

Plane Surveying: *Construction Layout*

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Types of Surveys

- Plane Survey
- Geodetic Survey
- Topographic Survey
- Property Survey
- Route Survey
- Hydrographic Survey
- As-built Survey
- Preliminary Survey



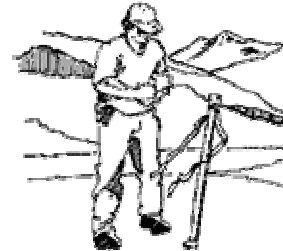
Common types of surveys

○Boundary Surveys

- [Monumented Land Survey \(Pin Survey\)](#)
- [Land Survey Plat](#)
- [Improvement Survey Plat](#)
- [American Land Title Association \(ALTA\) Survey](#)
- [Subdivision Plats](#)
- [Condominium Maps](#)

○Engineering Surveys

- [Topographic Surveys](#)
- [Plan and Profile](#)
- [Digital Terrain Modeling](#)
- [Aerial Mapping](#)
- [Right-of-way Acquisition](#)
- [Construction Surveying](#)
- [Subdivision Plats](#)



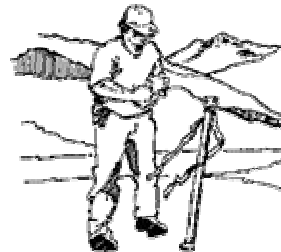
Common types of surveys

○Environmental Surveys

- [Remedial Construction Surveying](#)
- [Monitor well locations](#)

○Other Services

- [Drafting Services](#)
- [Planning Services](#)
- [Legal Descriptions](#)
- [Flood Certificates](#)
- [Elevation Certificates](#)



Construction Surveying

- Construction surveying is the translation of construction plans into physical points on the ground that can be used as a basis for the actual construction.
- The results of construction surveying are seen in almost any urban, suburban, and even rural setting.
- Almost any roadway, building, or other man-made improvement probably had some amount of construction surveying involved.
- Construction surveying provides not only the horizontal location of new improvements, but also the vertical information required to ensure that surfaces drain or pipes flow as required.



Construction Surveying

The need for accuracy is inherent in all of the surveyor's tasks, but especially evident in construction surveying.

It is not only important to perform all calculations correctly, but also to communicate clearly with the contractor about the distance of offsets and reference points for grades.

Additionally, scheduling should be coordinated in a manner that minimizes the risk of the stakes being damaged by human or natural activities, as any disturbance to the survey stake may carry over to actual construction



Accuracy and Precision

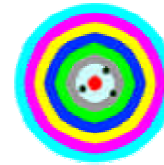
Accuracy is telling the truth . . . Precision is telling the same story over and over again.

(Yiding Wang, yiwang@mtu.edu)

The need for [accuracy](#) is inherent in all of the surveyor's tasks, but especially evident in construction surveying.



Precision



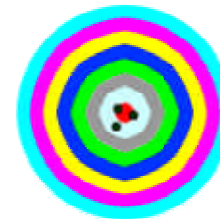
Accuracy

Accuracy and Precision

Precision is the degree of refinement in the performance of an operation, or the degree of perfection in the instruments and methods used to obtain a result.

An indication of the uniformity or reproducibility of a result.

Precision relates to the quality of an operation by which a result is obtained, and is distinguished from accuracy, which relates to the quality of the result.

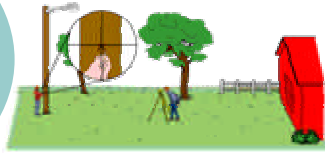


Accuracy with Precision

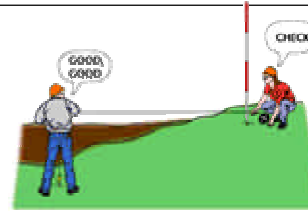


Accuracy is the degree of conformity with a standard (the "truth"). Accuracy relates to the quality of a result, and is distinguished from precision, which relates to the quality of the operation by which the result is obtained.

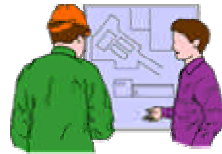
Common-sense Checks of Construction Layout



Calibrate all equipment before performing layout work.



Check your work from a different angle.



Have someone else check your work.



Justify your time requirements.

Do you “wingding”?

Often while performing construction layout activities, a quick, approximate 90-degree angle is needed to obtain a perpendicular line to your layout work.

Perhaps you are setting clearing stakes perpendicular to the centerline of a road—and a rough 90 is all that is needed.

For a quick perpendicular, it isn't practical to set up an instrument for this type of 90.

Experienced field personnel use two quick methods to establish this 90.



One is a simple process of using your anatomy and the other is using a simple prism device.

Winding:



Metes and Bounds

Expressing distances and angles, both graphically and in writing, is the primary means of communication for the surveyor. The boundaries of a parcel of land may be shown graphically by drawing a map called a “plat” or may be described in writing by a technique known as “metes and bounds.” The written description, metes and bounds, is also sometimes called the “legal description.” These written descriptions are found in deeds, wills, and other legal documents in which property must be precisely described. These documents are often kept on file in courthouse records, legal and real estate offices, and other legal-document depositories across the country.



Metes and Bounds

Reproduced below is part of a legal description of a piece of real estate located in Erath (pronounced E-rath) County, Texas. The original survey was done and the description written in the late 1800s.

Situated in Erath County, State of Texas, a part of the James Parclay League; Beginning at a stone mound in a spring branch on the North line of said Parclay survey, 986 varas from its N.W. Corner, from which a live oak tree brs. North 7 degrees west 14 varas, and another bears South 51 1/2 degrees E. 8 vrs.; Thence South 1466 vrs. to a stone mound from which a post oak bears . . .



Metes and Bounds

A legal description written in the 1990s is show below.

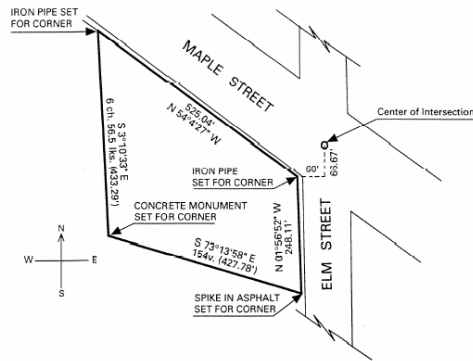
BEGINNING at an iron rod found for corner, said point being S. 44 deg. 24 min. 17 sec E. a distance of 1050.37 feet and S. 47 deg. 00 min. 02 sec. W. a distance of 594.93 feet from the Northmost corner of the E. Turner survey:

THENCE S. 47 deg. 00 min. 02 sec. W along and near a fence a distance of 476.03 feet to an iron rod found for corner;

THENCE . . .



Metes and Bounds



Tolerances

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

$$+ \text{ or } - 0.75 \sqrt{L} \text{ mm} \quad \text{where } L \text{ is the distance in meters}$$

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 $35^{\circ}52'10''$ and the measured angle is $35^{\circ}52'18''$ and the shortest leg associated with the angle is 48 meters, is the 8" difference within the tolerances set by ISO 4463?

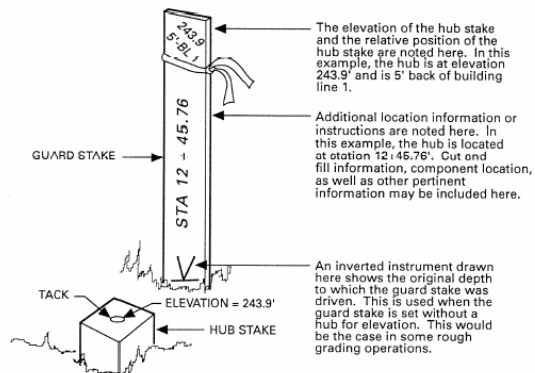
To calculate, plug the values into the formula above.

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

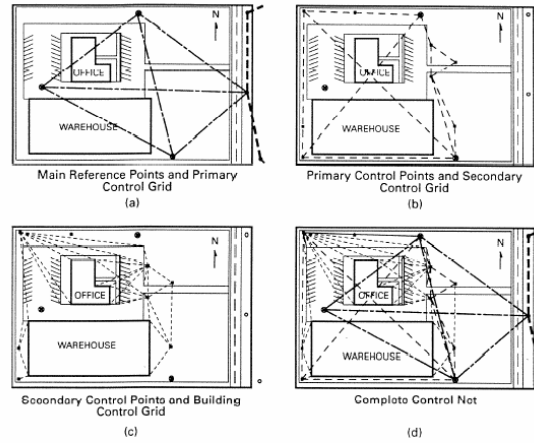
The observed difference of 8" is well within the allowable difference of 23.38".



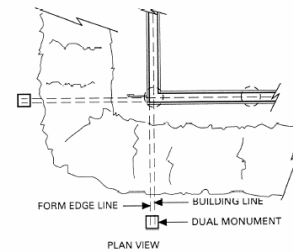
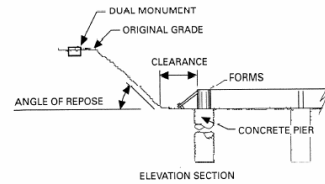
Typical guard stake markings



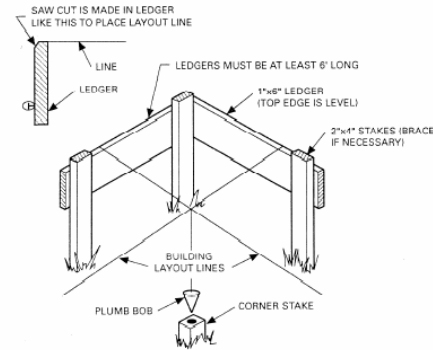
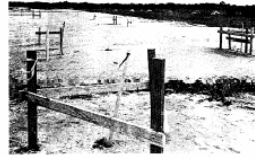
Control points



Monuments & Control lines

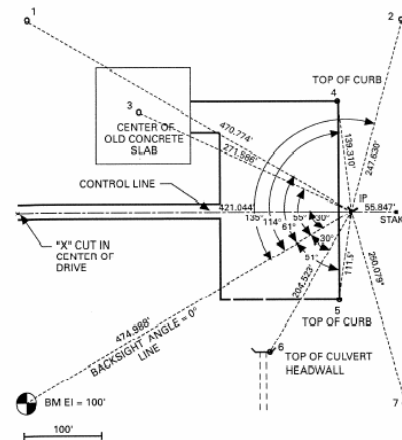


Batter boards



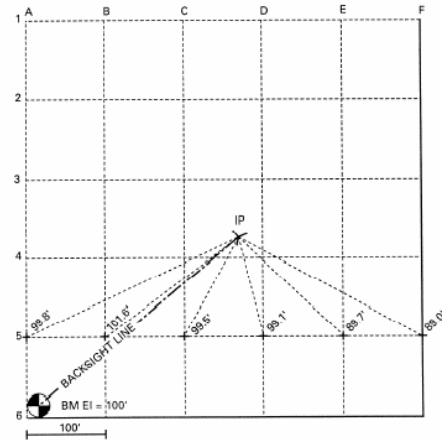
Field data collection

Direct (or radial) method

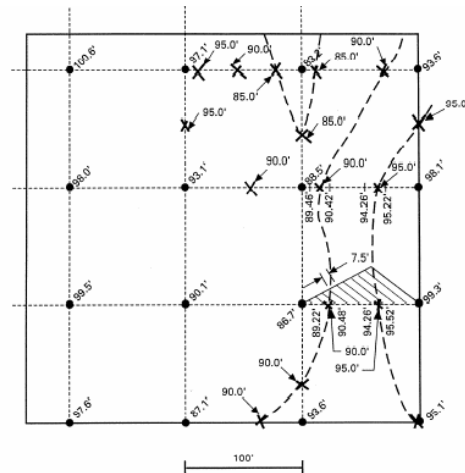


Field data collection

Grid method



Topo maps from field data

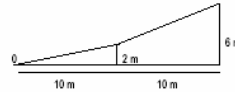


Volume of Excavation

Section Method

Draw sections depicting the depths of excavation across the width of the building at each end and along each lateral grid line.

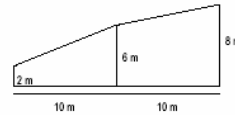
Example: The following example shows the calculation of the volume of excavation for the foundation of a 30 m long by 20 m wide building, grid lines being spaced at 10 m intervals.



Section 1-1 (at south end)

$$S_{1-1} = \left(\frac{2+0}{2} + \frac{2+6}{2} \right) 10 = 50 \text{ m}^2$$

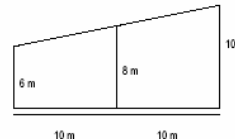
$$S_{1-2} = \frac{50+110}{2} = 80 \text{ m}^2$$



Section 2-2

$$S_{2-2} = \left(\frac{2+6}{2} + \frac{6+8}{2} \right) 10 = 110 \text{ m}^2$$

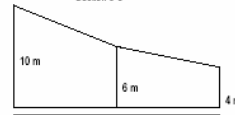
$$S_{2-3} = \frac{110+160}{2} = 135 \text{ m}^2$$



Section 3-3

$$S_{3-3} = \left(\frac{6+8}{2} + \frac{8+10}{2} \right) 10 = 160 \text{ m}^2$$

$$S_{3-4} = \frac{160+130}{2} = 145 \text{ m}^2$$



Section 4-4 (at north end)

$$S_{4-4} = \left(\frac{10+6}{2} + \frac{6+4}{2} \right) 10 = 130 \text{ m}^2$$

$$\text{Total volume} = 80(10) + 135(10) + 145(10) = 3600 \text{ m}^3$$

$$\text{Cost @ \$10.00 per m}^3 = 3600(10) = \$36,000.$$



Grid square method



$$V_1 = \left(\frac{0+2+2+6}{4} \right) (10)(10) = 250 \text{ m}^3$$

$$V_2 = \left(\frac{2+6+8+6}{4} \right) (10)(10) = 550 \text{ m}^3$$

$$V_3 = \left(\frac{2+6+8+6}{4} \right) (10)(10) = 550 \text{ m}^3$$

$$V_4 = \left(\frac{6+8+10+8}{4} \right) (10)(10) = 800 \text{ m}^3$$

$$V_5 = \left(\frac{6+8+6+10}{4} \right) (10)(10) = 750 \text{ m}^3$$

$$V_6 = \left(\frac{8+10+4+6}{4} \right) (10)(10) = 700 \text{ m}^3$$

Total volume = 250 + 550 + 550 + 800 + 750 + 700 = 3600 m³
Check section method (a)



Volume calculations

Short way of calculating volume using Grid Square Method

Let,

n1 = no. of corner points = 4 above

n2 = no. of intermediate side points = 6 above

n3 = no. of interior intersection points = 2 above

Now, total cut is:

$$\begin{aligned} \Sigma h_c &= 1(\Sigma \text{corner cut depths}) + 2(\Sigma \text{intermediate side point cuts}) \\ &\quad + 4(\Sigma \text{interior intersection point cuts}) \\ &= 1(0+6+4+10) + 2(2+8+10+6+6+2) + 4(6+8) = 144 \text{ m} \end{aligned}$$

Average cut:

$$\text{Total volume} = \text{Area} \times \text{Average cut} = 30(20)(6) = 3600 \text{ m}^3$$

Cost at \$10.00 per m³ = (3600)(10) = \$36,000. Check method (a).



Field Exercise

