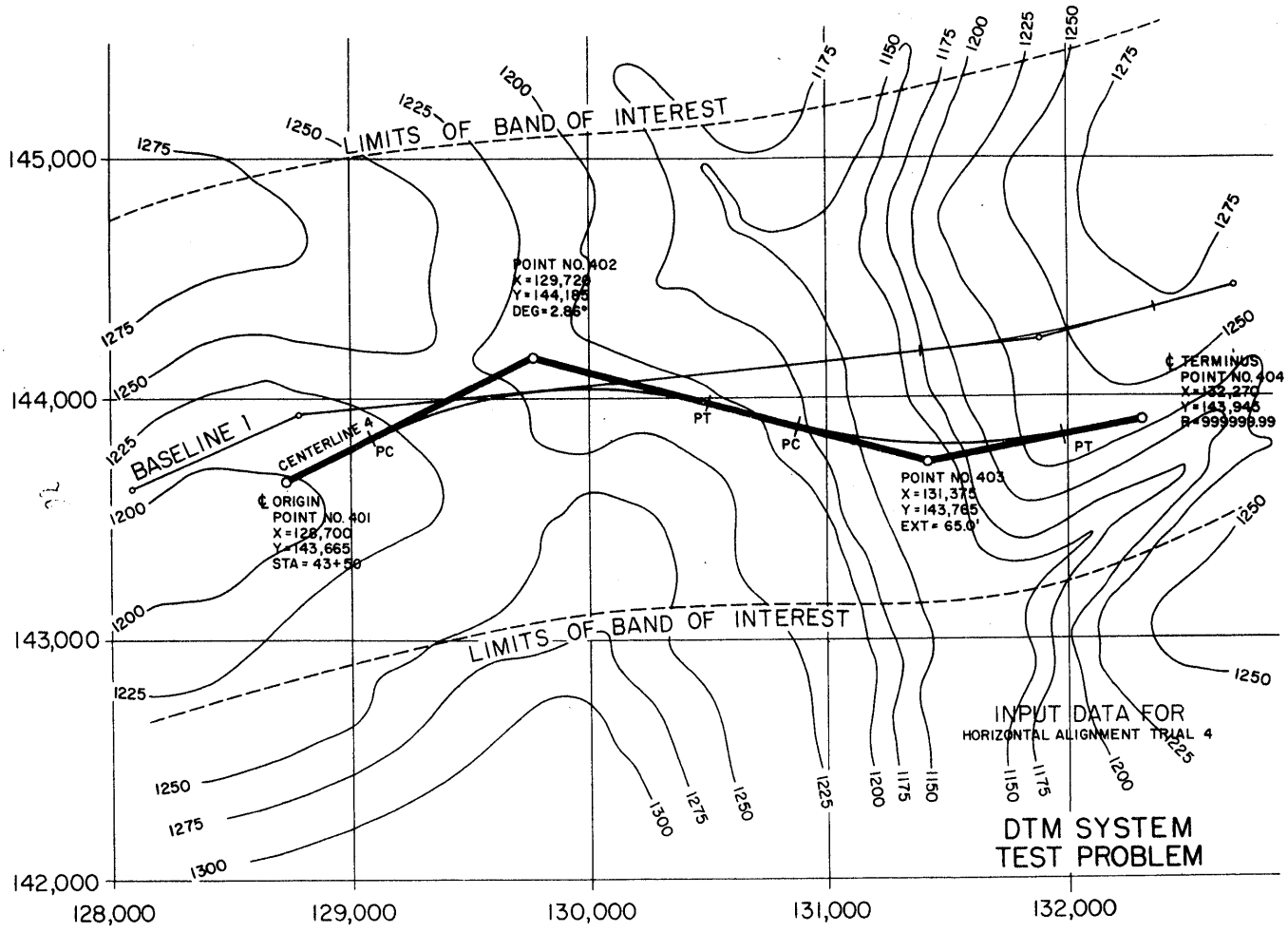
TEMP. HORIZONTAL FACTOR	TEMP. VERTICAL FACTOR
1.0	1.0

INPUT TO MATERIALS CLASSIFICATION/VOLUMES PROGRAM

CUT MULTIPL. FACTOR	FILL MULTIPL. FACTOR
0.0	1.0

INPUT TO MATERIALS CLASSIFICATION/VOLUMES PROGRAM

```
DTM DESIGN SYSTEM ** TERRAIN PREPARATION / EDIT                              001
    +25.00     +50.00    +800.00                                            002
+1 +12600.00    -830.00  MISSED LOW POINT OR BAD DATA                       003
 -1040.00  +1175.00   -830.00  +1150.00   -620.00  +1159.00                 004
```


LIMITS OF BAND OF INTEREST
LIMITS OF BAND OF INTEREST
BASELINE 1
CENTERLINE 4
℄ ORIGIN
POINT NO. 401
X = 128,700
Y = 143,665
STA = 43+50
POINT NO. 402
X = 129,728
Y = 144,185
DEG = 2.86°
POINT NO. 403
X = 131,375
Y = 143,765
EXT = 65.0'
℄ TERMINUS
POINT NO. 404
X = 132,270
Y = 143,945
R = 999999.99
PC
PT
PC
PT
INPUT DATA FOR
HORIZONTAL ALIGNMENT TRIAL 4
DTM SYSTEM
TEST PROBLEM
145,000
144,000
143,000
142,000
128,000
129,000
130,000
131,000
132,000

DTM
ALIGNMENT DESIGN
INPUT FORM

ENGINEER POR & JHS
DATE 3/27/62
PROJECT DTM TEST PROB.

HORIZONTAL GEOMETRY INPUT IT=3

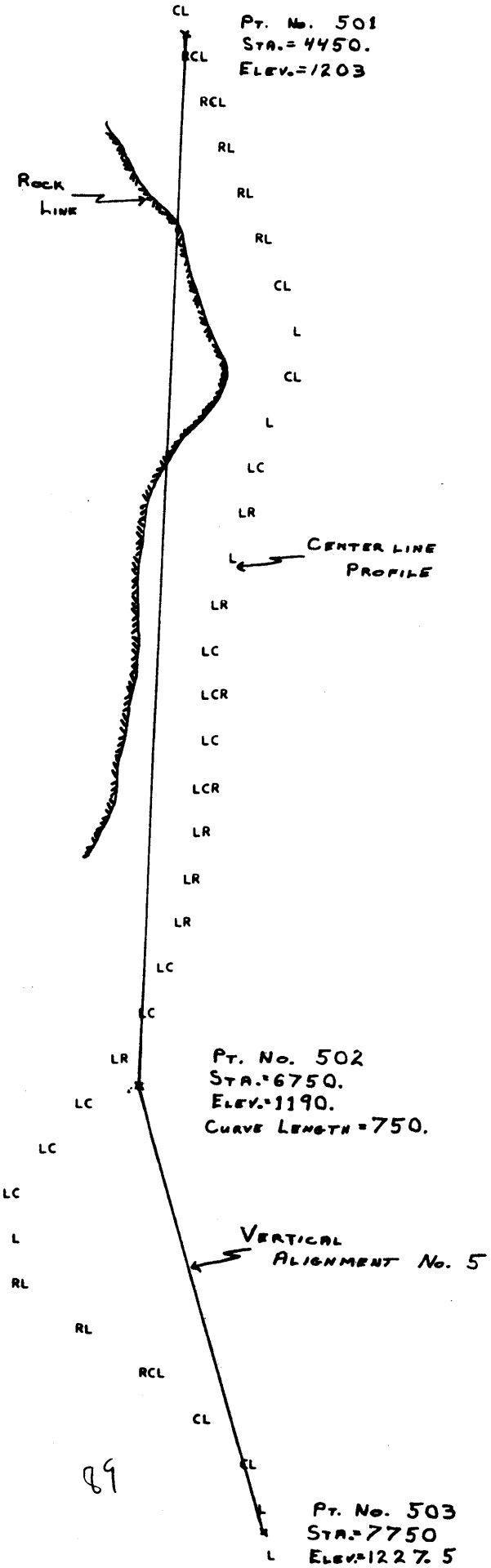
POINT NUMBER	X COORDINATE	Y COORDINATE	ORIGIN STA. RADIUS OR TERMINUS	DEGREE OF CURVATURE	TANGENT DISTANCE	EXTERNAL DISTANCE
101	128080.0	143630.0	10000.0	0.0	0.0	0.0
102	128785.0	143940.0	0.0	0.0	0.0	0.0
103	131885.0	144250.0	0.0	0.0	500.0	0.0
104	132700.0	144475.0	999999.99	0.0	0.0	0.0
401	128700.0	143665.0	4350.0	0.0	0.0	0.0
402	129720.0	144185.0	0.0	2.86	0.0	0.0
403	131375.0	143765.0	0.0	0.0	0.0	65.0
404	132270.0	143945.0	999999.99	0.0	0.0	0.0

NOTES:
1. All points must have point numbers with appropriate ℄ or ℄ numbers.
2. A value of 999999.99 in the radius column terminates the line.
3. A value of 888888.88 in the radius column sets up an intermediate terminus.

```
*      DTM DESIGN SYSTEM ** ALIGNMENT DESIGN / GEOMETRY OUTPUT
*3    ID   XCOORD/PC   YCOORD/PI   RADIUS/PT   DEGCUR/AZ   TAN/ANGLE   EXT/CURVLGTH
 3   101   128090.00   143630.00   10000.000   .00000000   .00000000   .00000000
 3   101   10000.000   10000.000   10000.000   65.961073   .00000000   .00000000
 3   102   128785.00   143940.00   .00000000   .00000000   .00000000   .00000000
 3   102   10761.002   10761.002   10761.002   84.289415   18.328341   .00000000
 3   103   131885.00   144250.00   5878.7636   .97462293   499.99999   21.224689
 3   103   13376.464   13876.463   14374.063   74.566584   -9.7228303  997.59917
 3   104   132700.00   144475.00   999999.99
 3   104   14719.552   14719.552   14719.552
 3   401   128700.00   143665.00   4350.0000   .00000000   .00000000   .00000000
 3   401   4350.0000   4350.0000   4350.0000   62.987342   .00000000   .00000000
 3   402   129720.00   144185.00   2003.3489   2.8600000   754.05432   137.21277
 3   402   4740.8473   5494.9016   6183.2377   104.23971   41.252366   1442.3904
 3   403   131375.00   143765.00   2548.3600   2.2483393   579.23446   64.999999
 3   403   6557.4104   7136.6448   7696.5255   78.628534   -25.611174  1139.1151
 3   404   132270.00   143945.00   999999.99
 3   404   8030.2117   8030.2117   8030.2117
```

```
*      DTM DESIGN SYSTEM ** ALIGNMENT DESIGN / OFFSETS OUTPUT
*5  IBL     BL STA      CL STA       OFFSET     LEFT ELEV    CL  ELEV   RIGHT ELEV   SKEW
 5   1   10600.000   4378.6972   215.03586   1201.1592   1199.4432   1198.1822   .998653
 5   1   10800.000   4512.0154   206.32817   1208.7604   1206.4795   1204.1987   .931678
 5   1   11000.000   4726.6844   128.34123   1219.9161   1218.2573   1216.5985   .931678
 5   1   11200.000   4937.8830   60.742000   1233.1836   1230.6613   1228.1391   .962848
 5   1   11400.000   5143.0143   15.546800   1241.3548   1240.4415   1239.5281   .985407
 5   1   11600.000   5344.5801  -8.7202000   1226.2262   1227.3498   1228.4735   .997520
 5   1   11800.000   5544.7066  -12.817100   1219.7848   1220.4033   1221.0217   .999565
 5   1   12000.000   5745.4184   3.1269000   1208.9808   1210.8046   1212.6284   .991606
 5   1   12200.000   5948.8090   39.606600   1208.1779   1210.9067   1213.6356   .973396
 5   1   12400.000   6157.1963   97.808600   1205.4397   1208.1673   1210.8948   .944344
 5   1   12600.000   6369.9057   170.23324   1200.1846   1201.8287   1203.4729   .939989
 5   1   12800.000   6582.6149   242.70670   1189.4652   1191.1654   1192.8655   .943317
 5   1   13000.000   6791.8404   303.97170   1168.2035   1169.3909   1170.5783   .967358
 5   1   13200.000   6996.6617   347.85900   1143.4589   1144.1105   1144.7621   .984581
 5   1   13400.000   7200.1047   375.45900   1148.2455   1147.0765   1145.9075   .995003
 5   1   13600.000   7413.8002   391.49020   1196.0106   1193.6466   1191.2825   .998741
 5   1   13800.000   7627.3297   396.89180   1226.3377   1226.0060   1225.6743   .999999
 5   1   14000.000   7840.8175   395.73786   1230.7878   1229.6839   1228.5800   .999973
```

* DTM DESIGN SYSTEM ** PROFILE PLOT



89

DTM

ROADWAY DESIGN

INPUT FORM 1

ENGINEER POR & THS

DATE 3/27/63

PROJECT DTM Test Prob.

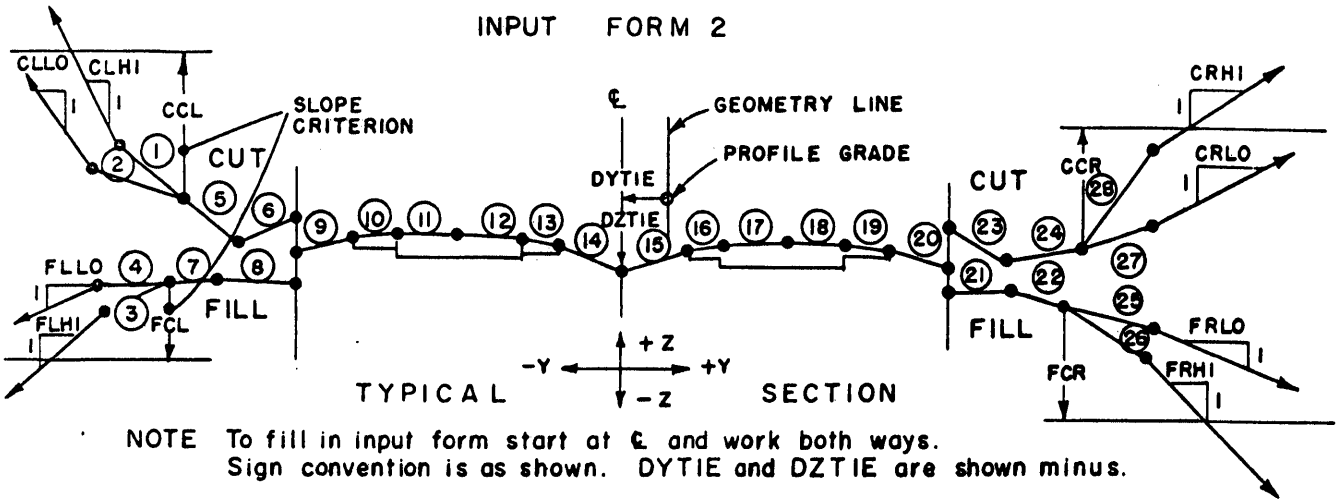
VERTICAL GEOMETRY INPUT IT=6

POINT NO.	STATION VPI		ELEVATION VPI		CURVE LENGTH	
501	4450	0	1203	0	0	0
502	6750	0	1190	0	750	0
503	7750	0	1227	5	999999	99

NOTE: Indicate terminus with 999999.99 in CURVE LENGTH column.

ENGINEER BOB & TMS
DATE 3/27/63
PROJECT DTM TEST PROB.

DTM
ROADWAY DESIGN
INPUT FORM 2



NOTE To fill in input form start at ℄ and work both ways.
Sign convention is as shown. DYTIE and DZTIE are shown minus.

LEFT SLOPES — ADDITIONAL PARAMETERS IT = 9 — RIGHT SLOPES

CLLO	CLHI	CCL	DYTIE	DZTIE	CCR	CRHI	CRLO
4 0	2 0	10 0	0 0	-1 0	10 0	-2 0	-4 0
FLLO	**FLHI**	**FCL**	**FMUL**	**CMUL**	**FCR**	**FRHI**	**FRLO**
4 0	2 0	10 0	1 25	1 0	10 0	-2 0	-4 0

TEMPLATE SEGMENTS IT = 7

DY	DZ	DY	DZ	DY	DZ	DY	DZ
(1)		(2)		(3)		(4)	
-2 0	1 0	-4 0	1 0	-0 0	0 0	-1 0	0 0
(5)		(6)		(7)		(8)	
-2 0	1 0	-2 0	-1 0	-0 0	0 0	-1 0	0 0
(9)		(10)		(11)		(12)	
-0 0	0 0	-6 0	-0 2	-12 0	-0 1	-12 0	0 1
(13)		(14)		(15)		(16)	
-6 0	0 2	-4 0	1 0 ℄	4 0	1 0	6 0	0 2
(17)		(18)		(19)		(20)	
12 0	0 1	12 0	-0 1	6 0	-0 2	0 0	0 0
(21)		(22)		(23)		(24)	
1 0	0 0	0 0	0 0	2 0	-1 0	2 0	1 0
(25)		(26)		(27)		(28)	
1 0	0 0	0 0	0 0	4 0	1 0	2 0	1 0

TEMPLATE CHANGES IT = 8

SEG. NO.	START STA.	END STA.	NEW DY	NEW DZ
14	7350 0	7550 0	-6 0	1 0
15	7350 0	7550 0	8 0	1 0

VOLUME START IT = 12

BLSTA	CLSTA	CUTV	FILLV	CUMC	CUMF	HAUL
10550 0	4350 0	0 0	0 0	315 0	-420 0	-105 0

```
*      DTM DESIGN  SYSTEM ** ROADWAY DESIGN / PREPARATION OUTPUT
*  COLLATED TEMPLATE AND TERRAIN WHICH FOLLOWS MAY BE USED AS INPUT TO TEMPLATE
*  PROGRAM IN PLACE OF HAND COLLATED DECK
 5  1  10600.000  4378.6972  215.03586  .00000000  .00000000  .00000000  .998653
 1  1  10600.000 -1060  1290 -670  1275 -440  1250 -210  1225  200  1200
 1  1  10600.000  335  1195  465  1200  700  1225  1000  1240  0  0
 5  1  10800.000  4512.0154  206.32817  .00000000  .00000000  .00000000  .931678
 1  1  10800.000 -1025  1265 -880  1275 -760  1280 -645  1275 -310  1250
 1  1  10800.000 -90 .1225  310  1200  400  1198  470  1200  730  1225
 1  1  10800.000  1080  1240  0  0  0  0  0  0  0  0
 5  1  11000.000  4726.6844  128.34123  .00000000  .00000000  .00000000  .931678
 1  1  11000.000 -1040  1260 -720  1270 -250  1250 -20  1225  310  1210
 1  1  11000.000  640  1225  1050  1245  0  0  0  0  0  0
 5  1  11200.000  4937.8830  60.742000  .00000000  .00000000  .00000000  .962848
 1  1  11200.000 -1020  1250 -610  1260 -210  1250  140  1225  370  1220
 1  1  11200.000  550  1225  1030  1250  0  0  0  0  0  0
 5  1  11400.000  5143.0143  15.546800  .00000000  .00000000  .00000000  .985407
 1  1  11400.000 -1050  1235 -850  1250 -750  1252 -270  1248  410  1230
 1  1  11400.000  960  1250  1000  1255  0  0  0  0  0  0
 5  1  11600.000  5344.5801 -8.7202000  .00000000  .00000000  .00000000  .997520
 1  1  11600.000 -1050  1225 -760  1237 -240  1225 -160  1220 -80  1225
 1  1  11600.000  375  1240  850  1250  980  1260  0  0  0  0
 5  1  11800.000  5544.7066 -12.817100  .00000000  .00000000  .00000000  .999565
 1  1  11800.000 -1060  1217 -675  1223 -200  1217  240  1225  550  1250
 1  1  11800.000  960  1267  0  0  0  0  0  0  0  0
 5  1  12000.000  5745.4184  3.1269000  .00000000  .00000000  .00000000  .991606
 1  1  12000.000 -1060  1200 -780  1210 -380  1200 -290  1197 -200  1200
 1  1  12000.000  270  1225  460  1250  960  1270  0  0  0  0
 5  1  12200.000  5948.8090  39.606600  .00000000  .00000000  .00000000  .973396
 1  1  12200.000 -1050  1185 -340  1180 -100  1200  220  1225  560  1250
 1  1  12200.000  960  1260  0  0  0  0  0  0  0  0
 5  1  12400.000  6157.1963  97.808600  .00000000  .00000000  .00000000  .944344
 1  1  12400.000 -1050  1170 -900  1175 -720  1180 -530  1175 -450  1170
 1  1  12400.000 -380  1175 -10  1200  320  1225  640  1230  980  1235
 5  1  12600.000  6369.9057  170.23324  .00000000  .00000000  .00000000  .939989
 1  1  12600.000 -1040  1175 -830  1150 -620  1159 -260  1175  130  1200
 1  1  12600.000  570  1220  930  1225  990  1230  0  0  0  0
 5  1  12800.000  6582.6149  242.70670  .00000000  .00000000  .00000000  .943317
 1  1  12800.000 -900  1175 -590  1150 -550  1140 -520  1150 -100  1175
 1  1  12800.000  430  1200  1000  1220  0  0  0  0  0  0
 5  1  13000.000  6791.8404  303.97170  .00000000  .00000000  .00000000  .967358
 1  1  13000.000 -990  1175 -590  1150 -450  1145 -270  1150  470  1175
 1  1  13000.000  830  1200  1030  1205  0  0  0  0  0  0
 5  1  13200.000  6996.6617  347.85900  .00000000  .00000000  .00000000  .984581
 1  1  13200.000 -800  1150 -410  1149  130  1140  660  1150  1050  1170
 5  1  13400.000  7200.1047  375.45900  .00000000  .00000000  .00000000  .995003
 1  1  13400.000 -730  1175 -490  1190 -250  1175  290  1150  670  1137
 1  1  13400.000  1060  1140  0  0  0  0  0  0  0  0
 5  1  13600.000  7413.8002  391.49020  .00000000  .00000000  .00000000  .998741
 1  1  13600.000 -920  1200 -660  1225 -490  1230 -320  1225  300  1200
 1  1  13600.000  660  1175  880  1150  1060  1140  0  0  0  0
 5  1  13800.000  7627.3297  396.89180  .00000000  .00000000  .00000000  .999999
 1  1  13800.000 -830  1225 -410  1232  90  1229  500  1225  670  1200
 1  1  13800.000  830  1175  930  1150  980  1148  1020  1150  0  0
 5  1  14000.000  7840.8175  395.73786  .00000000  .00000000  .00000000  .999973
 1  1  14000.000 -780  1250 -530  1255 -230  1250  540  1225  650  1200
 1  1  14000.000  750  1175  830  1155  900  1175  1020  1190  0  0
```

```
*     DTM DESIGN SYSTEM ** ROADWAY DESIGN / TEMPLATE
*     OUTPUT FROM THIS PROGRAM (WITH THE EXCEPTION OF THE
*     GEOMETRY OUTPUT, CARD TYPE 10) IS USED AS PASS ON DATA
*     TO ROADWAY DESIGN/VOLUMES.
*
*     VERTICAL GEOMETRY
*10   STA VPC     ELEV VPC    STA VPI     ELEV VPI    STA VPT     ELEV VPT   CURV LENG
*10  GRADE AHEAD
 10 -.00565217
 10  6375.0000  1192.1195  6750.0000  1190.0000  7125.0000  1204.0625  750.00000
 10  .03750000
 1
 2.0000000
 4.0000000
 2.0000000
 4.0000000
 10.000000
 10.000000
 10.000000
 10.000000
-4.0000000
-2.0000000
-4.0000000
-2.0000000
 .00000000
-1.0000000
 1.2500000
 1.0000000
 2  1  10600.000  4378.6972  215.03586  1203.0000  .99865300  9 -1
 3
-1060.0000  1290.0000 -670.00000  1275.0000 -440.00000  1250.0000
-210.00000  1225.0000  200.00000  1200.0000  335.00000  1195.0000
 465.00000  1200.0000  700.00000  1225.0000  1000.0000  1240.0000
-2.0000000  1.0000000 -4.0000000  1.0000000
 .00000000  .00000000 -1.0000000  .00000000
-2.0000000  1.0000000 -2.0000000 -1.0000000
 .00000000  .00000000 -1.0000000  .00000000
 .00000000  .00000000 -6.0000000 -.20000000
-12.000000 -.10000000 -12.000000  .10000000
-6.0000000  .20000000 -4.0000000  1.0000000
 4.0000000  1.0000000  6.0000000  .20000000
 12.000000  .10000000  12.000000 -.10000000
 6.0000000 -.20000000  .00000000  .00000000
 1.0000000  .00000000  .00000000  .00000000
 2.0000000 -1.0000000  2.0000000  1.0000000
 1.0000000  .00000000  .00000000  .00000000
 4.0000000  1.0000000  2.0000000  1.0000000
 2  1  10800.000  4512.0154  206.32817  1202.6494  .93167800  11  2
 3
-1025.0000  1265.0000 -880.00000  1275.0000 -760.00000  1280.0000
-645.00000  1275.0000 -310.00000  1250.0000 -90.000000  1225.0000
 310.00000  1200.0000  400.00000  1198.0000  470.00000  1200.0000
 730.00000  1225.0000  1080.0000  1240.0000  .00000000  .00000000
 2  1  11000.000  4726.6844  128.34123  1201.4361  .93167800  7  2
 3
-1040.0000  1260.0000 -720.00000  1270.0000 -250.00000  1250.0000
-20.000000  1225.0000  310.00000  1210.0000  640.00000  1225.0000
 1050.0000  1245.0000  .00000000  .00000000  .00000000  .00000000
 2  1  11200.000  4937.8830  60.742000  1200.2424  .96284800  7  2
```

```
 3
-1020.0000  1250.0000 -610.00000  1260.0000 -210.00000  1250.0000
 140.00000  1225.0000  370.00000  1220.0000  550.00000  1225.0000
 1030.0000  1250.0000  .00000000  .00000000  .00000000  .00000000
 2  1  11400.000  5143.0143  15.546800  1199.0829  .98540700  7  2
 3
-1050.0000  1235.0000 -850.00000  1250.0000 -750.00000  1252.0000
-270.00000  1248.0000  410.00000  1230.0000  960.00000  1250.0000
 1000.0000  1255.0000  .00000000  .00000000  .00000000  .00000000
 2  1  11600.000  5344.5801 -8.7202000  1197.9436  .99752000  8  2
 3
-1050.0000  1225.0000 -760.00000  1237.0000 -240.00000  1225.0000
-160.00000  1220.0000 -80.000000  1225.0000  375.00000  1240.0000
 850.00000  1250.0000  980.00000  1260.0000  .00000000  .00000000
 2  1  11800.000  5544.7066 -12.817100  1196.8125  .99956500  6  2
 3
-1060.0000  1217.0000 -675.00000  1223.0000 -200.00000  1217.0000
 240.00000  1225.0000  550.00000  1250.0000  960.00000  1267.0000
 2  1  12000.000  5745.4184  3.1269000  1195.6780  .99160600  8  2
 3
-1060.0000  1200.0000 -780.00000  1210.0000 -380.00000  1200.0000
-290.00000  1197.0000 -200.00000  1200.0000  270.00000  1225.0000
 460.00000  1250.0000  960.00000  1270.0000  .00000000  .00000000
 2  1  12200.000  5948.8090  39.606600  1194.5284  .97339600  6  2
 3
-1050.0000  1185.0000 -340.00000  1180.0000 -100.00000  1200.0000
 220.00000  1225.0000  560.00000  1250.0000  960.00000  1260.0000
 2  1  12400.000  6157.1963  97.808600  1193.3506  .94434400  10  2
 3
-1050.0000  1170.0000 -900.00000  1175.0000 -720.00000  1180.0000
-530.00000  1175.0000 -450.00000  1170.0000 -380.00000  1175.0000
-10.000000  1200.0000  320.00000  1225.0000  640.00000  1230.0000
 980.00000  1235.0000  .00000000  .00000000  .00000000  .00000000
 2  1  12600.000  6369.9057  170.23324  1192.1483  .93998900  8  2
 3
-1040.0000  1175.0000 -830.00000  1150.0000 -620.00000  1159.0000
-260.00000  1175.0000  130.00000  1200.0000  570.00000  1220.0000
 930.00000  1225.0000  990.00000  1230.0000  .00000000  .00000000
 2  1  12800.000  6582.6149  242.70670  1192.1861  .94331700  7  2
 3
-900.00000  1175.0000 -590.00000  1150.0000 -550.00000  1140.0000
-520.00000  1150.0000 -100.00000  1175.0000  430.00000  1200.0000
 1000.0000  1220.0000  .00000000  .00000000  .00000000  .00000000
 2  1  13000.000  6791.8404  303.97170  1194.7621  .96735800  7  2
 3
-990.00000  1175.0000 -590.00000  1150.0000 -450.00000  1145.0000
-270.00000  1150.0000  470.00000  1175.0000  830.00000  1200.0000
 1030.0000  1205.0000  .00000000  .00000000  .00000000  .00000000
 2  1  13200.000  6996.6617  347.85900  1199.7236  .98458100  5  2
 3
-800.00000  1150.0000 -410.00000  1149.0000  130.00000  1140.0000
 660.00000  1150.0000  1050.0000  1170.0000  .00000000  .00000000
 2  1  13400.000  7200.1047  375.45900  1206.8790  .99500300  6  2
 3
-730.00000  1175.0000 -490.00000  1190.0000 -250.00000  1175.0000
 290.00000  1150.0000  670.00000  1137.0000  1060.0000  1140.0000
 2  1  13600.000  7413.8002  391.49020  1214.8926  .99874100  8  1
 3
-920.00000  1200.0000 -660.00000  1225.0000 -490.00000  1230.0000
```

```
*       DTM  DESIGN SYSTEM ** ROADWAY DESIGN / VOLUMES
*11  ID   BL STA      CL STA     PROF GRADE  L SLOPE STK    CL OFFSET   SLOPE STK  R
 11   1   10600.000  4378.6972   1203.0000  4  168.62563   215.03586   281.14844  4
 11   1   10800.000  4512.0154   1202.6494  3  119.30695   206.32817   256.52823  3
 11   1   11000.000  4726.6844   1201.4361  3  35.994689   128.34123   204.12452  3
 11   1   11200.000  4937.8830   1200.2424  3 -67.110373   60.742000   157.08975  3
 11   1   11400.000  5143.0143   1199.0829  3 -120.34780   15.546800   137.58390  3
 11   1   11600.000  5344.5801   1197.9436  3 -104.06134  -8.7202000   101.64314  3
 11   1   11800.000  5544.7066   1196.8125  3 -100.83623  -12.817100   81.848008  3
 11   1   12000.000  5745.4184   1195.6780  3 -64.500247   3.1269000   87.008934  3
 11   1   12200.000  5948.8090   1194.5284  3 -45.558696   39.606600   133.53921  3
 11   1   12400.000  6157.1963   1193.3506  3  15.020215   97.808600   190.68276  3
 11   1   12600.000  6369.9057   1192.1483  3  98.583560   170.23324   244.85625  3
 11   1   12800.000  6582.6149   1192.1861  4  181.63994   242.70670   295.60241  3
 11   1   13000.000  6791.8404   1194.7621  4  202.01197   303.97170   392.61784  4
 11   1   13200.000  6996.6617   1199.7236  4  187.08699   347.85900   496.76224  4
 11   1   13400.000  7200.1047   1206.8790  4  225.88954   375.45900   548.78986  4
 11   1   13600.000  7413.8002   1214.8926  4  316.97676   391.49020   490.07464  4
 11   1   13800.000  7627.3297   1222.8999  3  334.01396   396.89180   455.04663  3
*12  BL STA      CL STA       CUT VOL     FILL VOL    ACUM CUT    ACUM FILL   MASS HAUL
 12  10600.000  4378.6972   .00000000   .00000000   315.00000  -420.00000  -105.00000
 12  10800.000  4512.0154   1130.2960  -901.29281   1445.2960  -1546.6160  -101.32000
 12  11000.000  4726.6844   10040.310  -.95298735   11485.606  -1547.8072   9937.7990
 12  11200.000  4937.8830   26278.240   .00000000   37763.846  -1547.8072   36216.039
 12  11400.000  5143.0143   44553.503   .00000000   82317.349  -1547.8072   80769.542
 12  11600.000  5344.5801   42561.888   .00000000   124879.23  -1547.8072   123331.43
 12  11800.000  5544.7066   27844.094   .00000000   152723.32  -1547.8072   151175.52
 12  12000.000  5745.4184   18594.221   .00000000   171317.54  -1547.8072   169769.74
 12  12200.000  5948.8090   14958.418   .00000000   186275.95  -1547.8072   184728.15
 12  12400.000  6157.1963   15622.285   .00000000   201898.23  -1547.8072   200350.43
 12  12600.000  6369.9057   11728.548   .00000000   213626.77  -1547.8072   212078.97
 12  12800.000  6582.6149   4342.2381  -507.72448   217969.00  -2182.4628   215786.54
 12  13000.000  6791.8404   62.546551  -13668.438   218031.54  -19268.010   198763.53
 12  13200.000  6996.6617   .00000000  -53754.978   218031.54  -86461.733   131569.81
 12  13400.000  7200.1047   .00000000  -86185.450   218031.54  -194193.54   23838.000
 12  13600.000  7413.8002   .00000000  -58893.204   218031.54  -267810.04  -49778.500
 12  13800.000  7627.3297   1327.6829  -10989.519   219359.22  -281546.93  -62187.710
```

* DTM DESIGN SYSTEM ** SLOPE STAKES PLOT

```
I 1070.000   DATUM = 15000000                    C . C                    4478
I 1080.000                                       C .  C                   4578
I 1090.000                                       C .  C                   4619
I 1100.000                                       C .  C                   4726
I 1110.000                                       C .  C                   4832
I 1120.000                                       C .   C                  4937
I 1130.000                                       C    .   C               5040
I 1140.000                                       C    .    C              5142
I 1150.000                                       C    .   C               5243
I 1160.000                                       C    .  C                5344
I 1170.000                                       C    .  C                5444
I 1180.000                                       C    .  C                5544
I 1190.000                                       C    .  C                5645
I 1200.000                                       C    .  C                5745
I 1210.000                                       C    .  C                5847
I 1220.000                                       C    .  C                5948
I 1230.000                                       C    .  C                6052
I 1240.000                                       C    .  C                6157
I 1250.000                                       C    .  C                6263
I 1260.000                                       C    .  C                6369
I 1270.000                                       C  .  F                  6476
I 1280.000                                       C  .  F                  6582
I 1290.000                                       F   .  F                 6687
I 1300.000                                       F   .  F                 6791
I 1310.000                                       F    .   F               6894
I 1320.000                                       F    .   F               6996
I 1330.000                                       F    .   F               7097
I 1340.000                                       F    .   F               7198
I 1350.000                                       F    .  F                7300
I 1360.000                                       F   .  F                 7400
I 1370.000                                       C   .  C                 7513
I 1380.000                                       C  .  C                  7613
```

```
I 4400.000                D                                                    
I 4500.000                D                                                    
I 4600.000                D                                                   4
I 4700.000                DC                                                  8
I 4800.000                D  C                                               19
I 4900.000                D     C                                            31
I 5000.000                D        C                                         49
I 5100.000                D           C                                      71
I 5200.000                D              C                                   92
I 5300.000                D                 C                               113
I 5400.000                D                    C                            131
I 5500.000                D                       C                         144
I 5600.000                D                          C                      156
I 5700.000                D                             C                   165
I 5800.000                D                              C                  173
I 5900.000                D                                C                181
I 6000.000                D                                 C               188
I 6100.000                D                                   C             196
I 6200.000                D                                    C            202
I 6300.000                D                                     C           208
I 6400.000                D                                      C          212
I 6500.000                D                                      C          214
I 6600.000                D                                      C          214
I 6700.000                D                                     C           206
I 6800.000                D                                   C             196
I 6900.000                D                                 C               163
I 7000.000                D                              C                  129
I 7100.000                D                           C                     76
I 7200.000                D  C                                               23
I 7300.000                F D                                                10
I 7400.000             F  D                                                  45
I 7500.000          F     D                                                  54
I 7600.000       F        D                                                  60
```

DTM Rock Model
TERRAIN DATA INPUT FORM

PROJECT DTM TEST PROBLEM
PAGE 1 of 1
DATE 3/28/62
RECORDED BY JHS

CARD TYPE IT (1–2): 02 BASELINE NUMBER IBL (4–6): 001

BLSTA (8–16)	± (18)	DIST (19–22)	ELEV (24–27)	± (29)	DIST (30–33)	ELEV (35–38)	± (40)	DIST (41–44)	ELEV (46–49)	± (51)	DIST (52–55)	ELEV (57–60)	± (62)	DIST (63–66)	ELEV (68–71)
10600	-	1000	1250	-	500	1215	-	250	1185	+	0	1165	+	250	1155
10600	+	500	1165	+	750	1180	+	1000	1195		0	0		0	0
10800	-	1000	1230	-	500	1225	+	0	1180	+	250	1175	+	500	1160
10800	+	1000	1200		0	0		0	0		0	0		0	0
11000	-	1000	1222	-	500	1227	-	250	1212		0	1187	+	250	1178
11000	+	500	1182	+	1000	1207		0	0		0	0		0	0
11200	-	1000	1225	-	500	1225	-	250	1225		0	1205	+	250	1195
11200	+	500	1195	+	1000	1215		0	0		0	0		0	0
11400	-	1000	1208	-	500	1223	-	250	1226		0	1213	+	500	1213
11400	+	1000	1228		0	0		0	0		0	0		0	0
11600	-	1000	1203	-	500	1215	-	250	1203		0	1203	+	250	1213
11600	+	500	1223	+	900	1238		0	0		0	0		0	0
11800	-	1000	1183	-	500	1186	-	250	1183		0	1186	+	250	1191
11800	+	500	1216	+	900	1233		0	0		0	0		0	0
12000	-	1000	1177	-	500	1177	-	250	1172		0	1187	+	250	1197
12000	+	500	1222	+	900	1242		0	0		0	0		0	0
12200	-	1000	1155	-	500	1155	-	250	1160		0	1180	+	250	1195
12200	+	500	1220	+	900	1230		0	0		0	0		0	0
12400	-	1000	1139	-	500	1139	-	250	1149		0	1169	+	250	1194
12400	+	500	1199	+	900	1209		0	0		0	0		0	0
12600	-	1000	1130	-	500	1120	-	250	1135		0	1150	+	250	1170
12600	+	500	1186	+	960	1190		0	0		0	0		0	0

NOTE: All terrain cards must be complete. Finish last card of each section with zero distances and elevations.

```
*      DTM DESIGN SYSTEM ** MATERIALS CLASSIFICATION / VOLUMES
*IDA   STATION   CUT VOL     FILL VOL    ACUM CUT   ACUM FILL   MASS HAUL
*                CUT AREA    FILL AREA
 1   10600.000  87124.765   .00000000
 1   10800.000  620356.48  -105.14814   .00000000 -105.14814 -105.14814
 1   10800.000  80371.489  -28.390000
 1   11000.000  563046.07  -105.14814   .00000000 -210.29628 -210.29628
 1   11000.000  71650.953   .00000000
 1   11200.000  464908.37  -997.19388   .00000000 -1207.4901 -1207.4901
 1   11200.000  53874.307  -269.24235
 1   11400.000  373042.48  -7289.4977   .00000000 -8496.9878 -8496.9878
 1   11400.000  46847.172  -1698.9221
 1   11600.000  309491.07  -8479.4214   .00000000 -16976.409 -16976.409
 1   11600.000  36715.416  -590.52173
 1   11800.000  363623.94  -2187.1175   .00000000 -19163.526 -19163.526
 1   11800.000  61463.050   .00000000
 1   12000.000  412080.55   .00000000   .00000000 -19163.526 -19163.526
 1   12000.000  49798.705   .00000000
 1   12200.000  372205.55   .00000000   .00000000 -19163.526 -19163.526
 1   12200.000  50696.802   .00000000
 1   12400.000  406408.00   .00000000   .00000000 -19163.526 -19163.526
 1   12400.000  59033.363   .00000000
```

APPENDIX 2
PROGRAMMING SYSTEMS

PROGRAMMING SYSTEMS

Programs in the DTM Design System have been written in the FORTRAN language for the IBM 1620. FORTRAN was selected as the source language for several reasons.

1. Compatibility

   FORTRAN is compatible with more machines and more manufacturers than any other presently available language.

2. Useability

   As a language it is easily understood by engineers and can be quickly translated into other languages.

3. Flexibility

   Program changes can be quickly accommodated and recompiled. This is important to both originating and using organizations.

4. Efficiency

   The language is comparatively efficient in both programming and in production processing. Higher efficiencies can undoubtedly be achieved by reprogramming in a symbolic language after the final form of the program is completely established. The final form will necessarily vary from organization to organization. Higher production speeds can also be attained by the use of floating point hardware.

The Terrain Preparation/Edit program was compiled with the 1620 FORTRAN With Format Processor and Standard Subroutines in order to take full advantage of the ability to output messages. This programming system is described in IBM 1620 FORTRAN (card FORTRAN With Format), File Number 2.0.002A, October, 1961.

All other programs in the System were compiled using the standard IBM 1620 FORTRAN with a set of modified subroutines. This programming system is described in IBM 1620 FORTRAN, File Number 2.0.002, 7 April 1961.

This processor was used primarily to alleviate the shortage of memory capacity. In order to fit the system programs onto a 20K machine, it was necessary to condense them to the utmost and to use the very smallest processor available. This space requirement and the requirement for some form of format control led to the development of the Flexible Format Subroutines and the Plot Subroutines. These subroutines are described fully in the Civil Engineering Systems Laboratory publications numbers 153 and 154. The major characteristics of these programs are as follows:

Flexible Format Subroutines

1. Reads and punches 80 card columns.
2. Numbers are placed in the output card in sequential form as expressed by the list of the punch statements.
3. E-forms of numbers are suppressed.
4. F-forms of numbers always require 11 digits.
5. I-forms of numbers require 2 digits in addition to the number of digits in the number.
6. Hollerith information can be read from a data card and subsequently punched onto the output by the placement of an "*" in card column one of the data card.
7. Typewriter printing has been supressed.

Plot Subroutines

1. Reads and punches 80 card columns.
2. Modified PCHFL and PCHFX subroutines control the format of the output. Their operation depends on the mode and sign of transmitted quantities.
3. The programs are written so that plot characters are placed in the proper card columns by the PCHFL and PCHFX subroutines.
4. Cards produced by the programs are listed on a specially wired 407 Accounting Machine wiring panel to produce measurable plots.

APPENDIX 3

407 PLOT PANEL

DTM DESIGN SYSTEM PLOT PANEL
Wiring Diagram for Type 407 Panel

Connect Wires
From——— To

A1, A41
A1, T21
B1-B20, U21-U40
A2-A20, T22-T40
A21-A40, U1-U20
B41, B54
F55, M41
G79-G80, H79-H80
H53, L54
I53, S7
J53, AC7
K53, V45
K74, L74
K76, O72
L76, M53
L53, R40
L55, N54
N53, O53
N55, O55
S1-S6, AC1-AC6
S8-S40, AC8-AC40
T1-T20, AE1-AE20
BG41-BG53, BH41-BH53
BG62-BG80, BH62-BH80
BI41, BJ41
BI44-BI60, BJ44-BJ60
BI73-BI78, BJ73-BJ78
BK41, BL41
BK76-BK80, BL76-BL80

COMPUTER
TECHNOLOGY

```
*      DTM DESIGN SYSTEM ** MATERIALS CLASSIFICATION / PREPARATION
*1  ID BL STA      OFF   ELEV  OFF   ELEV  OFF   ELEV  OFF   ELEV  OFF   ELEV
 1   1  10600.000 -1060  1290 -670  1275 -440  1250 -210  1225  168  1201
 1   1  10600.000  172  1203  173  1203  173  1203  174  1203  174  1203
 1   1  10600.000  180  1203  193  1203  205  1203  211  1203  215  1202
 1   1  10600.000  219  1203  225  1203  237  1203  249  1203  255  1203
 1   1  10600.000  255  1203  256  1203  256  1203  257  1203  281  1196
 1   1  10600.000  335  1195  465  1200  700  1225 1000  1240  0    0
 1   1  10800.000 -1025  1265 -880  1275 -760  1280 -645  1275 -310  1250
 1   1  10800.000 -90   1225  119  1211  154  1203  159  1202  161  1201
 1   1  10800.000  163  1202  163  1202  169  1202  182  1202  195  1202
 1   1  10800.000  202  1202  206  1201  210  1202  217  1202  229  1202
 1   1  10800.000  242  1202  249  1202  249  1202  251  1201  253  1202
 1   1  10800.000  257  1203  256  1203  310  1200  400  1198  470  1200
 1   1  10800.000  730  1225 1080  1240  0    0    0    0    0    0
 1   1  11000.000 -1040  1260 -720  1270 -250  1250 -20  1225  35   1222
 1   1  11000.000  78   1202  81   1201  83   1200  85   1201  85   1201
 1   1  11000.000  91   1201  104  1201  117  1201  124  1201  128  1200
 1   1  11000.000  132  1201  139  1201  151  1201  164  1201  171  1201
 1   1  11000.000  171  1201  173  1200  175  1201  177  1202  204  1214
 1   1  11000.000  310  1210  640  1225 1050  1245  0    0    0    0
 1   1  11200.000 -1020  1250 -610  1260 -210  1250 -67  1239  12   1201
 1   1  11200.000  15   1200  17   1199  19   1200  19   1200  25   1200
 1   1  11200.000  37   1200  50   1200  56   1200  60   1199  64   1200
 1   1  11200.000  71   1200  83   1200  96   1200  102  1200  102  1200
 1   1  11200.000  104  1199  106  1200  108  1201  157  1224  370  1220
 1   1  11200.000  550  1225 1030  1250  0    0    0    0    0    0
 1   1  11400.000 -1050  1235 -850  1250 -750  1252 -270  1248 -120  1244
 1   1  11400.000 -31   1200 -29   1199 -27   1198 -25   1199 -25   1199
 1   1  11400.000 -18   1199 -6    1199  5    1199  11   1199  15   1198
 1   1  11400.000  19   1199  25   1199  37   1199  50   1199  56   1199
 1   1  11400.000  56   1199  58   1198  60   1199  62   1200  137  1237
 1   1  11400.000  410  1230  960  1250 1000  1255  0    0    0    0
 1   1  11600.000 -1050  1225 -760  1237 -240  1225 -160  1220 -104  1223
 1   1  11600.000 -54   1198 -52   1197 -50   1196 -48   1197 -48   1197
 1   1  11600.000 -42   1198 -30   1198 -18   1198 -12   1197 -8    1196
 1   1  11600.000 -4    1197  1    1198  13   1198  25   1198  31   1197
 1   1  11600.000  31   1197  33   1196  35   1197  37   1198  101  1230
 1   1  11600.000  375  1240  850  1250  980  1260  0    0    0    0
 1   1  11800.000 -1060  1217 -675  1223 -200  1217 -100  1218 -58  1197
 1   1  11800.000 -56   1196 -54   1195 -52   1196 -52   1196 -46  1197
 1   1  11800.000 -34   1197 -22   1197 -16   1196 -12   1195 -8   1196
 1   1  11800.000 -2    1197  9    1197  21   1197  27   1196  27   1196
 1   1  11800.000  29   1195  31   1196  33   1197  81   1222  240  1225
 1   1  11800.000  550  1250  960  1267  0    0    0    0    0    0
 1   1  12000.000 -1060  1200 -780  1210 -380  1200 -290  1197 -200  1200
 1   1  12000.000 -64   1207 -43   1196 -41   1195 -39   1194 -37   1195
 1   1  12000.000 -37   1195 -31   1195 -19   1195 -6    1195 -0    1195
 1   1  12000.000  3    1194  7    1195  13   1195  25   1195  37   1195
 1   1  12000.000  43   1195  43   1195  45   1194  47   1195  49   1196
 1   1  12000.000  87   1215  270  1225  460  1250  960  1270  0    0
 1   1  12200.000 -1050  1185 -340  1180 -100  1200 -45  1204 -9   1195
 1   1  12200.000 -5    1194 -3   1193 -1   1194 -1   1194  4    1194
 1   1  12200.000  17   1194  29   1194  35   1194  39   1193  43   1194
 1   1  12200.000  49   1194  62   1194  74   1194  80   1194  80   1194
 1   1  12200.000  82   1193  84   1194  86   1195  133  1218  220  1225
 1   1  12200.000  560  1250  960  1260  0    0    0    0    0    0
 1   1  12400.000 -1050  1170 -900  1175 -720  1180 -530  1175 -450  1170
 1   1  12400.000 -380   1175 -10   1200  15   1201  46   1194  51   1193
```

```
1  1  12400.000   53  1192   55  1193   55  1193   61  1193   74  1193
1  1  12400.000   87  1193   93  1193   97  1192  102  1193  108  1193
1  1  12400.000  121  1193  133  1193  140  1193  140  1193  142  1193
1  1  12400.000  144  1193  146  1194  190  1215  320  1225  640  1230
1  1  12400.000  980  1235    0  0    0  0    0  0    0  0
1  1  12600.000 -1040  1175 -830  1150 -620  1159 -260  1175   98  1197
1  1  12600.000  119  1193  123  1192  125  1191  127  1192  127  1192
1  1  12600.000  134  1192  146  1192  159  1192  165  1192  170  1191
1  1  12600.000  174  1192  180  1192  193  1192  206  1192  212  1192
1  1  12600.000  212  1192  214  1191  217  1192  219  1193  244  1205
1  1  12600.000  570  1220  930  1225  990  1230    0  0    0  0
1  1  12800.000 -1050  1185 -900  1175 -590  1150 -550  1140 -520  1150
1  1  12800.000 -100  1175  181  1188  198  1192  199  1192  199  1192
1  1  12800.000  200  1192  200  1192  206  1192  219  1192  232  1192
1  1  12800.000  238  1192  242  1191  246  1192  253  1192  266  1192
1  1  12800.000  278  1192  285  1192  285  1192  287  1191  289  1192
1  1  12800.000  293  1193  295  1193  430  1200 1000  1220    0  0
```