UNIVERSITY OF NEW SOUTH WALES

SCHOOL OF SURVEYING

29.002 SURVEYING 2

FIELD EXERCISE: TACHEOMETRY I

1. AIM

To familiarise students with the technique of vertical staff tacheometry (stadia) and the calibration and standardization of instruments for this purpose.

2. EQUIPMENT

1 Self reducing diagram tacheometer Wild RDS
1 RDS metric and folding staff (with bubble)
1 Tripod Wild GST20
or
1 Scale Reading Theodolite Zeiss Th4, Wild T16 or Wild T1
1 Metric folding staff (with bubble) or telescopic staff
1 Tripod Zeiss S2R or Wild GST20
and
1 Ranging Rod
1 100 m steel band (standardized in Surveying 1)
1 Spring balance
1 Thermometer
5 Pegs
1 3 m Pocket Tape
1 Plumb bob
1 Hammer
1 Survey Umbrella

and also
5 Chaining Arrows
1 Clip Board

3. EXERCISE

3.1 Establish on a evenly sloping surface (allocated by supervisor) a baseline with marks for 0 m, 10 m, 30 m, 60 m, 90 m (pencil cross on top of peg), using your standardized band at standard tension. To align the pegs, set up your theodolite or tacheometer on the zero mark of your base line. Centre it and level it. Measure height of theodolite with tape to mm!

After the pegs have been placed, the distances between the pegs are measured twice with the band, fully supported and at standard tension. Measure temperature.

3.2 Set up staff on 10 m mark and stabilize it with the ranging rod perpendicular to the line of sight. Set vertical circle to 90^{o} exactly and read staff. Change face, set vertical circle to 270^{o} and read staff. Adjust always the altitude bubble before reading the vertical circle, if your instrument is not equipped with an automatic index.

Repeat this measurement on 30 m, 60 m and 90 m peg. This "levelling" provides the necessary data for the slope correction of the steel band measurements.

3.3 Lay your staff flat on the ground. Measure the staff graduation in steps of 0.25 m with your pocket tape. The zero of the pocket tape should coincide with the staff zero. Read pocket tape to 0.1 mm. Draw a sketch in the field book and book figures in sketch. Do not forget to draw any joints in the staff.

3.4 Each student measures five staff readings to every base line mark (10 m, 30 m, 60 m, 90 m), after having determined five times carefully his personal eyepiece constant. (Book!) To get five different readings on all 4 marks of the baseline, set up staff for the first reading on the mark, for the second, third, fourth and fifth reading at different positions between 0.10 and 2.00 m behind the mark (on line). Vary offsets randomly and measure them to cm. Measure the distance between mark and staff position with your pocket tape and get it booked. Use one table per student in the field book (See appendix for example!). When sighting to the staff, the vertical circle should read 90^{o} (horizontal) first,

before you take the readings. Each student gets this way a total of 20 staff readings to mm.

3.5 To enable a computation and check of the error of horizontal collimation (c) point twice (in two faces) to a distant target of your choice. The zenit distance to this target should be as close to 90^{o} as possible. This is done only once per group.

3.6 To determine the inclination of the transit axis (i_T), set up your instrument near the south/west corner of the GAS Building, so that the trig station on top of the ME Building can be observed. Level up carefully, specially in the vertical plane perpendicular to the target direction. Take the horizontal circle readings to the trig station in both faces, change zero 90^{o}, and observe again the direction to the trig station in both faces. After these direction measurements are done, observe two vertical angles to the trig station (both of them in two faces), to allow the computation of the vertical circle index error (i) later on. Do this only once per group, but use different observers.

4. REPORT

Each student submits the following computations:

4.1 Correct band observations for temperature and slope (if necessary).

4.2 From your own personal observations on the base line, compute in a table similar to the one shown in the appendix:

(i) the corrections Δ for all observations (in cm)

$\Delta = D - 100S$ S = staff intercept = upper hair - lower hair, D = known distance

(ii) Sum all Δ for all base line intervals (i.e. 10 m, 30 m, 60 m, 90 m), divide the sums by 5 and get the mean corrections Δm for all 4 intervals.

(iii) Calculate v as $v = \Delta - \frac{[\Delta]}{5} = \Delta - \Delta m$ and v^2.

(iv) Calculate the standard deviation of one single distance measurement by vertical staff tacheometry (stadia) for 10 m, 30 m, 60 m, and 90 m long distances:

$$S = \pm\sqrt{\frac{[vv]}{n-1}} = \pm\sqrt{\frac{[vv]}{4}} = \pm\sqrt{\frac{\Sigma v^2}{4}}$$

n = number of observations within one group
n = 5
You get S_{10}, S_{30}, S_{60}, S_{90}

(v) Plot s in function of the distance, to demonstrate a possible dependency of s on distance.
Compare your results with the following equation for the standard deviation s, by plotting this curve in your graph, too.

$$S = \pm\left[6 + 5.\left(\frac{D}{100}\right)^2\right] \quad \text{(Kobold)}$$

D = distance (in metres)
S = standard deviation (in centimetres)

(vi) Draw a diagram depicting the mean correction Δm as function of distance D and compute the regression line for these four points. (See appendix for formula and example). Plot the regression line into your graph. Copy this diagram for use in fieldwork "Tacheometry II".

4.3 Use observations (3.5) to compute the error of horizontal collimation C:

$$C = 0.5\ [(FR - 180^{o}) - FL]$$

where FR = horizontal circle reading in face right
FL = horizontal circle reading in face left.

4.4 Use observations from (3.6) to calculate the inclination of your transit axis i_T. Solve the following equations for this purpose, inserting c (calculated in 4.3) as known value:

$$FL = L_F - i_T \cot Z_{FL} - \frac{C}{\sin Z_{FL}}$$

$$FR = (L_F + 180^{o}) - i_T \cot Z_{FR} - \frac{C}{\sin Z_{FR}}$$

where L_F = true horizontal circle reading (face left) (unknown)

Z_{FL}, Z_{FR} = measured zenit distances (in two faces)

FL, FR = actual horizontal circle readings.

4.4 Using your observation 3.3, plot the differences δ = (pocket tape reading) minus (levelling staff reading) in function of the "levelling staff readings". Discuss the diagram with regard to scale errors and discontinuity at staff joints. How does an apparent scale error compare with the scale factor determined in 4.2(vi), namely B?

J.M. RUEGER
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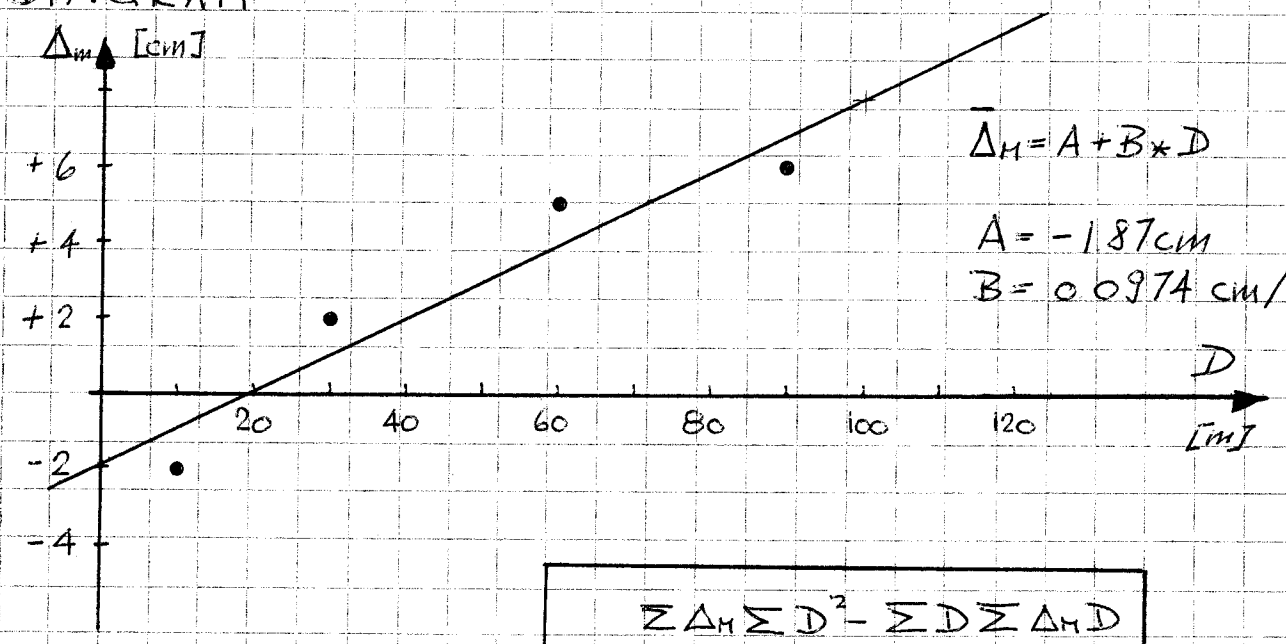
as amended: June 1984

APPENDIX FIELDWORK TACHEOMETRY I

CALIBRATION BOOKING AND COMPUTATION

STAFF READINGS		S	BAND		KNOWN	CORR			STANDARD
LOWER HAIR	UPPER HAIR	(Upper - Lower)	DISTANCE TO MARK	OFFSET	DISTANCE D	Δ = D - 100S	V	VV	DEVIATION S_D
1.700	1.800	10.0	10.00	0	10.00	0	+2	4	
1.700	1.812	11.3		+1.23	11.23	-7	-5	25	
1.700	1.809	10.9		+0.88	10.88	-2	0	0	
1.700	1.804	10.4		+0.36	10.36	-4	-2	4	
1.700	1.819	11.9		+1.91	11.91	+1	+3	9	$S_{10} = \pm 3.2$ cm
						-12.5	$-2_{\checkmark}$	42	
					Δ_M	-2			
1.600	1.899	29.9	30.00	0	30.00	+10	+8	64	
1.600	1.901	30.1		+0.22	30.22	+12	+10	100	
1.600	1.907	30.7		+0.68	30.68	-2	-4	16	
1.600	1.914	31.4		+1.34	31.34	-6	-8	64	
1.600	1.919	31.9		+1.87	31.87	-3	-5	25	$S_{30} = \pm 8.2$ cm
						+11.5	$+1_{\checkmark}$	269	
					Δ_M	+2			

DIAGRAM



Linear Regression:

$$A = \frac{\Sigma \Delta_M \Sigma D^2 - \Sigma D \Sigma \Delta_M D}{n \Sigma D^2 - (\Sigma D)^2}$$

$$B = \frac{n \Sigma D \Delta_M - \Sigma \Delta_M \Sigma D}{n \Sigma D^2 - (\Sigma D)^2}$$

n = number of data pairs

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