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THE PROCEDURE FOR PERFORMING CORRELATE EQUALIZATION OF A TRIANGULATION GRID USING MICROSOFT EXCEL

Annotation. One of the main tools in the Microsoft Office 2010 package is a spreadsheet program Microsoft Excel, which is part of the software of modern computers. Microsoft Excel is designed for the preparation and mathematical processing of spreadsheets under the control of the Windows operating system.

We aim to perform the process of equalization of the triangulation node by the correlate method using Microsoft Excel.

Key words: Excel, triangulation, measure, mathematical processing, Windows operation system, result, correlate method

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МЕТОДИКА ВЫПОЛНЕНИЯ КОРРЕЛЯЦИОННОГО УРАВНЕНИЯ ТРИАНГУЛЯЦИОННОЙ СЕТИ С ИСПОЛЬЗОВАНИЕМ MICROSOFT EXCEL

Аннотация. Одним из основных инструментов пакета Microsoft Office 2010 является программа для работы с электронными таблицами Microsoft Excel, входящая в состав программного обеспечения современных компьютеров. Microsoft Excel предназначен для подготовки и математической обработки электронных таблиц под управлением операционной системы Windows.

Мы стремимся выполнить процесс выравнивания узла триангуляции методом корреляции с использованием Microsoft Excel.

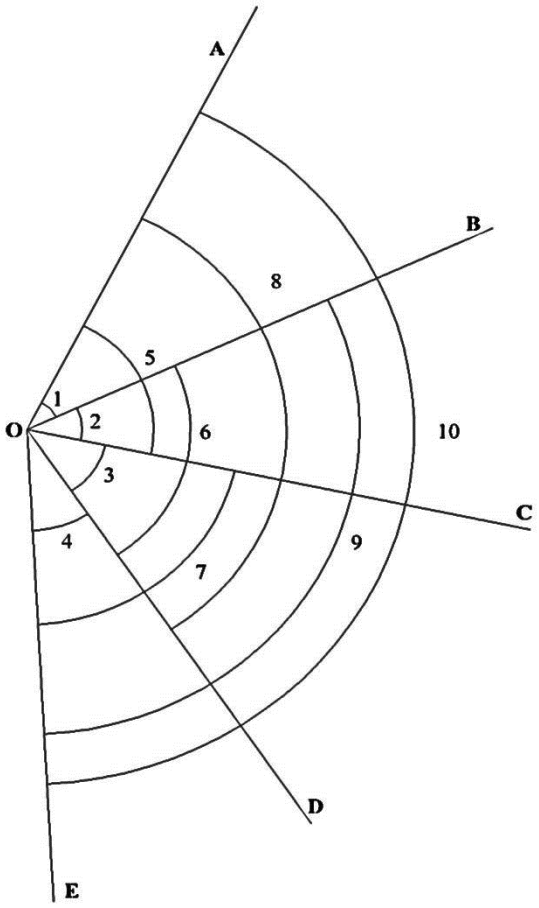
Ключевые слова: Excel, триангуляция, мера, математическая обработка, операционная система Windows, результат, корреляционный метод.

One of the main tools in the Microsoft Office 2010 package is a spreadsheet program Microsoft Excel, which is part of the software of modern computers. Microsoft Excel is designed for the preparation and mathematical processing of spreadsheets under the control of the Windows operating system.

We aim to perform the process of equalization of the triangulation node by the correlate method using Microsoft Excel.

Figure 1 shows a schematic of the measurement of angles in the triangulation type and Table 1 shows the results of the measured angles. V.D.Bolshakov, Yu.I.Markuze, D.O. Juraev , B. S. Kuz‘min learn this methods.

Measurement Scheme:



Measured Angle Values Table 1

Bur-chaklar	Bur-chaklar	O`lchangan qiymatlar x_i	Tenglama
1	A0B	58^0 15' 45",8	t_1
2	B0C	38^0 10' 10",8	t_2
3	C0D	61^0 01' 11",0	t_3
4	A0C	96^0 25' 53",1	$t_1 + t_2$
5	B0D	99^0 11' 21",3	$t_2 + t_3$
6	A0D	157^0 27' 04",6	$t_1 + t_2 + t_3$

As parameters, we take the first four of the ten measured angles. We define them by their equalized value t_1, t_2, t_3, t_4 (Table 1).

As an approximate value of the desired unknowns, we take the results of their measurements, namely:

$t_1^0 = 58^0 15' 45,''8$

$t_2^0 = 38^0 10' 10,''8$

$t_3^0 = 61^0 01' 11,''0$

Then we express the equal value of all ten measured quantities by the equal value of the four required unknowns to construct the dependence of the correlate equations.

$\overline{x_i} = x_i - V_i = f_i(t_1, t_2, t_3, t_4)$

(1) according to the formula

1) $\bar{x}_1 = t_1$ 4) $\bar{x}_4 = t_1 + t_2$

2) $\bar{x}_2 = t_2$ 5) $\bar{x}_5 = t_2 + t_3$ (2)

3) $\bar{x}_3 = t_3$ 6) $\bar{x}_6 = t_1 + t_2 + t_3$

To perform the process of correlate equalization of the triangulation network using Microsoft Excel is necessary to perform the following procedure:

1. In the Microsoft Excel program, we enter the measured values in the order shown in Figure 2, the selected desired unknowns (parameters), the approximate value of the detected parameters and the dependence of the constructed correlate equations[2].

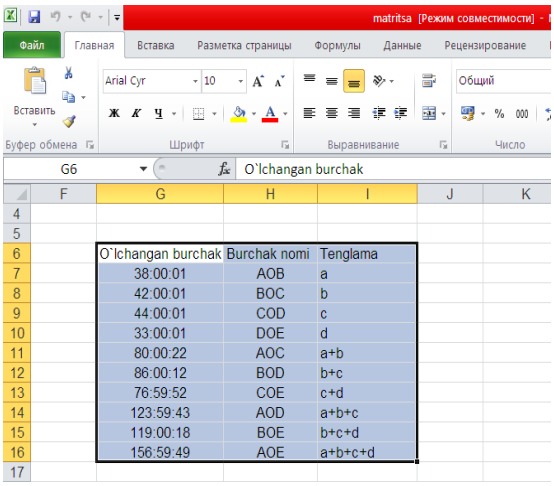


Figure 2.

2. We convert the measured values in degrees, minutes, seconds to radians in Microsoft Excel using geodetic instruments (theodolite tool). To do this, we enter the information in column 2 of Table 1 in the order shown in Figure 2 in Microsoft Excel - left-click on the arrow (format cell: number) in the corner of the item "Number" of the "Main" section of the program window (Figure 3a) and an additional working window as shown in Figure 3b is formed[2].

a) *b)*

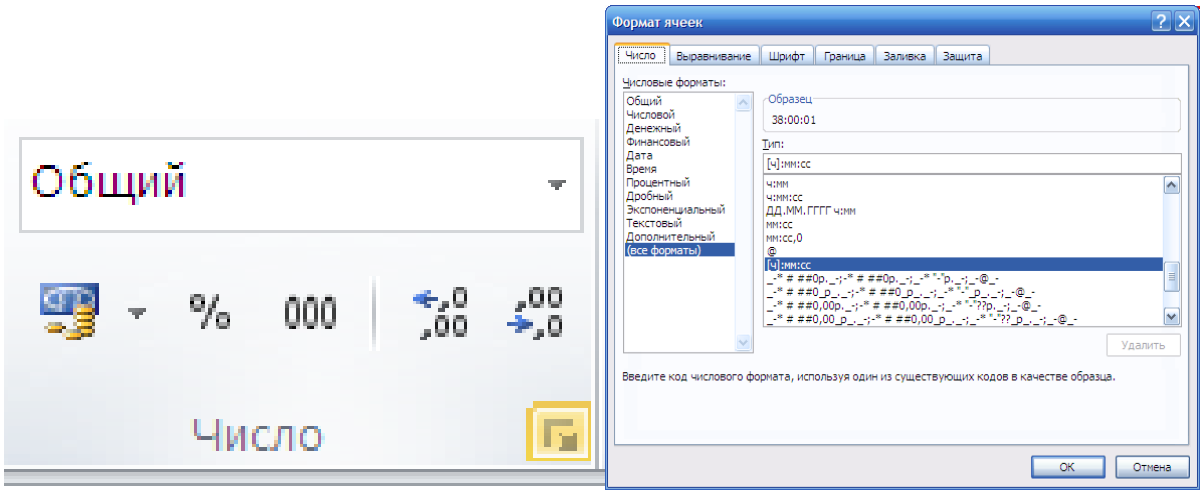


Figure 3.

Then we click on the "Number" item in the additional working window "Format cells" in Figure 3b, select the command "(all formats)" from the menu "Numeric formats:" and from the menu "Type" we select the "[ch]: mm: ss icon and activate the mode “Number” by pressing the button OK.

3. After activating the "Number" mode, multiplying the measured 180^0 values (expressed in degrees, minutes, seconds) entered in Microsoft Excel, $\pi = 3{,}141592.....$ our values become radian[10]. (Figure 4)

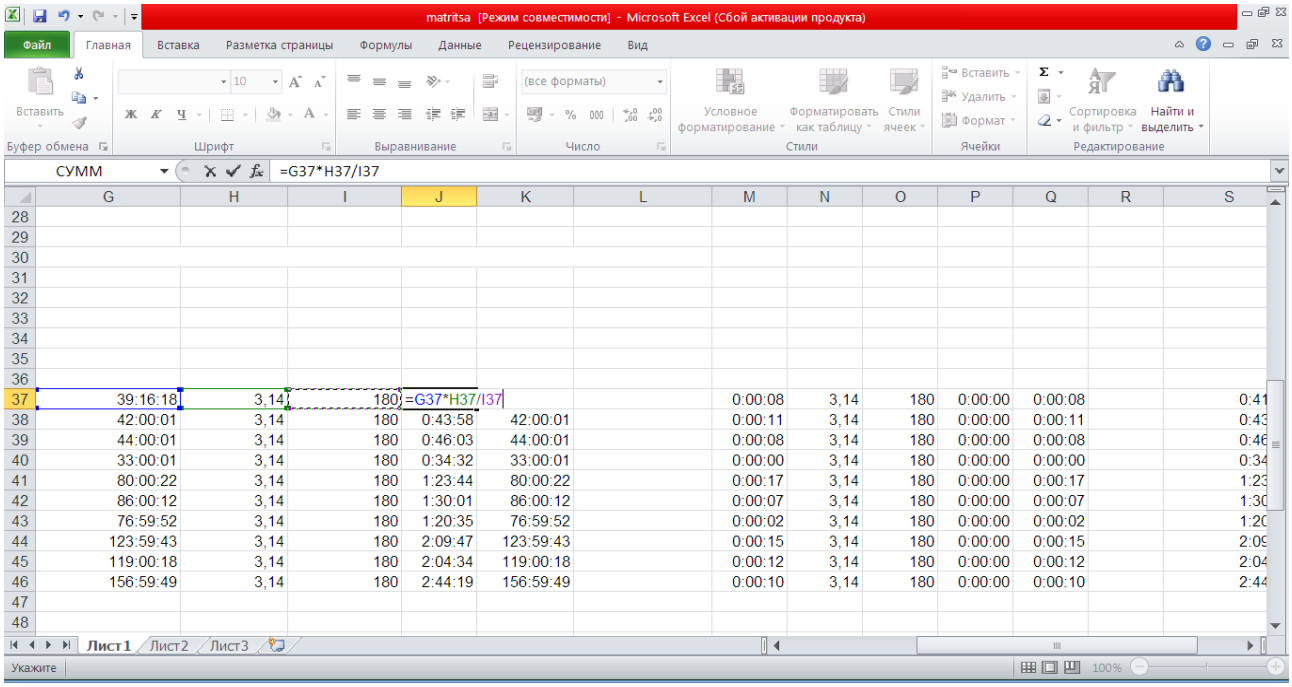


Figure 4.

4. Then we construct the correlate equation of corrections

$$V_i = a_{i1}\tau_1 + a_{i2}\tau_2 + a_{i3}\tau_3 + l_i \qquad i = 1,2.....6$$

(3)

This here: $a_{it} = \left(\frac{\partial \overline{x_i}}{\partial t_1}\right)$; $a_{i2} = \left(\frac{\partial \overline{x_i}}{\partial t_2}\right)$; $a_{ik} = \left(\frac{\partial \overline{x_i}}{\partial t_k}\right)_0$;

$$l_i = f_i(t_1^0, ..., t_k^0) - x_i = x_i^0 - x_i \qquad (4)$$

In the example of the 4th correction equation we show how to construct. The 4th equation is due to:

$$a_{41} = (\frac{d\bar{x}_4}{dt_1})_0 = +1;$$

$$a_{42} = (\frac{d\bar{x}_4}{dt_2})_0 = +1;$$

$$a_{43} = (\frac{d\bar{x}_4}{dt_3})_0 = 0;$$

Free limit:

$$l_4 = (t_1^0 + t_2^0) - x_4 = 58^0 15' 47,8'' + 38^0 10' 12,8'' - 96^0 25' 25,1'' = 3,5''$$

We write the equation of all corrections in the same way.

1) $V_1 = \tau_1 = -1,5$

2) $V_2 = \tau_2 = -1,0$

3) $V_3 = \tau_3 = 0,0$

4) $V_4 = \tau_1 + \tau_2 + 3,5 = +1,0$

5) $V_5 = \tau_2 + \tau_3 + 0,5 = -0,5$

6) $V_6 = \tau_1 + \tau_3 + 3,0 = +1,5$

We enter the above steps in the Microsoft Excel spreadsheet (Figure 5).

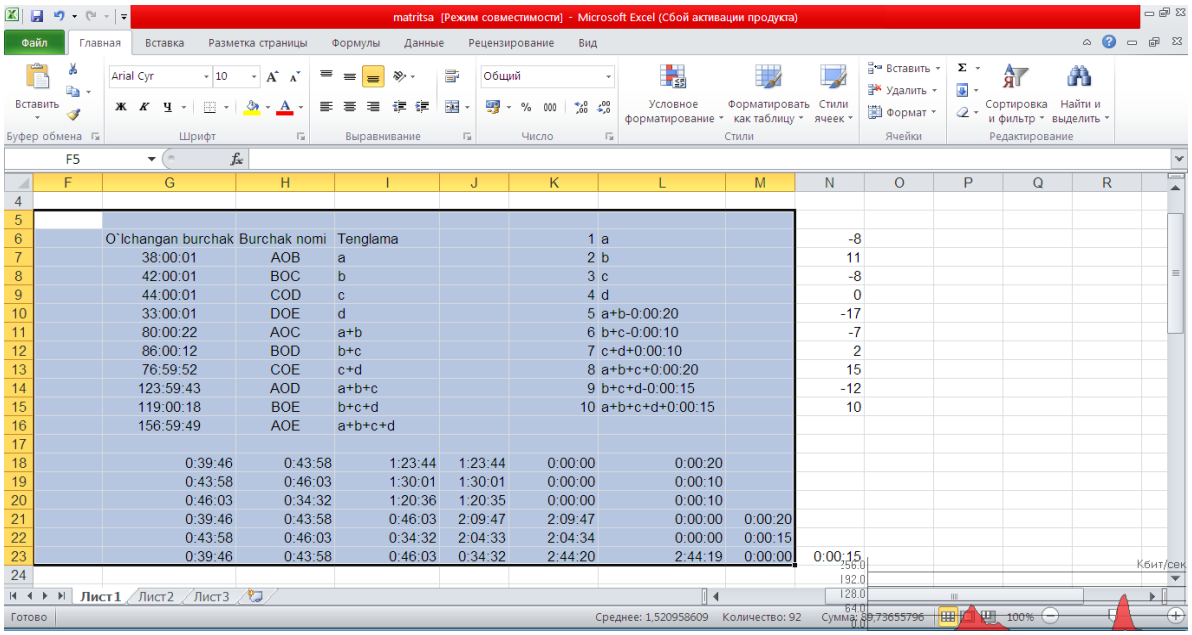


Figure 5[9].

5. After that, we compile the table of coefficients of the correction equation (1) according to the formula (5) in accordance with Table 1 and enter it into the spreadsheet of Microsoft Excel and calculate it using the program (Figure 6-7).

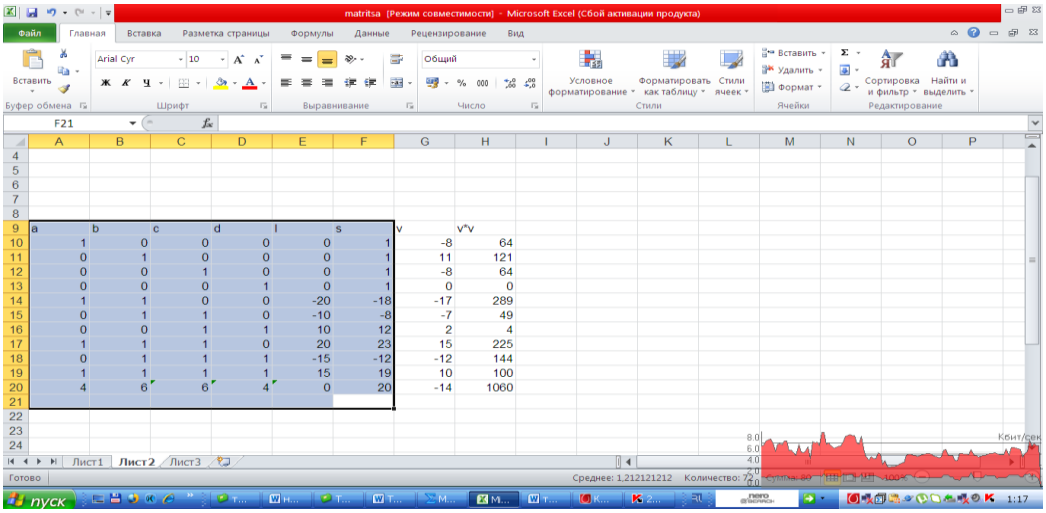


Figure 6[9].

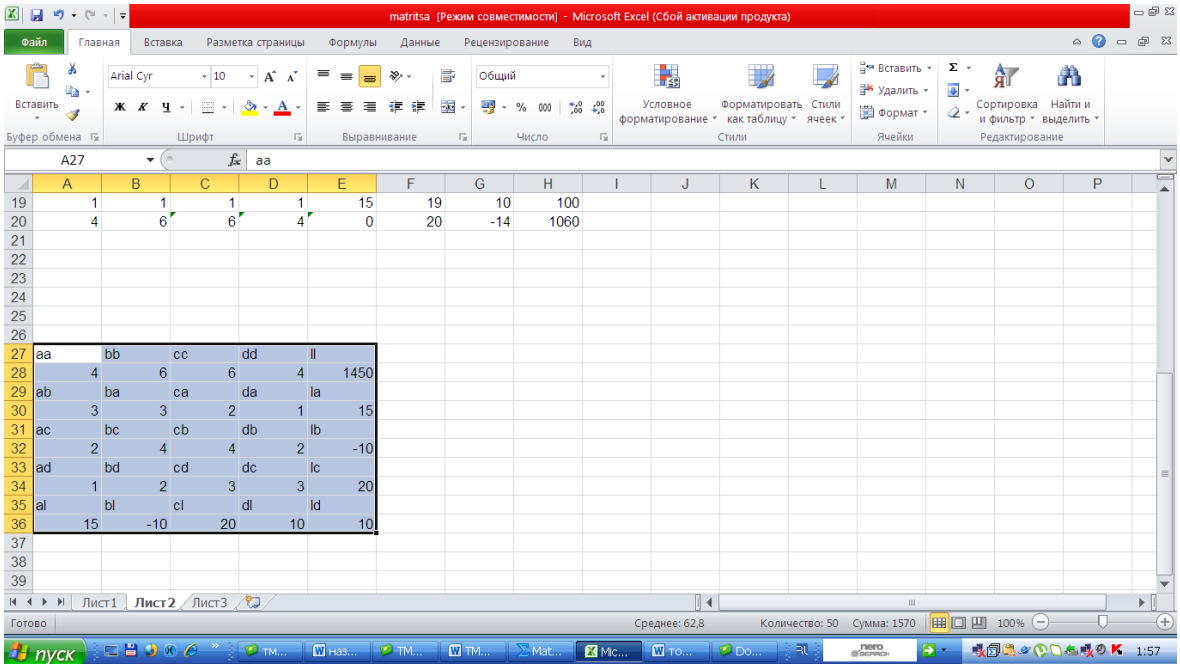


Figure 7[9].

Since it is the sum of the numbers on the columns, the sum of all the values of Si is equal to the sum of the values above the double line.

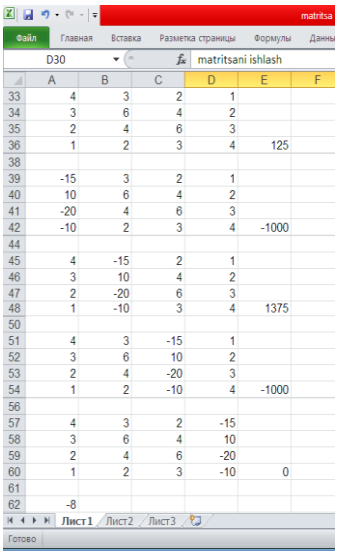
6. Solving normal equations:

The system of equations consisting of four unknowns is as follows:

$$[a_1a_1]\ \tau_1 + [a_1a_2]\tau_2 + [a_1a_3]\ \tau_3 + [a_1\ l] = 0$$
$$[a_1a_2]\ \tau_1 + [a_2a_2]\tau_2 + [a_2a_3]\ \tau_3 + [a_2\ l] = 0$$
$$[a_1a_3]\tau_1 + [a_2a_3]\ \tau_2 + [a_3a_3]\ \tau_3 + [a_3\ l] = 0$$

(3)

Solving a system consisting of this normal equation is done in Microsoft Excel using the Kramer method as shown in Figure 8[2].



	A	B	C	D	E	F
33	4	3	2	1		
34	3	6	4	2		
35	2	4	6	3		
36	1	2	3	4	125	
38						
39	-15	3	2	1		
40	10	6	4	2		
41	-20	4	6	3		
42	-10	2	3	4	-1000	
44						
45	4	-15	2	1		
46	3	10	4	2		
47	2	-20	6	3		
48	1	-10	3	4	1375	
50						
51	4	3	-15	1		
52	3	6	10	2		
53	2	4	-20	3		
54	1	2	-10	4	-1000	
56						
57	4	3	2	-15		
58	3	6	4	10		
59	2	4	6	-20		
60	1	2	3	-10	0	
61						
62	-8					

Figure 8.

7. Calculation of corrections to the measured results:

Vi for the measured angle value is found from the spreadsheet in Figure 6 according to the formula and the construction of this table is completed (Figure 9)[9]. Equality (1) and (4) are also checked.

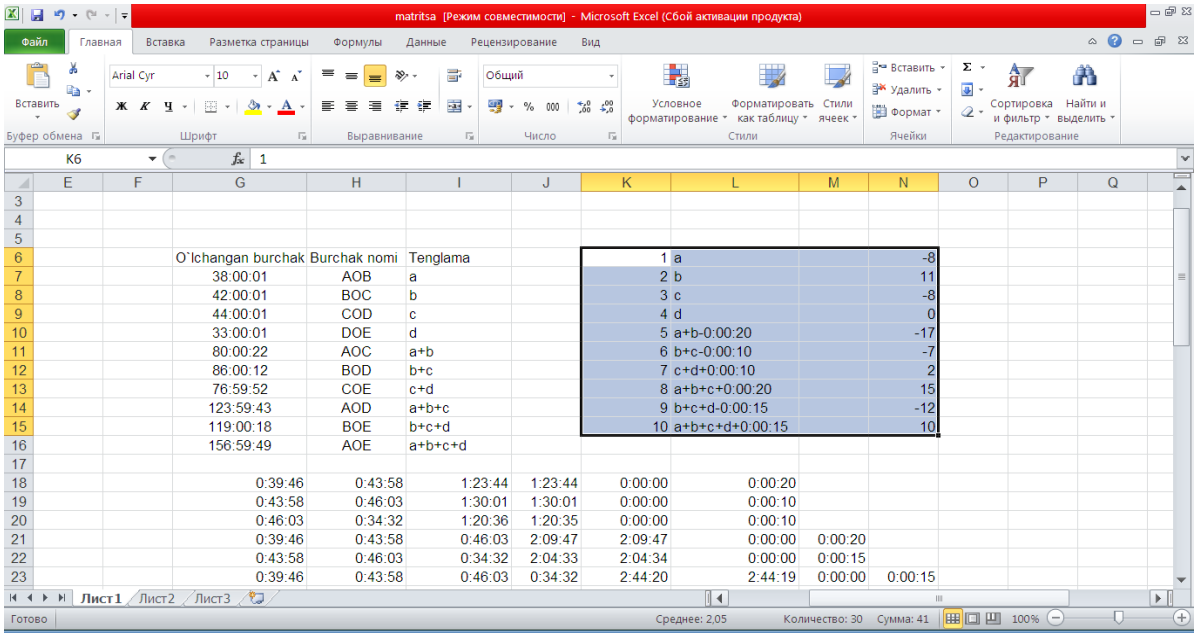


Figure 9.

9. Calculation the equivalent value of the unknowns (parameters).

Hence, in this example, the measured quantities are selected as parameters, and it is appropriate to perform the considered calculations together with the calculations of the next stage.

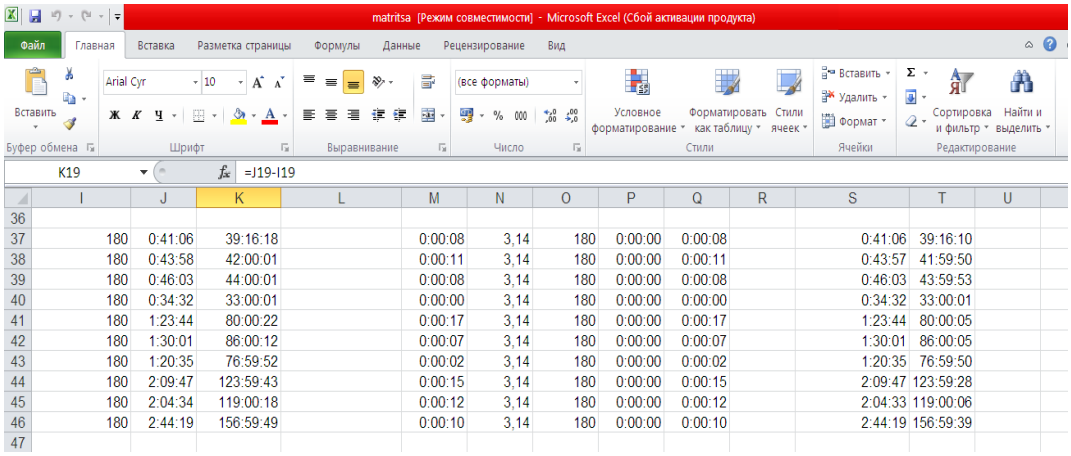
10. Calculating the equivalent value of the measured quantities.

The correction is the equalized value of the angles in Figure 10 using *Vi* .

11. Final check of equation[9].

It consists of recalculating the equalized value of the angle according to the dependence of equations (2) .

The test calculations are given in Figure 10.



	I	J	K	L	M	N	O	P	Q	R	S	T	U
36													
37	180	0:41:06	39:16:18		0:00:08	3,14	180	0:00:00	0:00:08		0:41:06	39:16:10	
38	180	0:43:58	42:00:01		0:00:11	3,14	180	0:00:00	0:00:11		0:43:57	41:59:50	
39	180	0:46:03	44:00:01		0:00:08	3,14	180	0:00:00	0:00:08		0:46:03	43:59:53	
40	180	0:34:32	33:00:01		0:00:00	3,14	180	0:00:00	0:00:00		0:34:32	33:00:01	
41	180	1:23:44	80:00:22		0:00:17	3,14	180	0:00:00	0:00:17		1:23:44	80:00:05	
42	180	1:30:01	86:00:12		0:00:07	3,14	180	0:00:00	0:00:07		1:30:01	86:00:05	
43	180	1:20:35	76:59:52		0:00:02	3,14	180	0:00:00	0:00:02		1:20:35	76:59:50	
44	180	2:09:47	123:59:43		0:00:15	3,14	180	0:00:00	0:00:15		2:09:47	123:59:28	
45	180	2:04:34	119:00:18		0:00:12	3,14	180	0:00:00	0:00:12		2:04:33	119:00:06	
46	180	2:44:19	156:59:49		0:00:10	3,14	180	0:00:00	0:00:10		2:44:19	156:59:39	
47													

Figure 10.

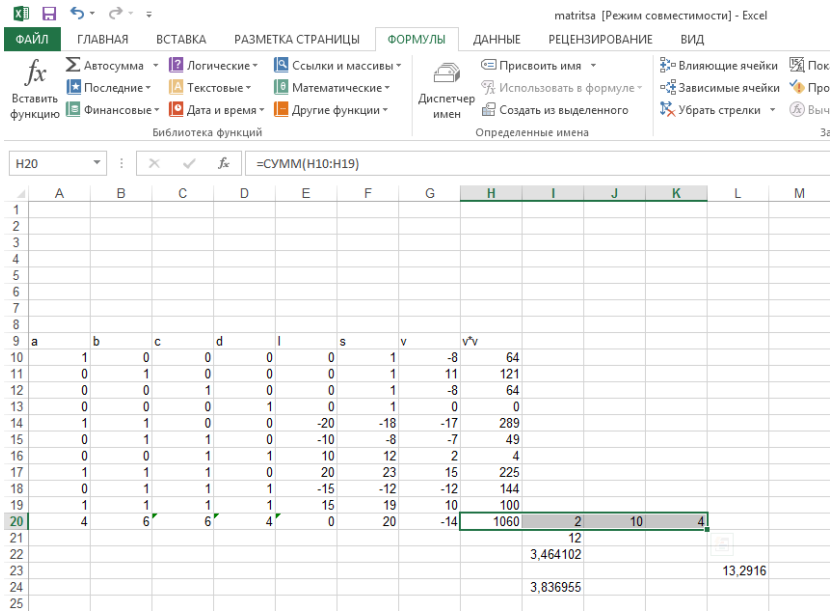
12. Accuracy assessment.

1. The mean square error of the directly measured results and the mean square of the “error of error”

$$m = \sqrt{\frac{[V^2]}{n-k}} \qquad (7)$$

$$m_m = \frac{m}{\sqrt{2(n-k)}} \qquad (8)$$

To use the above formula in Microsoft Excel, we need to do the work in the order shown below. To do this, we need to enter formulas (7) and (8) into Microsoft Excel. In formula (7) we enter the numbers under the root in the spreadsheet of the program (Figure 11).



	A	B	C	D	E	F	G	H	I	J	K	L	M
9	a	b	c	d	l	s	v	v^v					
10	1	0	0	0	0	1	-8	64					
11	0	1	0	0	0	1	11	121					
12	0	0	1	0	0	1	-8	64					
13	0	0	0	1	0	1	0	0					
14	1	1	0	0	-20	-18	-17	289					
15	0	1	1	0	-10	-8	-7	49					
16	0	0	1	1	10	12	2	4					
17	1	1	1	0	20	23	15	225					
18	0	1	1	1	-15	-12	-12	144					
19	1	1	1	1	15	19	10	100					
20	4	6	6	4	0	20	-14	1060	2	10	4		
21									12				
22									3,464102				
23												13,2916	
24									3,836955				
25													

Figure 11

Then we go to the command line "FORMULAS" from the command line of the program and click on the command "ROOT" from the menu "Mathematical" in the submenu "Library of functions" and type 1060 / (10-4) in the window “Number ” and click on the button OK, and the result will appear on the screen (Figure 12).

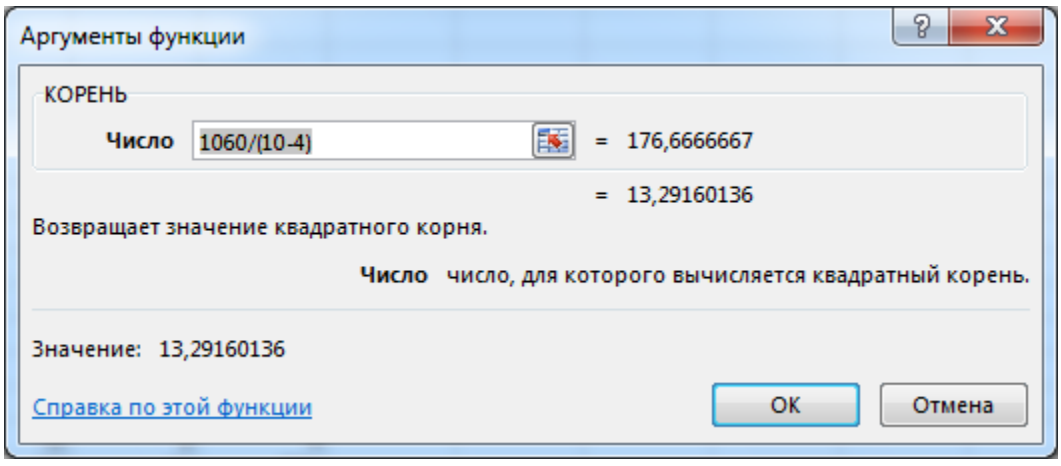


Figure 12.

After doing the above, we determine the values according to formula (8), again enter cell I-21 of the spreadsheet, create the formula = I20 * (J20-K20) and press Enter (Figure 13)[9].

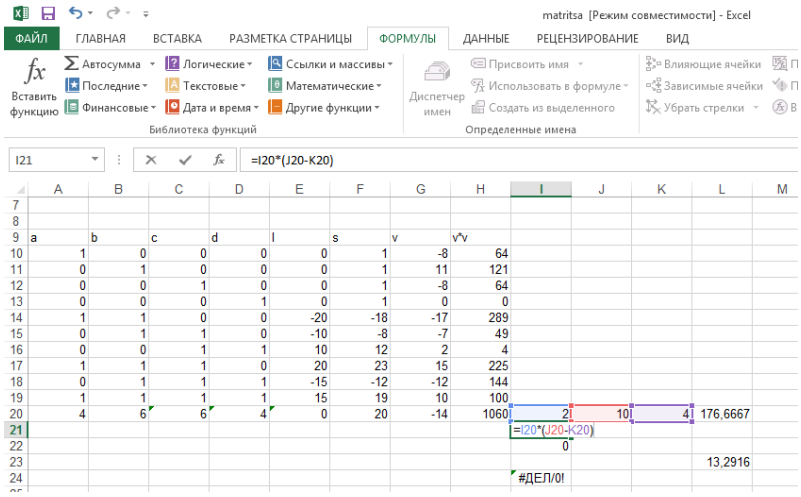


Figure 13.

Then we go to cell I-22, click "=", enter the command "FORMULAS" from the command line and click on the command "BASIC" from the submenu "Library of functions" from the menu "Mathematical" and the additional "Arguments function" In the "Number" window of the window, type the I-21 cell icon and OK press the button, and the result is displayed on the screen (Figure 14).

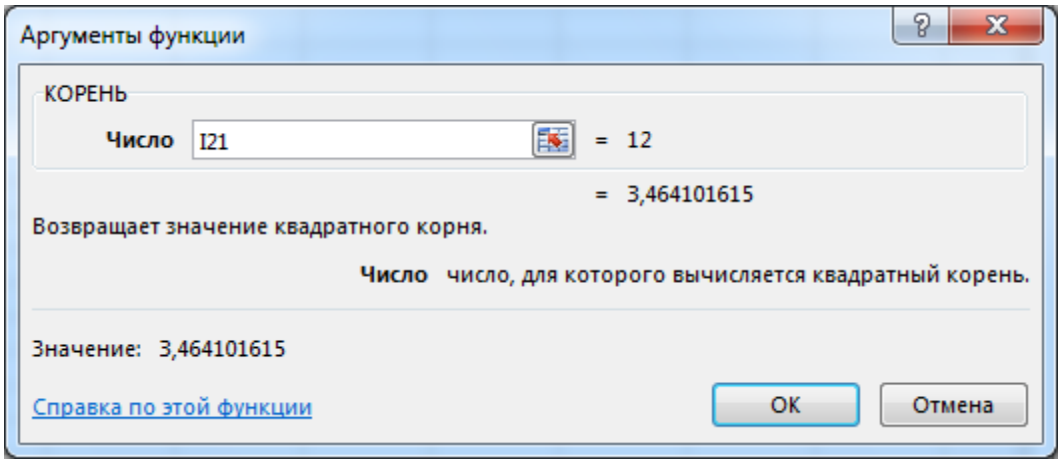


Figure 14.

Then we go to cell I-24, create the formula "= L23 / I22" and get the final result (Figure 15).

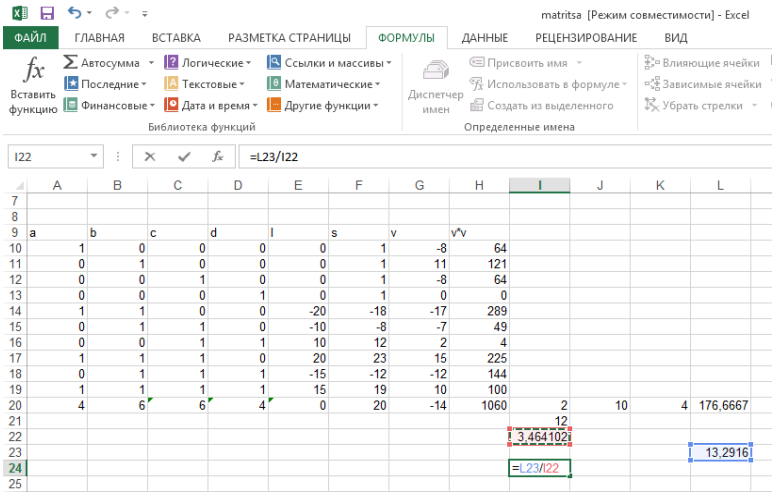


Figure 15.

In short, Microsoft Excel spreadsheet is a ready-made program that not only solves economic and financial problems, but also helps to solve complex calculations in the field of geodesy.

Thus, Microsoft Excel has the ability to solve existing problems in the discipline of "Theory of mathematical processing of geodetic measurements (correlate equalization of the triangulation network and the assessment of accuracy) and is a very useful program for solving complex problems in the field of geodesy.

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