The Liquid and Plastic Limit Data Treated System Based on VC++

Xiaodong Zhang, Jianqiao Li, Ruiyang Shi, Meng Zou, Yang Wang, Hao Li
Key laboratory of Bionic Engineering (Ministry of Education, China
Jilin University
Changchun, P. R. China
e-mail: xiaodong10@mails.jlu.edu.cn; jqli@jlu.edu.cn; shiry11@mails.jlu.edu.cn; zoumeng@jlu.edu.cn;
wangyang0718@mails.jlu.edu.cn; lihao1987102@sina.com

***Abstract*—According to two standards for soil test methods with liquid and plastic limit combined test, a liquid and plastic limit data treated system was developed using object-oriented visual programming Microsoft Visual C++6.0 based on analytical method. The flow char indicated that programs of the system used select structure and its nested structure as main its algorithm. Contrasted with manual graphic method, the liquid and plastic limit data treated system had high efficiency and reliable accuracy.**

Keywords—object-oriented visual programming; VC++; soil science;analytical method; liquid limit, plastic limit

I. Introduction

The soil liquid limit w_L (shorted as w_L) and soil plastic limit w_P (shorted as w_P) are both fundamental physical standards for evaluating mechanical properties of soil [1-3], which are often collectively referred to as the "Atterberg Limits ". Traditionally, using manual graphic method to treat the data of w_L and w_P had a low efficiency and caused man-made error easily. With the aids of computer hardware and software technology, data treated software or object-oriented visual program software were gradually applied to analyzing w_L and w_P data, which heighten the efficiency and improve accuracy during data treated process. However, there is almost not an object-oriented visual program for treating w_L and w_P data based on analytic method at present.

In this paper, according to two standard for soil test methods about liquid and plastic limit combined test, the object-oriented visual programming tool Microsoft Visual C++6.0 was used to develop an liquid and plastic limit data treated system referring to analytic method, the main algorithm of which is choose structure and its nested structure. Experimental results indicated that this system had a high efficiency and reliable accuracy compared with manual graphic method to treat w_L and w_P data.

II. Radical principle

The radical principle of liquid and plastic limit combined test for treating w_L and w_P data referr to *GB/T 50123-1999 Standard for Soil Test Method* (shorted as *Standard*) [4] and *JTG E40-2007 Test Methods of Soils for Highway Engineering* (shorted as *Test Methods*) [5]. In this paper, *Standard* was used as an example to discuss the data treated process with analytical method. In *Standard*, the equipment for liquid and plastic limit combined test was GYS-2 photoelectric liquid-plastic tester (Nan Jing soil instrument factory) with 76g and 30°cone penetrator.

(1) Three points (A point, B point and C point) corresponding to three different water contents of a soil specimen were chosen for liquid and plastic limit combined test. The depth of cone penetrator for each point were 3~4mm (A point), 5~7mm (B point) and 15~17mm (C point).

(2) The coordinate for each point was supposed to A (w_A, h_A), B (w_B, h_B), C (w_C, h_C). So straight line AC and straight line BC are expressed respectively as:

Straight line AC:

$$\frac{\lg w_C - \lg w_A}{\lg h_C - \lg h_A} = \frac{\lg w_C - \lg w_M}{g\, h_C - \lg h_P} \quad (1)$$

Straight line BC:

$$\frac{\lg w_C - \lg w_B}{\lg h_C - \lg h_B} = \frac{\lg w_C - \lg w_N}{g\, h_C - \lg h_P} \quad (2)$$

where w_A, w_B and w_C were the water contents of three different water contents for a soil specimen corresponding to each point respectively. h_A, h_B and h_C were the depths of cone penetrator corresponding to each point respectively. The depth of cone penetrator h_P equaled 2mm. So the values of w_M and w_N could be calculated according to Equ. (1) and Equ. (2).

(3) If the absolute value of difference between w_M and w_N was less than 2, h_P and the average value $\overline{w}$ between w_M and w_N were used as the coordinate of point D ($\overline{w}$, h_P) and straight line CD was drawn (Fig. 1). The equation of straight line CD was described as:

$$\lg w = \frac{\lg(w_C / \overline{w}) \lg(h / h_C)}{\lg(h_C / h_P)} + \lg w_C \quad (3)$$

where w and h were variable.

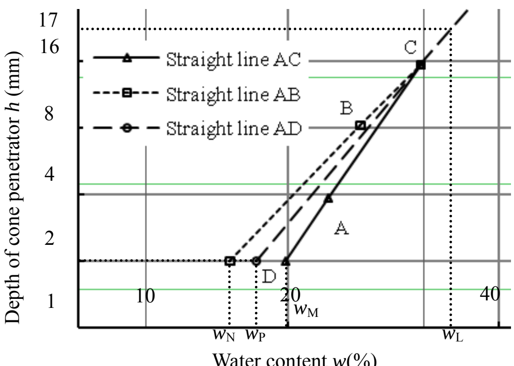

Figure 1. The relation between the depht of cone penetrator and the water content of soil.

III. PROGRAM DESIGN

A. Program flow chart

The flow chart of the liquid and plastic limit data treated system was illustrated in Fig.2. In flow chart, Equ.(6) and Equ.(7) were expressed respectively as:

$$h_{\mathrm{p}} = 29.6 - 1.22w_{\mathrm{L}} + 0.017w_{\mathrm{L}}^2 - 0.000074w_{\mathrm{L}}^3 \quad (6)$$

$$h_{\mathrm{p}} = \frac{w_{\mathrm{L}}}{0.524w_{\mathrm{L}} - 7.606} \quad (7)$$

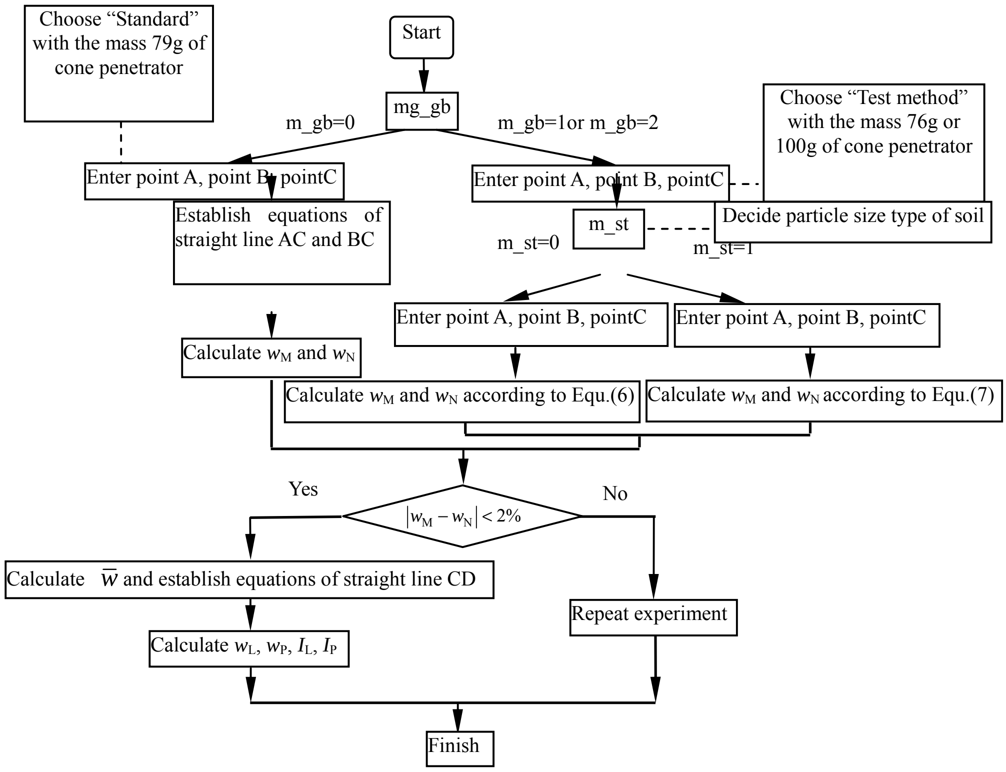

Figure 2. The flow chart of program

Flow chart indicated that select structure and its nested structure as the main algorithm of the liquid and plastic limit data treated system. So switch statement and condition statement were chosen to compose process program of the system.

B. Dialog box

The liquid and plastic limit data treated system was developed under Microsoft Visual C++6.0[7-8]. The dialog box of the system was established from MFC AppWizard based on MFC, the caption of which was "Liquid Limit and Plastic Limit Data Treating System" (Fig.3). Table. Ⅰ showed main controls distributed on the dialog box.

TABLE I. CONTROLS ON THE DIALOG BOX

Main controls	Function
Edit Box	Enter data or export result
Button	Execute program
Radio Button	Chose " Standard " or " Test Methods " and soil type
Static	Show controls function
Group Box	Divide different part of dialog box

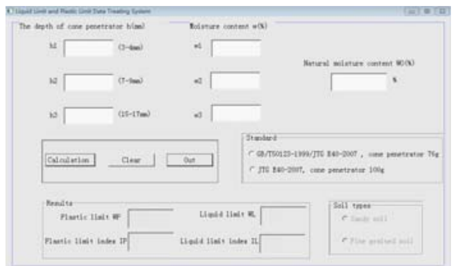

Figure 3. Dialog box

C. Program exemplification

In "Member Variables" label at "Class wizard", edit box and member variables were linked and member variables were set as "Double" type. Clicking the "Group" in "General" label of "GB/T50123-1999, cone penetrator 76g" and "Sandy soil" radio button attributes, the radio buttons were separated into "Standard" group and "Soil type" group. In "Member Variables" label at "Class wizard", the edit box and member variables were linked and member variables were set as "Double" type. "GB/T50123-1999, cone penetrator 76g" radio button and "Sandy soil" radio button were related with member variables and member variables were set as "Int" type in order to when "Calculation" button was clicked, only one data treated process was executed, which could prevent conflicts among programs.

In "Message Maps" label at "ClassWizard", response function was added to "Calculation" button. Firstly, "Calculation" button ID was selected from "Object ID" list box, and BN_CLICKED message was selected from "Message" list box. Then the response function name was defined as "OnJs" trough clicking "Add Function" button. After clicking "Edit Code" button, response function was added in "CMyDlg" class. Before the data treated program was executed, selecting "standard" and "soil type" and then clicking "Calculation" button, the response function called the data treated program in "OnJs" to treat data which were gained from liquid and plastic limit combined test.

Because *Test Methods* has similar data treated process to *standard* as a whole (Fig.2), in this paper, the data treated program of "GB/T50123-1999, cone penetrator 76g" was expressed as

void CMyDlg::OnJs()
{
double k_{AC}, k_{BC}, b_{AC}, b_{BC}, w_M, w_N , $\overline{w}$, $\overline{b}$, $\overline{k}$ =0.0;
UpdateData();
k_{AC}=(log10(h_C)-log10(h_A))/(log10(w_C)-log10(w_A));//The slope of straight line AC
k_{BC}=(log10(h_C)-log10(h_B))/(log10(w_C)-log10(w_B));//The slope of straight line BC
b_{AC}=log10(h_C)-k_{AC}*log10(w_C);//The intercept of straight line AC
b_{BC}=log10(h_C)-k_{BC}*log10(w_C);//The intercept of straight line BC
w_M=pow(10,(log10(2)-b_{AC})/k_{AC});//The water content of the depth of cone penetrator 2mm from straight line AC
w_N=pow(10,(log10(2)-b_{BC})/k_{BC});//The water content of the depth of cone penetrator 2mm from straight line BC switch(m_gb)
{
UpdateData();
case -1:
MessageBox("Please select standard！ ");
break;
case 0:
UpdateData();
if (fabs(w_M-w_N)>=2%)
{
MessageBox("Please repeat experiment！ ");
}
else
{
MessageBox("GB/T50123-1999, cone penetrator 76g!");
$\overline{w}$=(w_M+w_N)/2;
$\overline{k}$ =(log10(h_C)-log10(2))/(log10(w_C)-log10($\overline{w}$));//The slope of straight line CD
$\overline{b}$ =log10(h_C)-kav*log10(w_C);//The intercept of straight line CD
w_P=ceil((pow(10,(log10(2)- $\overline{b}$)/ $\overline{k}$))*100)/100;
w_L=ceil((pow(10,(log10(17)- $\overline{b}$)/ $\overline{k}$))*100)/100;
I_P=ceil((w_L- w_P)*100)/100;
I_L=ceil((w_O- w_P)*100/I_P)/100;
}
UpdateData(FALSE);
UpdateData(FALSE);
break;
case 1:
…}
UpdateData(FALSE);
break;
}
}

IV. EXAMPLE ANALYSIS

Three soil mixed specimens were gained from lakeside (A), forest (B) and paddy field (C) with fold sampling method. Particle size distribution experiments showed that all three soil specimens were all sandy soil [9-11].

GYS-2 photoelectric liquid-plastic tester with 76g and 30°cone penetrator was used for liquid and plastic limit combined test. The test data were treated with three methods: Liquid Limit and Plastic Limit Data Treated System, Microsoft Office Excel 2007 and manual graphic method. The data treated results were showed in Table. II

Table. II showed that there were the same results between the system and Microsoft Office Excel 2007, which illustrated that liquid and plastic limit data treated system had a reliable accuracy. Compared with manual graphic method, the system took average 6.5 times shorter than manual graphic method, so the system could improve the efficiency to treating data .

V. CONCLUSIONS

A liquid and plastic limit data treated system was developed under Microsoft Visual C++6.0 with analytical method based on two standards for soil test methods. The flow chart showed that select structure and its nested structure were main algorithms of the system. Compared with manual graphic method, the system had reliable accuracy and high efficiency

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TABLE II. THE DATA TREATED RESULTS

Specimen	Soil Liquid Limit and Plastic Limit Data Treating System		Microsoft Office Excel 2007		Manual graphic method	
	Liquid limit	***Plastic limit***	***Liquid limit***	***Plastic limit***	***Liquid limit***	***Plastic limit***

	w_L/%	w_P/%	w_L/%	w_P/%	w_L/%	w_P/%
A	79.1	50.9	79.1	50.9	79.2	47.6
B	56.5	39.9	56.5	39.9	56.5	42.6
C	31.6	20.2	31.6	20.2	33.4	21.2

REFERENCES

[1] B. Dolinar, M. Mišič and L. Trauner, "Correlation between surface area and atterberg limits of fine-grained soils," Clays and Clay Minerals, vol. 55, Oct. 2012, pp. 519-523, doi: 10.1346/ccmn. 2007.0550506.

[2] R. Zentar, N.-E. Abriak, V. Dubois, "Effects of salts and organic matter on Atterberg limits of dredged marine sediments," Applied Clay Science, vol 42, April 2008, pp. 391-397, doi: 10.1016/j.clay.2008.04.003.

[3] A. Sridharan, H. B. Nagaraj, "Plastic limit and compaction characteristics of fine-grained soils," Ground Improvement, vol 9, Jan. 2005, pp.17-22, doi: 10.1680/grim.2005.9.1.17.

[4] GB/T 50123-1999, "Standard for soil test method," 1999.

[5] JTG E40-2007, "Test methods of soils for highway engineering," 2007.

[6] J.Q.Li, X. D. Zhang, M. Zou, H. Li, "Soil liquid limit and plastic limit treating system based on analytic method, " Procedia Earth and Planetary Science, vol. 5, pp. 175-179, doi: 10.1016/j.proeps.2012.01.031.

[7] D. J. Kruglinski, S. Wingo, G. W. Sheperd, Programming Microsoft Visual C++, 5th ed., vol. 2. Washington: Microsoft Press, 1998, pp, 103-134, 367-411.

[8] V. Rajaraman, Computer programming in C, New Delhi: Prentice-Hall of India Private Limited, 1994, pp.6-21, 38-46, 72-85.

[9] H. Rahardjo, A. Satyanaga, E.-C. Leong, Y. S. Ng, H. T. C. Pang, "Variability of residual soil properties," Engineering Geology, vol. 141-142, July 2012, pp. 124-140, doi: 10.1016/ j.enggeo. 2012.05.009.

[10] ASTM D422-1963, "Standard Test Method for Particle-Size Analysis of Soils, " 2007.

[11] ASTM D6913-04, "Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis," 2009.

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