mgm(dou)

Interfaces for Pipe Network Design and Simulation with Visual Basic

By Litian Zhou

A Project
Submitted Under the Supervision of

Dr. Eric Schiller, Professor
Department of Civil Engineering

&

Dr. Tuncer I. Ören, Professor
Department of Computer Science

in Fulfillment
of the Requirements for the Degree of
Master of Engineering

Department of Civil Engineering
University of Ottawa
Ottawa, Canada
K1N 6N5

August 1996

Abstract

A more user-friendly program is provided here instead of the old one which is a network design for pipe lines. After a brief introduction to the pipe network, a comparison has been done between the old program and the new program. Then, a concept model of the new program is set up. Details of the interface design are given in succession. Finally, a manual and an example of the implementation of the interface are provided.

Contents

LIST OF FIGURES

Interfaces for Pipe Network Design with Visual Basic

By Litian Zhou
Department of Civil Engineering
Ottawa University
August 1996

PART I. INTERFACE DESIGN

1. Introduction

The new version of the PIPENET software is developed with Visual Basic and C language. It is more user friendly to manage the program for pipe network design, such as, data input, data edit, pipeline graphic, data output and more options, because the program is running in the Windows environment with which most Windows manipulations can be used.

The program is divided into two parts, BRANCH and LOOP. The BRANCH program is used to design branched (tree-type, nonlooped) water distribution networks, while the LOOP program is used to design looped and partly looped water distribution networks. The new version of the program completely changes the interface part of the old version but keeps the computation part of the old version.

2. Previous Program

The old versions of the BRANCH and LOOP programs are the menu driven computer program written in BASICA. The BRANCH consists of 3 programs, one for data input and edit, one for simulation and optimization, and one for main menu, which

are linked to one another. The LOOP program is integrated. Both of programs have the same way of data input and edit. The program shows a menu when it starts running :

```
P R O G R A M S
===============
1 >  L O O P
2 >  B R A N C H
3 >  Q U I T

ENTER Selection ?
```

Select option 2 by typing the number 2 and pressing the ENTER key (the return key) then you will go into next menu: First Main Menu:

```
                First Main Menu

program:  B F I L E R (Data Editor)      v 2.0  8Feb85

     OPTIONS:

          C - C R E A T E new file
          L - L O A D existing file
          H - H E L P
          D - D I R E C T O R Y of drive B:
          Q - Q U I T
```

These options describe the major actions that you can initiate from the main menu. After you select C the follow table of BRANCH will appear:

```
            NETWORK PARAMETER TABLE

Filename :  NONAME

     T I T L E       :
     NO. OF PIPES    :
     NO. OF NODES    :
     PEAK FACTOR     :
     MIN HL/KM       :
     MAX HL/KM       :
     MIN RESIDUAL    :

          [ESC] for options
          [TAB] next window
```

In LOOP program, there are no MIN HL/KM and MIN RESIDUAL but MAX UNBALANCED is used instead. After entering data in each field, press ENTER key to change into another field. You can press ESC key to go to Second Main Menu or press TAB key to go to next table:

PIPELINE DATA

```
1 of __                                          File :  NONAME

PIPE          NODE          LENGTH      DIA        HWC
 No.      FROM        TO     ( M )      (MM)
-------------------------------------------------------

/ =delete   ^ =insert   + =add   [TAB] =next
```

This table is for entering pipeline data. After you finish entering data, you can edit the data, such as, delete, insert and add. You can press ESC key to go back to the previous menu or press TAB key to go to next table:

Node Data

```
1 of __                                          File :  NONAME

NODE          FIX              FLOW            ELEV
 NO.                           (LPS)            (M)
-------------------------------------------------------

/ =delete   ^ =insert   + =add   [TAB] =next
```

This table is for entering node data. You also can edit the data you enter in. You can move the cursor by using ARROW keys. To move to next table press TAB key.

Reference Node Data

```
Reference Node :
Grade line     :
```

This table is designed to enter information for the source reference node, which has a specified HGL. In BRANCH, only one reference node (water source) is mentioned,

however, at least one reference node should be used. That is, multi-sources are available for LOOP program. The table looks like:

Nodes with fixed HGLs

```
Nodes(s) with FIXED head(s)
     and UNKNOWN flow(s)

     NODE          GRADE
      NO.           LINE
-------------------------

/ =delete      = insert       (TAB) =next screen
```

After entering data, you can press ESC key to go back to previous menu or press TAB key to go to next table:

```
                P I P E  C O S T  DATA
                    max # = 10

     DIA                  HWC                    UNIT
     (MM)                                        COST
-------------------------------------------------------

/ = del line  ^ = ins line   [TAB] = exit
```

This is the last table which is used to enter pipe cost. The program can optimize the design in minimum cost. You can press TAB to go back to the first table.

In the First Main Menu, if you select 2 by typing number 2 and pressing ENTER, the following message will appear on the screen.

```
Insert D A T A disk in Drive B:

Press [ + ] to change DRIVE

Press [RETURN] to CONTINUE
```

If your data disk is in Drive B, press the ENTER key and a table giving all BRANCH data files contained on the disk will appear on screen, as well as all data files

that have been created for the BRANCH network design program. An example of the table is shown below:

```
Filename:  BDATA    .B
=======================================================
BDATA    .BRA TEST     .BRA
```

If you select a file list on the table, highlight the name of the file then press ENTER to load the file. After you load a file, the tables will appear described above. You can edit the data if you want. When you are in the Network Parameter Table and data has been entered in all tables, you can press [ESC] to go into Second Main Menu:

Second Main Menu

```
     M E N U:
=============================================================

     S - SAVE (to same filename)    C - COPY TO another file
     R - R U N (branch program)
     L - LOAD/CREATE new file       Q - QUIT
     T - CHECK total demand         D - DIRECTORY on Drive B
     X - SORT & LIST data
     * - CHANGE NODE FLOWS          H - H E L P
=============================================================
<ESC> to abort
```

The above menu provides you with the main options after entering data or after loading an already created data file. If you select one, type the letter chosen and press <ENTER> key.

For option `X - SORT & LIST data,` the LOOP has a different name such as `X - COST, SORT, LIST data.` Because there is no optimization in LOOP simulation, the program provides a cost computation for the selected pipeline network in this option.

Some sub-menus which would appear after selecting the above options are neglected here. The same functions exist in the new version program. We will discuss this later.

3. The Model of New Project

The new version of the program provides a more powerful function than the old one. The interface models based on the Visual Basic which is a Microsoft Windows application. In this project, only the simulation and optimization is kept as the old program. However, part of the code is written in C language which can be compiled to a DLL (Dynamic Link Library) file, so that Visual Basic can call the functions in the DLL file. The code left is written in Visual Basic for input and output interface. The model is shown in Fig.3-1.

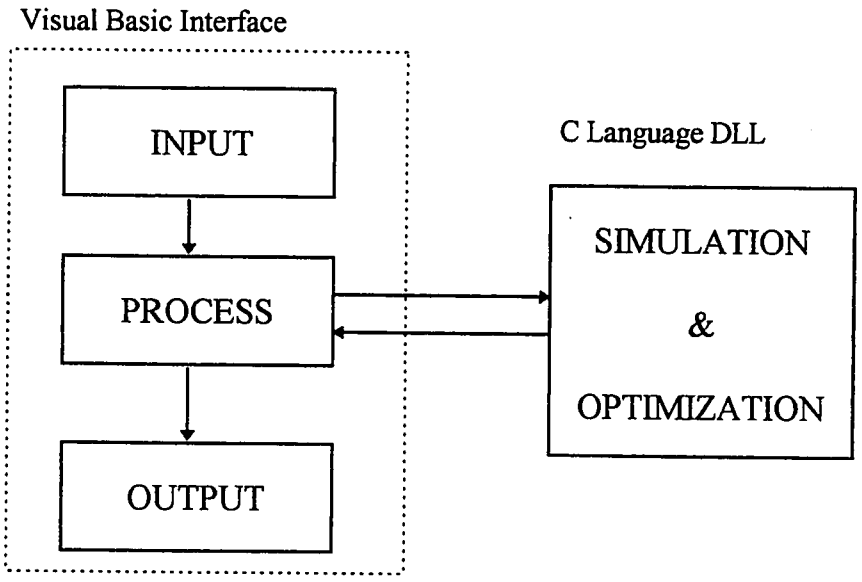


Fig. 3-1 The Model of the new project

The BRANCH program can do simulation and optimization. The LOOP program can only do simulation because of the complicated computation. In this project, there is no change in the computation. The DLL file is produced by Visual C++ . Because the project is completed in Visual Basic 3.0 (16 bits), the Visual C++ 1.x (16 bits) compiler is used for producing DLL file. The source codes of DLL files are shown in separate documents.

The new version of the program has following advantages:

i). No limitation on the arrays' sizes because the sizes of arrays declared in VB are dynamically.

ii). The pipeline network can be graphically designed. It is more direct and more easy than the old version.

iii). There are more options in new version than in old one because the new version is based on the Windows environment. You can open, close, hide, move and change size of windows (i.e. forms in VB application).

iv) The main computation is written in C language, so that it is faster than that written only in BASIC language.

In the following we will describe details of the new version program and show the advantages.

4. Interface Design

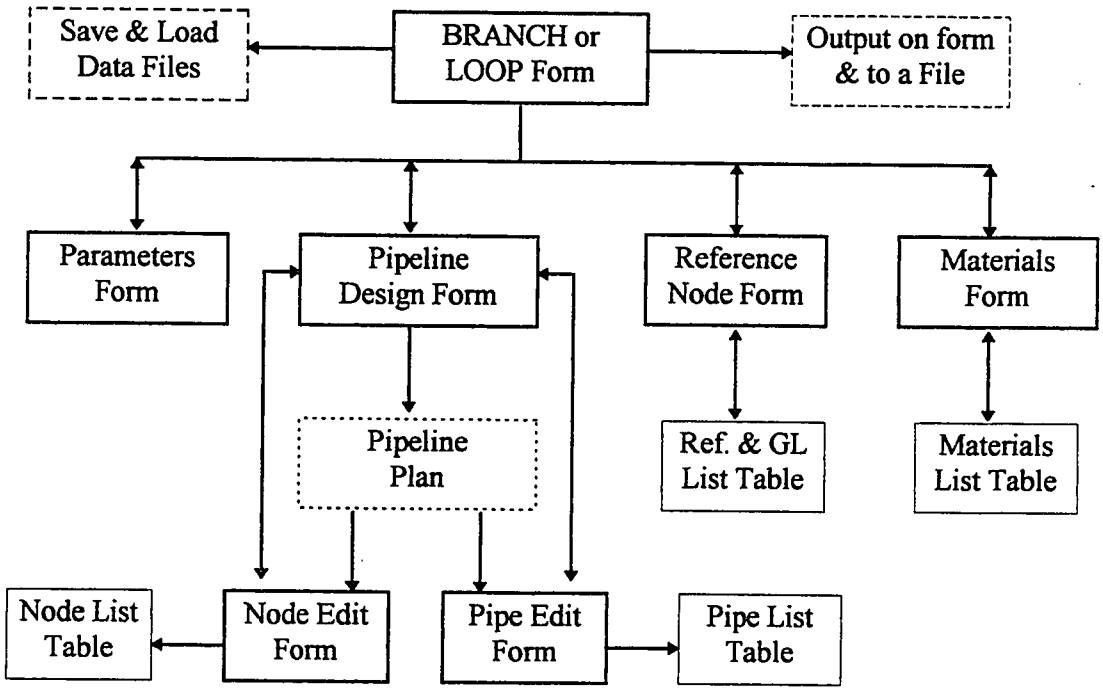


Fig. 4-1 The architecture of the interface design

The most of the work on the project is for data input and edit. Visual Basic offers the strong tools to do that. We can create forms to set up various objects for the purposes you want. In the project, there are about 10 forms in each BRANCH and LOOP programs for interface design. The interface design is simply shown in the Fig. 4-1. The flow chart shows the relations among the forms and tables. In the following are details of each form.

4.1 Form of MAINMENU

Fig. 4-2 shows the main menu form for program starting. Objects in the form are labels, text-boxes and commands. There are two options in the form: LOOP and BRANCH. You can select one of the two by clicking the correspond options and clicking OK button. If you want to quit the program, click Exit button.

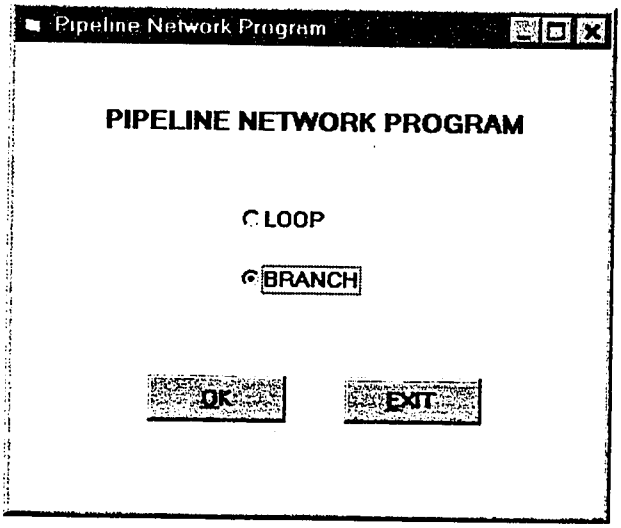


Fig. 4-2 Main menu of the program

4.2 Form of LOOP or BRANCH menu

The BRANCH or LOOP menu form is a menu for all operations of the project. For the BRANCH menu (see Fig. 4-3), the top menu bar includes four sub-menus: File, Run, Edit, and Help. For LOOP menu (see Fig. 4-4), one more sub-menu Output is added. The functions are as follows.

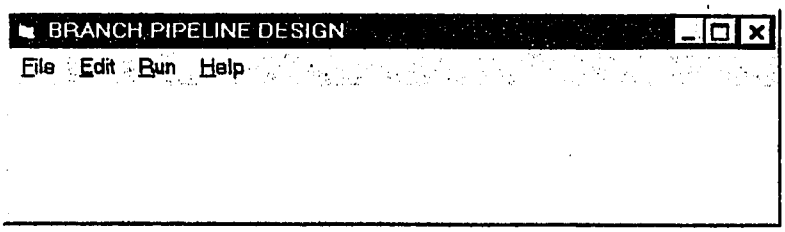


Fig. 4-3 BRANCH menu form

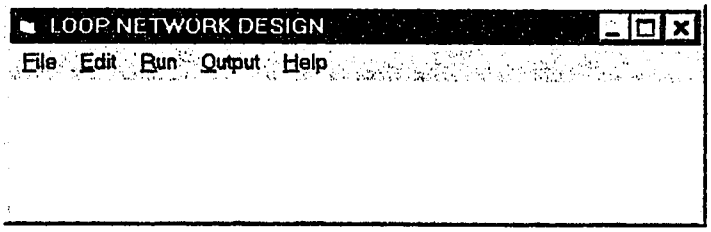


Fig. 4-4 LOOP menu form

File Sub-menu

New	Create a new project by first calling the Parameter Form for data input;
Show	Show the readable file so that you can check existing files;
Open	Open an existing file and call Parameter Form for data edit;
Save As	Save the project (input) data into a file;
Exit	Exit the BRANCH program and return to MAINMENU.

Edit Sub-menu

Edit	Go back to the forms in which you can edit data.
Re-Plan	Go back to the forms in which you can edit data, but you have to make pipeline plan again.

Run Sub-menu

Run	Run the project;
Total...	Show the total flow demand and the average demand
Review	Show the running results on the screen.
Save Output	Save the Output into a file.

Output Sub-menu (For LOOP menu form)

1 - Entire File

Screen printing all information of the project except output results.

2 - Pipe Data with Cost

Screen printing pipe numbers, diameters and costs for each pipe.

3 - Sorted by Pipe Size with Cost

Screen printing size sorted pipe information with cost .

4 - Sorted by Pipe Size / Number Range with Cost

Screen printing size sorted pipe data with cost between a given range of the pipe numbers.

5 - Summary by Pipe Size with Cost

Screen printing summary of pipe size data with cost.

6 - Summary by Pipe Size / Number Range with Cost

Screen printing the summary of pipe size data with cost in given range of pipe numbers.

7 - Arrange (Pipe & Node numbers) in ascending order

Re-arrange the Pipe and Node numbers in ascending orders, no print out.

8 - Save all

Save all the output into a file.

Help Sub-menu

Content	Show the instruction of operation;
About	Introduction of the pipeline program.

4.3 Form of Parameters

This form is for essential parameters input of the project. The parameters are used in the successive forms for data input and edit. The form which is constructed by using text boxes, labels and commands. The names of parameters are the same as that in old version program, such as, Title, No. of Pipes, No. of Nodes, Peak Factor, Min

HL/KM, Max HL/KM, Min Residual for a BRANCH project (see Fig. 4-5a). For a LOOP project, there are no Min HL/KM and Residual parameters but instead of Max Unbalanced (see Fig. 4-5b). In each field, you can type in the corresponding value of the parameter. Use [TAB] key to move from field to field.

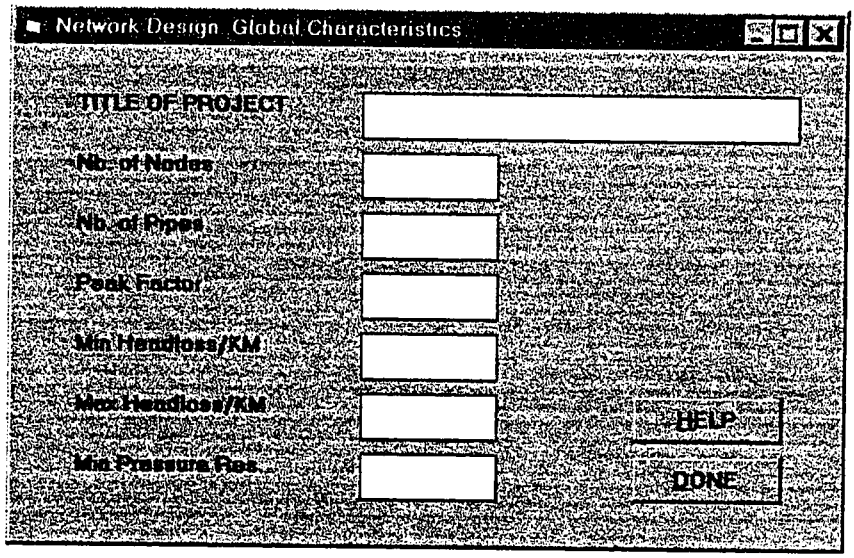


Fig. 4-5a The Form of Parameters of BRANCH

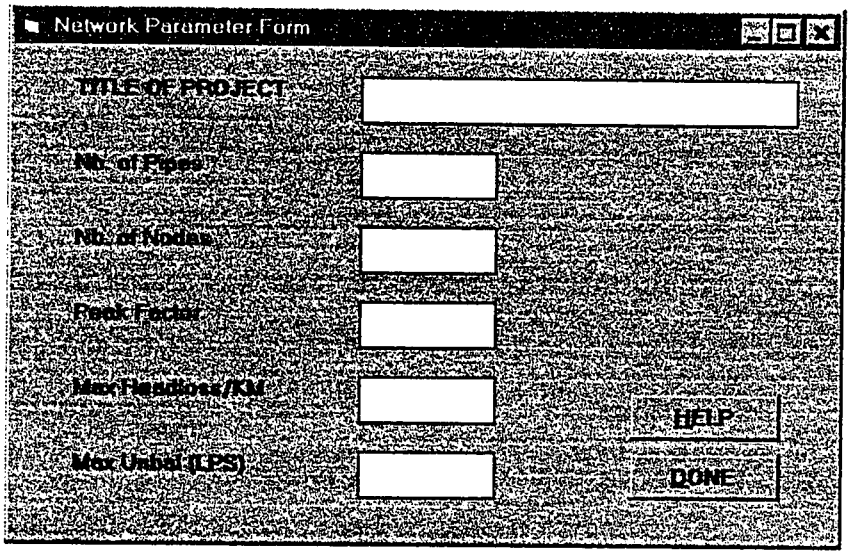


Fig. 4-5b The Form of Parameters of LOOP

Press or click Help button for instruction.

After parameters input and edit, press or click DONE button to go to next form.

4.4 Form of Pipeline Network

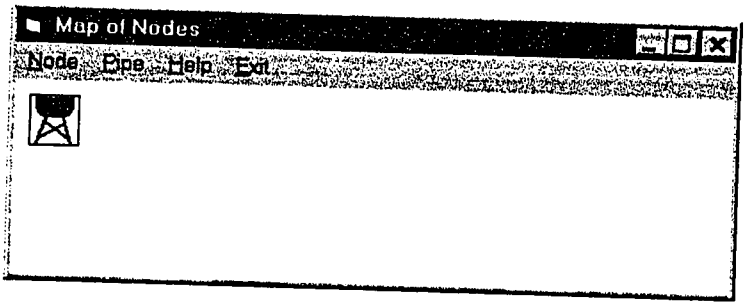


Fig. 4-6 The Form of Pipeline Network

This form is the second menu form on which you can make a layout for pipeline network. When the form appears, the icons of nodes also appear on the top left of the form. The number of icons is equal to the number of nodes which is defined in the previous form.

The form has a top bar menu including Sub-menu Node, Pipe, Help and Exit. The function of each Sub-menu is described below.

Node Sub-menu

Move	After choosing it, you can drag icons to anywhere in the form.
Edit	Call the Node Edit Form or double click the icon and the Node Edit Form will be triggered off.
Add	After choosing it, you can add a node by double clicking the node icon at the position you want in the form.
Delete	After choosing it, you can delete a node by double clicking it.

Pipe Sub-menu

Create	After choosing it, you can create a pipe between two nodes. The method is to click one icon first and then click another icon second.

Edit	Call the Pipe Edit Form or click the pipe Line in the form and the Pipe Edit Form will be triggered off.
Add	After choosing it, you can add a pipe between two existing nodes by just clicking the both nodes once separately.
Delete	After choosing it, you can delete a pipe by clicking it.
Change Icon	There are two kinds of icons, Source icon and Node icon. The Source icon represents the water source and the Node icon represents the user terminal. After you choose one of them, simply click the icon you want to change, then the icon would be changed.

Help Sub-menu

Content	The instruction of icon dragging, data input and edit
Tag	Show the tag meaning. The tag is attached to node icons and pipe lines.

Exit

Next	Exit the form and call the Reference Node and Grade Line Form.
Exit	Go back to the upper form, LOOP or BRANCH menu form.

In the form, the icons formed on the top left are created by the Picture Box. The picture box is an array which has the same index as the node array. So you can drag the icon to some position as the node (i.e. water source or terminal). The source icon and the terminal icon are created by using the icon editor which is provided in the Visual Basic libruary.

The pipe line is created by using the LINE tool from the tool bar of VB. As in the picture box, Line is also an array which has the same index as the pipe array. Each line represents a pipe connecting two nodes. Therefore you can use node icons and pipe lines to make a pipeline plan by drawing a picture. It is much more clear and more easy for pipeline network design.

Note:

(1) For Node-Submenu and Pipe-Submenu, you should select an option first and then you can do other things, especially from one option to an other option. For example, If you are editing the Pipe data and you want to edit Node data, you should click Edit in the Node-Submenu then you can do the editing.

(2) The option Create in the Pipe-Submenu only can be used once when all node icons are dragged to the proper position. If the entire network has been established, you can use Add, Delete options for Node and Pipe data edition.

4.5 Form of Node

This form is used for inputting data and editing the data of nodes. There are three text boxes for Node Number, Initial Flow and Elevation data input. There are two checking boxes. The checking box of Source is used to determine whether or not the node is a source. If it is checked, the value of Initial Flow should be zero. The checking box of Fix is used to determine if it has a fixed flow (i.e. it is not affected by the peak factor). If the checking box is checked, the value will be one, otherwise it will be zero.

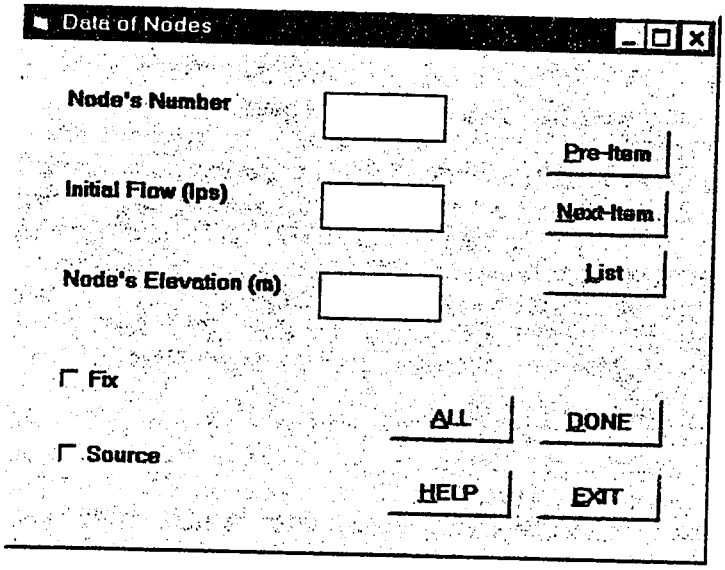


Fig. 4-7 Form of Data of Node

The other objects on the form are commands which can help to review, edit data and exit the form. The Pre-Item and Next-Item show the previous node data and next node data . The List shows a List Table of the node data input. If the data of nodes (terminals) are the same, you can click the ALL button so that all other nodes (terminals) will input the same data, except for the Fixed flow Node. After each node data is typed in or edited, you should click DONE for confirmation. When the EXIT is chosen, it will go back to the previous form, i.e. Form of Pipeline Network.

4.6 Form of Pipe

This form (Fig. 4-8) is for pipe data input and edit. There are six text boxes in the form, such as, Pipe Number, From Node, To Node, Length, Diameter and Roughness . You can type in the data in the proper textbox field and use [TAB] key to move from one field to another field. The Pre-Item and Next-Item show the previous pipe data and next pipe data. The List shows a List Table of the pipe data input. If some of the data are the same, such as length, diameter and roughness, you can click the ALL button instead of typing the data in all fields. After each pipe data are typed in or edited, you should click DONE for confirmation. When the EXIT is chosen, it will go back to the previous form, i.e. Form of Pipe Network (See Fig. 4-7).

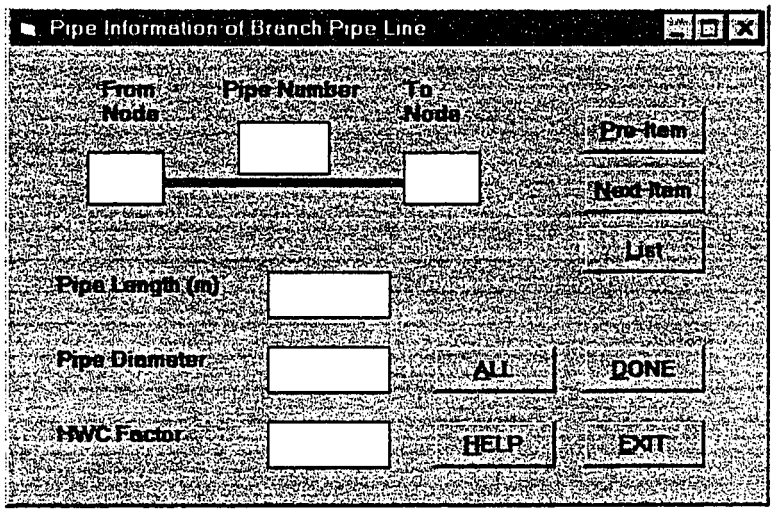


Fig. 4-8 The Form of Pipe

4.7 Form of Reference Node

This form (Fig. 4-9) is for determining the Reference Node and Gradeline. The reference node is water source node, which has a specified HGL (Hydraulic Gradeline). The two text boxes are used to input the node number and HGL. For a storage tank, the HGL is the ground elevation plus the height of the tank. Click DONE to go back to the Form of Pipe Network. For BRANCH project, only one referenced node can be chosen (See Fig. 4-9a).

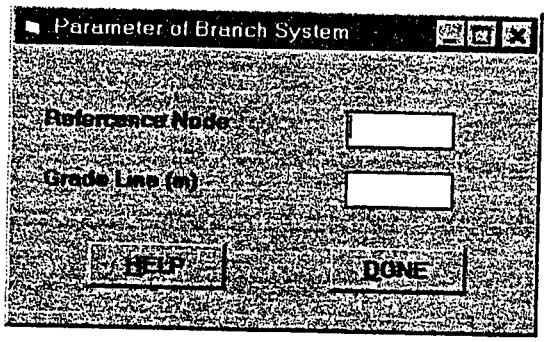


Fig. 4-9a The Form of Reference Node for BRANCH

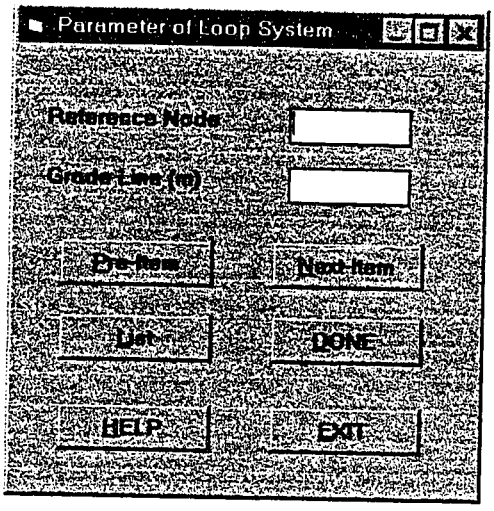


Fig. 4-9b The Form of Reference Nodes for LOOP

However, for LOOP project, at least one reference node should be chosen, i.e. multi-sources are available. Therefore, there are more objects in LOOP's reference form than that in BRANCH's (See Fig. 4-9b). These are Pre-Item, Next-Item, List and Exit. The functions of these objects are the same as described before in the upper forms. When Exit is chosen, we will enter the last form, the Form of Materials.

4.8 Form of Materials

This form (Fig. 4-10) is for pipe cost data input and edit. The form is divided into two regions. The left region is a frame of Pipe Materials which includes three combo boxes, Diameter, Roughness and Cost.

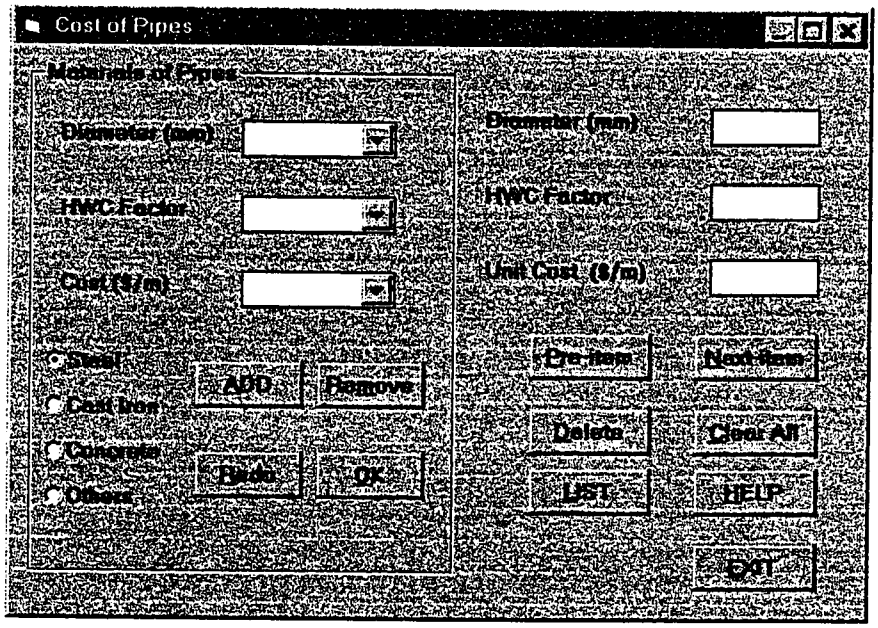


Fig. 4-10 The Form of Materials

The data in the combo boxes are stored automatically so that you can choose the data by only highlighting and clicking it. After all data are chosen in three box fields, you should click REDO button first and OK button second for confirmation. The data you have chosen will appear on the textbox fields of the right region . If you want to add an item to the list of the combo box, you should type the new item in the box field, then

click ADD button. If you want to delete a item from the list, you just highlight and click the item, then click Remove button. You also can select different materials of pipes from the option buttons.

In the right region , there are three text boxes for Diameter, Roughness and Unit Cost data input. The method of data input is described in the above paragraph, i.e. select data from three boxes, then click REDO first and OK second. Other objects are Commands. The Pre-Item and Next-Item show the previous pipe cost data and next pipe cost data. The LIST shows the table of the pipe cost data input. Clicking Delete button can delete the current pipe cost data, however clicking Clear All button can delete all the pipe cost data. This is useful when you want to renew the data. The HELP can give you the instruction of how to manage this form. When EXIT is chosen, the form (Reference Node) will come out.

4.9 Pipe Range Form

This form (Fig. 4-11) is used for a partial print out by selecting the range of pipe numbers. The left pipe number should be less or equal to the right pipe number. Press OK if the range of pipe numbers has been typed in, or press EXIT to go back to upper form.

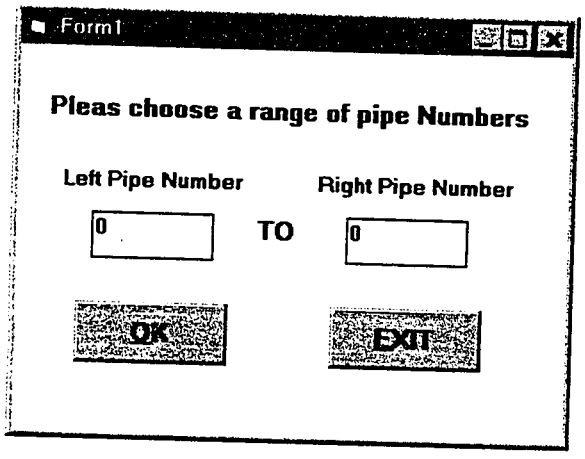


Fig. 4-11 The Pipe Range Form

4.10 Other Forms

The other forms are used for file open, file save and file show. The forms are imported from some Visual Basic books which are listed in the References. However, the codes of the forms have been changed for the project.

The texts and source codes of all forms are shown on separate documents.

PART II. MANUAL OF PIPENET PROGRAM

PIPENET is a program which is used to design water distribution networks. It includes two sub-programs: BRANCH and LOOP. BRANCH program simulates and optimizes branched (tree-type, nonlooped) water distribution networks. However, LOOP program simulates the hydraulic characteristics of a looped (closed circuit) water distribution network.

All files of the PIPENET program are stalled in a 3 1/4" disk. The program is based on the WINDOWS environment, so that the Windows 3.x or higher, such as Windows 95 or Windows NT is required. The program runs in Drive A. You can run the executing file PIPENET.EXE by using File Manager of Windows 3.x or by using Windows Explorer of Windows 95.

5. BRANCH

5.1. Introduction

BRANCH is used to design branched water distribution networks by choosing from among a set of candidate diameters for each pipeline so that the total cost of the network is minimized subject to certain design constraints. The network is characterized by links (individual pipes) and nodes (points of inputs or demands or pipe junctions). Both the construction costs and the design constraints can be expressed as linear, mathematical statements solvable by a technique know as linear programming. The length of a specified diameter of pipe is treated as the unknown value to be solved. Thus, the engineer proposes commercially available pipe diameters for each link, and the linear programming algorithm selects the optimal combination from these candidates. The program can handle existing pipes as well as parallel pipes. BRANCH formulates the linear programming model for the least-cost design of a branched network, solves the model, and outputs the design as well as the corresponding hydraulic information.

Data required to run BRANCH include descriptions of network elements such as pipe lengths, friction coefficients, nodal demands and ground elevation; data describing the geometry of the network, the candidate diameters and their unit costs; and system constraints (minimum pressures to be maintained at terminal and other specified nodes within the network). The program outputs include optimal length and number of candidate diameters for each link, total network cost, and hydraulic information.

5.2. Data Preparation

To prepare network data for BRANCH, the network should be represented as a series of nodes connected by links (the pipelines) as shown in Figure 1 in Annex. Each link and node must be given a unique integer number, which, for convenience, should be shown directly on the prepared schematic diagram. For clarity, avoid linking a source to

more than one line. Calculate average daily water demands for the design year within the region to be served by the network and distribute the demand among nodes in the network. Demands may be assigned to individual nodes in a variety of ways; common methods are based on population density, house counts, or area allocation. The important point is to distribute demands among nodes in a rational way to reflect where the demands are most likely to occur. Next, determine the ground elevation at each node of the network; include source nodes, demand nodes, and junction nodes. Next, determine the length and Hazen-Williams friction coefficient for each pipe included in the network. If you intend to perform a cost summary of the completed design, make sure that unit-installed costs (costs per linear meter) for each size of pipe considered are available. With the above data in hand, you are now ready to use program BRANCH.

5.3. Loading BRANCH

Insert the PIPENET disk in disk drive A of your computer. Using File Manager of Windows 3.x or Windows Explorer of Windows 95, find the executable file PIPENET.EXE and run it. You are presented with a MAINMENU form as shown in Fig. 4-2. Click option BRANCH and click OK button, then the Form of BRANCH menu appears.

5.4. Form of BRANCH menu

The BRANCH menu form (see Fig. 4-3) is a menu for all operations of the project. The top menu bar includes four sub-menus such as File, Edit, Run, and Help. The functions of them are described before, so here we do not repeat those.

5.4.1 Create A New File

If your are entering data for a particular network for the first time, you would select New in the sub-menu File. Once you have selected New, the program presents five major forms sequentially with data headings only. The forms are intended for direct data entry of (1) network parameters, (2) pipelines, (3) nodes, (4) reference nodes with fixed hydraulic grade line (HGL) and (5) pipe size, friction and cost. The program moves you from one form to another as you complete the required entries and exit the form. The first form is shown as follows.

5.4.2 Form of Parameters

This form (see Fig. 4-5) is for essential parameters input. The parameters are used in the successive forms for data input and edit. The form which is constructed by using text boxes, labels and commands. The names of parameters are Title, No. of Pipes, No. of Nodes, Peak Factor, Min HL/KM, Max HL/KM, and Min Residual. In each field, you can type in the corresponding value of the parameter, use [TAB] key to move from field to field.

- TITLE OF PROJECT is a description of the project or design for user reference.

- No. of Nodes and No. of Pipes must be integer values. This automatically sets the number of nodes as one more than the number of pipes, which must be the case of any completely branched network.

-The Peak Factor is a number by which average flow values assigned to each node are multiplied. The number is larger or equal to 1.

- Min Headloss/KM and Max Headloss/KM are the minimum and maximum allowable headloss (gradient) in meters per kilometer for pipelines in the network. The program will only examine pipelines for possible inclusion in the optimal design for

gradients that fall within this range. Therefore, diameters that are obviously too small or too large for the calculated flow are not considered. This restriction minimizes the number of variables included in the linear programming formulation and speeds up solution. A reasonable starting range for Min HL/KM is 0.1 to 0.5 and the for Max HL/KM is 10 - 30. These values may have to be adjusted to achieve the exact minimum residuals at terminal nodes.

- Min Pressure Res is the minimum pressure in meters that should be maintained at the terminal or other specified nodes in the network.

You can press or click Help button for instruction.

After parameters input and edit, press or click DONE button to go to next form.

5.4.3 Form of Pipeline Network

This form (see Fig. 4-6) is the second menu form on which you can make a layout for pipeline network described in the first part. When the form appears, the icons of nodes also appear on the top left of the form. The number of icons is equal to the number of nodes which is defined in the former form. The form has a top bar menu including Sub-menu Node, Pipe, Help and Exit.

If you have created a new file or opened an existing file, and if you enter the form first time, then first drag the icons on the top left of the form to the proper positions until there are no icons left. Next, choose Create option from the Pipe sub-menu. Now you can create pipes by clicking one icon first and another icon second. The pipe numbered will appear between the both node icons. You should continue doing this until all pipes are created. The layout of the pipe network is now finished. Next, you should input node data and pipe data if it is a new project, or edit node and pipe data if it is an existing project.

You can input node data or edit the data by choosing the Edit option from the Node sub-menu; also you can put in pipe data or edit the data by choosing the Edit option from the Pipe sub-menu.

Note:

(1) For Node Sub-menu and Pipe Sub-menu, you should select the option first. Then you can do other things, especially from one option to an other option. For example, if you are editing the pipe data and you want to change to edit node data, you should click the Edit option in the Node Sub-menu, then you can edit the node data.

(2) The option Create in the Pipe Sub-menu only can be used once when all node icons are dragged to the proper positions. If whole network has been established, you can use Add, Delete options for Node and Pipe data edition.

(3) If you do not want to make a layout of the pipe network, i.e. you do not drag any icon on the top left of the form, when you choose Edit option from Node sub-menu or from Pipe sub-menu, the Form of Node or Form of Pipe will appear immediately.

If you choose the Edit option from the Node sub-menu after making the layout of the pipe network, you can just double click any node icon for node data editing. When you double click a node icon, the Form of Node will appear.

5.4.4 Form of Node

This form (see Fig. 4-7) is for node (source and terminal) data input and edit. There are three text boxes for Node Number, Initial Flow and Elevation data input. The node numbers may be arbitrarily assigned and do not have to appear in any particular order. If the number assigned to an interior node (non-terminal node) is less than 500, the program will not consider its elevation when selecting pipe sizes; only the terminal node

elevations are considered. However, if the node number is 500 or greater, the program will consider its elevation and insure that the minimum residual pressure is maintained there and at all terminal nodes. You should only have to consider the minimum residual pressure at interior nodes if it is located at a high point in the system. Flows are entered as negative values if they are demands and as positive values if they are inflows or sources.

There are two checking boxes. The checking box of Source is used to determine whether or not the node is source. If it is checked, the value of Initial Flow should be zero and the node has a fixed hydraulic grade line. The checking box of Fix is used to determine if it has a fixed flow (i.e. it is not affected by the peak factor). If the checking box is checked, the value will be one, otherwise it will be zero.

The other objects on the form are commands which can help to review, edit data and exit the form. The Pre-Item and Next-Item show the previous node data and next node data . The List shows a List Table of the node data input. If the data of nodes (terminals) are same, you can click ALL button so that all other nodes (terminals) will be input the same data, except Fixed flow Node.

After each node data are typed in or edited, you should click DONE for confirmation. When the EXIT is chosen, it will go back to the previous form, i.e. Form of Pipeline Network.

If you choose the Edit option from the Node sub-menu after making the layout of the pipe network, you can just double click any node icon for node data editing. When you double click a node icon, the Form of Node will appear.

5.4.5 Form of Pipe

This form (see Fig. 4-8) is for pipe data input and edit. There are six text boxes in the form, such as, Pipe Number, From Node, To Node, Length, Diameter and Roughness. The pipe number may be any integer number from 1 to 36,000. The "from" and "to" nodes are the end nodes for the pipes. Flow is assumed to move from the "from" node to the "to" node. This assumption is not critical. If the flow is found to be in the opposite direction, the program will internally switch the "from" and "to" nodes to indicate the correct flow direction in the output.

Pipe lengths are given in meters (m) and internal diameters in millimeters (mm). The Hazen-Williams friction coefficient is dimensionless and usually has a value between 80 and 140, depending on the type and age of the pipe. The Pipe Diameter and HWC factor are zero unless the pipe already exists in the network (you are expanding and/or extending an existing network). The program will determine the optimal diameter for new pipes in the network. If the pipe is existing, place its diameter and Hazen-Williams in the proper fields. If you want the program to consider placing a parallel pipe next to an existing pipe, number the existing pipe between 1 and 499. If you want the existing pipe to remain fixed with no parallel pipe, number it 500 or greater.

You can type in the data in the proper Textbox field and use [TAB] key to move from one field to another field. The Pre-Item and Next-Item show the previous pipe data and next pipe data. The List shows a List Table of the pipe data input. If some of the data are same, such as length, diameter and roughness, you can click ALL button instead of typing the data in all fields.

After each pipe data are typed in or edited, you should click DONE for confirmation. When the EXIT is chosen, it will go back to the previous form, i.e. Form of Pipe Network.

Now you can choose Next option from Exit sub-menu of the Form of Pipe Network, then the Form of Reference Node will appear.

5.4.6 Form of Reference Node

This form (see Fig. 4-9a) is designed for you to enter information for the source reference node, which has a specified HGL (Hydraulic Gradeline). Only one reference node is specified. The two text boxes are used to input the node number and HGL. For a storage tank, the HGL is the ground elevation plus the height of the tank. If the system has multiple sources, you must designate one as the reference. Remember that the node placed in this form should have zero flow entered in the Form of Node. Once you have completed this form, Click DONE to go to the next form, Form of Materials.

5.4.7 Form of Materials

This form (see Fig. 4-10) is for pipe cost data input and edit. You can also see the section 4.8 on page 17 which explains how to use the form.

5.5. File Management

Once you have completed the data input and edit, you will go back to the Form of Pipeline Network. If there is not any modification on the layout, you can choose the Exit option from the Exit sub-menu. You, then go back to the Form of BRANCH Menu. You can choose Save As... from the File sub-menu to save the input data you have just inputed. You also can choose Show option from the File sub-menu and select a readable file to read. It is useful for checking input and output data files.

5.6 Run Program BRANCH (Simulation)

Choose Run option from the Run sub-menu to run program BRANCH and obtain an optimal network design. During the program run, the result will appear on the form, Form of BRANCH Menu. If you want to review the output, choose Review option from the Run sub-menu. If you want to save the output into a file, choose Save Output from the Run sub-menu. If you want to see the total flow demand, you can choose Total.. option from the Run sub-menu.

The running results include the pipe numbers, "from" and "to" nodes, flow, headloss, pipe length, optimal diameter, and cost of the line. The node numbers are included as well as nodal flows, elevations, hydraulic grade lines, and pressures. If the problem does not have a feasible solution (the pressure constraints cannot be met with the candidate pipe sizes), the following message will appear on the form:

Constraints cannot be met ...

1. DECREASE minimum headloss/km and /or RESIDUAL HEAD and/or
2. INCREASE maximum headloss/km and /or
3. INCLUDE larger diameter size in list

The above message means that the program cannot find a feasible solution to the problem given the design conditions specified and the constraints imposed. To obtain a feasible and optimal design, one or more changes in the design specifications must be made. Try changing the minimum or maximum HL/KM, the residual head, or adding larger candidate pipe sizes to the list. Normally, the problem can be solved by adding a larger pipe size in the candidate list. If pressures at some of the terminal nodes are greater than the specified minimum, you may wish to increase the maximum allowable gradient. This will allow smaller size pipes to be considered for some of the lines, which will likely increase headloss along some branches so that the minimum pressure at terminal nodes may be achieved. Note that in the output, some of the lines will be broken into two

pipe sizes. The total length of the two sizes will be equal to the specified length of the line. In some cases, one of the sizes may be only a very short length. In such cases, you may wish your final design to include only the pipe size with the longer length. In short, you must use some engineering judgment. A cost summary of the design is also given in the output.

After all of the output has been displayed, you can review the output, or print the output into a file. If you want to change some parameters, or some pipe diameters without changing the layout, you can choose Edit option from Edit sub-menu to go to the Form of Parameters. For example, if you want to change peak factor, just change the value in the proper field. Then you can run the program again and check the new output. If you want to re-plan the pipe network, choose Re-Plan in the same sub-menu. The pervious layout will disappear.

5.7. Quit BRANCH Program

Choose Exit option from the File sub-menu to go back to MAINMENU. If you want to exit the PIPENET program, click EXIT button.

5.8. Example

A sample of BRANCH water distribution network design and simulation is shown on the following pages to illustrate the use of the program. Figure 1 in ANNEX shows the sample network , which consists of 13 pipes and 14 nodes including two sources. One pipe, #2000 is assumed to be existing, and we will not consider using a parallel line (hence it is numbered greater than 499). Pipe number 4 is also existing, but we will allow the program to consider strengthening this line with a parallel line if necessary, selected from the list of candidate diameters. Node 1 we assume is a reservoir with a fixed HGL and node 14 is a pump with a fixed flow. The program will assign the HGL for this node.

Procedures

(1) Insert the disk into the disk driver Drive A.

(2) Load the program PIPENET by clicking it in the Manager of Window3.x or in the Explorer of Windows95, the MAIN menu appears (see Fig. 4-2).

(3) From the form of MAIN menu, choose BRANCH and click OK to enter the BRANCH menu.

(4) From the form of BRANCH menu (see Fig. 4-3), click the File Sub-menu and choose New; then the Form of Parameters will appear.

(5) Enter the data shown in Table 1 of the Annex. The completed form is shown in Fig. 5-1. Click DONE after finish entering, so the Form of Pipeline will be present.

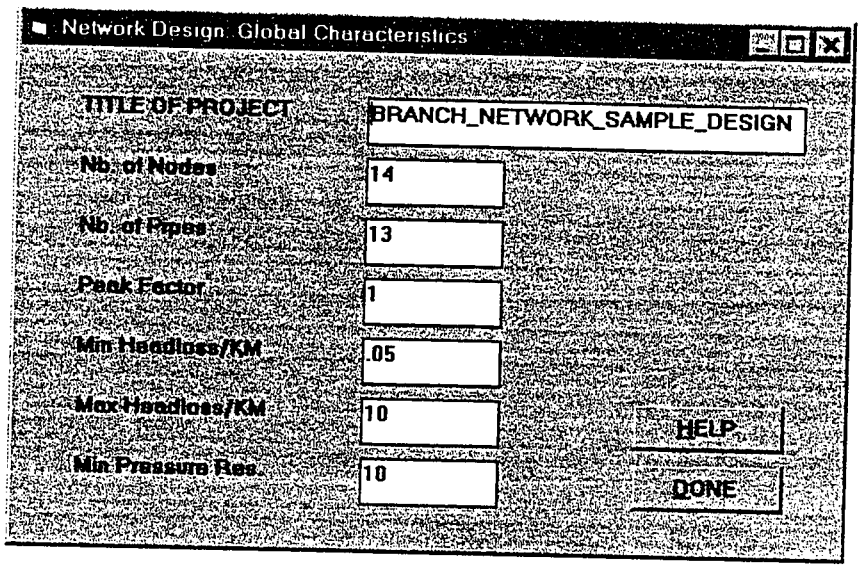


Fig. 5-1 The Parameters of the BRANCH Network

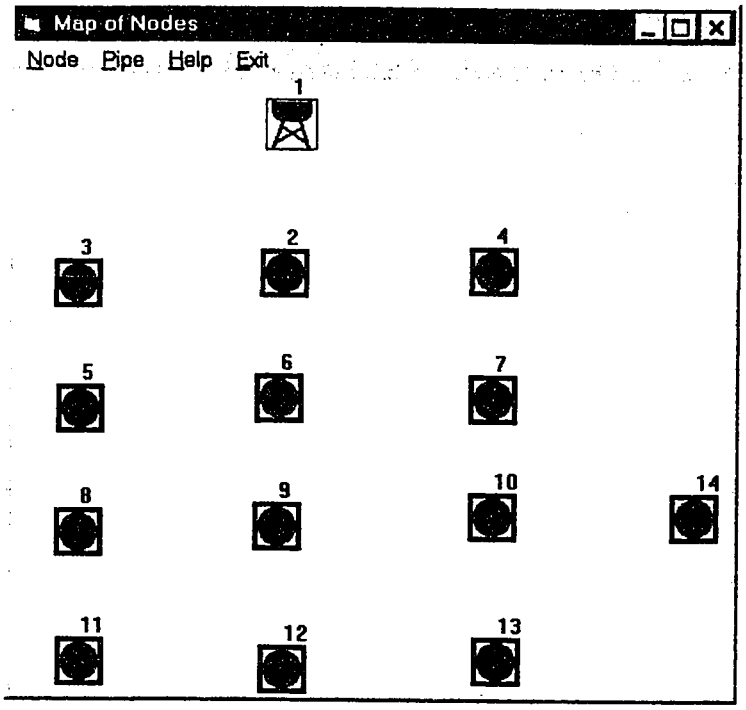


Fig. 5-2 The Map of Nodes dragged

(6) In the Form of Pipeline (see Fig. 4-6), there is an icon of a source on the top left. It represents source node which will be considered as the reference node. Other node icons are under the source node.

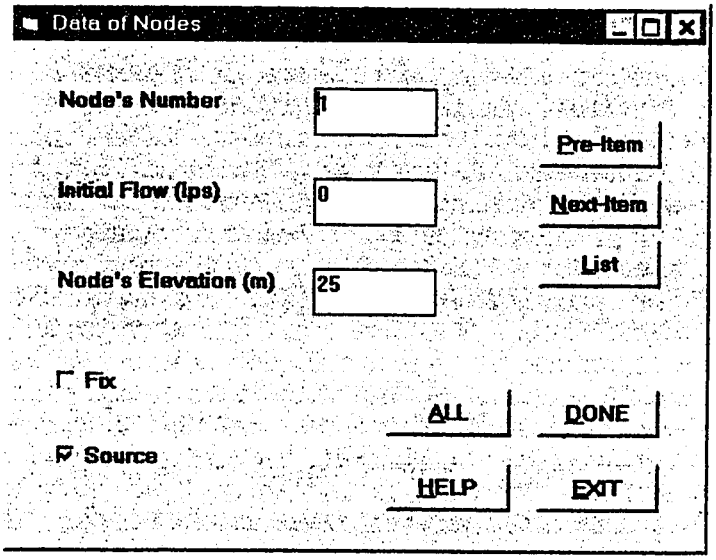
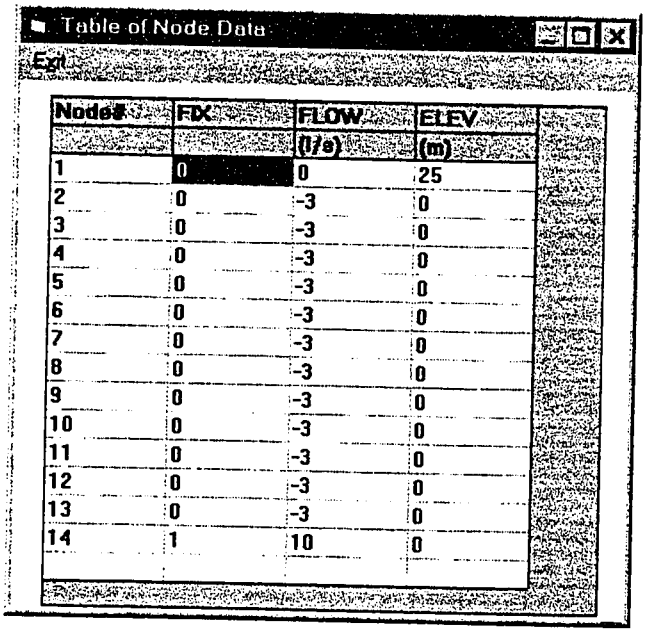


Fig. 5-3 The data of Node #1 in the Form of Node.

You can drag the upper icon to some position, then go back to drag the next. You should keep dragging until there are no icons left (see Fig. 5-2) .

Click Node on the menu bar, then choose Edit. Now you can double click any node icon to invoke the Form of Node for node data input and edit (see Fig. 5-3).

In the Form of Node, enter the data shown in Table 1 of the Annex for each node. If it is a source node, only check Source Box. If it is a fixed node, only check Fix box. For other nodes, leave the Source Box and Fix Box blank. After entering data in current node, you should click DONE for confirmation. You can use Pre-Item and Post-Item buttons to move from current node to previous node or to next node. After entering data in all nodes, you can click List for checking (see Fig. 5-4) and click EXIT to go back.



Node#	FIX	FLOW (l/s)	ELEV (m)
1	0	0	25
2	0	-3	0
3	0	-3	0
4	0	-3	0
5	0	-3	0
6	0	-3	0
7	0	-3	0
8	0	-3	0
9	0	-3	0
10	0	-3	0
11	0	-3	0
12	0	-3	0
13	0	-3	0
14	1	10	0

Fig. 5-4 The Table of Node Data

Click Pipe on the menu bar, then choose Create. Now you can create a pipe line between two nodes by clicking one node icon first and another second. You can repeatedly click both node icons until all pipe lines are created (see Fig. 5-5). Then, click

Pipe Sub-menu and choose Edit. Now you can click the pipe line to invoke the Form of Pipe for pipe data input and edit. In the Form of Pipe (see Fig. 5-5), enter the data shown in Table 1 in Annex for each pipe. Remember to click DONE for confirmation after entering data in current pipe. You also can use Pre-Item and Post-Item to move from one node to another, use List for data checking (see Fig. 5-6), and click EXIT to go back.

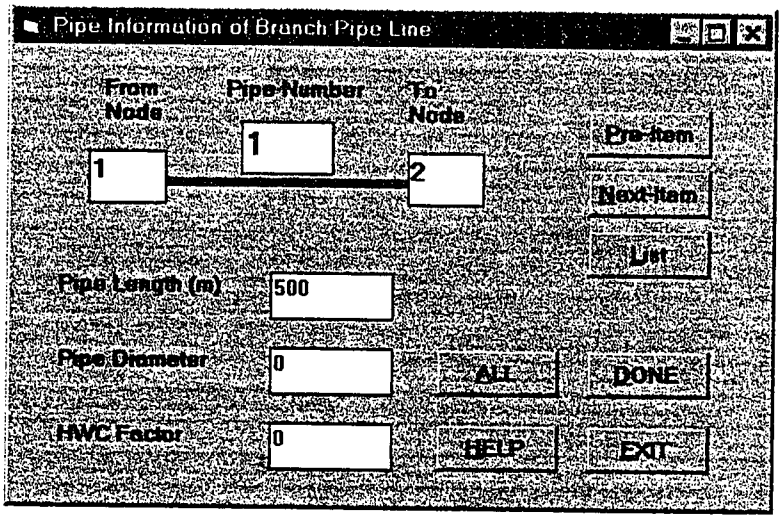
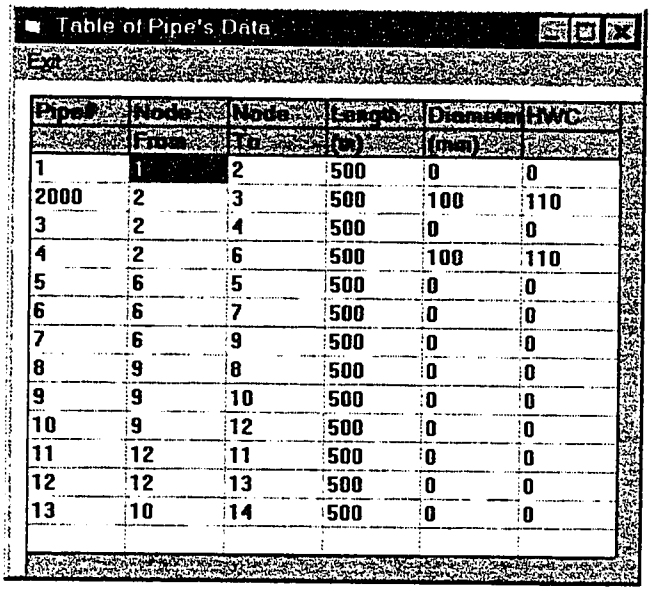


Fig. 5-5 The data of Pipe 1 in the Form of Pipe



Pipe#	Node From	Node To	Length (m)	Diameter (mm)	HWC
1	1	2	500	0	0
2000	2	3	500	100	110
3	2	4	500	0	0
4	2	6	500	100	110
5	6	5	500	0	0
6	6	7	500	0	0
7	6	9	500	0	0
8	9	8	500	0	0
9	9	10	500	0	0
10	9	12	500	0	0
11	12	11	500	0	0
12	12	13	500	0	0
13	10	14	500	0	0

Fig. 5-6 The table of data of pipes

Consequently, all information of the BRANCH design are shown in the Fig. 5-7.

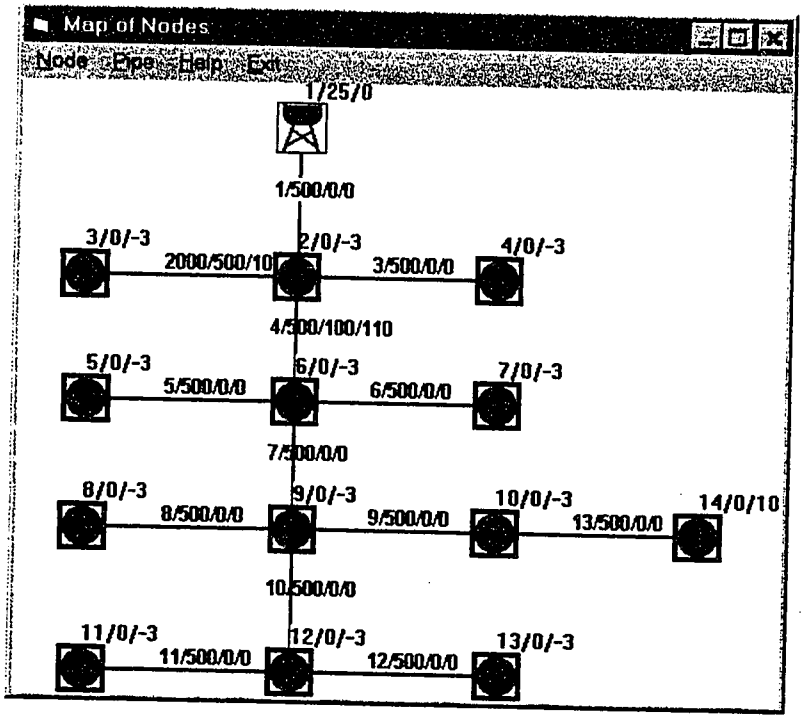


Fig. 5-7 The final design of the pipe network

If there is no problem, click Exit Sub-menu and choose Next to go to the Form of Reference Node (see Fig. 5-8).

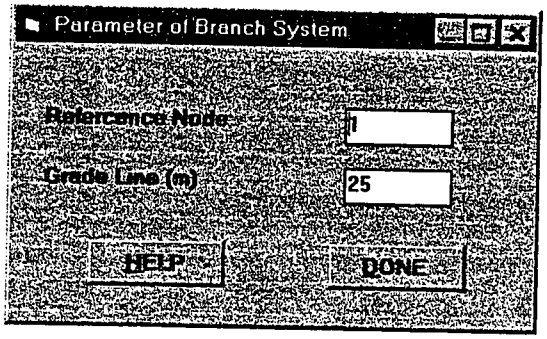


Fig. 5-8 The data of reference for BRANCH Network

In this form , enter the reference node -- resource node and its hydraulic grade line HGL based on Table 1 in Annex. Click DONE for confirmation and go to the Form of Pipe Cost (see Fig. 5-9).

In this Form, first choose Steel in the option boxes; Secondly, according to the data in Table 1 in Annex, select items from three combo lists, then click Redo, OK in order. The data you have chosen are presented in the text fields automatically. After all data are entered, you can click LIST for checking (see Fig. 5-10) and click EXIT for leaving, i.e. go back to the Form of Pipeline.

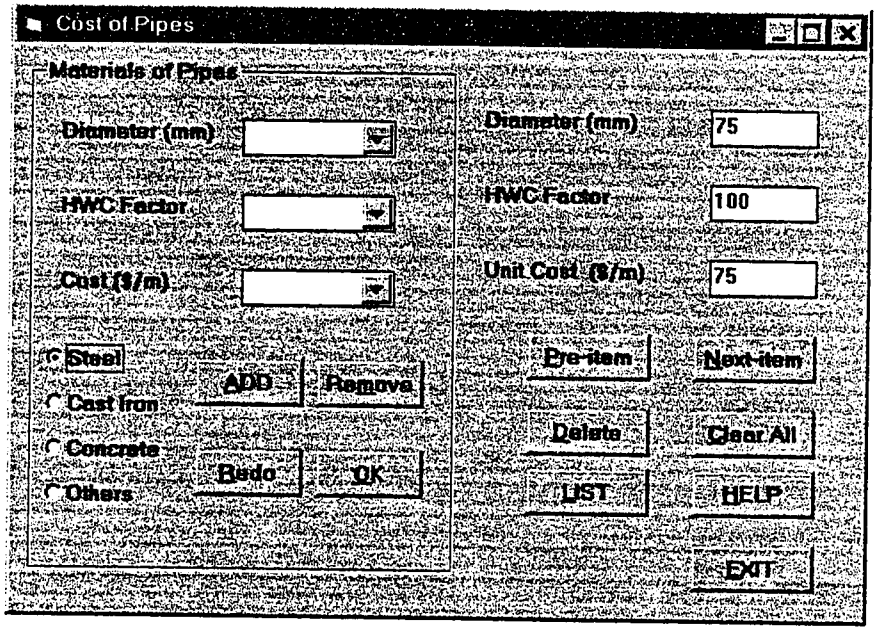


Fig. 5-9 The data of pipe cost in the Form of Cost of Pipe

If there is no problem, click Exit Sub-menu and choose Exit to go back to the form of the BRANCH menu.

(7) You can save the data by clicking File sub-menu and choosing Save As.

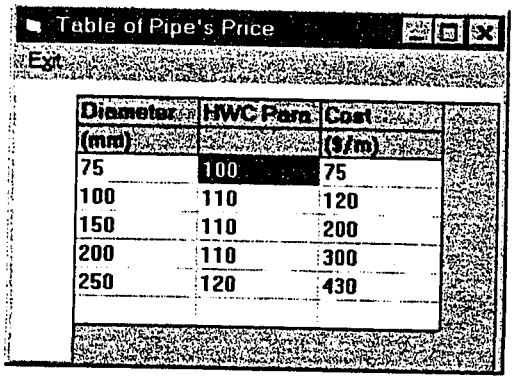


Fig. 5-10 The Table of the pipe costs

(8) You can check the total flow demanded by clicking Run Sub-menu and choosing Total. Then result of the total flow demanded is shown in Fig. 5-11.

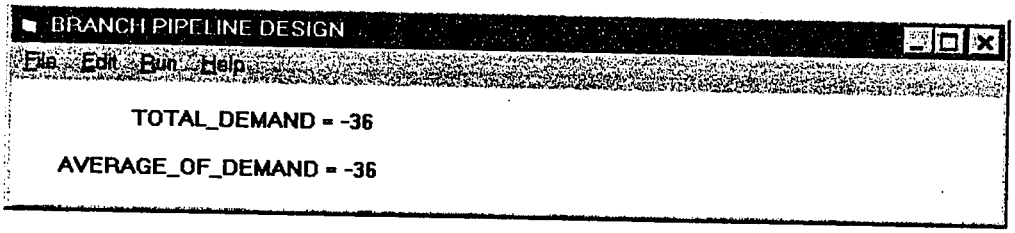


Fig. 5-11 The total flow demanded

(9) You can run the program by clicking Run Sub-menu and choose Run. Then the output is shown on the form (see following two pages). You can choose Review in the Run Sub-menu to see the output again. If you want to save the output, choose Save Output in the Run Sub-menu, the output will be saved into a file named by you.

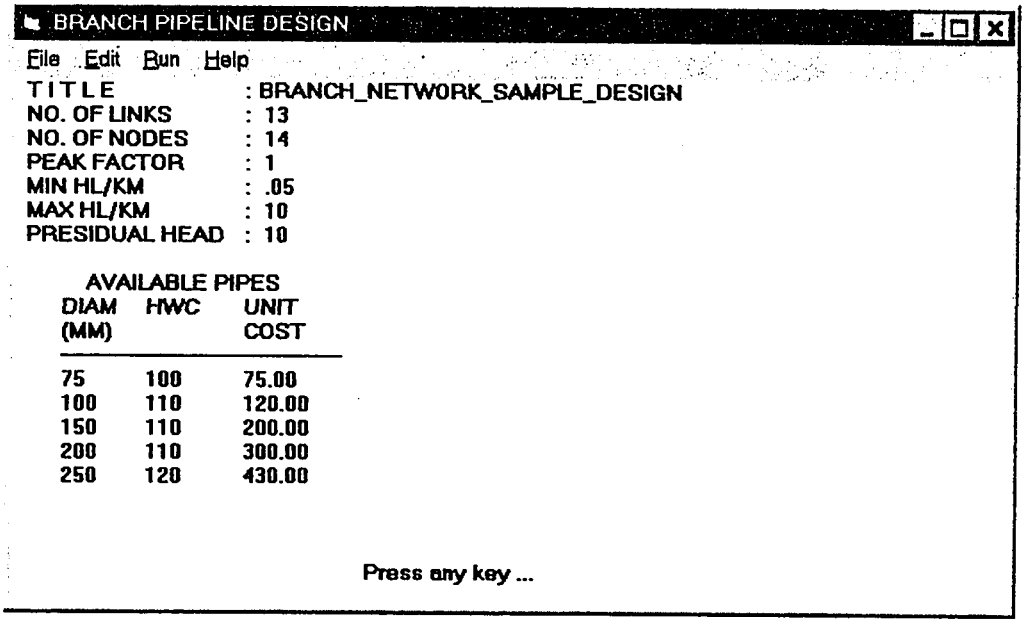


Fig. 5-12 The output of the parameters and cost information

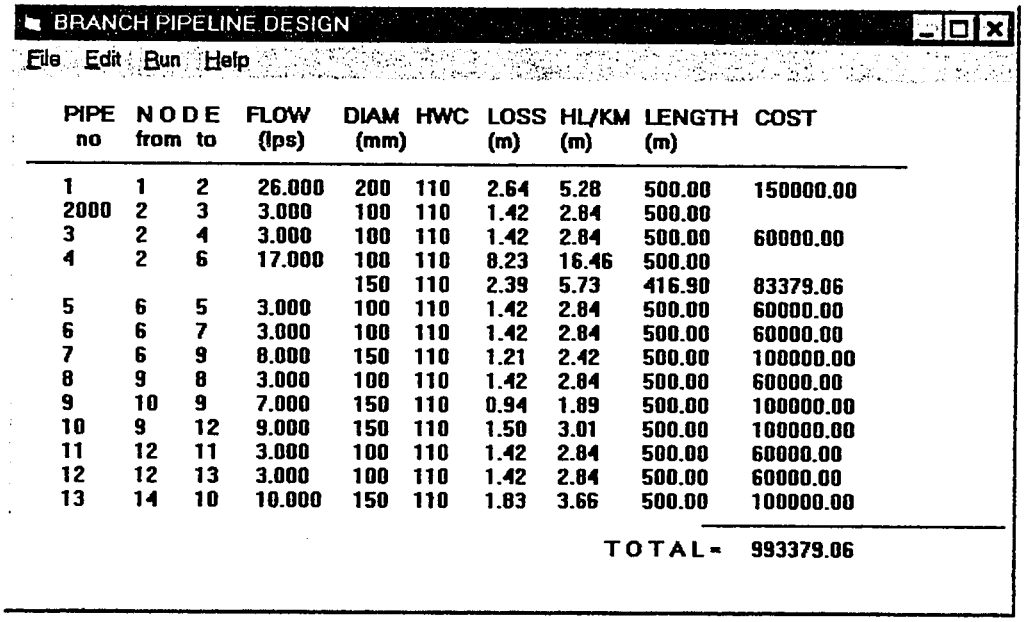


Fig. 5-13 The output of the result of the branched pipeline design

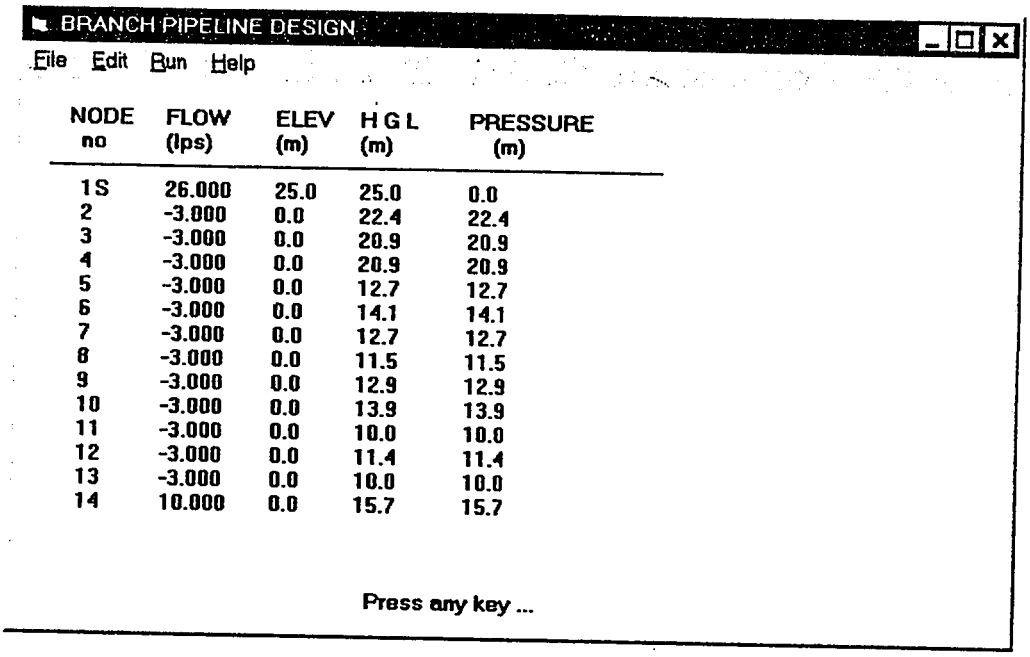


Fig. 5-14 The output of the result of node flows and pressures

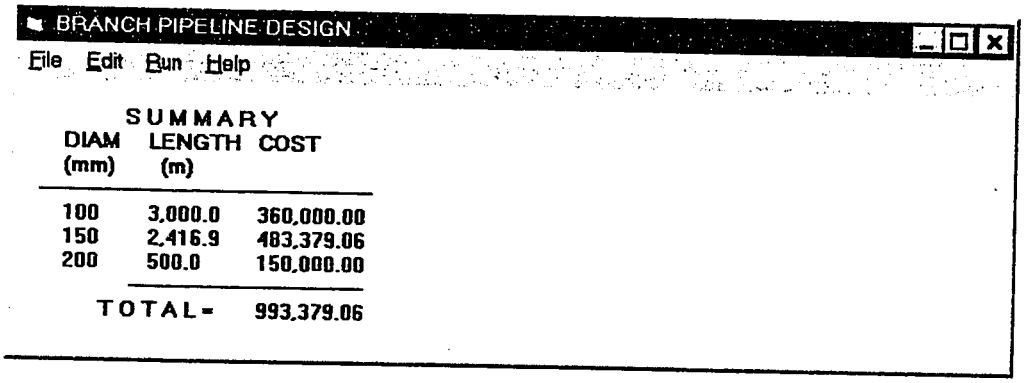


Fig. 5-15 The summary of the output result

6. LOOP

6.1. Introduction

LOOP simulates the hydraulic characteristics of a looped water distribution network. The network is characterized by pipes and nodes (points of inputs/demands or pipe junctions). Data required to run LOOP include descriptions of the elements of the network such as pipe lengths, diameters, friction coefficients, nodal demands and ground elevation, and data describing the geometry of the network. The program outputs include flows and velocities in the links and pressures at the nodes. The program does not accommodate network appurtenances such as in-line booster pumps or pressure reducing valves. It can simulate up to 10 nodes with known hydraulic grade lines (generally storage reservoirs).

LOOP will accept any looped, partially looped/branched network. LOOP is normally used to simulate the hydraulic response of a network to a single input or multiple inputs with at least one known hydraulic grade line (HGL) elevation. For networks with multiple inputs, at least one source node HGL must be specified. For other sources, either the HGL must be specified (such as would be the case with a storage reservoir with known elevation and height) or the inflow from the source must be given.

LOOP uses the Hardy-Cross algorithm to determine the flow corrections to the assumed flows in pipelines. The flow correction is based on the concept of maintaining flow continuity at each node and that the sum of the headlosses around any loop is zero. Once the flows that meet the above conditions are determined, the HGL elevations at each node can be easily calculated. The Hazen-Williams equation is used in this program to calculate headlosses. LOOP contains a subroutine that determines the number of loops in the network and the pipes that comprise each loop. It also contains a subroutine that determines an initial flow distribution that satisfies continuity at each node. This initial "balanced" flow distribution is needed to begin the Hardy-Cross algorithm. These two

subroutines substantially reduce the amount of data that must be provided by the user. LOOP also contains a subprogram for generating a cost summary once a final design is completed. The same subprogram can be used to give a listing of input data.

6.2. Data Preparation

To prepare network data for LOOP, the network should be represented as a series of nodes connected by links (the pipelines) as shown in Figure 2 in Annex. The requirements of the data and steps of the data preparing are the same as the BRANCH's example. See section 5.2 on page 21 for references.

6.3. Loading LOOP

Insert the PIPENET disk in disk drive A of your computer. Using File Manager of Windows 3.x or Windows Explorer of Windows 95, find the executable file PIPENET.EXE and run it. You are presented with a MAIN menu form (see Fig. 4-2).

Click option LOOP and click OK button, then the follow menu form appears.

6.4. Form of LOOP menu

The LOOP menu form (see Fig. 4-2) is a menu for all operations of the project. The top menu bar includes five sub-menus such as File, Edit, Run, Output and Help. The functions of them are described in PART I (page 9, 10).

6.4.1 Create A New File

See section 5.4.1 on page 23 to find the same method to create a new file.

6.4.2 Form of Parameters

This form (see Fig. 4-5b) is for essential parameters input. The parameters are used in the successive forms for data input and edit. The names of parameters are Title, No. of Pipes, No. of Nodes, Peak Factor, Max HL/KM, and Max Unbalanced. In each field, you can type in the corresponding value of the parameter, use [TAB] key to move from field to field.

- TITLE OF PROJECT is a description of the project or design for user reference.

- No. of Nodes and No. of Pipes must be integer values. These values are entered in the parameter list once only. If pipes or nodes are subsequently added to or deleted from the network, the program internally updates the value(s).

-The Peak Factor is a number by which average flow values assigned to each node are multiplied. The number is larger or equal to 1.

- Max Headloss/KM is maximum allowable headloss (gradient) in meters per kilometer that can occur in any pipeline. This parameter is used merely as a "flag". That is, if during the hydraulic simulation a pipeline has a flow that produces a HL/KM value above the "flag" value, the value will be marked with a note "HI" in the program output; the hydraulic simulation is not affected.

- Max Unbalanced, is the stopping criterion for the Hardy-Cross algorithm. It specifies the maximum unbalanced flow allowed for any loop in the network. If the unbalanced flow for all loops is below the value, the Hardy-Cross routine is stopped (a value from 0.001 to 0.01 is commonly used).

You can press or click Help button for instruction.

After parameters input and edit, press or click DONE button to go to next form.

6.4.3 Form of Pipeline Network

The style of the form and the methods to create nodes and pipes, edit nodes and pipes are the same as those described in section 5.4.3. See the page 24.

6.4.4 Form of Node

This form (see Fig. 4-7) is for node (source and terminal) data input and edit. To find out how to input and edit the data of nodes, including the graphic nodes, see section 5.4.4 of page 25.

6.4.5 Form of Pipe

This form is for pipe data input and edit. There are six text boxes in the form; Pipe Number, From Node, To Node, Length, Diameter and HWC Factor . The pipe number may be any integer number from 1 to 36,000. If you are simulating an existing network and plan to use parallel or extension pipelines, it is advisable to number the existing pipes in one series, say 1 to 199, and new pipes in another, say 200-299. This will allow you to easily keep track of new and existing pipelines in the program output and also to easily designate which are the new pipelines for cost analysis.

Pipe lengths are given in meters (m) and internal diameters in millimeters (mm). The Hazen-Williams friction coefficient is dimensionless and usually has a value between 80 and 140, depending on the type and age of the pipe. See section 5.4.5 of page 27 to get more details.

Now you can choose Next option from Exit sub-menu of the Form of Pipe Network, then the Form of Reference Node will appear.

6.4.6 Form of Reference Node

This form (see Fig. 4-9b) is designed for you to enter information for the source reference node, which has a specified HGL (Hydraulic Grade Line). For a storage tank, the HGL is the ground elevation plus the height of the tank (usually taken to be the mean water level). If the system has a single source,, information for this node is placed here. If the system has multiple sources, you should place information only for those nodes with fixed HGL's. These will usually be nodes that simulate elevated or ground storage reservoirs. Remember that nodes placed in this form should have zero flow value assigned to them in the Form of Node. Once you have completed this form, Click DONE to go to the next form, Form of Materials.

6.4.7 Form of Materials

This form (Fig. 4-10) is for pipe cost data input and edit. You can also see section 4.8 on page 17 which explains how to use the form.

6.5. File Management

Once you have completed the data input and edit, you will go back to the Form of Pipeline Network. If there is not any modification on the layout, you can choose Exit option from Exit sub-menu. You then go back to the Form of LOOP Menu. You can choose Save As... from the File sub-menu to save the input data you have just inputted. You also can choose Show option from the File sub-menu and select a readable file to read. It is useful for checking input and output data files.

6.6. Run Program LOOP (Simulation)

Choose Run option from the Run sub-menu to perform the hydraulic simulation of the distribution network described by your current data set. The program will proceed through the various algorithms, which may take some time depending on the size of the network. During the program run, the result will appear on the form, Form of LOOP Menu. If you want to review the output, choose Review option from the Run sub-menu. If you want to save the output into a file, choose Save Output from the Run sub-menu. If you want to see the total flow demand, you can choose Total option from the Run sub-menu.

The running results include the pipe numbers, correct "from" and "to" nodes, pipe length, diameter, flow, headloss per kilometer, and total headloss. During output printing, you can press any key for continuous presentation when you are asked to do that. After all of the output has been displayed, you can review the output, or print the output into a file.

If you want to check the cost information, you can click Output and choose the number you want. You also can save all cost information of the pipeline network by choosing Save All option.

If you want to change some parameters, or some pipe diameters, without changing the layout, you can choose Edit option from Edit sub-menu to go to the Form of Parameters. For example, if you want to change peak factor, just change the value in the proper field. Then you can run the program again and check the new output. If you want to re-plan the pipe network, choose Re-Plan in the same sub-menu. The pervious layout will disappear.

6.7. Quit LOOP Program

Choose Exit option from the File sub-menu to go back to MAINMENU. If you want to exit the PIPENET program, click EXIT button.

6.8. Example

A sample of LOOP water distribution network design and simulation is shown on the following pages to illustrate the use of the program. Figure 2 in ANNEX shows the sample network , which consists of an elevated storage reservoir (node 300), two constant flow pumps as sources (nodes 100 and 200), and 24 pipes and 20 nodes in a partially looped/branched configuration. Pipe numbers appear in the small boxes along the lines and the node numbers are noted in the circles connected by the lines. Other known data include pipe lengths, trial diameters, Hazen-Williams friction coefficients, node elevations, and pumped inflows and outflows.

Procedures

(1) Insert the disk into disk driver Drive A.

(2) Load program PIPENET by clicking it in the Manager of Window3.x or in the Explorer of Windows95, the MAIN menu appears (see Fig. 4-2).

(3) From the form of MAIN menu, choose LOOP and click DONE to enter LOOP menu (see Fig. 4-4).

(4) From the form of LOOP menu, click File Sub-menu and choose New; then the Form of Parameters will appear.

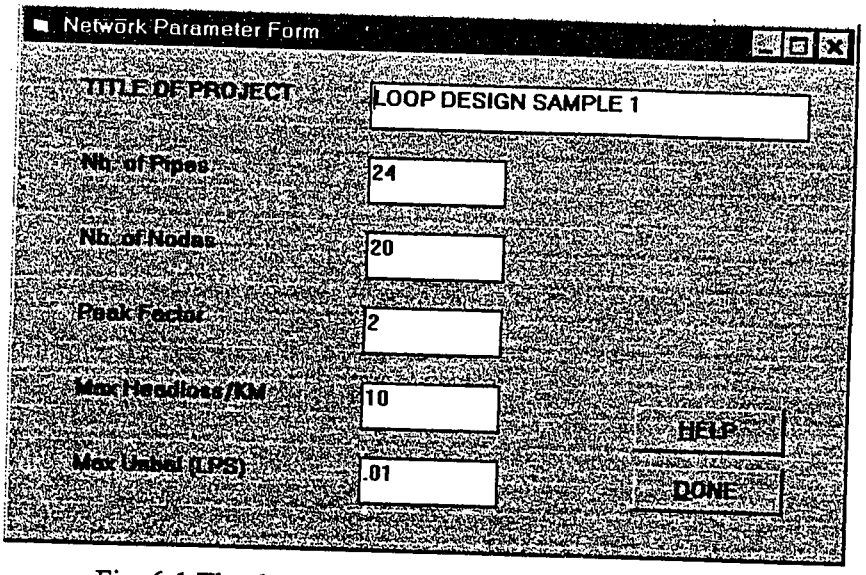


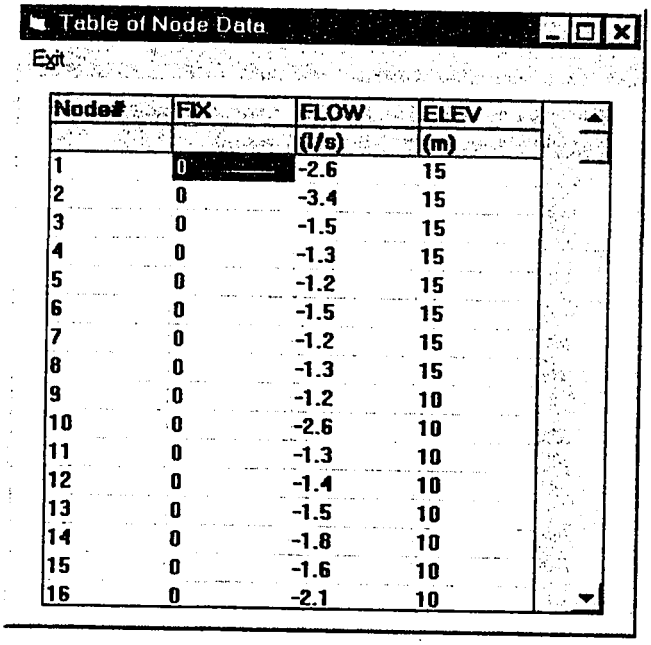
Fig. 6-1 The data of parameters of the LOOP Network

(5) Enter the data from Table 2 of Annex. The form completed is shown in Fig. 6-1. Click DONE after finish entering, so the Form of Pipeline will appear (see Fig. 4-6).

(6) In the Form of Pipeline, there is an icon of a water reservoir on the top left. It represents source node which will be considered as the reference node. Other node icons are under the source node. You can drag the upper icon to some position, then go back to drag the next. You should drag all the icons to the proper positions .

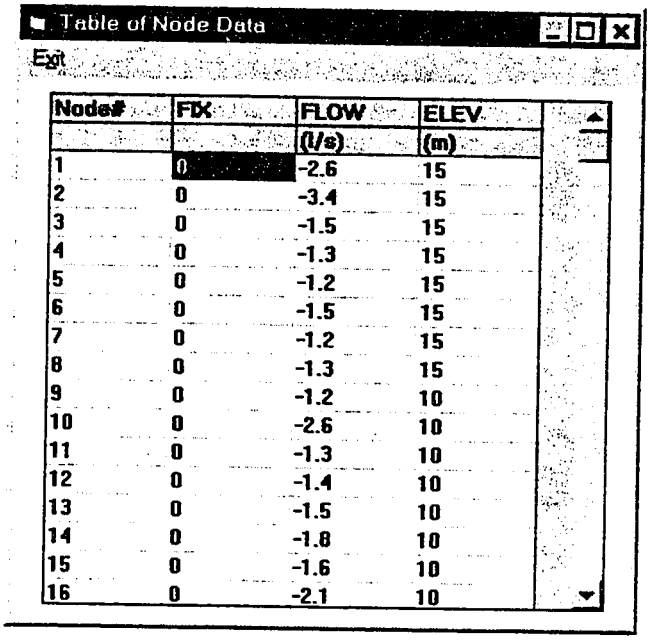
Click Node on the menu bar, then choose Edit. Now you can double click any node icon to invoke the Form of Node for node data input and edit (see Fig. 4-7).

You can see paragraph (6) in section 5.8 which describes how to drag icons, create pipes, as well as edit data of nodes and pipes. The data list table of nodes for LOOP are shown in Fig. 6-2a and Fig. 6-2b; however, the data list table of pipes for LOOP are shown in Fig. 6-3a and Fig. 6-3b. Similar to BRANCH, click Exit to go back to the Form of Pipeline. The intermediate design and the result of the design are shown in Fig. 6-4 and Fig. 6-5 respectively.



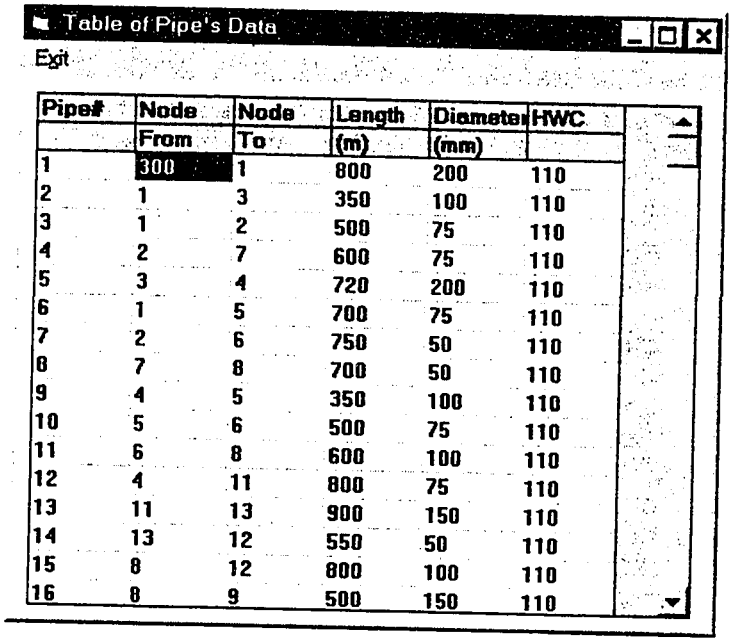
Node#	FIX	FLOW (l/s)	ELEV (m)
1	0	-2.6	15
2	0	-3.4	15
3	0	-1.5	15
4	0	-1.3	15
5	0	-1.2	15
6	0	-1.5	15
7	0	-1.2	15
8	0	-1.3	15
9	0	-1.2	10
10	0	-2.6	10
11	0	-1.3	10
12	0	-1.4	10
13	0	-1.5	10
14	0	-1.8	10
15	0	-1.6	10
16	0	-2.1	10

Fig. 6-2a The Table of Node Data



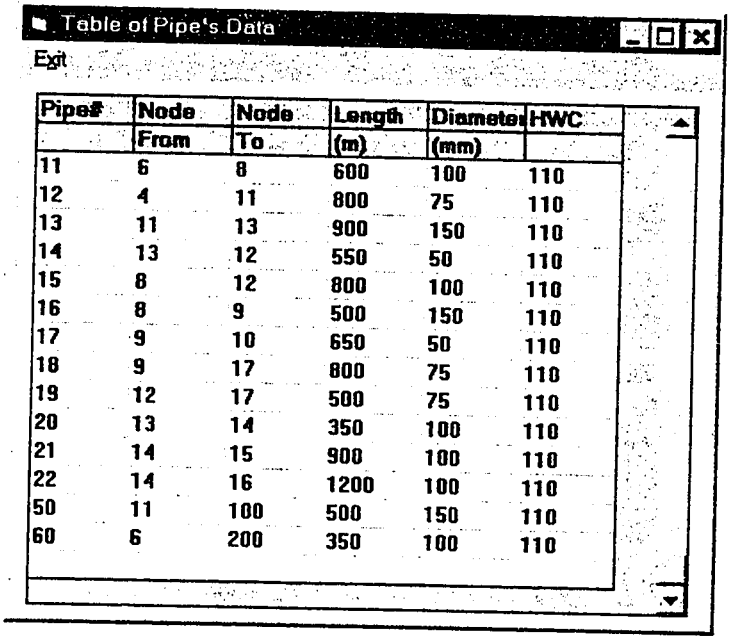
Node#	FIX	FLOW (l/s)	ELEV (m)
1	0	-2.6	15
2	0	-3.4	15
3	0	-1.5	15
4	0	-1.3	15
5	0	-1.2	15
6	0	-1.5	15
7	0	-1.2	15
8	0	-1.3	15
9	0	-1.2	10
10	0	-2.6	10
11	0	-1.3	10
12	0	-1.4	10
13	0	-1.5	10
14	0	-1.8	10
15	0	-1.6	10
16	0	-2.1	10

Fig. 6-2b The Table of Node Data (Continue)



Pipe#	Node From	Node To	Length (m)	Diameter (mm)	HWC
1	300	1	800	200	110
2	1	3	350	100	110
3	1	2	500	75	110
4	2	7	600	75	110
5	3	4	720	200	110
6	1	5	700	75	110
7	2	6	750	50	110
8	7	8	700	50	110
9	4	5	350	100	110
10	5	6	500	75	110
11	6	8	600	100	110
12	4	11	800	75	110
13	11	13	900	150	110
14	13	12	550	50	110
15	8	12	800	100	110
16	8	9	500	150	110

Fig. 6-3a The table of the pipe data



Pipe#	Node From	Node To	Length (m)	Diameter (mm)	HWC
11	6	8	600	100	110
12	4	11	800	75	110
13	11	13	900	150	110
14	13	12	550	50	110
15	8	12	800	100	110
16	8	9	500	150	110
17	9	10	650	50	110
18	9	17	800	75	110
19	12	17	500	75	110
20	13	14	350	100	110
21	14	15	900	100	110
22	14	16	1200	100	110
50	11	100	500	150	110
60	6	200	350	100	110

Fig. 6-3b The table of the pipe data (continue)

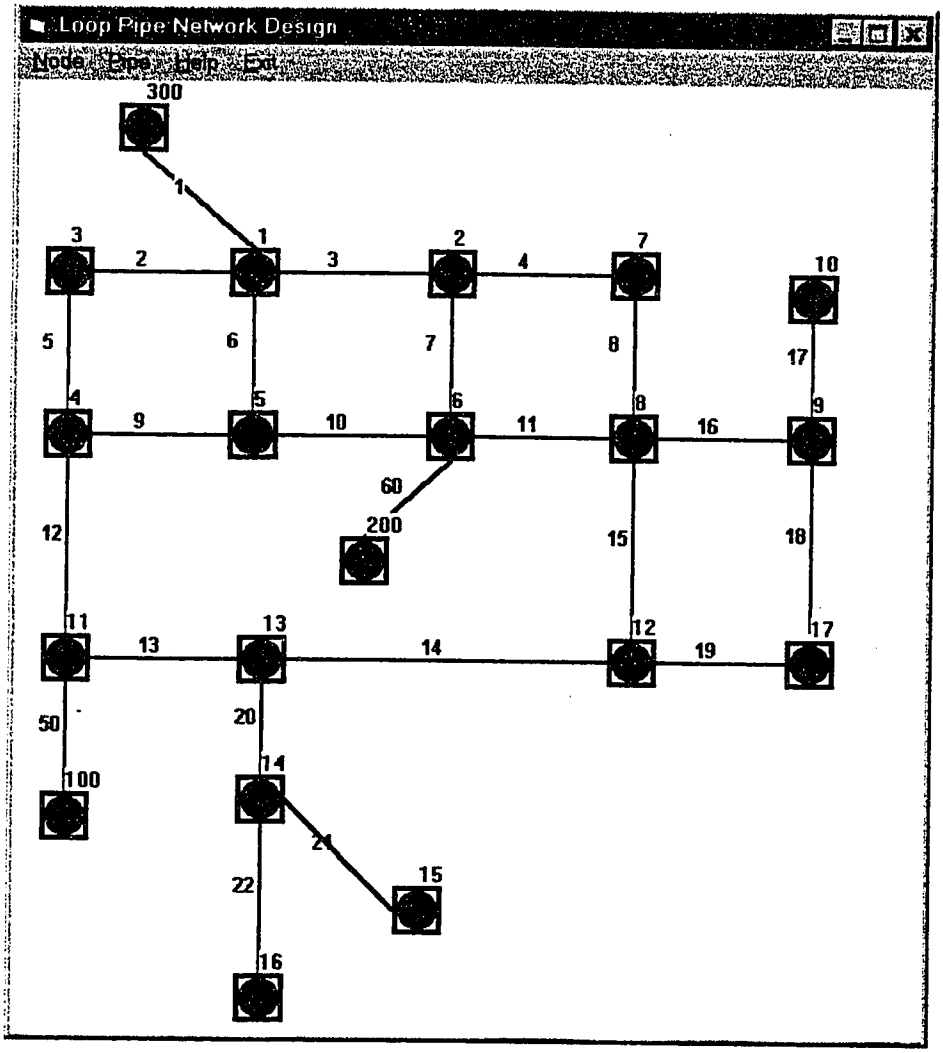


Fig. 6-4 The Map of the Network Design

If there is no problem, click the Exit Sub-menu and choose Next to go to the Form of Reference.

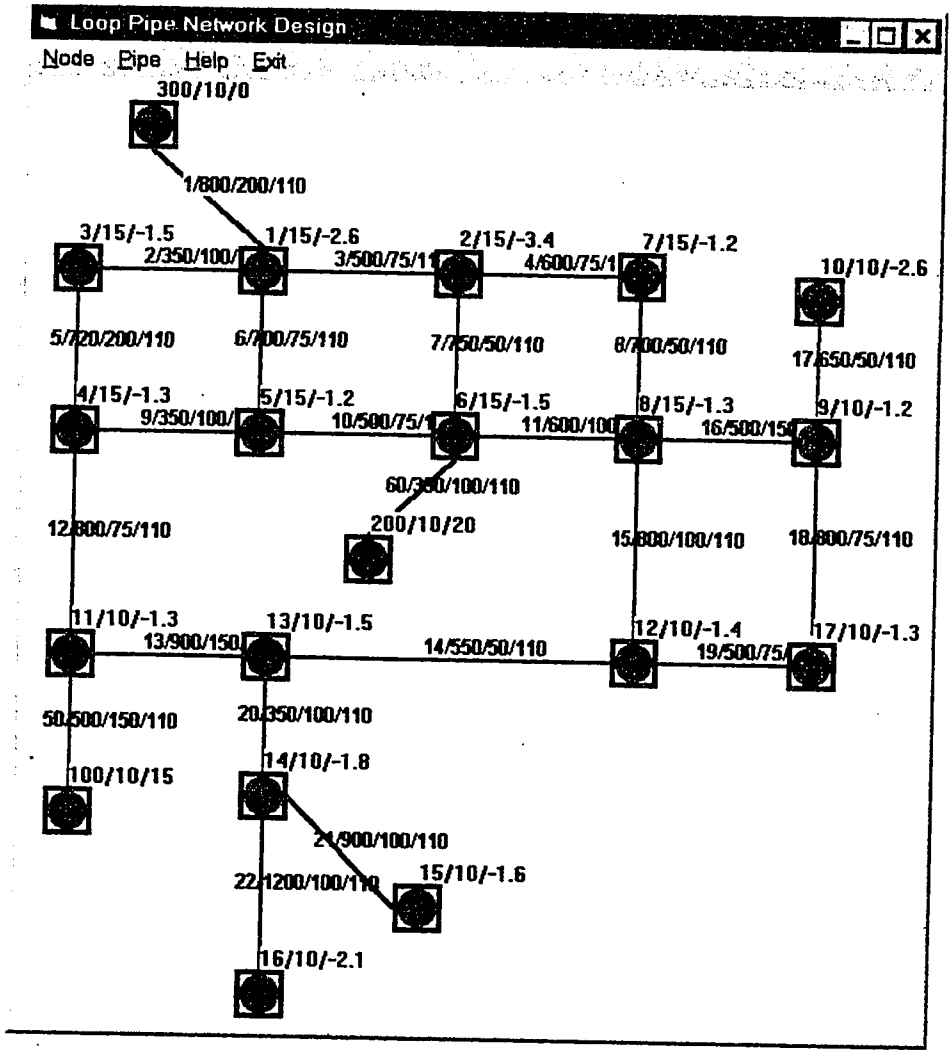


Fig. 6-5 The Result of the LOOP Network Design

In the form (see Fig. 4-9b), enter the reference node -- resource node and its hydraulic grade line HGL based on Table 2 in Annex. You also can use Pre-Item and Post-Item to move from one node to another, use LIST to invoke a Table for data checking (see Fig. 6-6), and click EXIT to go to the Form of Pipe Cost.

The method of data input and editing in the Form of Pipe Cost is the same as that described in the BRANCH example (see Fig. 5-9 and 5-10). After all data are entered, you click EXIT for leaving, i.e. go back to the Form of Pipeline.

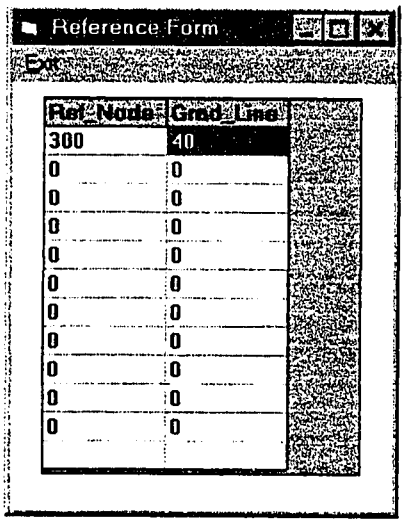


Fig. 6-6 The Table of Reference Nodes

If there is no problem, click the Exit Sub-menu and choose Exit to go back to the form of LOOP menu.

(7) You can save the data by clicking File Sub-menu and choosing Save As.

(8) You can check the total flow demanded by clicking Run Sub-menu and choosing Total (see Fig. 6-7).

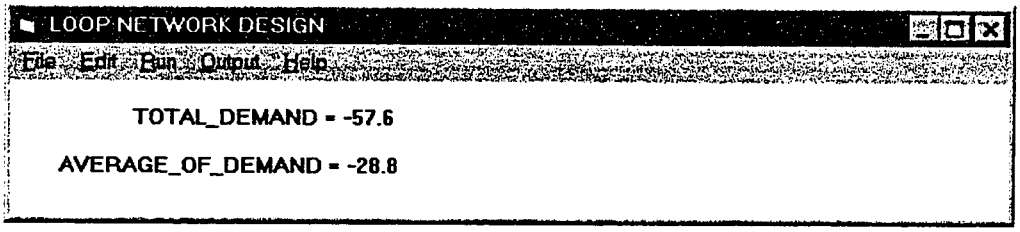


Fig. 6-7 Total Flow Demand of the LOOP Network

(9) You can run the program by clicking the Run Sub-menu and choose Run. Then the output is shown on the form (see Fig. 6-8, Fig. 6-9 and Fig. 6-10). You can choose Review in the Run Sub-menu to see the output again. If you want to save the output, choose Save Output in the Run Sub-menu, the output will be saved into a file named by you.

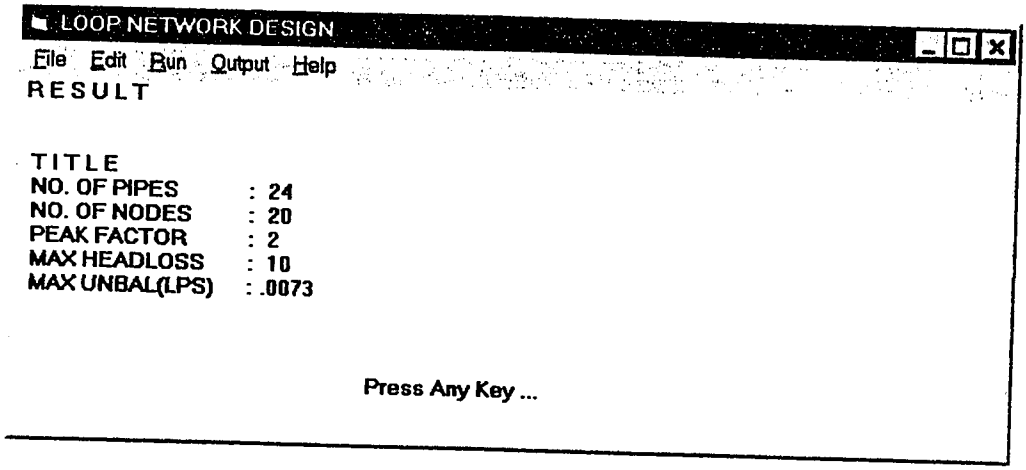


Fig. 6-8 The Parameters of the LOOP Network

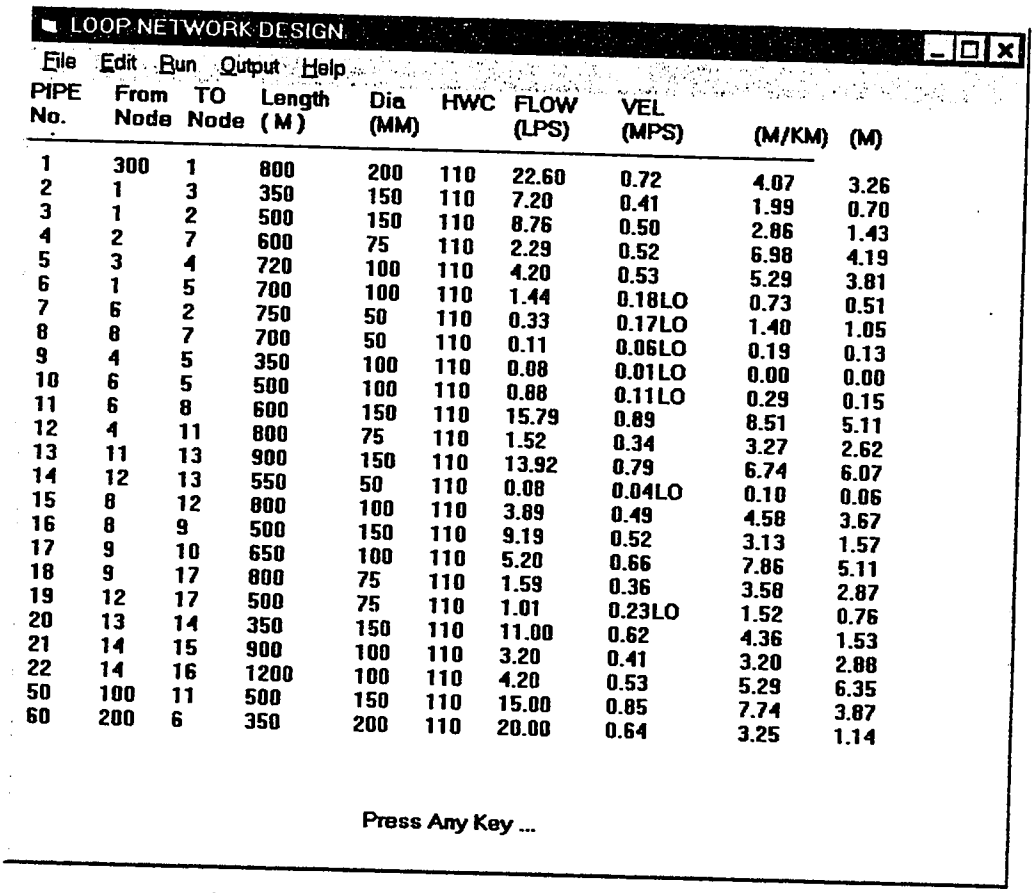
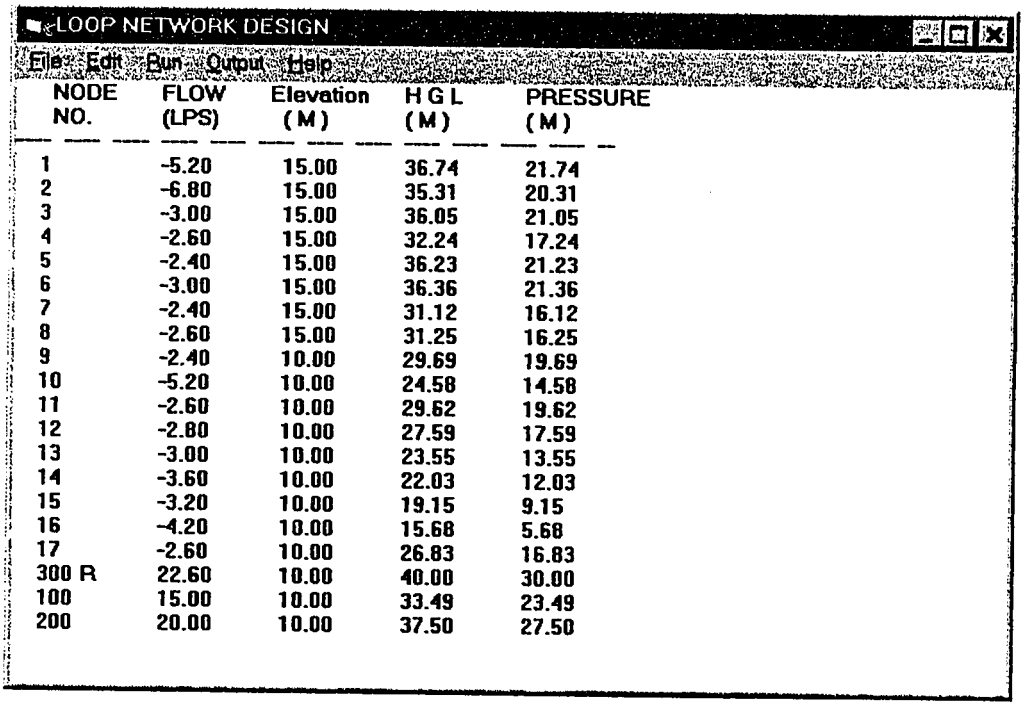


Fig. 6-9 The Output of the Result of LOOP network



NODE NO.	FLOW (LPS)	Elevation (M)	H G L (M)	PRESSURE (M)
1	-5.20	15.00	36.74	21.74
2	-6.80	15.00	35.31	20.31
3	-3.00	15.00	36.05	21.05
4	-2.60	15.00	32.24	17.24
5	-2.40	15.00	36.23	21.23
6	-3.00	15.00	36.36	21.36
7	-2.40	15.00	31.12	16.12
8	-2.60	15.00	31.25	16.25
9	-2.40	10.00	29.69	19.69
10	-5.20	10.00	24.58	14.58
11	-2.60	10.00	29.62	19.62
12	-2.80	10.00	27.59	17.59
13	-3.00	10.00	23.55	13.55
14	-3.60	10.00	22.03	12.03
15	-3.20	10.00	19.15	9.15
16	-4.20	10.00	15.68	5.68
17	-2.60	10.00	26.83	16.83
300 R	22.60	10.00	40.00	30.00
100	15.00	10.00	33.49	23.49
200	20.00	10.00	37.50	27.50

Fig. 6-10 The Output of the Result of the Node Information

(10) If you want to get more information from the result of the LOOP Network design, you can click the Output Sub-menu. Then you can select one of the eight items. For example, you want to know the cost for each pipe size in the Network. Click the third item "Sorted by Pipe Size with Cost", the output (Fig. 6-11) appears. Also if you want to know the summary of the cost for all pipe sizes, click item 5, consequently the output (Fig. 6-12) appears. In addition, if you want to know the cost of some specific range of pipes, click item 4 or item 6. First a form is popped up to let you enter the range of pipe numbers from the smallest one to the biggest one. Seeing Fig. 6-13, here "1" is entered in the left box and "17" is in the right box. The pipes which their numbers are less or equal to 17 are new pipes in the LOOP Network. After entering the range, click OK then the cost of the pipes in the selected range appears on the screen (see Fig. 6-14).

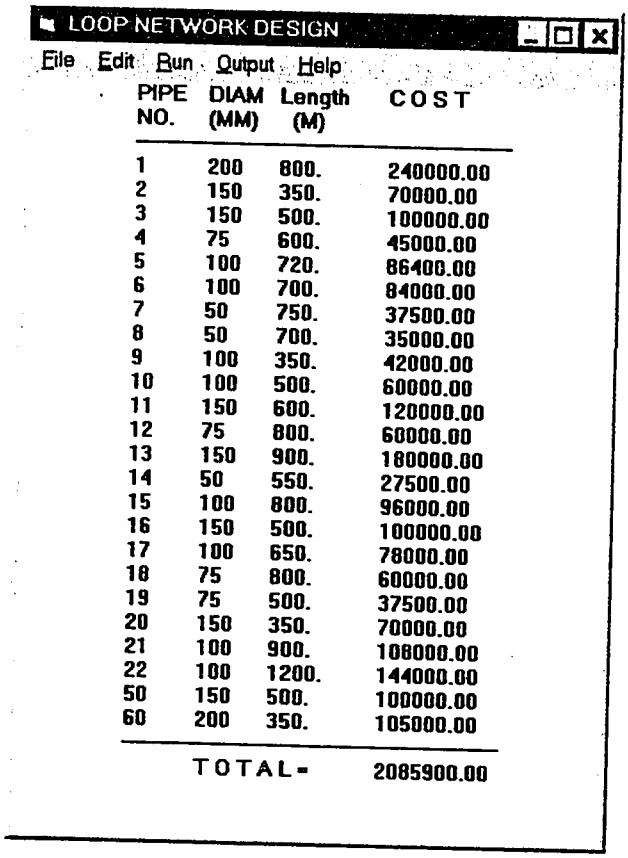


Fig. 6-11 The Cost of the Sorted Pipe Numbers

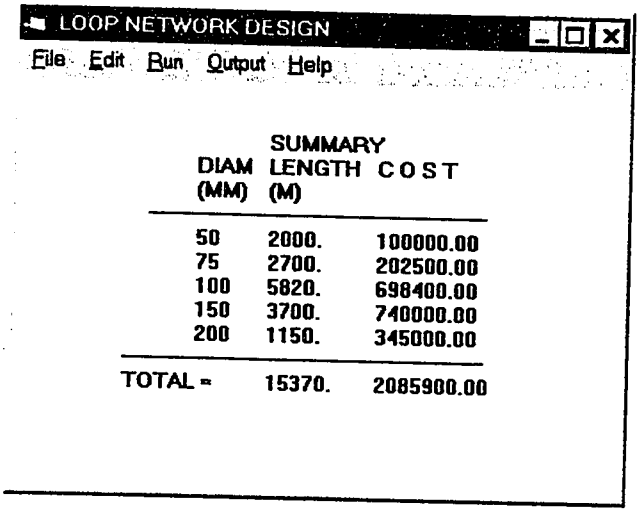


Fig. 6-12 The Summary of the Sorted Pipe Size with the Cost

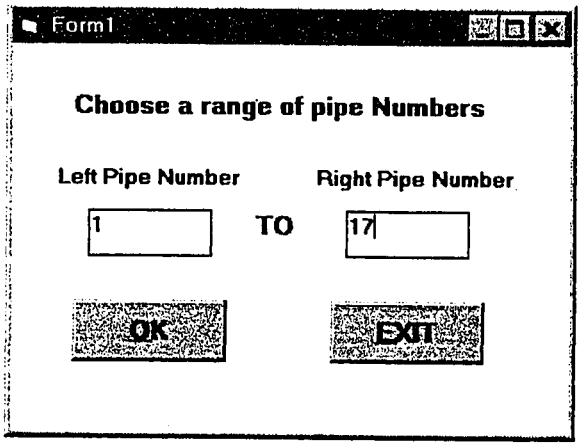


Fig. 6-13 The Form of the Range of Pipe Numbers

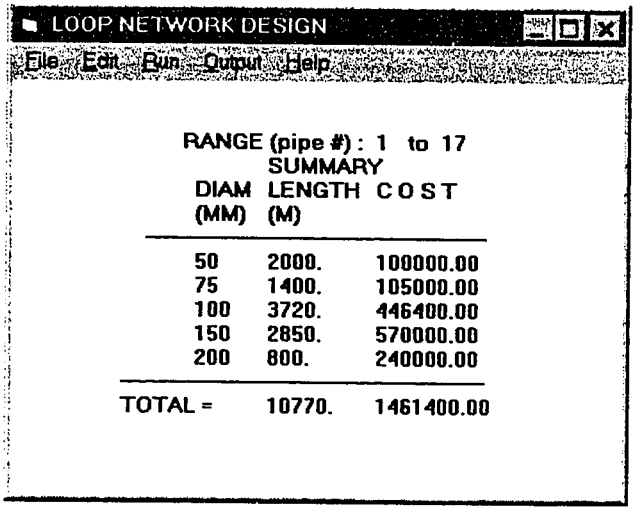


Fig. 6-14 The Summary of the Ranged/Sorted Pipe Size with the Cost

(12) Because the LOOP program cannot make optimization automatically, the first result of the design is not good enough. Therefore, adjusting is needed. You can adjust the pipe sizes of some pipes to avoid the pressures higher than the maximum value or lower than the minimum value. At the same time, you should consider the costs before and after the adjusting. You should try several times to find the better design.

7. Conclusion

The user interface means that the user can easily handle the software. The advantages include faster learning, more options and a more robust program. At this point, the interface design for the water distribution network software is satisfied. It has the following features.

(1) The water distribution network design uses computer graphics, such as icons, dragging objects. These allow the pipeline network design to be accomplished more directly.

(2) The windows design provides more options for users.

(3) The data input, data output and data edit are easily controlled.

(4) More information is given in the run time, therefore the program is easy to follow and program crushes are avoided.

However, there still are a lot of work to be done to farther improve the program. This requires not only interface but also computation. The more complex software will require more user-friendly interface techniques.

REFERENCE

Thomas W. Torgerson (1993), *Visual Basic Professional 3.0 Programming*, A Wiley-QED, New York.

John Clark Craig (1993), *Microsoft Visual Basic Workshop*, Microsoft Press, US.

Peter Norton (1994), *Peter Norton's Visual Basic for Windows*, 3ed, Covering Release 3.0.

O. Gurewich & N. Gurewich (1994), *Master Visual C++2*, 2nd edition, Sams, Indiana.

Steven Holzner (1991), *C Programming*, Brady, New York.

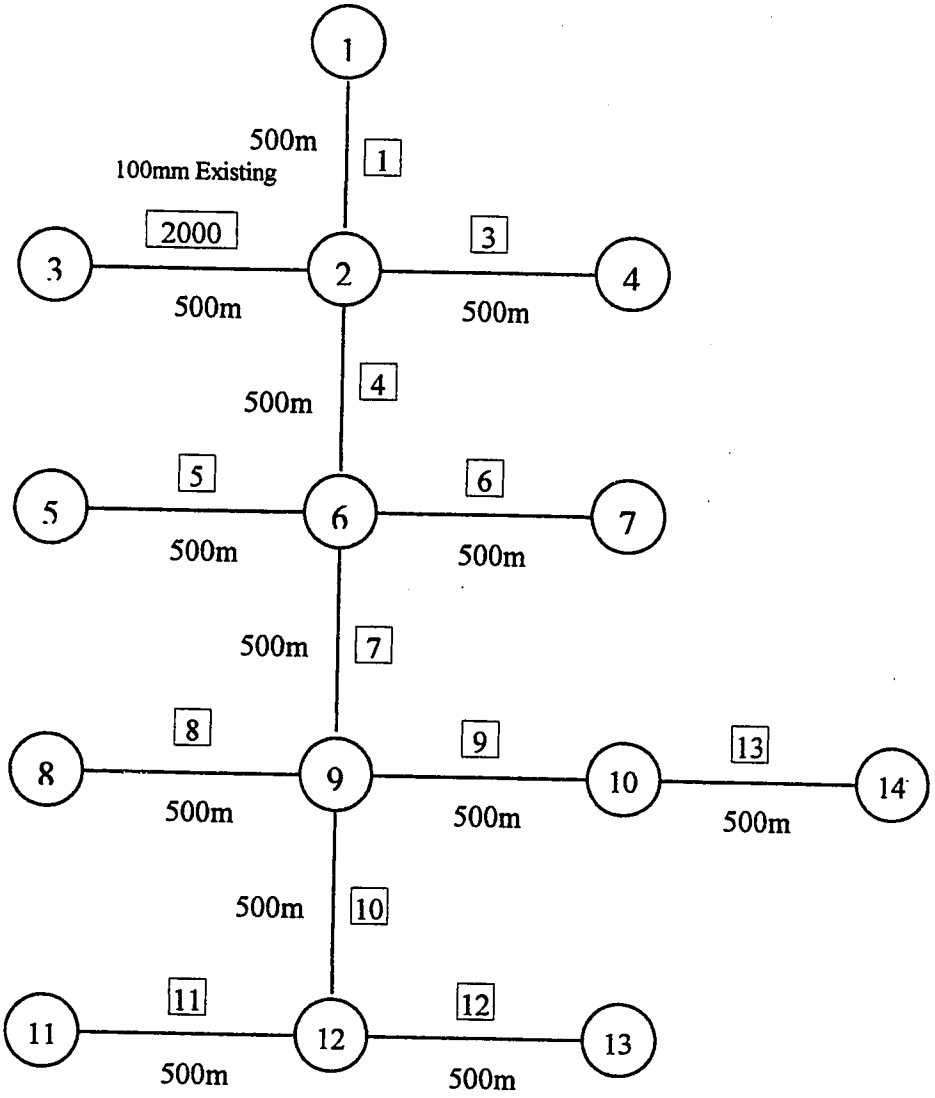
T.J. Casey (1992), *Water and Wastewater Engineering Hydraulics*, Oxford University Press, Oxford.

Thomas M. Walski (1984), *Analysis of Water Distribution System*, Van Nostrand Reinhold Co., New York.

Daniel S. Del Puerto (1985), BRANCH and LOOP Manuals and Source Code, World Bank & UNDP.

ANNEX

Figure 1. Sample Branch Network Design



1 Node and node number

8 Pipe and pipe number

500m Pipe length

Flow in node 1 = 0; flow in nodes 2-13 = -3; flow in node 14 = 10
Pipe 2000 existing; Pipe 4 existing.

Table 1. Data of Branch Pipeline Network Sample

T I T L E : BRANCH_NETWORK_SAMPLE_DESIGN
NO. OF PIPES : 13
NO. OF NODES : 14
PEAK FACTOR : 1.0
MIN HL/KM : 0.05
MAX HL/KM : 10.0
RESIDUAL HEAD : 10.0

NODE #	FIX	F L O W	ELEVATION
1	0.0	0.0	25.0
2	0.0	-3.0	0.0
3	0.0	-3.0	0.0
4	0.0	-3.0	0.0
5	0.0	-3.0	0.0
6	0.0	-3.0	0.0
7	0.0	-3.0	0.0
8	0.0	-3.0	0.0
9	0.0	-3.0	0.0
10	0.0	-3.0	0.0
11	0.0	-3.0	0.0
12	0.0	-3.0	0.0
13	0.0	-3.0	0.0
14	1.0	10.0	0.0

PIPE NO.	N O D E FROM	TO	LENGTH	DIA	HWC
1	1	2	500.0	0.0	0.0
2000	2	3	500.0	100.0	110.0
3	2	4	500.0	0.0	0.0
4	2	6	500.0	100.0	110.0
5	6	5	500.0	0.0	0.0
6	6	7	500.0	0.0	0.0
7	6	9	500.0	0.0	0.0
8	9	8	500.0	0.0	0.0
9	10	9	500.0	0.0	0.0
10	9	12	500.0	0.0	0.0
11	12	11	500.0	0.0	0.0
12	12	13	500.0	0.0	0.0
13	14	10	500.0	0.0	0.0

DIAM (MM)	HWC	UNIT COST
75	100	75
100	110	120
150	110	200
200	110	300
250	120	430

REFERENCE NODE	GRADE LINE
1	25.0

Figure 2. Sample Loop Network Design

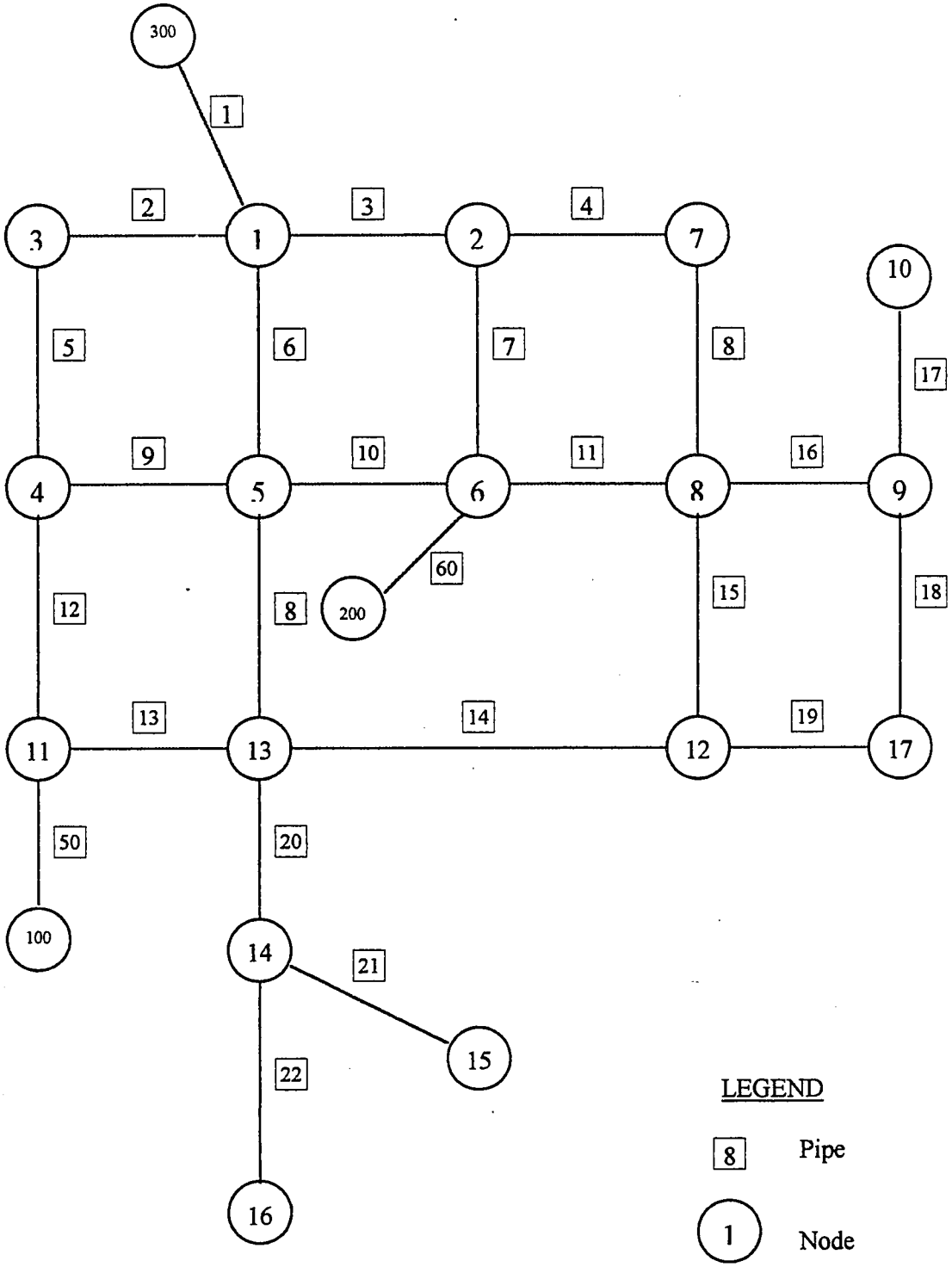


Table 2. Data of Loop Design Sample

T I T L E : LOOP_DESIGN_SAMPLE_2
NO. OF PIPES : 24
NO. OF NODES : 20
PEAK FACTOR : 2
MAX HEADLOSS : 10
MAX UNBAL(LPS) : .01

PIPE NO.	N O D E FROM	TO	LENGTH (M)	DIA (MM)	HWC
1	18	1	800.0	200	110
2	1	3	350.0	150	110
3	1	2	500.0	150	110
4	2	7	600.0	75	110
5	3	4	720.0	100	110
6	1	5	700.0	100	110
7	6	2	750.0	50	110
8	8	7	700.0	50	110
9	4	5	350.0	100	110
10	6	5	500.0	100	110
11	6	8	600.0	150	110
12	4	11	800.0	75	110
13	11	13	900.0	150	110
14	12	13	550.0	50	110
15	8	12	800.0	100	110
16	8	9	500.0	150	110
17	9	10	650.0	100	110
18	9	17	800.0	75	110
19	12	17	500.0	75	110
20	13	14	350.0	150	110
21	14	15	900.0	100	110
22	14	16	1200.0	100	110
50	19	11	500.0	150	110
60	20	6	350.0	200	110

NODE NO.	FIX	FLOW (LPS)	ELEVATION (M)
1	0	-5.20	15
2	0	-6.80	15
3	0	-3.00	15
4	0	-2.60	15
5	0	-2.40	15
6	0	-3.00	15
7	0	-2.40	15
8	0	-2.60	15
9	0	-2.40	10
10	0	-5.20	10
11	0	-2.60	10
12	0	-2.80	10
13	0	-3.00	10
14	0	-3.60	10
15	0	-3.20	10
16	0	-4.20	10
17	0	-2.60	10
300	0	22.60	10
100	1	15.00	10
200	1	20.00	10

REFERENCE NODE	GRADE LINE
18	40.00
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0

DIAM (MM)	HWC	UNIT COST
50	110	50
75	110	75
100	110	120
150	110	200
200	110	300
250	120	430