ENGINEERING SURVEYING

REFERENCE

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Surveying

85% theoretical (35 % +50% final)

15% practical (5%field +10 % reports)

الدكتور محمد عبدالله عبد

GREEK ALPHABET

A	α		alpha	N	ν	nu
B	β		beta	Ξ	ξ	xi
Γ	γ		gamma	O	o	omicron
Δ	δ		delta	Π	π	pi
E	ϵ		epsilon	P	ρ	rho
Z	ζ		zeta	Σ	σ	sigma
H	η		eta	T	τ	tau
Θ	θ	ϑ	theta	Υ	υ	upsilon
I	ι		iota	Φ	ϕ	phi
K	κ		kappa	X	χ	chi
Λ	λ		lambda	Ψ	ψ	psi
M	μ		mu	Ω	ω	omega

Chapter one

Surveying

Surveying: may be define as the science and art of making measurements of the relative positions of natural and man-made features on the earth surface, and plotting of these measurements to some suitable scale to form a map, plan or section.

Types of survey

A simple classification is:

1. Land surveys, which fix property lines, calculate land areas and assist with the transfer of real property from one owner to another.

2. Engineering surveys, which collect the data needed to plan and design engineering projects. The information ensures the necessary position and dimension control on the site so that the structure is built in the proper place and as designed.

3. Informational surveys obtain data concerning topography, drainage and man-made features of a large area. This data is portrayed as maps and charts.

1-Types of surveying by accuracy

Another way to make a simple classification is:

1- Plane surveying (neglected earth curvature)

Plane surveys, which consider the surface of the earth to be a plane. Curvature is ignored and calculations are performed using the formulas of plane trigonometry and the properties of plane geometry. These may be considered accurate for limited areas.

2- Geodetic surveying (earth curvature):-

Geodetic surveys are precise and over large areas require the curvature of the earth to be considered. Distances and angle measurements must be very, very accurate.

A wide variety of techniques are used including triangulation, traversing, trilateration, levelling and astronomical direction fixing.

2- Type of surveying by using

1- Topographic surveying:-

Topographic surveys are performed to gather data necessary to prepare topographic maps. These are multicolour contour maps portraying the terrain; and rivers; highways, railways, bridges and other man-made features.

2- Cadastral surveying:-

Cadastral surveys are executed by the Federal Government in connection with the disposal of vast areas of land known as the public domain.

3-Route surveying (highway, tunnel, railway):-

Route surveys are necessary for the design and construction of various engineering projects such as roads, railways, pipelines, canals and powerlines.

4- City surveying:-

The survey made in connection with the construction of streets, water supply and sewage lines fall under this category.

5- Mine surveying:-

Mine surveys determine the position of underground works such as tunnels and shafts, the position of surface structures and the surface boundaries. Or, This is used for exploring mineral wealth.

6- Photogrammetry:-

Aerial surveys use photogrammetry to produce a mosaic of matched vertical photographs, oblique views of landscape and topographic maps drawn from the photographs.

7- Hydrograph:-

Hydrographic surveys map the shorelines of bodies of water; chart the bottom of streams, lakes, harbours and coastal waters; measure the flow of rivers; and assess

other factors affecting navigation and water resources. The sounding of depths by radar is involved in this type of survey.

8- Gravity(magnetic) Geodesy

3-Types of surveying Classification Based on Instruments Used :-

Based on the instruments used, surveying may be classified as:
(*i*) Chain survey(Taping)
(*ii*) Compass survey
(*iii*) Plane table survey
(*iv*) Theodolite survey
(*v)* Tacheometric survey
(*vi*) Modern survey using electronic distance meters and total station
(*vii*) Photographic and Aerial survey
(*viii*) Leveling surveying

(*viiii*)- GPS

Types of Construction Projects

The part is devoted to construction surveying applications an area that accounts for much surveying activity. Listed below are the types of construction projects that depend a great deal on the construction surveyor or engineering surveyor for the successful completion of the project:

1. Streets and highways
2. Drainage ditches
3. Intersections and interchanges
4. Sidewalks
5. High- and low-rise buildings
6. Bridges and culverts
7. Dams and weirs
8. River channelization
9. Sanitary landfills
10. Mining—tunnels, shafts
11. Gravel pits, quarries
12. Storm and sanitary sewers
13. Water and fuel pipelines
14. Piers and docks
15. Canals
16. Railroads
17. Airports
18. Reservoirs

19. Site grading, landscaping
20. Parks, formal walkways
21. Heavy equipment locations (millwright)
22. Electricity transmission lines.

MEASURMENTS IN SURVEYING

Field measurements (observation):-

There are four basic kinds of measurements in plane surveying:

- Length (distance)
- Angle
- Elevations: (height, level)
- point (coordinates) :

The kinds of measurement are:

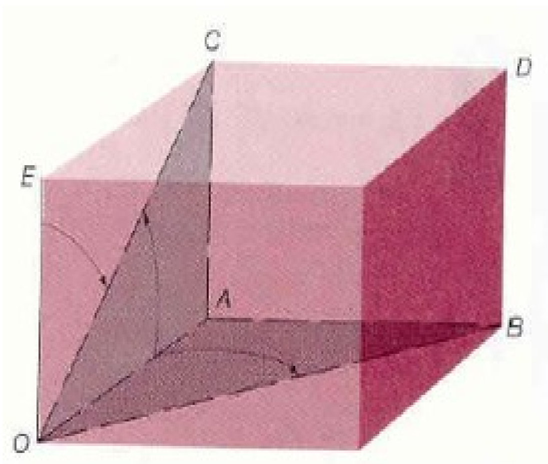
1- Angles: a- Horizontal angles
b- Vertical (or zenith) angles

2- Distance: a- Horizontal distances
b- Vertical distances
c- Slope distances (Oblique)

3- Coordinates:

a- Rectangular coordinate (Grid system x, y, z or E, N, Z).

b- Geographic coordinate (ϕ, λ, z, t).



FIigure 1-1 Kinds of measyrements in surveying

By using combinations of these basic measurements it is possible to compute relation positions between any points. Measurement of distances and angles it is the essence surveying.

Angular Units of Measurements

Magnitudes of measurements must be given in terms of specific units. Units in surveying**.** The most common ones are sexagesimal system and centesimal system

A. The Sexagesimal System:

This system uses degrees, minutes by using combinations of these basic measurements it is possible to compute relative positions between any points. Measurement of distances and angles is the essence of surveying.

Angle**:** it is simply figure formed by the intersection of two lines or figures generated by the rotation of a line about a point from an initial position to a terminal position. The point of rotation is called *the vertex of the angle*.
There are several systems of angle measurement. The most common ones are **sexagesimal** system and **centesimal** system this system uses degrees, minutes and seconds. In this system, a complete rotation of a line (circle) is divided in to 360 degrees of arc. One degree is divided in to 60 minutes and 1 minute is further divided in to 60 seconds of arc.

The sexagesimal units are used in many parts of the world, including the UK, and measure angles
in degrees (°), minutes (′) and seconds (″) of arc, i.e.
1° = 60′
1′ = 60″
and an angle is written as, say, 125° 46′ 35″.

35^0 17′46″ 90^0, 00′ 00″

One can perform additions, subtractions and conversions in the sexagesimal system as follows:

+ 35017′46″ - 90000′00″
  25047′36 35017′46″
 60064′82″ = 61005′22″ 54982′14″

Conversion 35^0 30″ = 35.50^0 142.1250^0 = $142^0$07′30″

B. The Centesimal System

This system uses the grad for angular measurement. Here, a complete rotation is divided in to 400 grads. The grad is sub divided in to 100 parts called centigrad and the centigrad is further sub divided in to100 centi-centigrad (1c =100cc) For conversion 1g = 0.90
Example. 100 grad = 90 degrees

The centesimal system is quite common in Europe and measures angles in gons (g), i.e.
1 gon = 100 cgon (centigon)
1 cgon = 10 mgon (milligon)

C. Radian system

A radian is that angle subtended at the center of a circle by an arc on the circumference equal in length to the radius of the circle, i.e.

2π rad = 360° = 400 gon
Thus to transform degrees to radians, multiply by $\pi/180°$, and to transform radians to degrees, multiply by $180°/\pi$. It can be seen that:
1 rad = 57.2957795° = 63.6619972 gon
A factor commonly used in surveying to change angles from seconds of arc to radians is:
α rad = α "/206 265
where 206 265 is the number of seconds in a radian.

1 degree =1/360 circle = 60 min = 3600 s= 0.01745 rad

1 rad = 57° 17′ 44.8" or about 57.30°
1 grad (grade) =1/400 circle = 1/100 quadrant = 100 centesimal min = 10^4 centesimals (French)
1 mil =1/6400 circle = 0.05625°

D-Units of Angle Measurement

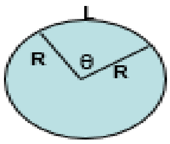
The sexagesimal System

1 degree(°) = 60 minutes (')
1 minutes (') = 60 seconds (")
example : 200 ° 20' 30"

The Decimal or centesimal system (gradian system)

1 g = 100 c
1 c = 100 cc
example : 140 g 30 c 25 cc
1 g = 0.90 °

The radian System



θ in radian = L / R
Angle in radian for complete circle = 2πR /R
= 2π
= 360 °
= 400 g
This leads that (π = 180 ° = 200 g)

angle_conversion.doc 09/25/07 2:04 PM (last print/update)

DMS to Decimal Degree
DMS to Radian

Decimal Degree to DMS
Decimal Degree to Radian

Radian to Decimal Degree
Radian to DMS

Radians with π

Grads to Whatever

***Convert 50.3422222^0 to DMS.
50^0 + .3422222 X 60 = 50^0 20.533332'
= 50^0 20.533332' = 50^0 20' .533332 X 60" = 50^0 20' 32" appx.
Also see the very bottom of the page below the last paragraph.

Conversion	Suggested Formula or Calculator Entry	Example (w/calculator 1-line expression and result)
DMS to Decimal Degree	D+M/60+S/3600 (see *below 1)	Convert 50^0 20' 32" to Decimal Degree. 50+20/60+32/3600 = 50.34222222…
DMS to Radian	(D+M/60+S/3600)*π/180	Convert 50^0 20' 32" to Radian Measure. (50+20/60+32/3600)*π/180 = .8786375302…
Decimal Degree to DMS	*decimal degree*►DMS TI Calculator See above for hand done ***	Convert 50.3422222^0 to DMS. See above for hand done *** 50.3422222►DMS = $50^0$20'32" TI Calculator
Decimal Degree to Radian	*decimal degree**π/180	Convert 50.3422222^0 to Radian Measure. 50.3422222*π/180 = .8786375302…
Radian to Decimal Degree	*radian measure**180/π	Convert .8786375302 radians to Decimal Degree. .8786375302*180/π = 54.3422222…
Radian to DMS	*radian measure**180/π►DMS TI Calculator	Convert .8786375302 radians to DMS. .8786375302*180/π►DMS = 50^0 20' 32" TI Calculator
Express a Radian Measure that is NOT a Multiple of π as a Radian Measure that IS a Multiple of π	*decimal degree*/π Then write as *ans**π	Write .8786375302… radians as a multiple of π. .8786375302/π = .2796790122… Then conclude that .8786375302… radians is approximately equal to .2796790122π radians
Grads to Whatever	Fact: $300^0 = 2\pi$ rad = 400 grad A rare occurrence would be to have an angle in grads. If so, I suggest converting to degrees first and then to whatever. $degrees = 300/400 \cdot grads$	Convert 50 grads to Decimal Degree. $d = 300/400 \cdot 50 = 37.5^{\circ}$

Land Surveying Measurement Conversions:-

A- Units of Length Measurement :

English system

1Mile = 1760 yards (yd)
= 5280 ft
1 Yard = 3 foot (ft)
1 Foot = 12 inches (in)

Metric System

1 Kilometer (km) = 1000 meter (m).
1 Meter (m) = 10 decimeter (dcm).
1 Dicemeter(dcm) = 10 cm.
1 centimeter = 10 mm.
1 link = 0.20 m.

1 inch = 2.54 cm. & 1 ft = 0.3048 m & 1 km = 0.6214 mile
1 mile = (5280*12*2.54)/(100*1000) = 1.609344 km

Units of Area and Volume Measurement:-

B- Units of Area Measurement

English System

In^2 , ft^2 , yd^2 , $mile^2$ (ft^2 , acre)
1 acre = 43560 ft^2

Metric System

1 donum = 1000 m^2
1 hectare (ha) = 10000 m^2
1 km^2 = 100 ha
1 fadan = 4200 m^2

C- Units of Volume Measurement

English System

1 ft^3 = 1728 in^3
1 yd = 27 ft^3

Metric system

1 m^3 = 1000000 cm^3
1 m^3 = 1000 liters
1 liter = 1000 cm^3

• Kilometer is used for large scale drawings.

Hectare
1 Hectre = 10,000 square meters
1 Hectre = 2.471 acres

Acres
1 Acre = .4047 hectare
1 Acre = 4047 square meters

Mile
1 Mile = 1.6 kilometers
1 Mile = 1,609.26 meters
1 Mile Square = 640 acres
1 Mile Square = 259 hectares
1 Mile Square = 2.59 square hectares

Yard
1 Yard = 36 inches
1 Yard = 3 feet
1 Yard Square = 9 square feet

ROUNDING NUMBERS

It is well understood that in rounding numbers, 54.334 would be rounded to 54.33, whilst 54.336 would become 54.34. However, with 54.335, some individuals always round up, giving 54.34, whilst others always round down to 54.33. Either process creates a systematic bias and should be avoided. The process which creates a more random bias, thereby producing a more representative mean value from a set of data, is to round to the nearest even digit. Using this approach, 54.335 becomes 54.34, whilst 54.345 is 54.34 also.

PRECISION AND ACCURACY

Accuracy — Refers to the degree of perfection obtained in measurements. It is a measure of the closeness to the true value. Or-Degree of perfection obtained in the results.

Precision — the closeness of one measurement to another. The degree of refinement in the measuring process. The repeatability of the measuring operation. **Or-** Degree of perfection used in the survey.

If multiple observations are made of the same quantity and small discrepancies result, this indicate ***high precision.*** The degree of precision attainable is dependent on equipment sensitivity and observer skill.

a) Results are precise but not accurate
b) Results are neither precise nor accurate
c) Results are both precise and accurate

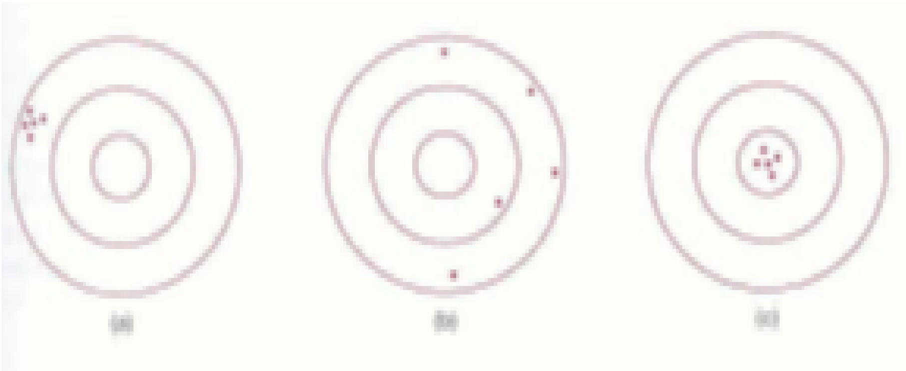
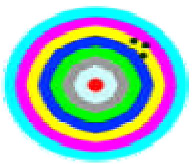


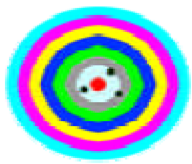
Figure 1-2 Examples of accuracy and precision
(a) Results are precise but not accurate
(b) Results are neither precise nor accurate
(c) Results are both precise accurate

Accuracy and Precision

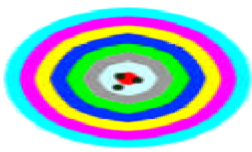
Accuracy is telling the truth . . . Precision is telling the same story over and over again. The need for accuracy is inherent in all of the surveyor's tasks, but especially evident in construction surveying.



Precision



Accuracy



Accuracy with Precision

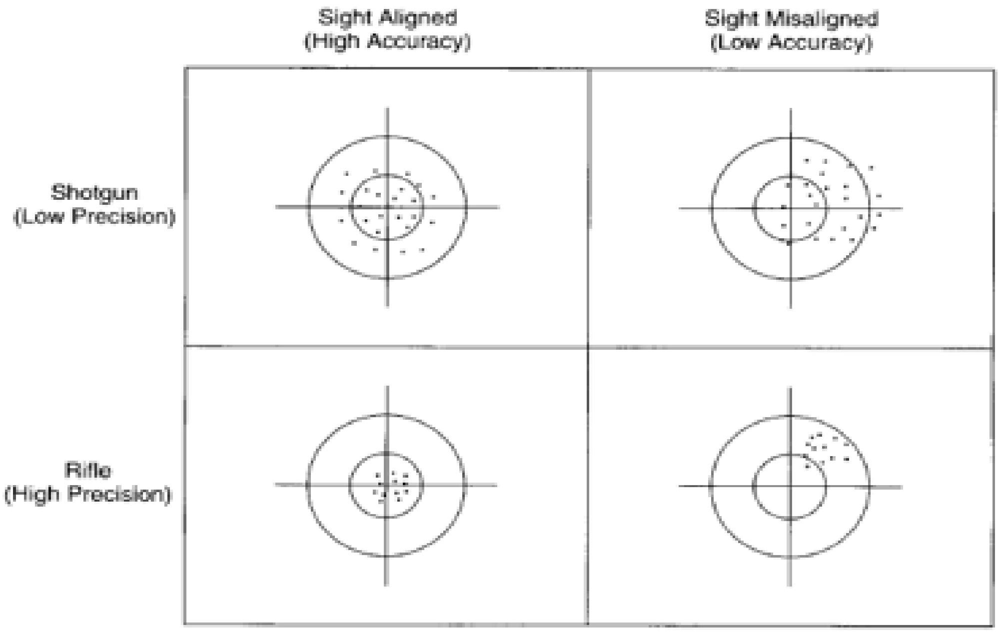


Figure 1-3 an illustration of the difference between accuracy and precision.

In the following example, the more precise method (steel tape) resulted in the more accurate measurement.

	"True "distance	Measured distance	Error
Cloth tape	157.22	157.2	0.02
Steel tape	157.22	157.21	0.01

However, it is conceivable that more precise method can result in less accurate answers. But if the steel tape had previously been broken and in correctly repaired, the result would still be relatively precise but very inaccurate.

Error of Closure

The difference between a measured quantity and its true value is called *error of closure*. In some cases, the closure can be taken simply as the difference between two independent measurements.

For example, suppose a distance from point A to point B is first determined to be 123.25 m. The line is measured a second time, perhaps from B to A, using the same instrument and methods. A distance of 123.19 m is obtained. The error of closure is simply 123.25 – 123.19 = 0.06m. It is due to accidental errors, as long as blunders have been eliminated and systematic errors corrected.

Relative Accuracy

For horizontal distances, **the ratio of the error of closure to the actual distance(measured distance) is called the relative accuracy.**

Relative accuracy is generally expressed as a ratio with unity as the first number of numerator. For example, if a distance of 500 ft were measured with a closure of 0.25 ft, we can say that the relative accuracy of that particular survey is 0.25/500, or 1/2000. This is also written as 1:2000. This means basically that for every 2000 ft measured, there is an error of 1 ft. The relative accuracy of a survey can be compared with a specified allowable standard of accuracy in order to determine whether the results of the survey are acceptable.
Relative accuracy can be computed from the following formula:

Relative accuracy = 1: D/C
Where D = distance measured.
C = error of closure.

1- R.A.= 0.02/157.2 =1/

2- R.A.= 0.01/157.21 =1/

Ex:
Distance measured =196.33 m, the same distance previously known =196.28 m

Error of closure = 196.33 -196.28 = 0.05 m

Accuracy ratio = 0.05/196.28 = 1/3900

Tolerances

The standard sets the maximum allowable difference between the calculated distance and the measured distance between primary control points as:

$$+ \text{ or } - 0{,}75\sqrt{L}\ \text{mm} \qquad \text{where L is the distance in meters}$$

Restated, this simply means that the maximum allowable difference between calculated distances and actual measured distances must be no more than 75% of the square root of the measured distance in meters expressed in millimeters. (In parts of Europe, the comma is used as we use a decimal point in the United States.)

For example, if the calculated distance between primary control points is 36 meters and the measured distance is 36.003 meters, would this be within the limits set by the ISO 4463?

To calculate, plug the values into the formula above.

$$\text{Allowable difference} = .75 \times \sqrt{36} \text{ meters expressed in millimeters}$$

Note: Convert to mm by dividing by 1000.

$$(.75 \times 6) \div 1000 = 5 \text{ mm}$$

Since the difference between the calculated and the measured distances was .003 m (3 mm), the difference does not exceed the limit and is acceptable under the ISO 4463 standard.

A similar standard is used for angles. It is stated as:

$$+ \text{ or } - 0{,}05/\sqrt{L} \text{ gon}$$

Restated, this means that the maximum allowable difference between calculated angles and measured angles must be no more than .05 divided by the length (in meters) of the shortest line associated with the angle. This is expressed in gons. A gon is a European angle measurement equal to .9 degrees. (There are 400 gon in a circle.)

In U.S. terminology and using degrees instead of gons, this formula would be:

$$+ \text{ or } - .045/\sqrt{L} \text{ degrees}$$

For example, if the calculated angle between primary control points is 35°52'10" and the measured angle is 35°52'18" and the shortest leg associated with the angle is 48 meters, is the 8" difference within the tolerances set by ISO 4463?

To calculate, plug the values into the formula above.

$$\begin{aligned}\text{Allowable difference} &= .045/\sqrt{48} \\ &= .006495° \text{ or } 23.38''\end{aligned}$$

The observed difference of 8" is well within the allowable difference of 23.38".

Defining Terms

Accuracy — Refers to the degree of perfection obtained in measurements. It is a measure of the closeness to the true value.
Precision — The closeness of one measurement to another. The degree of refinement in the measuring process. The repeatability of the measuring operation.

Problem 2.28
Explain the difference between accuracy and precision.
Accuracy is how close a measurement is to the actual or real value.
Precision is how repeatable a measurement is.

The **accuracy ratio** of a measurement or a series of measurements is the ratio of the error of closure to the distance measured. The error of closure is the difference between the measured location and its theoretically correct location. Because relevant systematic errors and mistakes can and should be eliminated from all survey measurements, the error of closure will normally be composed of random errors.
To illustrate, a distance is measured and found to be 196.33 ft. The distance was previously known to be 196.28 ft. The error is 0.05 ft in a distance of 196.28 ft:
Accuracy ratio =0.05/196.28 =1/3,926 =1/3,900
The accuracy ratio is expressed as a fraction whose numerator is 1 and whose denominator is rounded to the closest 100 units. Many engineering surveys are specified at 1/3,000 and 1/5,000 levels of accuracy; property surveys used to be specified at 1/5,000 and 1/7,500 levels of accuracy. With polar layouts now being used more often in total station surveys, the coordinated control stations needed for this type of layout must be established using techniques giving higher orders of accuracy (e.g., 1/10,000, 1/15,000, etc.). Sometimes the accuracy ratio, or error ratio, is expressed in parts per million (ppm). One ppm is simply the ratio of 1/1,000,000; 50 ppm is 50/1,000,000, or 1/20,000. See Tables 3.1 and 3.2 and Tables 9.2–9.5 for more current survey specifications and standards.

1- Define Surveying?

Surveying can be defined as an art to determine the relative position of points on above or beneath the surface of the earth with respect to each other by measurement of horizontal and vertical distances, angles and directions.

2-State the principles of Surveying?

Surveying is Location of a point by measurement from other points of reference and Working from whole to part.

3-What are the steps involved in the survey?

Steps to be followed during survey are,
1-Reconnaissance.
2-Marking and fixing survey stations.
3-Running survey lines.

11. Differentiate Accuracy and Precision?

Precision: It is the degree of perfection used in the instruments, the methods and observations.

Accuracy: It is the degree of perfection obtained.