International Journal of Education and Learning
Vol.4, No.2 (2015), pp.17-28
http://dx.doi.org/10.14257/ijel.2015.4.2.03

# Educating Students with Land Surveying

Tomas U. Ganiron Jr

*Institute of Transportation Engineers, Washington, USA*
*College of Architecture, Qassim University, Buraidah City*
*tomasuganironjr@gmail.com*

***Abstract***

*This descriptive research focuses on the role of land surveying in the development of an architectural plan starting at the initial architectural sketch through the detailed engineering planning which will leads smoothly to the construction phase. It comprises a leveling network that has been established and all points have been described completely. Parameters such as horizontal distance, horizontal angles and elevation differences between all points were measured through many closed leveling loops using theodolite (Leica Builder 300), tape measure & wheels (steel tape) and stave (leveling rod). The observations were used in a mathematical model and processed by traverse adjustment techniques. It is essential to check the error of closure for interior angles and for both latitude and departure before applying the double meridian distance (DMD) method to obtain the required area of the land. The adjusted unknowns and observations were computed precisely to about a few millimeters accuracy. Technical descriptions of the land such as distance, bearing, boundaries and area are necessary to visualize the shape & exact location of the land.*

***Keywords:*** *double meridian distance, latitude, departure, bearing, engineer survey*

## 1. Introduction

We deal with a lot of important issues in our lives but the three that seem most timeless and universal are our families, our health, and our rights to our land. Our welfare is directly affected by our ability to define our space. That's one of the land surveyor's most important jobs, to mark, describe, and map property ownership. His or her work creates a stable framework on which we can build our homes and communities, and generate the wealth necessary to sustain those communities. If we don't know the location of the boundaries of our land we can't enjoy any unique use of it. We could not buy, sell, mortgage or develop land in an orderly and predictable fashion.

The land surveyor provides that knowledge. The rules of land surveying may vary depending on whether you practice in the states of the original 13 colonies, or in the Public Land Survey System [1]. There's one fundamental principle that governs our work. In the words of Justice Cooley of the Michigan Supreme Court, "No man loses title to his land or any part of it merely because the evidence of where it once was becomes uncertain [2]." The perpetuation of property rights and title is tied to the land.

Land surveyors use computers, precise measuring tools, and mapping systems to gather and analyze data (evidence) in the field. They then interpret that data to establish the most probable location for property corners. Their opinions are formed from knowledge of common law, rules of evidence, state and federal laws, and local standards of practice. In many ways it is much an art as it is science.

ISSN: 2234-8034 IJEL

## 2. Literature Review

In order to resolve the deficiencies of the common law and deeds registration system, Robert Torrens introduced the new title system in 1858, after a boom in land speculation and a haphazard grant system resulted in the loss of over 75% of the 40,000 land grants issued in the colony (now state) of South Australia [3]. He established a system based around a central registry of all the land in the jurisdiction of South Australia, embodied in the Real Property Act 1886 (SA) [4]. All transfers of land are recorded in the register. Most importantly, the owner of the land is established by virtue of his name being recorded in the government's register. The Torrens title also records easements and the creation and discharge of mortgages

The Torrens title system operates on the principle of "title by registration" (*i.e.*, the indefeasibility of a registered interest) rather than "registration of title." The system does away with the need for a chain of title (i.e. tracing title through a series of documents) [5]. The State guarantees title and is usually supported by a compensation scheme for those who lose their title due to the State's operation. There are other parcels of land which are still unregistered.

The Certificate of Title shows: the present owners, easements such as underground pipes that may require access for storm water or sewage, and 'right of carriageway' for neighbors get access to their property, covenants such as building restrictions, caveats such as a requirement for someone's approval before transfer of ownership and mortgages [6].

The measure of land is its area. But area itself is not measured. It is calculated. The calculation of the area of a piece of land is easy enough when it has a regular shape. A regularly shaped piece of land, of course, has many practical advantages. Towns, cities, counties and large portions of this country are laid out in a grid, not merely for aesthetic reasons or for ease of laying them out, but because a grid allows for an eminently efficient use of the land. But for surveyors and assessors, the advantage of the regular shape, especially of small lots, is that it makes area calculations a matter of simple multiplication.

Unfortunately, parcels of land are seldom regular in shape. Often, especially in colonial days, they were occupied long before they were surveyed. Inhabitation followed the terrain, an invariable feature of which is its irregularity. The resulting pieces of ground usually had straight lines between corners, but indeterminate shapes.

Calculating the area of such a form has been known since Euclid [7]. The trick is to break up the irregular shape into manageable components, and then perform the appropriate multiplications and sums. By colonial times, the mathematics involved was greatly facilitated by the invention of logarithms and trigonometric function tables. Given these, and reasonably accurate field measurements, any colonial surveyor could calculate its area with a pencil - "more or less".

The colonial surveyors were using a standardized method called "DMD", the abbreviation for double mean distance or double meridian distance [8].

Once transits were used, the first step in the DMD method was to balance the angles. They could be interior or exterior. The field check was to add up the number of sides to the figure, either less by two (interior) or more by two (exterior), times 180 degrees [9]. That sum could be compared to the sum of the angles turned for an initial check. The angles were not always adjusted for balance, but if they were, the error was most likely distributed proportionately among all the angles.

The second step was to calculate the latitudes and longitudes. This required looking up the cosines and sines for the directions of the property lines with respect to north and south. (This is the rationale for quadrants in the first place). These functions were generally carried to eight places after the decimal point, and then multiplied by the lengths of the lines [4, 10].

The results were arranged in columns: N, S, E, and W. North and East were positive, and South and West were negative.

The third step was to balance these columns. Theoretically, the sum of the latitudes and the sums of the departures must equal zero, for the figure to close. Since measurements are inherently imprecise, they never really equaled zero, and were mildly suspect when they did. From the difference in the starting and ending latitudes and departures, the direction and length of the closing line were calculated. The error of closure was most easily eliminated by placing it in the line(s) whose direction most nearly mimicked the closing line. The error could also be distributed in other ways. The most methodical way was to distribute the error proportionately, the correction in each line being determined by the closing line multiplied by the ratio of a line length to the total perimeter length. However the error was reapportioned, the latitudes and departures would then be recalculated.

The next step was to calculate a series of areas, one corresponding to each of the parcel lines. A longitudinal line was drawn, at least hypothetically, through the westerly-most corner of the parcel plat, and latitudinal lines drawn from the corners to that line. The result was a series of areas, the first and last of which were triangular and the rest trapezoidal in shape. At this point, the procedure was to add the two departures of each area and multiply the sum by the longitudinal divergence of the line shown in Figure 1.

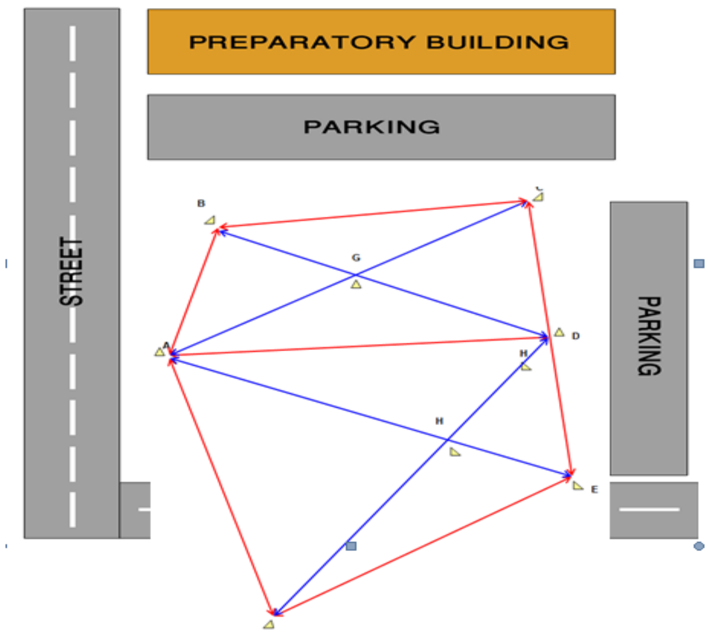


**Figure 1. Location Plan**

The result was not an absolute number for each area, but a number with a positive or negative sign, derived from the signs ascribed in step two. The last step was to add all these areas and divide the sum by two. By simply adding the two sides of each trapezoidal area, a rectangular area double the size of the trapezoid was calculated, thus requiring the division by two.

Local leveling networks such as A, B, C, D, E, F, G, and H were established. There were twenty leveling sections were measured between points shown in figure 2.

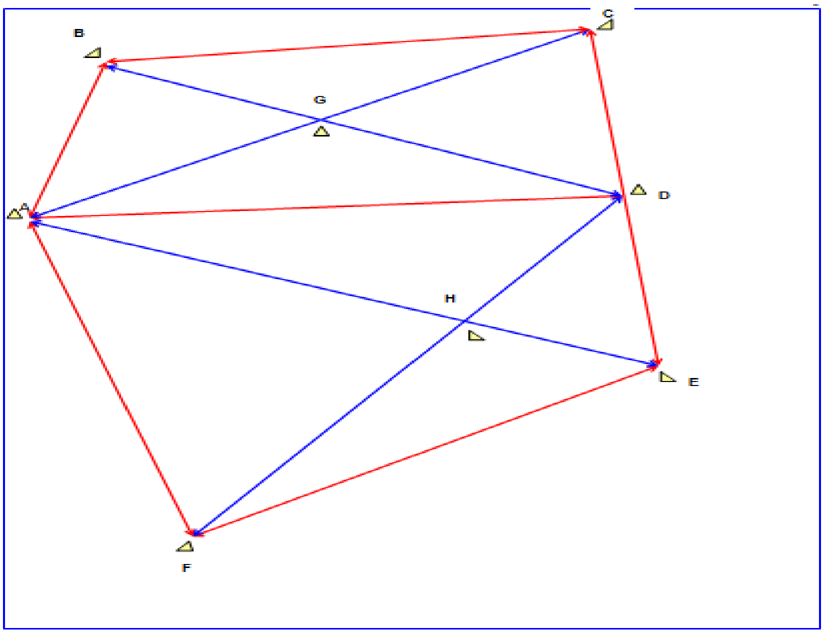


**Figure 2. Leveling Network**

Having points of a network been established, each selected point is described well by distance and angle. Data are gathered using steel tape and theodolite. The data used in mathematical models were processed and analyzed by using two techniques of traverse adjustment, the compass rule and transit rule. It covered the double prime distance (DMD) and double area as methods in the computation of area for traverse adjustment. The observed elevation differences are tabulated in Table 1.

**Table 1. Observed Elevation Differences**

| No. | Leveling Section | | Distances (m) | Elev. Diff. $\Delta h_i$ (m) |
|---|---|---|---|---|
| | From | To | | |
| 1 | A | B | 45.60 | 1.385 |
| 2 | A | C | 127.00 | 0.715 |
| 3 | A | D | 124.90 | 0.205 |
| 4 | A | E | 161.80 | 0.515 |
| 5 | A | F | 100.00 | 2.410 |
| 6 | B | C | 100.00 | 2.350 |
| 7 | B | D | 123.75 | 0.715 |
| 8 | C | D | 50.00 | 2.100 |
| 9 | D | F | 100.00 | 0.310 |
| 10 | D | E | 50.00 | 3.000 |
| 11 | E | F | 100.00 | 0.665 |
| 12 | F | H | 55.90 | 0.660 |
| 13 | G | A | 68.90 | 2.450 |
| 14 | G | B | 48.50 | 1.600 |
| 15 | G | C | 58.10 | 0.320 |
| 16 | G | D | 75.25 | 0.410 |
| 17 | H | A | 111.80 | 3.800 |
| 18 | H | D | 55.90 | 1.750 |
| 19 | H | E | 50.00 | 0.610 |
| 20 | H | F | 50.00 | 2.800 |

Figure 3 explains the steps of the program of computation adjustment.

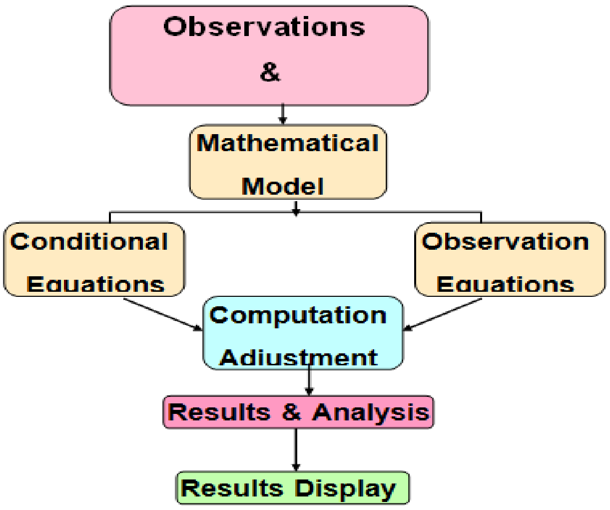


**Figure 3. Program of Computation Adjustment**

## 3. Aims and Objectives

The aims of this project are summarized as follows:

- The project provides the opportunity to conduct a major practical surveying.
- The project develops teamwork and data handling skills.

The objectives are:

- In this project, points of network are to be selected and well described.
- Data, angles, distances and elevation differences are to be collected using leveling rod, steel tape and theodolite.
- Mathematical models for observations and unknowns are to be formed.
- Traverse adjustments and double meridian distance are to be applied for data processing and analysis.

## 4. Methodology

Data are gathered in the field by using leveling rod, steel tape and theodolite. First, the points of network are selected and strictly described to be distinguished easily. The main points are described with respect to the orientation building by a distance and an angle for each point. These points A, B, C, D, E, F, G, and H are described also with respect to each other shown in Figure 4. The elevation differences $\Delta h_i$ are measured between every two points by setting up the theodolite at the mid distance approximately and taking the back sight BS rod/staff reading at the known elevation point and the foresight FS rod/staff reading at the unknown point shown in Figure 5.


**Figure 4. Site of Network**

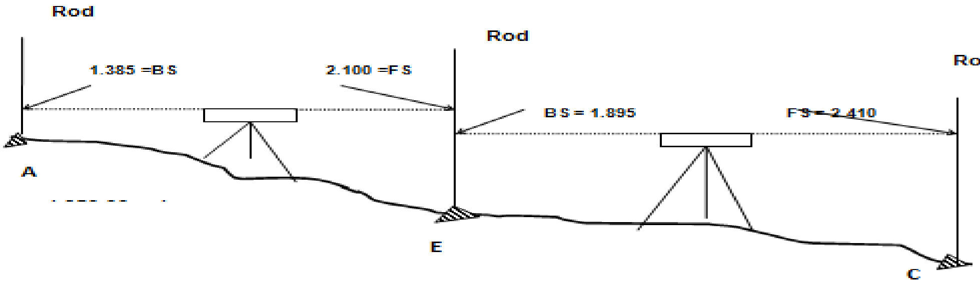


**Figure 5. Differential Leveling**

Table 2 points out the practice field work by theodolite. The lines, distances, elevations and horizontal angles are shown as follows:

**Table 2. Theodolite Observation**

| Line | Distance (m) | Elevation Difference (m) | Angles ( H ) |
|---|---|---|---|
| A-B | 45.60 | 1.385 | 206° 30′ 44″ |
| B-C | 100 | 2.350 | 81° 60′ 30″ |
| C-D | 50 | 2.100 | 155° 15′ 32″ |
| D-E | 50 | 3.000 | 157° 25′ 32″ |
| E-F | 100 | 0.665 | 250° 15′ 34″ |
| A-G | 68.9 | 2.450 | 52° 25′ 46″ |
| B-G | 48.5 | 1.600 | 104° 45′ 32″ |
| G-C | 58.10 | 0.320 | 243° 20′ 33″ |
| G-D | 75.25 | 0.410 | 287° 52′ 32″ |
| F-H | 74.6 | 2.800 | 32° 30′ 32″ |
| A-H | 79.8 | 3.800 | 91° 30′ 48″ |
| A-F | 100 | 2.410 | 128° 40′ 46″ |
| E-H | 51.4 | 0.600 | 287° 10′ 34″ |
| D-H | 63.25 | 1.750 | 220° 60′ 32″ |
| B-A | 45.60 | 1.895 | 206° 30′ 44″ |
| C-B | 100100 | 1.260 | 81° 60′ 31″ |
| F-E | | 2.660 | 250° 15′ 32″ |

 

## 5. Surveying Instruments Used

The surveying equipment used in this work is the Leica Builder 300 theodolite with accuracy ranges 2″ - 5″ for measuring horizontal angles and ± 1 mm for measuring elevation differences. Stave, steel tape, markings, tripod & tribrach were used for measuring elevations and distances.

**Figure 6. Leica Builder 300 Theodolite**

## 6. Results and Discussion

This section presents the observations and unknown parameters, mathematical model, approximate initial values for unknowns and observations, angle computations to unknown, latitudes and departures corrections and table resulted from adjusted bearings.

### 6.1. Latitude and Departure

**6.1.1. Observation and Unknown Parameters:** The vectors of unknown parameters are

$$L_{n-m} = \begin{vmatrix} L_{A-B} \\ L_{B-C} \\ L_{C-D} \\ L_{D-E} \\ L_{E-F} \\ L_{F-A} \end{vmatrix} \qquad D_{n-m} = \begin{vmatrix} D_{A-B} \\ D_{B-C} \\ D_{C-D} \\ D_{D-E} \\ D_{E-F} \\ D_{F-A} \end{vmatrix}$$

The unknown parameters are the latitudes of points A, B, C, D, E and F.

where

$L_{n-m}$ -are the projections on the north-south directions times its horizontal distance and cosine of its bearing.

$D_{n-m}$ - are the projection on the East –west directions times its horizontal distance and sine of its bearing

n = 6 no of observation. m = 6 no of unknown parameters

$$H_{n\text{-}m} = \begin{vmatrix} H_{A\text{-}B} \\ H_{B\text{-}C} \\ H_{C\text{-}D} \\ H_{D\text{-}E} \\ H_{E\text{-}F} \\ H_{F\text{-}A} \end{vmatrix} \qquad \theta_{n\text{-}m} = \begin{vmatrix} \theta_{A\text{-}B} \\ \theta_{B\text{-}C} \\ \theta_{C\text{-}D} \\ \theta_{D\text{-}E} \\ \theta_{E\text{-}F} \\ \theta_{F\text{-}A} \end{vmatrix}$$

The unknown parameters are the points A, B, C, D, E and F.

where

$H_{n\text{-}m}$ - are the horizontal distance of line.

$\theta_{n\text{-}m}$ - are the bearings measured from north or south direction.

**6.1.2. Mathematical Model:** As shown in Table 3, all observation equations are formed according to this mathematical model:

$L_{A\text{-}B} = (H_{A\text{-}B}) \cos \Theta_{A\text{-}B}$ (1)

$L_{B\text{-}C} = (H_{B\text{-}C}) \cos \Theta_{B\text{-}C}$ (2)

$L_{C\text{-}D} = (H_{C\text{-}D}) \cos \Theta_{C\text{-}D}$ (3)

$D_{A\text{-}B} = (H_{A\text{-}B}) \sin \Theta_{A\text{-}B}$ (7)

$D_{B\text{-}C} = (H_{B\text{-}C}) \sin \Theta_{B\text{-}C}$ (8)

$D_{C\text{-}D} = (H_{C\text{-}D}) \sin \Theta_{C\text{-}D}$ (9)

$L_{D\text{-}E} = (H_{D\text{-}E}) \cos \Theta_{D\text{-}E}$ (4)

$L_{E\text{-}F} = (H_{E\text{-}F}) \cos \Theta_{E\text{-}F}$ (5)

$L_{F\text{-}A} = (H_{F\text{-}A}) \cos \Theta_{F\text{-}A}$ (6)

$D_{D\text{-}E} = (H_{D\text{-}E}) \sin \Theta_{D\text{-}E}$ (10)

$D_{E\text{-}F} = (H_{E\text{-}F}) \sin \Theta_{E\text{-}F}$ (11)

$D_{F\text{-}A} = (H_{F\text{-}A}) \sin \Theta_{F\text{-}A}$ (12)

**Table 3. Adjusted Bearings and Traverse Computations**

| LINE | Adjusted bearing | latitude | | departure | |
|---|---|---|---|---|---|
| | | N(+) | S(-) | E(+) | W(-) |
| A-B | N 24° 24′ 19" E | 63.34 | | 15.81 | |
| B-C | N 68° 9′ 9" E | 56.80 | | 77.89 | |
| C-D | S 20° 28′ 3" E | | 22.18 | 14.67 | |
| D-E | S 20° 28′ 3" E | | 22.18 | 14.67 | |
| E-F | S 17° 38′ 1" W | | 43.34 | | 35.16 |
| F-A | S 49° 12′ 49" W | | 30.94 | | 87.88 |

### 6.2. Double Meridian Distance (DMD) and Double Area (DA)

**6.2.1. Observation and Unknown Parameters:** The unknown parameters are the double meridian distance and double areas of A, B, C, D, E and F.

$$DMD_{n\text{-}m} = \left| \begin{array}{c} DMD_{A\text{-}B} \\ DMD_{B\text{-}C} \\ DMD_{C\text{-}D} \\ DMD_{D\text{-}E} \\ DMD_{E\text{-}F} \\ DMD_{F\text{-}A} \\ DMD \end{array} \right| \qquad DA_{n\text{-}m} = \left| \begin{array}{c} DA_{A\text{-}B} \\ DA_{B\text{-}C} \\ DA_{C\text{-}D} \\ DA_{D\text{-}E} \\ DA_{E\text{-}F} \\ DA_{F\text{-}A} \\ DA \end{array} \right|$$

**6.2.2. Mathematical Model:** As shown in Table 4, the DMD of the first line is equal to the departure of line itself. The DMD of the succeeding line is equal to the DMD of preceding line plus the departure of preceding line plus the departure of the line itself. The DMD of the last line is equal to the departure of the line but opposite in sign.

$$DMD_{A\text{-}B} = Dep_{A\text{-}B} \quad (13)$$
$$DMD_{B\text{-}C} = Dep_{A\text{-}B} + Dep_{B\text{-}C} + DMD_{A\text{-}B} \quad (14)$$
$$DMD_{C\text{-}D} = Dep_{B\text{-}C} + Dep_{C\text{-}D} + DMD_{B\text{-}C} \quad (15)$$
$$DMD_{E\text{-}F} = Dep_{D\text{-}E} + Dep_{E\text{-}F} + DMD_{D\text{-}E} \quad (16)$$

Multiply the DMD of the line by its latitude:

$$DA_{A\text{-}B} = DMD_{A\text{-}B}\,(L_{A\text{-}B}) \quad (18) \qquad DA_{D\text{-}E} = DMD_{D\text{-}E}\,(L_{D\text{-}E}) \quad (21)$$
$$DA_{B\text{-}C} = DMD_{B\text{-}C}\,(L_{B\text{-}C}) \quad (19) \qquad DA_{E\text{-}F} = DMD_{E\text{-}F}\,(L_{E\text{-}F}) \quad (22)$$
$$DA_{C\text{-}D} = DMD_{C\text{-}D}\,(L_{C\text{-}D}) \quad (20) \qquad DA_{F\text{-}A} = DMD_{F\text{-}A}\,(L_{F\text{-}A}) \quad (23)$$

Algebraically all the product and divide it by two to get the area

$$\sum DA = DA_{A\text{-}B} + DA_{B\text{-}C} + DA_{C\text{-}D} + DA_{D\text{-}E} + DA_{E\text{-}F} + DA_{F\text{-}A}$$

$$A_T = \frac{\sum DA}{2}$$

**Table 4. Double Meridian Distance and Double Area**

| LINE | Adjusted bearing | Distance ( m) | Lat. | | Dep. | | DMD | DA | |
|---|---|---|---|---|---|---|---|---|---|
| | | | N (+) | S (-) | E (+) | W (-) | | (+) | (-) |
| A-B | N $24^0$24’19’’ E | 45.60 | 63.34 | ---- | 15.81 | ---- | 15.81 | 1001.40 | ---- |
| B-C | N $68^0$9’9’’ E | 100 | 56.80 | ---- | 77.89 | ---- | 109.51 | 6220.16 | ---- |
| C-D | S $20^0$28’3’’ E | 50 | ---- | 22.18 | 14.67 | ---- | 202.07 | ---- | 4481.91 |
| D-E | S $20^0$28’3’’ E | 50 | ---- | 22.18 | 14.67 | ---- | 231.41 | ---- | 5132.67 |
| E-F | S $17^0$38’1’’ W | 100 | ---- | 43.34 | ---- | 35.16 | 210.92 | ---- | 9141.27 |
| F-A | S $49^0$12’49’’ W | 100 | ---- | 30.94 | ---- | 87.88 | 87.88 | ---- | 2719.00 |
| | | ∑ | 120 | 120 | 123.04 | 123.04 | | ∑7221.57 | ∑21474.86 |
| | | | | | | | | X | Y |

### 6.3. Bearing Adjustment Using Compass Rule

**Table 5. Adjusted Bearing**

| Line | Distance | Bearing | Adjusting Bearing |
|---|---|---|---|
| A-B | 45.60 | N 26$^0$30'44'' E | N 24$^0$24'19'' E |
| B-C | 100 | N 70$^0$ 15'34'' E | N 68$^0$9'9'' E |
| C-D | 50 | S 22$^0$34'28'' E | S 20$^0$28'3'' E |
| D-E | 50 | S 22$^0$34'28'' E | S 20$^0$28'3'' E |
| E-F | 100 | S 19$^0$44'26'' W | S 17$^0$38'1'' W |
| F-A | 100 | S 51$^0$19'14'' W | S 49$^0$12'49'' W |

### 6.4. Latitude and Departure Adjustments using Traverse Rule

**Table 6. Latitude Adjustment**

| Line | Distance | Adjusting Bearing | Latitude | | Adjusted latitude | |
|---|---|---|---|---|---|---|
| | | | N (+) | S (-) | N (+) | S (-) |
| A-B | 45.60 | N 24$^0$24'19'' E | 40.80 | ---- | 63.34 | ---- |
| B-C | 100 | N 68$^0$9'9'' E | 33.78 | ---- | 56.80 | ---- |
| C-D | 50 | S 20$^0$28'3'' E | ---- | 46.17 | ---- | 22.18 |
| D-E | 50 | S 20$^0$28'3'' E | ---- | 46.17 | ---- | 22.18 |
| E-F | 100 | S 17$^0$38'1'' W | ---- | 94.12 | ---- | 43.34 |
| F-A | 100 | S 49$^0$12'49'' W | ---- | 62.50 | ---- | 30.94 |

**Table 7. Departure Adjustment**

| **Line** | **Distance** | **Adjusting Bearing** | **Departure** | | **Adjusted Departure** | |
|---|---|---|---|---|---|---|
| | | | **E (+)** | **W (-)** | **E (+)** | **W (-)** |
| **A-B** | 45.60 | N 24$^0$24'19'' E | 20.36 | ---- | 15.81 | ---- |
| **B-C** | 100 | N 68$^0$9'9'' E | 94.12 | ---- | 77.89 | ---- |
| **C-D** | 50 | S 20$^0$28'3'' E | 19.19 | ---- | 14.67 | ---- |
| **D-E** | 50 | S 20$^0$28'3'' E | 19.19 | ---- | 14.67 | ---- |
| **E-F** | 100 | S 17$^0$38'1'' W | ---- | 33.78 | ---- | 35.16 |
| **F-A** | 100 | S 49$^0$12'49'' W | ---- | 78.07 | ---- | 87.88 |

### 6.5. Double Meridian Distance (DMD) and Double Area (DA) Adjustments

**Table 8. Double Meridian Distance and Double Area Adjustments**

| LINE | Adjusted latitude | | Adjusted Departure | | DMD | DA | |
|---|---|---|---|---|---|---|---|
| | N (+) | S (-) | E (+) | W (-) | | (+) | (-) |
| A-B | 63.34 | ---- | 15.81 | ---- | 15.81 | 1001.4054 | |
| B-C | 56.80 | ---- | 77.89 | ---- | 109.51 | 6220.168 | |
| C-D | ---- | 22.18 | 14.67 | ---- | 202.07 | | 4481.9126 |
| D-E | ---- | 22.18 | 14.67 | ---- | 231.41 | | 5132.6738 |
| E-F | ---- | 43.34 | ---- | 35.16 | 210.92 | | 9141.273 |
| F-A | ---- | 30.94 | ---- | 87.88 | 87.88 | | 2719.00 |
| | 120 | 120 | 123.04 | 123.04 | | ∑7221.573 | ∑21474.866 |
| | | | | | | X | Y |

## 7. Conclusion

Having the adjustment both latitude and departure been determined, the double meridian distance, double area and total required area of the land can be determined based on the distance and direction of the bearings. The sum of interior angle for the case of observations is $\sum \Theta$ = $707^0 21'32''$. However, the sum of allowable interior angle is (n-2)$180^0$ =$720^0$ . The error of close for interior angle is -$2^0 6'25''$.So this suggests that the interior angles should be adjusted. Applying the compass rule for interior angles adjustment, the sum of allowable interior angles is equal to the sum of interior angles for the case of observation.

Moreover, the sum of latitude in North direction is 74.58 meters. Moreover, the sum of latitude in South direction is 248.96 meters. The error in latitude is -174.38 meters.

Similarly, the sum of departure in East direction is 152.86 meters while the sum of departure in West direction is 120.85m. The error in departure is 32.01meters.

To eliminate the errors both latitude and departure, traverse rule was applied for traverse adjustments. The results of this adjustments that the difference between the North and South direction for latitude is 0.00. On the other hand, the difference between the East and West direction for departure is 0.00.

The latitude and departure of network points can be determined as long as the angles and distances of the network have been determined. So, this network should be adjusted through transit and compass rule techniques to be able to compute the total areas of the land through double meridian distance.

## References


[1] M. Fajardo, "Elements of roads and highways", Goodwill Bookstore, Manila **(2009)**.

[2] T. U. Ganiron Jr, "Analysis of double meridian distance for a closed traverse area towards developing a contour map and land title", Journal of Engineering Science and Technology Review, vol. 7, no. 2, (**2014**), pp. 36-49.

[3] J. McCormac, "Surveying ($13^{th}$ edition)", John Wiley and Sons, New York (2012).

[4] A. Ashworth, "Willis's practice and procedure for the quantity surveyor", Wiley-Blackwell, New York (**2013**).

[5] T. U. Ganiron Jr, "An analysis of public perception of floods in Manila City", International Journal of Disaster Recovery and Business Continuity, vol. 5, (**2014**), pp.1-14.

[6] S. Ostrowski, "Measurement using the new rules of measurement", Wiley-Blackwell, New York (**2013**).

[7] T. U. Ganiron Jr, "The influence of Megatren system on ridership in Metro Manila", International Journal of u- and e- Service, Science and Technology, vol. 8, no. 1, (**2015**), pp. 91-104.

[8] T. U. Ganiron Jr, "Exploring the emerging impact of Metro rail transit (MRT-3) in Metro Manila", International Journal of Advanced Science and Technology, vol. 74, **(2015**), pp. 11-24.

[9] D. Wilson, "Easements relating to land surveying and title examination", John Wiley & Sons, New York (**2013**).

[10] C. S. Lacsamana, T. U. Ganiron Jr and H. S. Taylor, "Development of multi-level holistic model in integrated learning", International Journal of Education and Learning, vol. 4, no. 1, (**2015**), pp. 1-10.


## Author

**Dr. Tomas U. Ganiron Jr**, obtained his Doctor of Philosophy in Construction Management at Adamson University (Philippines) in 2006, and subsequently earned his Master of Civil Engineering major in Highway and Transportation Engineering at Dela Salle University-Manila (Philippines) in 1997 and received Bachelor of Science in Civil Engineering major in Structural Engineering at University of the East (Philippines) in 1990. He is a registered Civil Engineer in the Philippines and Professional Engineer in New Zealand. His main areas of research interest are construction engineering, construction management, project management and recycled waste materials. He has been the resource person in various seminars in New Zealand (like in Auckland University of Technology, University of Auckland and University of Canterbury). He was connected with Advanced Pipeline System in New Zealand as Construction Manager wherein he supervised the sewerage and waterworks projects. He was the former Department Head of Civil Engineering in FEATI University (Manila) and former Department Head of Physics in Emilio Aguinaldo College (Manila). He is also very active in other professional groups like Railway Technical Society of Australasia and Australian Institute of Geoscientists where he became committee of Scientific Research. He has received the Outstanding Civil Engineer in the field of Education given by the Philippine Media Association Inc. (1996), ASTM Award CA Hogentogler (2008) by IPENZ in New Zealand and Outstanding Researcher (2013) in Qassim University, Buraidah City. On the second week of February 2015, Dr. Ganiron Jr. was included in the Ranking of Scientists according to Google Scholar Citation public profile (http://www.webometrics.info/en/node/81).