TRAVERSE SURVEYING TABLE SIMPLE AND SURE

HAMID FALLAH

***Abstract*—** Creating surveying stations is the first thing hat a surveyor learn they can use it for control and implementation in projects such as buildings, roads, tunnels, monitoring, etc., whatever is related to the preparation of maps. In this article, the method of calculation through the traverse table and by checking several examples of errors of several publishers of surveying books in the calculations of this table, we also control the results of several software in a simple way.

Surveyors measure angles and lengths in creating stations, so the most important task of a surveyor is to be able to correctly remove the error of angles and lengths from the calculations and to determine whether the amount of error is within the permissible limit for Delete it or not.

***Keywords*—**UTM, localization, scale factor, CARTESIAN, traverse.

I. Introduction

LET'S take a look at Fig.1 and Fig.2 and Fig.3 When we talk about traverse, it is usually divided into two parts in books, closed traverse according to fig.1,fig.2 and open traverse according to fig.4, but actually traverse is to perform calculations so that we can remove the error of lengths and angles from calculations, so fig.4 The only transfer of coordinates is using length and angle, and we cannot call it a traverse, only if we can remove the error of lengths and angles from calculations if we use two fixed stations at the beginning and end of the traverse. Usually, in projects such as dam construction, fig.2 is used to calculate the coordinates of surveying stations, and in road construction, they use fig.3, which of course uses GPS to create base stations along the way, which of course GPS provides us with exact latitude and longitude coordinates, and we must convert them into coordinates that can be used for traverse. Also, Fig.5 is used in tunnels. Fig.6 is a surveying traverse table that was used for Figure.1 DARAB city traverse, [1], [2].

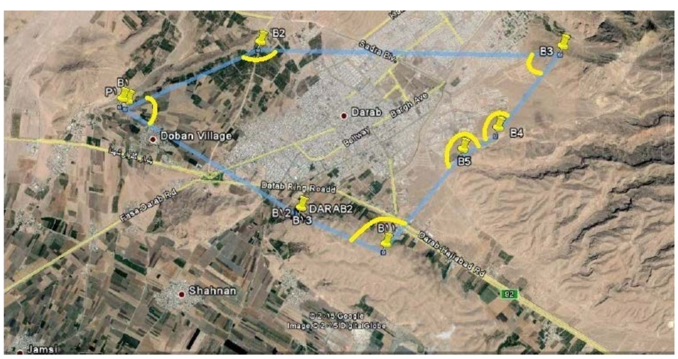


Fig.1

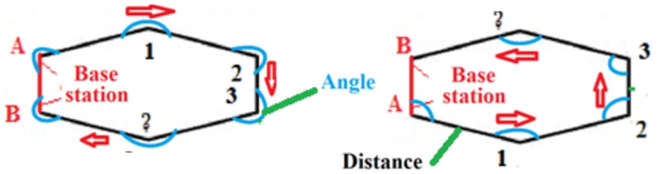


Fig.2

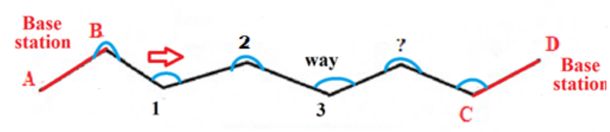


Fig.3

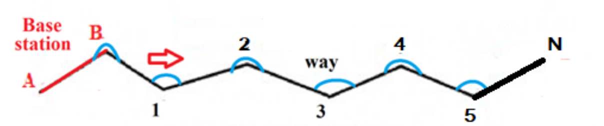


Fig.4

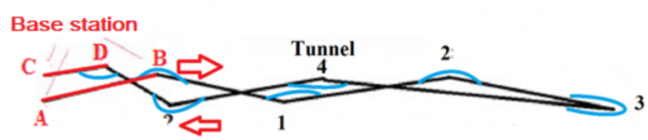
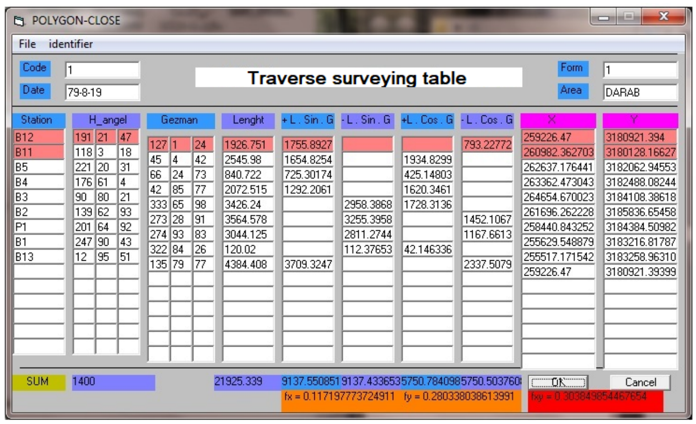


Fig.5



Station	H_angel			Gezman			Lenght	+ L . Sin . G	- L . Sin . G	+L . Cos . G	- L . Cos . G	X	Y
B12	191	21	47	127	1	24	1926.751	1755.8927			793.22772	259226.47	3180921.394
B11	118	3	18	45	4	42	2545.98	1654.8254		1934.8299		260982.362703	3180128.16627
B5	221	20	31	66	24	73	840.722	725.30174		425.14803		262637.176441	3182062.94553
B4	176	61	4	42	85	77	2072.515	1292.2061		1620.3461		263362.473043	3182488.08244
B3	90	80	21	333	65	98	3426.24		2958.3868	1728.3136		264654.670023	3184108.38618
B2	139	62	93	273	28	91	3564.578		3255.3958		1452.1067	261696.262228	3185836.65458
P1	201	64	92	274	93	83	3044.125		2811.2744		1167.6613	258440.843252	3184384.50982
B1	247	90	43	322	84	26	120.02		112.37653	42.146336		255629.548879	3183216.81787
B13	12	95	51	135	79	77	4384.408	3709.3247			2337.5079	255517.171542	3183258.96310
												259226.47	3180921.39399
SUM	1400						21925.339	9137.550851	9137.433653	5750.784098	5750.503760		

fx = 0.117197773724911 fy = 0.280338038613991 fxy = 0.303849854467654

OK Cancel

Fig.6

But is the method of Fig.4 used in projects? You may be surprised that it is still used in large projects such as long tunnels, in such a way that two different routes are taken and at the end of the route, two common stations are considered. The average coordinates from two different routes are used as the base coordinates. In Figure 7, you can see this method that was used in the ALIGOODARZ tunnel, which caused a deviation of 2.5 meters from the axis of the path at 500 meters to the end of the path. Figure 8 shows the plan of the path. Also, in the water tunnel to URMIA, the coordinates of the stations were transferred in the same way, causing the tunnel axis to deviate by 20 meters per kilometer at the end of the route, because when two identical faults are created in each of the routes, you cannot identify them. Also, if you do not make a mistake in measuring the lengths and angles, the maximum error will be as shown in Fig.9.

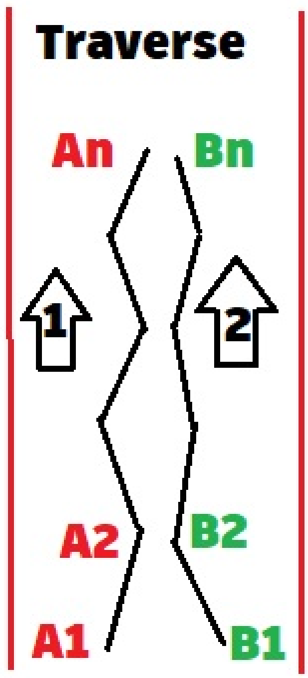


Fig.7

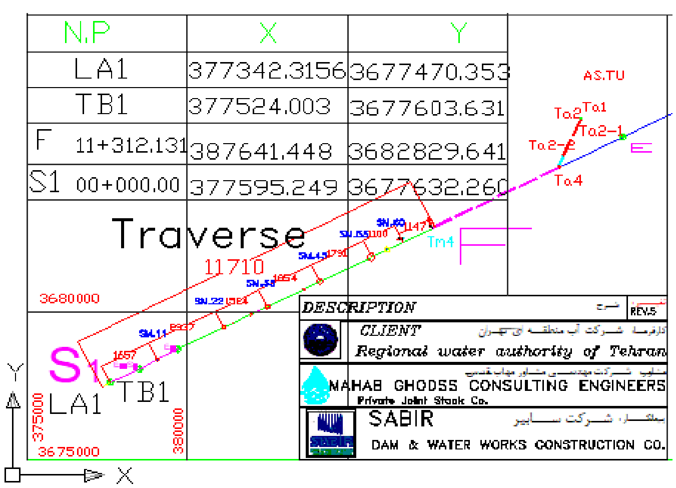


Fig.8

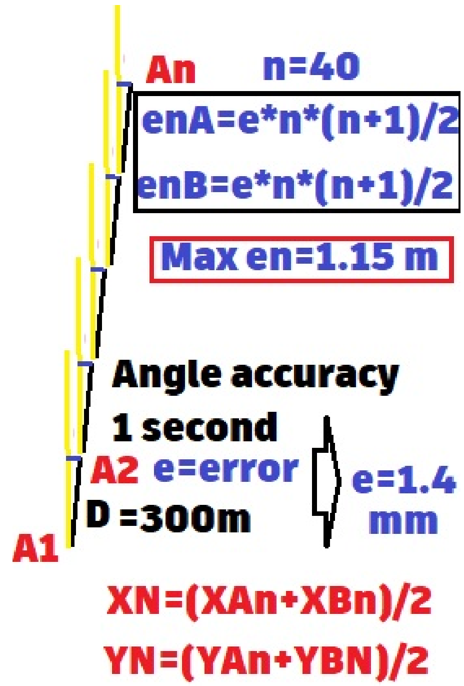


Fig.9

In Figure 9, you can see that if the error of each angle is equal to 1 second and we have a mapping station every 300 meters, without taking into account the measurement error, the maximum error at 12 km will be equal to 1.15 meters, while if the total method Use 5. The error of the stations is much less, which we will examine further. In guiding the tunnels, they also use another method, in the form of triangulation, they transfer the coordinates of the stations, that is, by using two base stations, they calculate the coordinates of the third station, and according to Figure 10, each triangle must share the same distance with the next triangle. But this method is less accurate than the method in Figure 5 because more lengths and angles are used

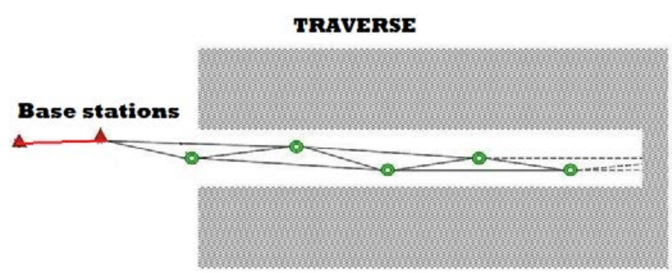


Fig.10

To check that the error of the method in figure 5 is less than 10, you can use the example of figure 11, taking into account that the distance between each station and the neighboring stations can be a maximum of 300 meters, in the triangular method, we have to use more stations.

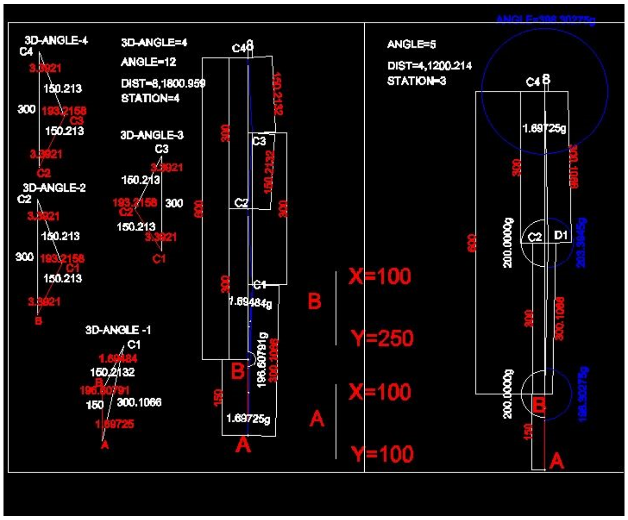


Fig.11

Suppose the length measurement error is equal to zero, and in each triangle, the first and third angles each have 2 seconds of error, so that the first one is positive and the second one is negative, so you cannot remove the angle error and it will be transferred to the next triangles. Do the same way for Fig.11 on the right side, create a positive error of 2 seconds each for the first two angles, and create a negative error of two seconds for angles 4 and 5 and calculate the coordinates. The coordinates of point C4 at the end of the path in both methods compare, you can see that the error caused by the triangulation method on the left side is more than the one on the right side. In the method on the left, the error created at point C4 is equal to 7.3 mm, and in the method on the right, it is equal to 5.7 mm, so we conclude that the method in Figure 5 is more accurate than the method in Figure 10.

But the triangular method in many cases increases the surveying speed while providing the accuracy we need when you justify TOTAL STATION using the FREE STATION program. In dam construction, stations are created in the highest area and surveyors use them in the FREE STATION program.

The CIVIL 3D program is one of the popular programs for surveyors, which has a traverse calculation program, but how does it calculate the calculation error? Let's design a challenging traverse for it and control the result of its calculations.

In Figure 12, you can see a traverse at the beginning of the tunnel. We are going to transfer the coordinates to points 1, 2, and 3 using A, B coordinates, and we measured the angles and lengths. Suppose there is no error in the angles and the angles are measured with an accuracy of 1 second. And the TOTAL STATION has an error of 5 mm at a distance of 300 meters. We are going to calculate its error and apply it to the calculated coordinates. The CIVIL 3D program has performed the calculations in Fig.13, whether the errors are applied correctly or not? As it is clear from the calculated coordinates, the angles 1 and 2 have changed, and this means that it caused the deviation of the tunnel axis, when the error caused by the length you intend to remove should not change the angles.

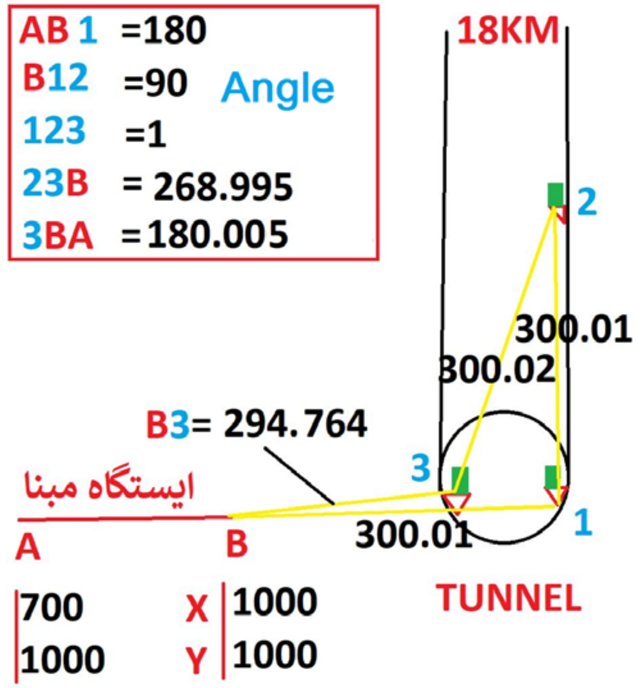


Fig.12

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!
!   Point     Northing       Easting     Elevation
 NE    5   1000.000000    700.000000
 NE    1   1000.000000   1000.000000
 NE    2   1000.000000   1300.005399
 NE    3   1300.006790   1300.003317
 NE    4   1000.029171   1294.768599
!
! From  At   To                        Angle
Distance
! Point Point Point          Angle      Distance
Std Error Std Error
D          4     1              294.7640
0.0052
A    3    4     1     268.99500
0.00081
D          2     3              300.0100
0.0052
A    1     2     3      90.00000               0.00080
D          3     4              300.0200
0.0052
A    2     3     4      1.00000                0.00069
D          1     2              300.0100
0.0052
A    5     1     2     180.00000
0.00090
!
!
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Fig.13

How can we do the calculations in the surveying table? First, let's refer to two surveying books [5].

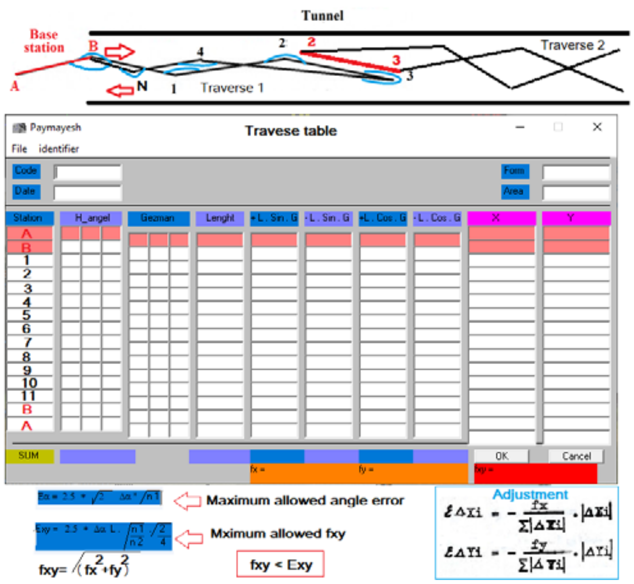

Fig.14

How can we do the calculations in the surveying table? In the lower part of the traverse table, you can calculate the maximum allowed error with the mentioned formula, and the traverse error you made must be less than this value, and in the lower right part of the table, it shows the formula and the error removal method, which should be proportional Its effect should be applied at the station and the angles should not be changed after applying them, because before calculating the traverse table, the error of the angles is calculated and removed. In many mapping books, the error is applied to the coordinates using the formula in Fig.15, which causes the angles to change and is completely wrong. If you pay attention to the formula for calculating the coordinates of points using length and angle, the reason It is quite clear. The correct formula for applying the error is according to Fig.16.

Adjustment

$$\varepsilon \Delta X_i = -\frac{f_x}{\sum|\Delta L_i|}\cdot|\Delta L_i|$$

$$\varepsilon \Delta Y_i = -\frac{f_y}{\sum|\Delta L_i|}\cdot|\Delta L_i|$$

Fig.15

Adjustment

$$\varepsilon \Delta X_i = -\frac{f_x}{\sum|\Delta X_i|}\cdot|\Delta X_i|$$

$$\varepsilon \Delta Y_i = -\frac{f_y}{\sum|\Delta Y_i|}\cdot|\Delta Y_i|$$

Fig.16

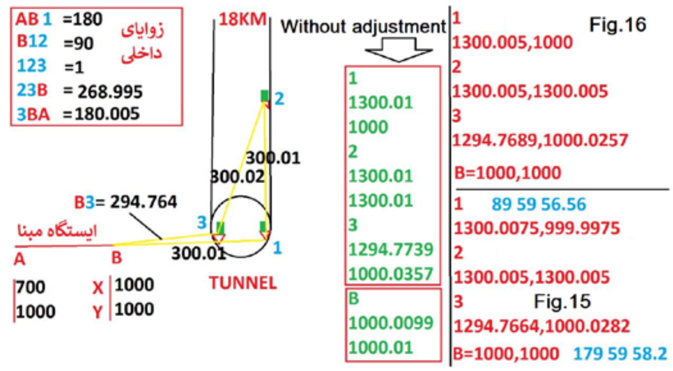

Fig.17

In Fig.17, you can see three different lists of coordinates. On the left side, if the error is not applied to the coordinates, and on the right side, it is applied in two different ways in Fig.15 and 16. As you can see, if the errors are If the ratio of lengths is applied, it will change the angles, although it can move the axis of the tunnel by 5 mm at a distance of 300 meters, but if you consider an 18 km tunnel that includes 60 stations on the way and 60 stations on the way back. Only these calculations with 4 angles and lengths will cause a deviation of 30 cm at the end of the tunnel.

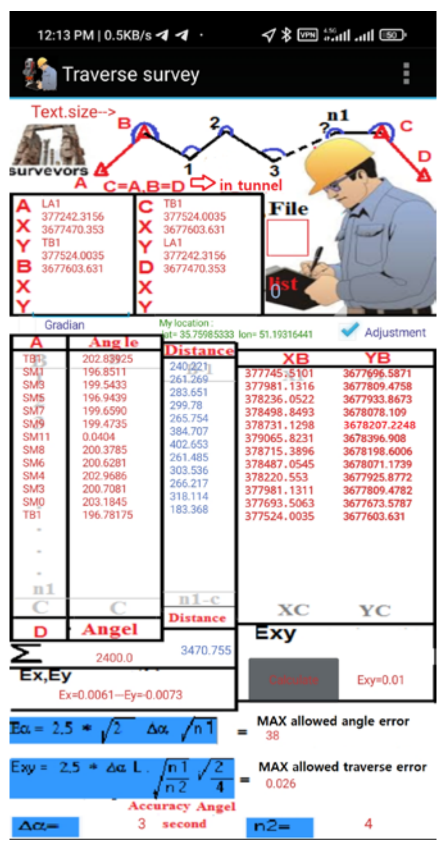

Fig.18

In Fig.17, you can see three different lists of coordinates. Calculating the traverse table after entering the angles on each station and the lengths between the stations, which are rounded to the right, requires precision and time-consuming, but today, with the design of the software, these calculations can be easily done on a computer and mobile phone. Fig.1 shows an example of traverse in DARAB city, whose program is designed under Windows and Fig.18 shows an example of calculation of navigation in a 12-kilometer tunnel, whose program is designed in Android [3], [4].

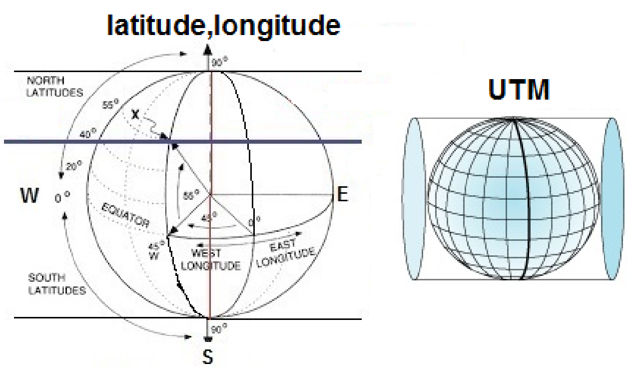

Fig.19

In road construction, you are faced with the traverse according to Fig.3, where you must first calculate the coordinates of your main stations. You can use UTM coordinates or convert UTM coordinates to local coordinates by applying scale factor Fig.19, [5]. If the points are in two different zones, you will enter a new challenge or you must change the base longitude for the zone or use the Cartesian coordinates of the points to localize the coordinates Fig.20.

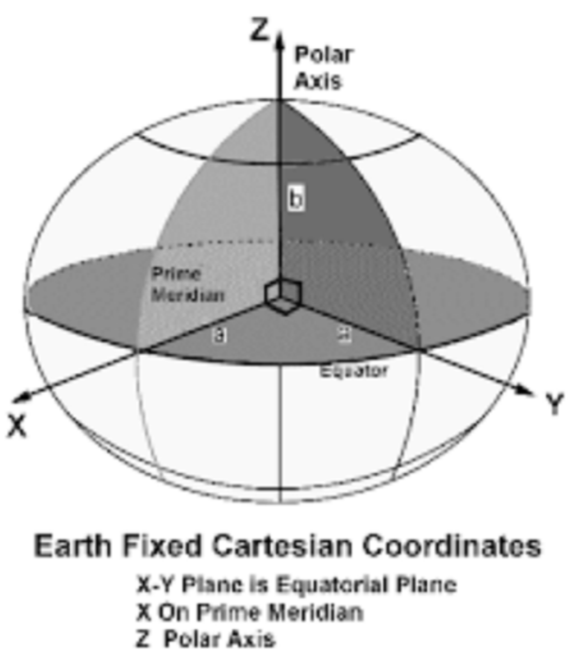

Fig.20

References

[1] https://t.me/naghshebardaraneparseh
[2] https://t.me/naghshebardaraneparseh/18
[3] http://cafebazaar.ir/app/?id=traverse.parseh&ref=share
[4] https://play.google.com/store/apps/details?id=traverse.parseh
[5] http://cafebazaar.ir/app/?id=local.parseh&ref=share