Monitor Lab 3 Report

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1. evaluate all protocols from the set measurements completely and calculate the respective standard deviations.

[Theory]

$$d = \bar{r} - r$$

$$\mathrm{v} = \mathrm{d} - \frac{[d]}{s}$$

$$s_r = \sqrt{\frac{[vv]}{(n-1)(s-1)}}$$

$$s_{\bar{r}} = \frac{s_r}{\sqrt{n}}$$

Where

n=number of the set, s=number of the bunch, r=reduced mean, $\bar{r}$=mean of all set

[Application]

Hence we get result of standard deviations (table 1):

Table 1. standard deviations

	Standard deviation (mgon)	Square Mean SD (mgon)
TS30 (without deformation)	0.77	1.08
TS30 (with deformation)	0.76	
TM5000 (without deformation)	1.84	2.26
TM5000 (with deformation)	1.31	

2. Determine the distance measurement accuracy, for a cross deviation accuracy of 0.1mm. Make a statement whether the accuracy of the tacheometer is sufficient to determine that distances, when a distance accuracy of $\sqrt{(\mathbf{1}\boldsymbol{mm})^{\mathbf{2}} + (\mathbf{1}\boldsymbol{ppm})^{\mathbf{2}}}$ is the given.

[Theory]

Observation equation for cross deviation:

$$\mathrm{q} = s_i sint_i, \qquad where\ t_i = \alpha^{def} - \alpha^0$$

Law of Error Propagation:

$$\sigma_q^2 = (sint)^2\sigma_s^2 + s^2(cost)^2\sigma_t^2, \qquad where\ \sigma_t = \sqrt{2}s_{\bar{r}}$$

From that we get the expression for σ_s:

$$\sigma_s = \sqrt{\frac{\sigma_q^2 - s^2(cost)^2\sigma_t^2(\frac{\pi}{200})^2}{(sint)^2}}$$

[Application]

σ_q is given as 0.1mm, and from question 1 we can get the s, t and $s_{\bar{r}}$ (as is shown in table 2 and 3):

Table 2. distance measurements

	s_{A2}	s_3	s_2	s_1
TS30 (m)	19.9648	14.9419	10.0135	4.9756

Table 3. difference angle between epochs

	t_{A2}	t_3	t_2	t_1
TS30 (mgon)	0	-1.4	-13.4	-10
TM5000 (mgon)	0	-2.9	-9.5	-12.4

Hence we get the final results for σ_s (table 4.1):

Table 4.1. distance measurement accuracy

	σ_{A2}	σ_3	σ_2	σ_1
TS30 (m)	$\sqrt{Inf}$	$\sqrt{-245.98}$	$\sqrt{-1.08}$	$\sqrt{-0.17}$
TM5000 (m)	$\sqrt{Inf}$	$\sqrt{-265.97}$	$\sqrt{-10.88}$	$\sqrt{-1.38}$

As we can see from the table, all of our results seem to be totally wrong with a complex form, that is to say, our standard deviations $s_{\bar{r}}$ were too big. Specifically, our measurements during the lab exercise were totally wrong or invalid. After looking back to the initial measurement sheets, we found that the measurements of point 2 and 3 had big errors with both instruments, thus leading to the big standard deviations.

Now if we use the accuracy of the instruments (0.15 mgon) as the σ_t, we can get a better distance accuracy (as is shown in table 4.2):

Table 4.2. distance measurement accuracy with given angle accuracy

	σ_{A2}	σ_3	σ_2	σ_1
TS30 (mm)	0.0882	0.0936	0.0972	0.0993

Then we calculate the given accuracy of $\sqrt{(1mm)^2 + (1ppm)^2}$ for distance measurement (table 5):

Table 5. given accuracy of distance measurement

	σ_{A2}	σ_3	σ_2	σ_1
TS30 (mm)	1.0002	1.0001	1.0001	1.0000

Comparing table 5, table 4.1 and table 4.2, obviously our measurement accuracy is not sufficient enough to determine the distances because the error of our angle measurements was too big. But with a normal angle accuracy that under the instrument standard (in this case 0.15 mgon), the accuracy of the tacheometer will then be sufficient to determine the distances.

3. Calculate the cross deviations for all epochs and determine the achieved accuracy of the cross error. Compare the calculated cross deviations with the given values and discuss the differences.

[theory]

Expression for cross deviation:

$$\mathrm{q} = s_i sint_i, \qquad where\ t_i = \alpha^{def} - \alpha^0$$

Accuracy calculation:

$$\mathrm{acc} = (\mathrm{q} - q_{given})/q_{given}$$

$$\sigma_q^2 = (sint)^2\sigma_s^2 + s^2(cost)^2\sigma_t^2, \qquad where\ \sigma_t = \sqrt{2}s_{\bar{r}}$$

[application]

From the formula above we can calculate the cross deviations of all epochs, which are shown in table 6:

Table 6. cross deviations

	P_{A2}	P_3	P_2	P_1
TS30 (mm)	0	0.3286	2.1077	0.7816
TM5000 (mm)	0	0.6806	1.4943	0.9692

Then we can also get the differences comparing to the given values (1.0 mm, 2.0 mm, 0.5mm for P1, P2 and P3) and calculate the accuracy (table 7 and 8):

Table 7. differences between calculation and given values

	P_{A2}	P_3	P_2	P_1
TS30 (mm)	0	-0.1714	0.1077	-0.2184
TM5000 (mm)	0	0.1806	-0.5057	-0.0308

Table 8. error of cross error

	P_{A2}	P_3	P_2	P_1
TS30 (%)	0	-34.28	5.38	-21.84
TM5000 (%)	0	36.13	-25.29	-3.08

Considering the differences and errors above, we can see that our measurement results are unsatisfactory. The error of those three points is too big and unstable whatever instrument we used. The main reason might be our artificial mistakes when doing the measurement, that is to say, more specifically, our unfamiliarness with the instruments and the measuring procedure. During our measuring, we had trouble with alignment on point 2 and 3 because of the sometimes' mixing up of the two stations. Also, we might have changed the stations or moved the instruments when doing the measurement. Last but not least, we became more and more hurried as the measurement went on, thus leading to careless observation and writing.

4. Describe your own experiences with the two used aiming marks. Assess the achieved accuracy from set measurements and the perceived impression at aiming. Would you rather use the Mires or the cross-sign marks for this task?

We used cross-sign mark with the tacheometer (TS30), a cross in the middle, and Mire mark with the theodolite, several circles around the center. Personally, it was a little bit unclear and time consuming for me to align the instrument and the target when using cross marks, and quicker and easier with Mire marks. However, once successfully aligned, the cross marks are more accurate than the Mire marks because they have definite center intersection. From the view of our accuracy results, we can also get the information that data measured by TS30 is more accurate than by TM5000. Therefore, for me I would prefer cross marks for this task.