UNIVERSITY OF NEW SOUTH WALES

SCHOOL OF SURVEYING

29.001 SURVEYING I

FIELD EXERCISE: DIRECT DISTANCE MEASUREMENT

1. AIM

The students shall be introduced into different possibilities of band measurements, into their precision and into the standardization of bands.

2. EQUIPMENT

1 Clip Board
1 100 m Steel Band and Reader ('3 mm' band)
2 Sighting Tripods
1 Spring-Balance
1 Thermometer
3 Pegs
2 Plumb-bobs
1 Hammer
1 Clinometer (BREITHAUPT, SUNNTO) or Abney Level
1 Pocket Tape

3. EXERCISE: P A R T A (STANDARDIZATION)

Standardize your band twice by measuring the distance between the two terminals of two standard bases. The two bases are situated on the (westerly) walkway along Engineering Road (between GAS Building and Barker Street).

AB = 83.977 m (A,B: G.I.N. in concrete)
CD = 83.600 m (C,D: Bolts in concrete)

These measurements should be made to millimetres with the band fully supported and at tensions of 50 N, 60 N, 70 N, 80 N and 90 N (once each on both baselines!). The temperature should be noted. The baselines are assumed to be horizontal.

P A R T B

3.1 Select a line on the lawn along the two walkways between Anzac Gate and Science Road, for which the ground is either level or uniformly sloping. Drive into the ground two pegs 90 m apart and a third intermediate peg on the same line, 30 m from one end and 60 m from the other end, to within 1 cm of ground level. Mark the centres of the pegs with a pencil cross.

3.2 Set the two sighting tripods over the 30 m line, at equal heights. Measure the line to millimetres by each of the following three methods, varying the tensions again between 50 N and 90 N (in 10 N steps), and get five measurements for each method. (Lay band on ground in between measurements).

3.3 i) Band fully supported on ground (i.e. direct from peg to peg).
ii) From tripod spike to tripod spike, with no intermediate support.
iii) From tripod spike to tripod spike, with one intermediate support at mid-point.

The temperature should be observed for each measurement. The slope from tripod spike to tripod spike should be measured from both ends, using the clinometer or the Abney Level. Use the mean slope obtained in the reductions for all three methods, if the tripod spikes are on equal heights above ground. Otherwise, measure ground slope specially.

3.4 Repeat 3.2 and 3.3 for 60 m line.

3.5 Repeat 3.2 and 3.3 for 90 m line. Then, remove all three pegs, have your field notes signed by the demonstrator and return all equipment to the Store.

3.6 All bookings on field form.

4. REPORT

Each student shall submit the following calculations, which should be set out neatly in tabular form:-

4.1 The temperature at which the band would be of nominal length at a tension of 70 N for both baselines. (Reduce first all observations to 70 N pull, and compute the mean temperature during baseline measurements). Compute the mean of both 'standard' temperatures for the following calculations.

$$t_s = \frac{\ell + \ell c t_f - \ell_{Base}}{\ell c}$$

t_s = standard temperature (for which band/tape has nominal length)
t_f = field temperature during baseline measurements
c = coefficient of linear expansion
ℓ = measured lengths, reduced to 50 N tension
ℓ_{Base} = known base length

4.2 Correct the total 45 field measurements for variation from the standard conditions determined in 4.1 (temperature, pull, sag) and for slope.

$$d = \ell - \ell(1 - \cos\alpha) + \ell c(t_f - t_s) + \ell\frac{(T_f - T_s)}{A \cdot E} - \frac{W^2 \ell^3}{24 T_f^2} \cos^2 \alpha$$

d = horizontal distance
ℓ = measured length (band/tape reading)
t_f = field temperature, during measurement of ℓ
t_s = standard temperature
c = coefficient of linear expansion
T_f = field tension, applied to measure ℓ
T_s = standard tension (70 N)
A = cross-sectional area of band/tape
E = modulus of elasticity
W = unit weight of band/tape (weight per metre)
α = vertical angle, slope angle

2nd term in formula → slope correction
3rd term in formula → temperature
4th term in formula → tension correction
5th term in formula → sag correction: divide by 4 if intermediate support at midpoint.

4.3 Calculate the mean and the standard deviation of one single observation for all 9 sets of 5 measurements. Plot the standard deviations in function of the distance for methods i), ii) and iii) in the same diagram.

4.4 Determine the means (and their standard deviations) of all 10 observations from methods i) and iii) for each of the three distances and adjust them, using the condition equation ($\bar{d}_i$ = adjusted observations):-

$$\bar{d}_{30} + \bar{d}_{60} + \bar{d}_{90} = 0$$

with $\bar{d}_{90}$ = negative.

Naturally, weights must be introduced here.

$$p_{30} = \frac{1.0}{\bar{S}^2_{30}} \qquad p_{50} = \frac{1.0}{\bar{S}^2_{50}} \qquad p_{90} = \frac{1.0}{\bar{S}^2_{90}}$$

where $\bar{S}_i$ = standard deviation of mean of distance 'i' (in millimetre)

misclose $w = d_{30} + d_{60} + d_{90}$ (d_{90} = negative)

where d_i = mean of 10 observations

Correction (residual) to d_i: $V_i = \dfrac{-W}{p_i \sum \frac{1}{p_i}}$

Checks: $V_{30} + V_{60} + V_{90} + W = 0$

$$d_{30} + V_{30} + d_{60} + V_{60} + d_{90} + V_{90} = 0 \quad (d_{90} = \text{negative})$$

4.5 Compare the size of $\bar{S}_i$ and V_i and comment on differences.

5. CONSTANTS

Apply the following constants for the calculation of corrections:-

Cross-sectional area	1.62 mm^2 ('3 mm' band)
Weight (unit)	0.125 Nm^{-1} ('3 mm' band)
Coefficient of linear expansion	1.15×10^{-5} $^oC^{-1}$
(Young's) Modulus of elasticity	$E = 2 \times 10^5$ Nmm^{-2}

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