Chapter-2 Tape Measurement

2.1 Methods: *Direct* (tapes) *Indirect*: (EDM, Stadia)

2.2 Types of measurement

1) **Pacing**: Useful but imprecise Looking for survey marks rough check
Accuracy 1/50 to 1/100 Good on level ground or constant slope

2) **Odometer** Measure from fence line to another, identifies of property lines

3) **EDM**: Send waves and measure phase difference

4) **Stadia**: Cross hair configuration (fixed angel intercept)

5) **Tacheometry**: Phase difference (EDM)
Fixed angle intercept (Stadia)
Fixed base intercept (Substance bar)

Substance bar
high accuracy on short distances
independent of vertical angle
good for hilly and mountains country

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2.3 Gunter's Chain: Chain = 66 ft.

2.4 Fiberglass Tapes
Woven Tapes (Cloth) linen with brass wires electricity 30 m not pop.
Not very precise meters, centimeters and half-centimeters

2.5 Steel tapes most common. Good accuracy 1:10,000
Various length (30 m) heavy duty, light weight
Coefficient of thermal expansion $-12 * 10^{-6}/C^{o}$
Invar wires: 36% nickel – 64% steel very low coefficient of thermal expansion good for precise work.

2.5.1 Types of Readouts

Marked in 3 ways

1. *Graduated through*
2. *Cut tape:* first and last decimeters marked in mm
   Disadvantage: Mistake in subtraction.
3. *Add tape*: Marked in meters and decimeters with extra decimeter marked in mm
   Disadvantage. Difficult to hold zero on the mark

Graduated through is best.

2.6 Standard Condition for Steel Tapes

68^{o}F (20^{o}C)
Fully supported throughout
Under 10 lb (50 Neutrons) tension

2.7 Taping Accessories

1. *Plumb Bob* solid brass 10 oz with thread
   transfer from ground to tape end vice versa
2. *Range poles*: wood or steel 2-4 m
3. *Taping pins* 30 cm with flags
4. *Tension handle*
5. *Thermometer*
6. *Hand level (abny)*
7. *Plumb Bob Target*

2.8 Taping Method

Head surveyor holds zero mark
Rear surveyor unwind tape
If ground is level, tape is laid
If ground is sloping, use plumb bob
Apply tension – record or mark the ground

2.9 Taping Corrections

If standard conditions are not met – correction must be done

2.9.1 Taping Errors

Make correction for systematic errors
Use technique and equipment – reduce random error

Systematic Error

Slope, Erroneous tape length, Temp. Tension and Sag

Random errors:

Slope, temp tension and sag alignment marking and plumbing

2.10 Slope Corrections

-Hor. Dist. (H) / Slope dist. (S) = Cos θ

$H = S \cos \theta$

-Also $H^2 + V^2 = S^2$ $H = (S^2 - V^2)^{1/2}$

-Slope – gradient (rate of grade) Ratios V/H * 100 %

= (tan θ) * 100 %

-Given: Slope distance. S and slope angle

H/S = Cos θ then $H = S \cdot \cos \theta$

-Given: Slope distance. S and gradient (slope)

Grad./100 = tan θ ; Find θ

Then; H/S = Cos θ ; Find H

-Given: Slope distance. And S vertical. distance.

$H = (S^2 - V^2)^{1/2}$

2) Erroneous tape length correction

Nominal length = 20.00 m Actual length (under standard conditions) = 19.995
Distance measured = 200.000
Correction per tape length = -0.005
Number of tires tape used = 200.000/20 = 10
Total correction = 10 * 0.005 = 0.05 m
= 19.95/20 * 200 = 199.95

Layout example: *Reverse the sign of the correction*

Example:

Slope distance = 150 m Grade. 2% Horiz. Dist. = ??

Tan θ = 2/100 = 0.02 ; find θ ?
H = 150 Cos θ

Example: If S = 150 m and V = 3.00 m
3/150 = tan θ Find θ
H = 150 Cos θ or H = 150^2 - 3^2

- If slope is too steep – use breaking tape operation and keep tape horizontal for short distance.
- If tape length is large (100 m) (route survey) measure slope distance and slope angle using clinometer (Abney hand level)

2.11 Erroneous tape length correction

Tapes are considered correct under standard condition. Long use cause change in length (repair or correction) nominal length

Example: Tape nominal =30 m actual = 29.95 m
Correction per length = 29.95 – 30 = -0.05 m
Distance = 150 m
Correction = -0.05 * 150/30 = -0.25
Correct distance =150 - .25 = 149.25 m
To layout 150m =150 + 0.25 = 150.25 change sign

2.12 Tension and sag correction.

Standard tension 10 lb 5 kg (f) 50 N
Tension (Pull) correction due to Elongation
C_P = (P - Ps) L/A*E (see Table 2.1)
P = applied force
P_s = Standard force
A = cross sectional area of tape
E = Average Modulus of elasticity force/areas

If P > Ps correction is positive (add) and vice versa

Ex. 29, given: 30 m steel tape
P_s = 50 N
P = 100 N X-Area = 0.02 cm^2
Required Tension Error

C_P = (100 – 50) 30/0.02 * 21 * 10^5 * 9.87 = + 0.0036 m per tape length

182.716 m distance – correction

Error = 182.716/30 * 0.0036 = + 0.022 m

Corrected distance = 182.716 + 0.022 = 82.738 m

Can calculate area (X-sec) by tape area = Weight/Length * Specific Weight

2.12 Sag Correction

$C_s = -W^2 L/24 P^2 = -w^2L^3/24 P^2$
W = Tape weight
w = Tape weight per unit length
$W^2 = w^2 L^2$ $W = wL$

See Ex. 2.11

Normal Tension

Tension to compensate for Sag

$P_n = 0.204W (AE/(P_n - P_s))^{1/2}$ Solve by trial and error

Determine normal tension by experiment

1. Lay out tape on flat floor
2. Select a mark and hold 100.00 at this mark
3. Attach a tension handle and apply P_s and mark 0.00 point
4. Repeat switching
5. Raise tape, use plumb bobs and apply tension until both bobs on the 100 and 0.00 marks. Record P_n.

Temp. Correction

Standard 68^oF or 20^oC
Coefficient of thermal expansion a = 0.00000645 per unit length per ^oF
= 0.0000116 per unit length per ^oC

$C_t = a (T - T_s) L$

See Ex. 2.6, 2.7

Invar steel tape low a $8.6 * 10^{-7}/^oC$