Application of Excel in Leveling and Traverse Survey

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Abstract. It mainly discusses the application of Excel in field leveling and traverse adjustment calculation in this thesis. Excel has powerful functions of formula editing and function, so we use it to process survey data. We realize the advantages of Excel software in the measurement data processing. It is convenient, flexible, simple, and clear. A good Excel calculation table can be used in future work. It only needs to adjust the original data without repeating the arrangement and design of calculation formulas. It can completely replace the programmable calculator and bring a lot of convenience to the work.

1. Introduction

The core problem of measurement is to process data. This tedious task involves arithmetic and logical operations such as geometry and trigonometric functions. Excel’s powerful functions can not only automate engineering plane control survey, line design, and detailed survey but also complete the automation of related drawing software to realize real-time observation, real-time calculation, and real-time drawing. It has a wide application prospect.

In China, Excel has played an increasingly important role in the processing of measurement data. It plays an irreplaceable role not only in the practical application of many projects but also in the research and development of many professional measurement software. In foreign countries, researchers have tightly combined the measurement data itself with simple data processing software, Now, their more focus is on establishing a complete set of the data information base, striving to develop their own more potential, to achieve data sharing, real-time update, and transmission of data, and to achieve high quality and high efficiency of data processing.

Qi Jianwei [1], Chen Xianhui [2], and others introduced the methods and ideas of using Excel for measurement and calculation according to their years of work experience and practical work and provided some commonly used formulas. They believed that Excel was convenient for processing measurement and calculation data, flexible and fast. Yi Tianyang [3] uses Excel to control the calculation of closed wires and the measurement of reports. Excel is simple and efficient compared with other adjustment software, and it is a good method. When Tian Xiaohu [4] and others deal with the calculation of distance and azimuth angle in Excel's engineering survey, they think this method is
simple and accurate. Xiang Jiping and Luo Zhongai [5] analyzed the functions and characteristics of Excel and discussed its application in traverse adjustment. Zeng Renshu [6] uses Excel to process leveling route, close, and echo traverse data, and thinks that the calculation speed is fast and the precision is high.

This thesis takes Excel software as the research object, with the help of the specific work of school campus levelling and Xinzhou kiln mine traverse survey, uses Excel software functions and automatic filling functions to process data. The purpose of this research is to apply Excel to daily measurement and calculation more deeply and widely, and then frees itself from the cumbersome manual calculation.

2. Research content
The main content of this research is the application of Excel in data processing. As the name implies, it is to make an intuitive table according to the basic theory and formula of measurement. As long as you enter the known data and observation data in the specified cells of the table, you can harvest the final desired results.

In the actual production process, what we do is to use the difference of font or color to distinguish the nature of cells in a table to ensure that the mapping calculation table model is simple and intuitive to use. If the title and comments are uniformly set to black, the basic known data and measured data that need to be entered or modified are shaded in gray. The introduction of intermediate data means that when the calculation relationship between the known data and the target data is too complicated and the target data cell is difficult or impossible to directly obtain the result, we can establish intermediate data to achieve the goal [7]. Any operator who has a good understanding of surveying and mapping theory and Excel can refer to the basic calculation mode to modify and expand the table calculation function at will because the calculation process of Excel is intuitive and open. Therefore, the table model has good scalability.

Data Source: Leveling data comes from campus field surveys, traverse survey data comes from Xinzhou Kiln Minefield survey.

3. Methods and applications
3.1. Fourth Class Leveling
Given that the elevation of control point 1 is 1036m, the median elevation difference between each point is calculated by measuring the black and red surface readings of the front and rear scales and the front and rear sight distances, and the elevation of each unknown control point is calculated in turn.

1) Input the elevation information of the known control point 1 into the Excel table, and fill the observed data into the corresponding table position, as shown in Figure 1.

2) Calculate the front and rear sight distance, sight distance difference and elevation difference median, etc., to calculate the elevation of the rear point.

3) Back distance calculation: enter formula = IF (OR (C9= "", C10= ""), "", IF ((C9-C10)/10 > $P $4, "Back distance overrun", (C9-C10)/10)) in cell C1.

Calculation of front distance: enter formula = IF (OR (E0= "", E10= ""), "", IF ((E9-E10)/10 > $P $4, "front distance overrun", (E9-E10)/10)) in cell E11.

Calculation of line-of-sight difference: enter formula = IF (OR (C11 = "", C11 = "Back distance overrun", E11= "", E11= "Front distance overrun"), "", IF (ABS (C11-E11) > $P $5, "Line-of-sight difference overrun", C11-E11)) in cell C12.

Calculation of cumulative line-of-sight difference: enter formula = IF (OR (C12= "", C12= "line-of-sight difference overrun"), "", IF (ABS (C12+E8) > $P $6, "Line-of-sight difference overrun", C12+E8)) in cell E12.

4) I11=IF (OR (I9= "", I10= ""), "", I9-I10).
J11=IF (OR (J9= "", J10= ""), "", J9-J10).
Calculate whether the black and red readings exceed the limit:
K9=IF (OR (I9= "", J9= ""), "", IF (H9= "A", IF (ABS ($P $2+I9-J9) > $P $7, "Black Red Reading Overrun", $P $2+I9-J9), ""), IF (H9= "B", IF (ABS ($P $3+I9-J9) > $P $7, "Black Red Reading Overrun", $P $3+I9-J9), ""))).

K10=IF (OR (I10= "", J10= ""), "", IF (H10= "A", IF (ABS ($P $2 +I10-J10) > $P $7, "Black and Red Number Overrun", $P $2+I10-J10), IF (H10= "B", IF (ABS ($P $3+I10-J10) > $P $7, "Black and Red Reading Overrun", $P $3+I10-J10), ""))).

K11=IF (OR (K9= "", K9= "black and red reading overrun", K10= "", K10= "black and red reading overrun"), "", IF (ABS (K9-K10) > $P $8, "height difference overrun", K9-K10)).

Calculate the median height difference: enter the formula = IF (OR (K11= ", K11= "the difference of height difference exceeds the limit"), ", I11-K11/2) in cell L11.

The calculation results are shown in Figure 1.

| Site Number | Back Distance | Front Distance | Ruler Number | Black Face | Red Face | Difference |
|-------------|---------------|----------------|--------------|------------|----------|------------|
| 1 A1        | 1371          | 0019           | east A       | 1894       | 0021     | 0          |
| 1 A2        | 37.4          | 37.6           | posterior-anterior | -0003 -0032 +1  +032.5 1898.5 |
| 2 A2        | 2101          | 2196           | east B       | 1914       | 0621     | 0          |
| 2 A3        | 51.4          | 51.8           | posterior-anterior | -0004 -0079 0  | Black and Red Reading Overrun |
| 2 A3 Line-of-Sight Difference Overrun | 51.8          | 51.8           | posterior-anterior | -0004 -0079 0  | Black and Red Reading Overrun |

Figure 1 Calculation result of campus leveling

3.2. Adjustment Calculation of Traverse Survey

Traverse survey is an integral part of plane control survey, which is to select a batch of plane control points in the survey area to form a plane control network, and use accurate methods to measure the plane positions of these points and calculate their coordinates. In this thesis, taking the total station as an example, the traverse calculation in the industry is carried out in Excel, which can be divided into closed traverse and echoing traverse.

3.2.1. Adhesive conductor

It is known that the coordinates of point 2 are X=1864.222 and Y=1413.350. The coordinates of each point are calculated in turn by observing the rotation angle and side length between wires, as shown in Figure 2.

1) First, make a calculation table in Excel and input the corresponding contents.
2) For conversion of angle and radian format, enter "= RADIANS (B5)" in cell C5.
3) Calculate angle closure error: enter "= F14-F30" in cell F33.
   Enter "= 60*SQR (COUNT (B5:B15))" in cell E33 to obtain the angle-closure tolerance.
   Input "= IF (ABS (F33)< E33," qualified angle closure error "," over-limit angle closure error ")" in cell F34 to detect the measured angle.
4) Calculate coordinate azimuth angle

Calculate the radian form of coordinate azimuth angle: enter the formula in cell E6
"= IF (D6 > 2*PI (), D6-2*PI (), IF (D6 < 0, D6+2*PI (), D6))" and automatically fill down.

Calculate the azimuth form of each wire edge coordinate: enter "= DEGREES (E6)" in cell F6, in degrees. The azimuth angle of each wire edge coordinate can be obtained by pulling down and automatically filling.

Calculate the corrected azimuth: Enter "= RADIANS (F4)" in cell G4, and enter "= RADIANS (F6) + F33/COUNT (B5: B21)" in cell G6 to calculate the corrected azimuth of the second side, and then subtract one more coordinate azimuth correction number for each next side.

5) calculate that coordinate increment and the coordinate increment closure error

Calculate the x increment between two adjacent points: enter "=H6*COS (G6)" in cell I6.
Calculate the y increment between two adjacent points: enter "=H6*SIN (G6)" in cell J6.
Calculate the incremental closure error of X: enter "= SUM (I6: I21)-(M21-M5)" in cell I33.
Calculate the incremental closure error of Y: enter "= SUM (J6: J21)-(N21-N5)" in cell J33.
Calculate the full-length closure error of the conductor: enter "= SQRT (I33*I33+J33*J33)" in cell K33.

Calculate the guide full-length relative closing difference: Enter the formula "=H32/K33" in cell L33.

6) Calculation of coordinate increment correction number

Calculate the sitting increment correction of X: enter the formula "=-I33/SUM (H6: H22) * H6" in the cell K6.
Calculate the coordinate increment correction number of Y: enter "=-J33/SUM (H6: H22) * H6" in cell L6.
All coordinate incremental corrections can be obtained by automatically filling K6 and L6 down.

7) Coordinate Calculation
Enter "+M5+I6+K6" in the M7 cell, and the cell will be filled automatically to get the X value of each point.

Enter "+N5+J6+L6" in cell N7 to automatically fill in the Y value of each point.

The calculation results are shown in Figure 3.

### 3.2.2. Closed conductor

It is known that the coordinates of point 1 are X=33092.472 and Y=6943.887. The coordinates of each point are calculated in turn by observing the rotation angle and side length between conductors.

The distribution of conductors is shown in Figure 4.

#### 1) First, make a calculation table in Excel and input the corresponding content.

#### 2) For conversion of angle and radian format, write 

\[ \text{= RADIANS (B6+C6/60+D6/3600)} \]

in the cell E6, and drag down to obtain the radian format of all observation angles.

#### 3) Calculate azimuth angle

\[ \text{= IF ((H5+G6) > PI (), (H5+G6)-PI (), (H5+G6) + PI ())} \]

in cell H7, and select and drag down to form the radian of azimuth angle.

Calculate azimuth in degrees, minutes, and seconds in I7, K7, and J7:

| Dot Number | Turning Angle | Turning Angle Radian | Calculating Azimuth | Calculating Azimuth Radian | S | D | Length | X | Y | Setting Length | X | Y | Setting Length | Closing Differ. | Relative Accuracy | Coordinates |
|------------|---------------|----------------------|--------------------|---------------------------|---|---|--------|---|---|----------------|---|---|----------------|----------------|-----------------|-------------|----------------|---------------|
| 2          | 264.1933      | 4.610102913          | -1.028872559       | 184.5002                   | S | S | 207.299 | -73.799 | 267.976 | -1.074 | 0.621 |
| 3          | 147.7417      | 2.578651062          | 1.012132506        | 187.312 | 54.176 | 178.575 | -9.678 | 0.390 |
| 4          | 214.5617      | 3.73014822          | 1.697190422         | 186.606 | 99.400 | 89.791 | -0.337 | 0.191 |
| 5          | 79.4033       | 1.392278            | 0.10806157         | 150.034 | 15.166 | -0.544 | 0.315 |
| 6          | 97.4950       | 1.70198711          | -0.94620778        | 283.940 | 0.99326157 | 1970.220 | 1986.385 |

Figure 3: Calculation result of the adjustment of echoing traverse

The distribution of conductors is shown in Figure 4.

1) First, make a calculation table in Excel and input the corresponding content.
2) For conversion of angle and radian format, write \( \text{= RADIANS (B6+C6/60+D6/3600)} \) in the cell E6, and drag down to obtain the radian format of all observation angles.
3) Calculate the azimuth angle

\[ \text{Enter } = \text{IF } ((H5+G6) > \text{PI ()}, (H5+G6)-\text{PI ()}, (H5+G6) + \text{PI ()}) \]

in cell H7, and select and drag down to form the radian of azimuth angle.

Calculate azimuth in degrees, minutes, and seconds in I7, K7, and J7:

Figure 4: Distribution diagram of closed traverse
Enter "= INT (DEGREES (H7))" in cell I7 to get degrees, enter " = INT (DEGREES (H7)-I7) * 60)" in cell J7 to get minutes, and enter "= ROUND (DEGREES (H7)-I7-J7/60) * 3600, 0)" in the cell, K7 to get seconds.

Calculate angle closure error: enter = IF ((H5+G6) > PI (), (H5 +G6)-PI (), (H5+G6) + PI ()) in cell B36.

4) Calculate the coordinate increment

"M5 = ROUND (L5*COS (H5), 4)" , "N5 = ROUND (L5*SIN (H5), 4)."

Calculate the sum of polygon sides: enter = SUM (L4: L20) in cell L36.

Calculate the coordinate incremental closure fx, fy, and the full-length relative closure [D]/f in cells M36, N36 and Q36.

For example: in cell Q36, enter: =INT (L36/P36). Calculate the corrected coordinate increment in cells P5 and Q5, and input: P5=ROUND (M5-M36/L36*L5, 5); Q5=ROUND (N5-N36/L36*L5, 5).

The calculation result is shown in Fig. 5.

4. Conclusion

You can apply design formulas, logic functions, autofill, and other functions to process the actual level and wire measurements in the process of using an Excel spreadsheet to process measurement and calculation data. The Excel calculation table can be used in future work, only the original data needs to be adjusted, and there is no need to repeat the arrangement and design of calculation formulas. Other data can also be calculated using the auto-fill function or the copy formula method, which can completely replace the programmable calculator. And the calculation results can be listed in a table to make the results obvious and easy to see.

We realize the advantages of Excel software in traverse survey data processing through the application of Excel in leveling and error measurement, which is convenient, flexible, simple, and clear. Excel, as popular application software, can be learned by users without too much computer professional knowledge and has complete functions, which not only improves the accuracy of data calculation, but also greatly improves the efficiency of data processing, reduces the work intensity of surveyors, and brings a lot of conveniences to work.

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Figure. 5 Calculation Result of Closed Traverse Adjustment
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