Introduction to the Application of Weights in Surveying Measurements

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We all know that some measurements are better than others, even in the same survey. For example, if we are running a traverse and some angles are turned under better conditions, or you turn 2 sets of angles (4 angles) at one setup and just one angle at another setup, one of the angles would be better than the other. That is, some angles are more precise than others. This introduces the concepts of ***weights.***

As it applies to adjustments, measurements with higher weight would receive less adjustment. For example, if one measurement had a weight of [4] and another had a weight of [1], the measurement with the weight of 4 would receive one fourth of the error of the measurement with a weight of [1].

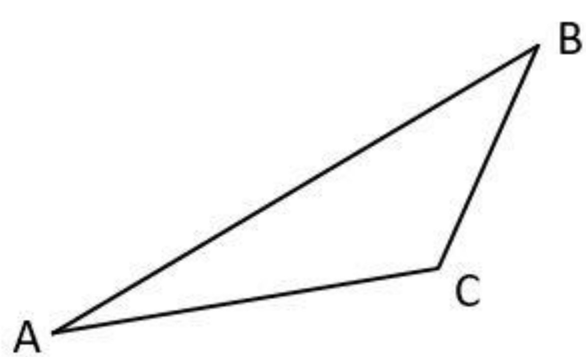
Weights can be assigned according to number of repetitions, judgement, precision index, or many other methods. (more about this later).

Assigning Weights Based on Observation Repetition

In the example below let us assume that angle A was turned one time, angle B was turned 4 times (2 sets), and angle C was turned 2 times (one set). If we assign a weight of [1] to angle A, a weight of [4] to angle B, and a weight of [2] to angle C, the correction to angle B would be ¼ (0.25) that of angle A, and the correction to angle C would be ½ (0.5) that of angle A (inversely proportional).

These weights were assigned according to the number of angles turned at each traverse station. When the field angles are added together you can see we have an error of 6". When we correct for this error, we will take the weights into effect.

Example -1



A = 17°23’46”   B = 35°03’30”   C = 127°32’50”   Total = 180°00’06”

Applications of Weights in Measurements

Assigned weights of each angle: “A” = [1], “B” = [4], “C” = [2]

Remember, the weights are inversely proportional to their value, that is [4] = ¼ (0.25), [2] = ½ (0.50), and [1] will = 1.0. if you add these up the sum will be 1.75.

In order to calculate the amount of the total error each angle will be adjusted; we will divide the individual weight by the sum of the weights. $C = \frac{W}{\Sigma W} \times error$

Correction to A = $\frac{1}{1.75} x6'' = 3.43''$ Correction to B = $\frac{0.25}{1.75} x6'' = 0.86''$

Correction to C = $\frac{0.50}{1.75} x6'' = 1.71''$ When all corrections are added, the sum is 6”

Corrected angles:

$AngleA: 17°23'46'' - 00°00'03.43'' = 17°23'42.57''$(rounded to 43")

$AngleB: 35°03'30'' - 00°00'00.86'' = 35°03'29.14''$(rounded to 29")

$AngleC: 127°32'50'' - 00°00'01.71'' = 127°32'48.29''$(rounded to 48")

Total = 180°00'00"(rounded = 180°00'00")

Assigning Weights Based on Professional Judgement

In this case it is the party chief who determines the weights of the angles from the conditions in the field. The party chief assigns the weights of the angles as follows (not having formal standard errors).

The worst angle will receive a weight of [1]; the angle that is better than one but still not particularly good will receive a weight of [2]; the angle that is better than the first two but still not the best will receive a weight of [3]; and the best angle will receive a weight of [4].

Remember, the angle adjustments will be made inversely proportional to their weights. The larger the weight, the smaller the adjustment.

In this case the Party Chief made their own system. They divided the angles into four categories as follows.

Category 1: might be one where the setup is on soft ground and the surveyor is having a hard time keeping the instrument level, and their backsight or foresight (or both) is short. This could receive a weight of one [1].

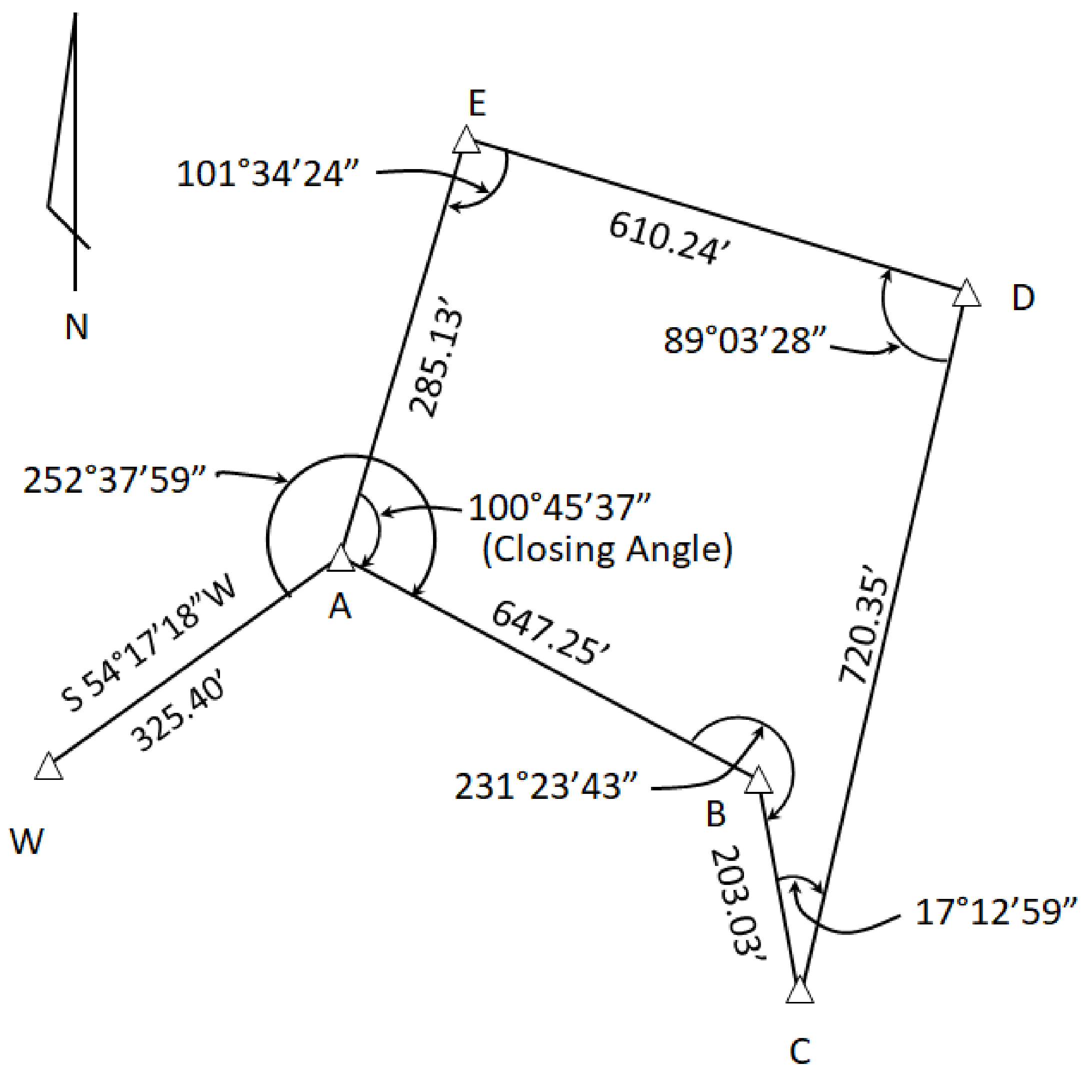
Category 2: the second example might be where the surveyor is on firm ground but still has a short backsight and is having a hard time seeing his foresight. This type of angle could receive a weight of two [2].

Category 3: the third example might be where the surveyor is on firm ground, with good sites both front and back, but the conditions are not particularly good. It could be foggy or there might be a lot of heat waves. This type of angle could receive a weight of three [3].

Category 4: the last example is the best angle. The surveyor is on firm ground with good sites, turning an angle with strong strength of figure. The weather is high overcast skies and about 65°F. This type of angle could receive a weight of four [4].

Let us have a look at an example using the above categories.

Example - 2



To find the angular error we use the formula (n-2)180°= Σ Angles. In our case we have a traverse with five angles, therefor using the above formula the angles add up to. (5-2)180° = 540°

Adding the field angles, we get:

100°45'37" + 231°23'43" + 17°12'59" + 89°03'28" + 101°34'24" = 540°00'11"

We have an 11" error.

The angle 252°37'59" is not part of the traverse and is used just to establish a basis of bearing, therefor it will not be adjusted. Angles A (closing Angle). B, C, D, and E, being part of the traverse will need to be adjusted.

The weights of each angle are as follows: A = [4]; B = [2]; C = [1]; D = [3], E = [3]
Inverse sum of the weights is:
0.25 + 0.5 + 1 + 0.33 + 0.33 = 2.41 (sum of the Inverse of the weights)

Weighted corrections for each angle:

Angle A = $\frac{0.25}{2.41} x 11'' = 1.14''$ Angle B = $\frac{0.50}{2.41} x 11'' = 2.28''$ Angle C = $\frac{1}{2.41} x 11'' = 4.56''$

Angle D = $\frac{0.33}{2.41} x 11'' = 1.51''$ Angle E = $\frac{0.33}{2.41} x 11'' = 1.51''$

Corrected Angles

$A)\ 100^\circ 45'37'' - 00^\circ 00'01.14'' = 100^\circ 45'35.86''$ (round up to 36")
$B)\ 231^\circ 23'43'' - 00^\circ 00'02.28'' = 231^\circ 23'40.72''$ (round up to 41")
$C)\ 17^\circ 12'59'' - 00^\circ 00'04.56'' = 17^\circ 12'54.44''$ (round down to 54")
$D)\ 89^\circ 03'28'' - 00^\circ 00'01.51'' = 89^\circ 03'26.49''$ (round down to 26")
$E)\ 101^\circ 34'24'' - 00^\circ 00'01.51'' = 101^\circ 34'22.49''$ (round up to 23")
Total 540°00'00"

Notice that angles D and E have the same correction (1.51"). I rounded angle D down and angle E up in order to make the math close.

As you can see, this is a more equitable way to distribute the angular errors in a traverse.

Several programs such as StarNet, and others allow you to use weights to distribute the error.   Using weights helps you take control of measurements and helps distribute errors in a more realistic manner that can result in a better, more accurate survey.

There are weighting strategies for other surveying measurements, for instance in adjusting GPS/GNSS data and derived vectors. While surveying field and office software automate many aspects of measurement adjustment, understanding how weighting works and how weights are assigned is essential for surveying practioners and professionals.