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Soil Liquid Limit and Plastic Limit Treating System Based on Analytic Method

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Abstract

According to two present China national standards, a software as Soil Liquid Limit and Plastic Limit Data Treating System, with analytic method, was developed using object-oriented visual programming tool. The analytic method used in the developed system was different to traditional method of treating soil liquid limit and plastic limit data. N-S algorithm flowchart demonstrated that switch statement and condition statement were taken as main algorithm and second level select nested structure was taken as main frame for the developed system. Three kinds of soil specimens were tested with liquid and plastic limit combined test and the test data was treated with graphic method, Excel software and Soil Liquid Limit and Plastic Limit Data Treating System. The comparative conclusion indicated that Soil Liquid Limit and Plastic Limit Data Treating System improved efficiency and accuracy evidently for treating soil liquid and plastic limit data and had advantages of easy operation and high reliability.

Keywords: soil science; analytic method; liquid limit; plastic limit; analytic method; Soil Liquid Limit and Plastic Limit Data Treating System

1. Introduction

Soil liquid limit w_L and plastic limit w_P are very important physical parameters for soil science, which are also called Atterberg limits [1, 2, 3]. Traditionally, soil liquid limit and plastic limit data are treated by manual work, so as to cause significant error [4, 5]. Thought using data treated software or computer

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language to treat data have high efficiency and accuracy, there are no object-oriented visual program for this purpose at present [6, 7]. Currently, main algorithms of treating soil liquid limit and plastic limit data are analytic method, regression analytic method, least squares method [8], etc.

In this paper, according to *GB/T 50123-1999 Standard for Soil Test Method* and *JTG E40-2007 Test Methods of Soils for Highway Engineering*, combining analytic method, using the object-oriented visual programming tool Microsoft Visual C++6.0 developed Soil Liquid Limit and Plastic Limit Data Treating System.

2. Data analysis

2.1. N-S algorithm flowchar

The radical principle of liquid and plastic limit combined test in this research is based on *GB/T 50123-1999 Standard for Soil Test Method* (shorted as *Standard*) and *JTG E40-2007 Test Methods of Soils for Highway Engineering* (shorted as *Test Methods*) [4, 5]. Comparative conclusion of other references about methods of treating data indicates that analytic method is applied to being basic principle of Soil Liquid Limit and Plastic Limit Data Treating System [7, 8].

N-S algorithm flowchar of Soil Liquid Limit and Plastic Limit Data Treating System is showed in Figure 2 [9]. In flowchar, w_1, w_2 and w_3 represent the water content at depth h_1 (3-4mm), h_2 (7-9mm) and h_3 (15-17mm) of cone penetrator respectively and w_0 represent natural water content.

From N-S algorithm flowchar, it is showed that second level select nested structure is main structure for the developed system. So switch statement and condition statement were used for main algorithm and second level select nested structure was used for main structure when developing Soil Liquid Limit and Plastic Limit Data Treating System.

$$h_p = 29.6 - 1.22w_L + 0.017w_L^2 - 0.000074w_L^3 \quad (1)$$

$$h_p = \frac{w_L}{0.524w_L - 7.606} \quad (2)$$

In the N-S algorithm flowchar, quation (1) is used for sandy soil and equation (2) is used for fine grained soil and in order to define $h_{\mathrm{P}}^{'}$, $h_{\mathrm{P}}^{'}$ and w_{A} instead of h_{p} and w_{L} respectively.

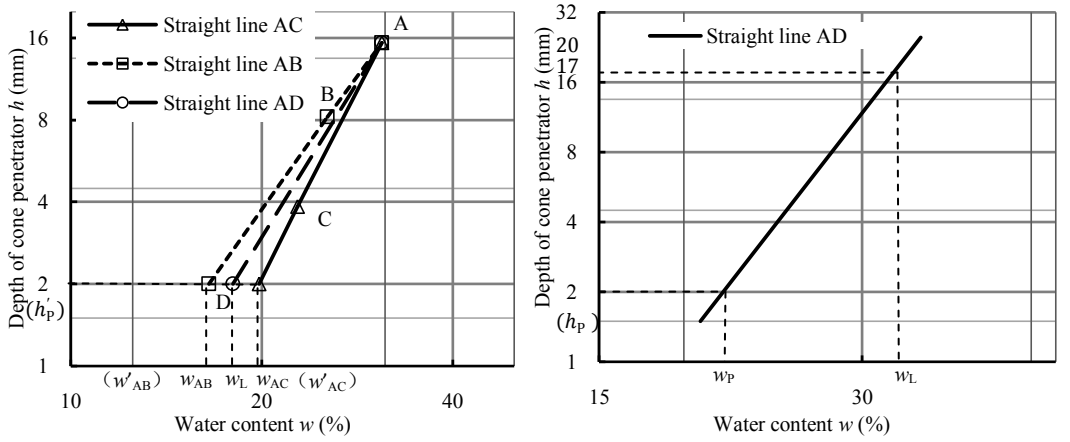

Fig.1. (a) Relationship between water content *w* and depth of cone penetrator *h*; (b) Determination of liquid limit and plastic limit from straight line AD

<table>
<tr><td colspan="6">Enter w_1, w_2, w_3, w_0; h_1, h_2, h_3</td></tr>
<tr><td colspan="6">Chose Standard or Test Methods</td></tr>
<tr><td colspan="2">GB/T 50123-1999, cone penetrator 76g.</td><td colspan="2">JTG E40-2007, cone penetrator 100g.</td><td colspan="2">JTG E40-2007, cone penetrator 76g.</td></tr>
<tr><td colspan="2">The slope and intercept of straight line AB and AC.</td><td colspan="2">The slope and intercept of straight line AB and AC.</td><td colspan="2">The slope and intercept of straight line AB and AC.</td></tr>
<tr><td colspan="2" rowspan="2">The water content of straight line AB and AC at 2mm.</td><td colspan="2">Chose sandy soil or fine grained soil.</td><td colspan="2">Chose sandy soil or fine grained soil.</td></tr>
<tr><td>Sandy soil.</td><td>Fine grained soil.</td><td>Sandy soil.</td><td>Fine grained soil.</td></tr>
<tr><td colspan="2">Absolute value<2%.
Yes. Not.</td><td>Calculate h_P' corresponding to the water content at point A with equation (1).</td><td>Calculate h_P' corresponding to the water content at point A with equation (2).</td><td>Calculate h_P' corresponding to the water content at point A with equation (1).</td><td>Calculate h_P' corresponding to the water content at point A with equation (2).</td></tr>
<tr><td>Define point D, draw straight line AD, define the slope and intercept of the straight line AD (Figure 1a).</td><td rowspan="3">Please retest!</td><td>Calculate the water content at h_P' from straight lines AB and AC respectively and the absolute value of the difference between two water contents (Figure 1a).</td><td>Calculate the water content at h_P' from straight lines AB and AC respectively and the absolute value of the difference between two water contents (Figure 1a).</td><td>Calculate the water content at h_P' from straight lines AB and AC respectively and the absolute value of the difference between two water contents (Figure 1a).</td><td>Calculate the water content at h_P' from straight lines AB and AC respectively and the absolute value of the difference between two water contents (Figure 1a).</td></tr>
<tr><td rowspan="2">On the straight line AD,the water content at cone penetrator depth 17mm is liquid limit w_L, and the water content at cone penetrator depth 2mm is plastic limit w_P (Figure 1b).</td><td colspan="2">Absolute value<2%.
Yes. Not.</td><td colspan="2">Absolute value<2%.
Yes. Not.</td><td colspan="2">Absolute value<2%.
Yes. Not.</td></tr>
<tr><td>On the straight line AD, the water content at 20mm cone penetrator depth is the liquid limit w_L; Calculate h_P corresponding to w_L with equation (1); On the straight line AD, the water content at h_P is the plastic limit w_P (Figure 1b).</td><td>Please retest!</td><td>On the straight line AD, the water content at cone penetrator depth 20mm is liquid limit w_L; Calculate h_P corresponding to w_L with equation (2); On the straight line AD, the water content at h_P is plastic limit w_P (Figure 1b).</td><td>Please retest!</td><td>On the straight line AD, the water content at cone penetrator depth 17mm is liquid limit w_L, and water content at cone penetrator depth 2mm is plastic limit w_P (Figure 1b).</td><td>Please retest!</td></tr>
<tr><td colspan="6">Plastic limit index I_P</td></tr>
<tr><td colspan="6">Liquid limit index I_L</td></tr>
</table>

Fig.2. N-S algorithm flowchart

2.2. Software implementation

Soil Liquid Limit and Plastic Limit Data Treating System were developed under windows 7. A "MFC AppWizard" based on based dialog box was established with Microsoft Visual C++6.0 and response function of treating soil liquid and plastic limit data was edited on "CMyDlg" class. Properties of dialog box were set in order to enable minimality. Figure 3 showed the based dialog box of Soil Liquid Limit and Plastic Limit Data Treating System.

Fig.3. Based dialog

3. Instance analysis

The instrument for liquid and plastic limit combined test is GYS-2 photoelectric liquid-plastic tester (Nan Jing soil instrument factory) with 76g and 30° cone penetrator. Using fold sampling method, soil mixed specimens were gained from paddy field (A group), lakeside (B group) and forest (C group) and their particle size was analyzed. The analytical results showed that all three soil specimens were all sandy soil [10, 11]. Test data was treated with graphic method, Soil Liquid Limit and Plastic Limit Data Treating System and Excel software respectively. Treating results were showed in Table 1.

Table1 The treating results with three methods

Sample number	Average cone penetrator depth h/mm	Water content w/%	Graphic method		Soil Liquid Limit and Plastic Limit Data Treating System		Excel software	
			Liquid limit w_L/%	Plastic limit w_P/%	Liquid limit w_L/%	Plastic limit w_P/%	Liquid limit w_L/%	Plastic limit w_P/%
A group	3.85	22.76	33.4	21.2	31.6	20.2	31.6	20.2
	8.22	27.35						
	15.36	30.93						
B group	3.32	56.23	79.2	47.6	79.1	50.9	79.1	50.9
	8.44	68.63						
	16.85	78.94						
C group	3.74	43.56	56.5	42.6	56.5	39.9	56.5	39.9
	8.68	50.92						
	15.45	55.66						

Table 1 showed that Soil Liquid Limit and Plastic Limit Data Treating System and Excel software had the same results, but the results of graphic method were different evidently. The reason is that graphic method needs to draw points and straight line on the double logarithmic paper by manual work leading to

influence the accuracy of results.

In the case of no repetitious test, it took 13 minutes at last to treat a group of test data with graphic method; however it took 2 minutes at most with Soil Liquid Limit and Plastic Limit Data Treating System, the efficiency of which has 6.5 times higher than graphic method. Therefore, using Soil Liquid Limit and Plastic Limit Data Treating System can improve the efficiency of treating test data.

4. Conclusion

In order to solve the problem of large workload ,low efficiency and poor accuracy which methods of traditional treating soil liquid and plastic limit data, a software Liquid Limit and Plastic Limit Data Treating System was developed was developed, using the object-oriented visual programming tool Microsoft Visual C++6.0. The system used switch statement and condition statement as main algorithm, and second level select nested structure as main frame, as well as combining analytic method implemented complicated treating data process. After testing three types of soil specimens with the liquid and plastic limit combined test, the test data was treated using Soil Liquid Limit and Plastic Limit Data Treating System, Excel software and graphic method. Results demonstrated that the developed system improved efficiency and accuracy evidently for treating soil liquid and plastic limit data, and furthermore, the system had advantages of easy operation and high reliability and diminished interference from human factors, so as to be applied to treat large amounts of test data.

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