المحتويات

- أخطاء المساحة و مصادرها
- ضبط شبكات المساحة
- اختيار نقاط المساحة
- Total Station
  شروط الدقة في استخدام جهاز
- أنظمة الاحداثيات المختلفة
- Surfer
  نبذة عن برنامج
Part One:

Surveying Errors (sources and types)

الجزء الأول

أخطاء المساحة: مصادر و أنواع
Sources of Errors

Measure a distance several times and compare the obtained measurements?

They are not equal and the reason:

- The imperfections of the instruments
- The fallibility of the human operator
- The uncontrollable nature of the environment
Errors always exist in measurements, where:

The error ($e_i$) = the measured value ($x_i$) – the true value ($x$)

But since the true value can never be determined, we can use instead the most probable value ($x_m$). Thus:

$$e_i = x_i - x_m$$

Where,

$$x_m = \frac{\sum_{i=1}^{n} x_i}{n}$$
Types of Errors

- **Blunders (Mistakes)**
- **Random Errors**
- **Systematic Errors**
Blunder Errors (Mistakes)

- caused by human carelessness, fatigue and haste
- can be positive or negative, large or small and their occurrence is unpredictable
- recording 43.18 instead of 34.18 and sighting a wrong target when measuring an observation
- Blunders are disastrous if left in the surveying measurements
- must be eliminated by careful work and by using field procedures that provide checks for blunders
Random Errors

- caused by imperfections of the measuring instruments, the surveyor to make an exact measurement, and the variations in the environment.
- can be minimized by using better instruments and properly designed field procedures and by making repeated measurements.
- have small magnitudes.
- Positive and negative errors of the same magnitude occur with the same frequency. Cancel each other.
- Consider the mean value.
Systematic Errors

- **behave according to a particular system or physical law of nature, which may or may not be known**

- **When the law of occurrence is known, systematic errors can be calculated and eliminated**

- **always occurs with the same sign and magnitude and is therefore often referred to as a constant error**

- **Examples: assuming occupy point coordinates, earth curvature and temperature or pressure corrections**

- **Correction doesn’t require field re-measurements**
Example:

Given 12 measurements of a certain distance, as follows:

58.80, 58.79, 58.77, 58.18, 58.85, 58.80, 58.83, 58.78, 58.82, 58.79, 58.82 & 58.81

- First iteration \( (n = 12) \)

\[
x_m = \frac{\sum_{i=1}^{n} x_i}{n} = 58.75 \text{ m}
\]

\[
\sigma_x = \pm \sqrt{\frac{\sum_{i=1}^{n} (x_i - x_m)^2}{n - 1}} = \pm 0.18 \text{ m}
\]

\[
\text{max. error} = 3\sigma_x = \pm 0.54 \text{ m}
\]
Second iteration (n = 11):

\[ x_m = 58.81 \text{ m} \quad \sigma_x = \pm 0.02 \text{ m} \quad \text{max. error } = \pm 0.06 \text{ m} \]

<table>
<thead>
<tr>
<th>Measurement (m)</th>
<th>First Iteration ( v_i = d_i - \bar{d} ) (m)</th>
<th>Second Iteration ( v_i = d_i - \bar{d} ) (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>58.78</td>
<td>0.03</td>
<td>-0.03</td>
</tr>
<tr>
<td>58.83</td>
<td>0.08</td>
<td>0.02</td>
</tr>
<tr>
<td>58.80</td>
<td>0.05</td>
<td>-0.01</td>
</tr>
<tr>
<td>58.85</td>
<td>0.10</td>
<td>0.04</td>
</tr>
<tr>
<td>58.18</td>
<td>-0.57</td>
<td>blunder \Rightarrow rejected</td>
</tr>
<tr>
<td>58.77</td>
<td>0.02</td>
<td>-0.04</td>
</tr>
<tr>
<td>58.79</td>
<td>0.04</td>
<td>-0.02</td>
</tr>
<tr>
<td>58.80</td>
<td>0.05</td>
<td>-0.01</td>
</tr>
<tr>
<td>58.81</td>
<td>0.06</td>
<td>0.00</td>
</tr>
<tr>
<td>58.82</td>
<td>0.07</td>
<td>0.01</td>
</tr>
<tr>
<td>58.79</td>
<td>0.04</td>
<td>-0.02</td>
</tr>
<tr>
<td>58.82</td>
<td>0.07</td>
<td>0.01</td>
</tr>
</tbody>
</table>
Precision and Accuracy

- **x**: Observation
- **●**: True value

- (a) High precision, high accuracy
- (b) High precision, low accuracy
- (c) Low precision, high accuracy
- (d) Low precision, low accuracy
Precision and Accuracy

In general, to obtain high precision and high accuracy in surveying, the following strategies must be followed:

- Follow techniques that will help detect and eliminate all the blunders.
- Eliminate or correct all systematic errors by frequent calibration and adjustment of the instruments.
- Minimize the random errors by using good instruments and field procedures.
Part Two:

Control points Selection

الجزء الثاني

اختيار نقاط التحكم
Control points

Control points may be:

- Benchmark points \((z)\)
- Horizontal coordinate points \((x, y)\)
- Combined \((x, y, z)\)
Benchmark points

The following conditions should be considered:

- Its elevation should be accurately measured
- Evenly distributed to enable surveyors to use them to determine elevations every where in the region
- Well marked and fixed in the ground
- Have precise description to locate them easily
Benchmark points

نقاط تحكم مناسب
Surveys took on the form of networks of triangles. The vertices of the triangles often became horizontal control points. Initial positions were determined using astronomical observations.

Horizontal coordinates (latitude and longitudes) were determined separately from vertical coordinates (elevation).
GPS points

The following conditions should be considered:

- Suitable location (away from multistory buildings, electric wires, traffic, changeable area, etc)

- Enough distributed points, see at least two other points (backsight and foresight)

- Well marked and fixed in a firm ground

- Have precise description to locate them easily, well documentation
GPS points

نقاط تحكم أحداثيات أفقية بالجي بي أس
GPS points

نقاط تحكم إحداثيات أفقية بالجي بي أس
GPS points
نقاط تحكم احداثيات أفقية بالجي بي أس
GPS points

نقاط تحكم أحداثيات أفقية بالجي بي أس
Increasing the accuracy of GPS coordinate calculation:

- **Point location**
- **The specification of the used receiver**
- **Number of used receivers**
- **Surveyor and GPS operator**
  - Before measuring
  - During measuring
  - After measuring
Property surveys to establish boundaries - Traverse

- **Open traverse**

- **Closed traverse**

(a) Loop traverse  (b) Connecting traverse

△ : Known point  ○ : Survey point

Known direction
Property surveys to establish boundaries - Traverse

The following conditions should be considered:

- Minimum number of stations, as needed
- Lines should be as close as possible to the details to be surveyed
- Distances between traverse stations should be approximately equal
- Stations should be chosen on firm ground, or monumented in a way to make sure that they are not easily lost or damaged
- Easy to see the backsight and foresight stations from one station
Part Three:

Adjustment of Surveying Networks

الجزء الثالث

ضبط شبكات المساحة
Leveling Networks

Ordinary leveling
K=30 mm

Precise leveling
K=5 mm

\[ \varepsilon = h' - h \]

\[ \varepsilon = \pm k \sqrt{D} \text{ mm} \quad D= \text{Distance in Km} \]

\[ \Delta h_i = -\frac{n_i}{\sum n_j} (\varepsilon) \]
Coordinate Networks (Traversing)

Closed loop traverse

- 1. Estimation of the location and workability of the site
- 2. Choosing and fixing the points of the Traverse at the designated locations
- 3. Measurement of the internal or external angles of the Traverse
- 4. Measurement of the lengths of the emission
- 5. Determination of the standard deviation of any emission
- 6. Information of the primary Traverse (Decision Point GPS)
Coordinate Networks (Traversing)

Adjustment process includes:

- **Angle correction**
- **Distance correction**
1. Angles Adjustment

- True sum of internal angles = \((n - 2) \times 180^\circ\)
- Determine the measured sum
- Angle error \(\varepsilon_\alpha =\) measured sum – true sum
- If angle error \(\varepsilon_\alpha \leq (60 – 90)^\circ \sqrt{n}\) , accept the error, else, reject.
- Correct each angle by adding \(- \frac{\varepsilon_\alpha}{n}\) to it
- Compute the corrected azimuth for each traverse side using:

\[
\alpha_2 = \alpha_1 + \phi \pm 180^\circ
\]

If \(\alpha_1 + \phi < 180^\circ\) \(\Rightarrow\) add 180° to get \(\alpha_2\)
If \(\alpha_1 + \phi > 180^\circ\) \(\Rightarrow\) subtract 180° to get \(\alpha_2\)
2. Position Adjustment

- Starting from the known point, calculate the coordinate of all points ending to the start point

- Error in the easting direction ($\varepsilon_x$) = $x_{measured} - x_{true}$

- Error in the northing direction ($\varepsilon_y$) = $y_{measured} - y_{true}$

- Accept or reject errors according to specifications

- Correct positions according to compass rule

  Correction to $\Delta y$ of line $ij = - \frac{\text{length of line } ij}{\text{total traverse length}} \cdot \varepsilon_y$

  Correction to $\Delta x$ of line $ij = - \frac{\text{length of line } ij}{\text{total traverse length}} \cdot \varepsilon_x$
## Allowable errors in traverse surveying

<table>
<thead>
<tr>
<th></th>
<th>Important areas (example: urban areas)</th>
<th>Less important areas (example: rural areas)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measured distances</td>
<td>$\Delta \ell = 0.0005\ell + 0.03 \text{ m}$</td>
<td>$\Delta \ell = 0.0007\ell + 0.03 \text{ m}$</td>
</tr>
<tr>
<td>Measured angles</td>
<td>$\Delta = 60'' \sqrt{n}$</td>
<td>$\Delta = 90'' \sqrt{n}$</td>
</tr>
<tr>
<td>Closure error</td>
<td>$\varepsilon = 0.0006 \sum \ell + 0.20 \text{ m}$</td>
<td>$\varepsilon = 0.0009 \sum \ell + 0.20 \text{ m}$</td>
</tr>
</tbody>
</table>

Where $\ell = \text{measured length}$, $\Delta = \text{angle closure error in seconds}$, $n = \text{number of measured angles}$, $\varepsilon = \sqrt{\varepsilon_y^2 + \varepsilon_x^2}$ (Equation 7.39), $\Delta \ell = \text{allowable error in the measured distance}$.
Example:

Known:
A (5000.00 m, 5000.00 m)
Azimuth of AB = 209° 37' 30"
## Angle correction step

<table>
<thead>
<tr>
<th>Line</th>
<th>Preliminary Azimuth</th>
<th>Correction</th>
<th>Corrected Azimuth</th>
</tr>
</thead>
<tbody>
<tr>
<td>AB</td>
<td>209° 37' 30&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+(\hat{B})</td>
<td>66° 23' 10&quot;</td>
<td>- 5&quot;</td>
<td>96° 00' 35&quot;</td>
</tr>
<tr>
<td></td>
<td>276° 00' 40&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 180</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BC</td>
<td>96° 00' 40&quot;</td>
<td>- 10&quot;</td>
<td>357° 46' 15&quot;</td>
</tr>
<tr>
<td>+(\hat{C})</td>
<td>81° 45' 45&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>177° 46' 25&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>+180</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CD</td>
<td>357° 46' 25&quot;</td>
<td>- 15&quot;</td>
<td>269° 26' 25&quot;</td>
</tr>
<tr>
<td>+(\hat{D})</td>
<td>91° 40' 15&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>449° 26' 40&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-180</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DE</td>
<td>269° 26' 40&quot;</td>
<td>- 20&quot;</td>
<td>151° 43' 35&quot;</td>
</tr>
<tr>
<td>+(\hat{E})</td>
<td>62° 17' 15&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>331° 43' 55&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-180</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EA</td>
<td>151° 43' 55&quot;</td>
<td>- 25&quot;</td>
<td>209° 37' 30&quot;</td>
</tr>
<tr>
<td>+(\hat{A})</td>
<td>237° 54' 00&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>389° 37' 55&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-180</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AB</td>
<td>209° 37' 55&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>209° 37' 30&quot;</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note:** It is also possible to correct the angles by comparing their sum to \((n-2)\cdot180 = 540°\), correcting the angles individually, and then recalculating the azimuths again.

Closure error = + 25"
Correction per angle = -25"/5 = -5"
### Position correction step

<table>
<thead>
<tr>
<th>Station</th>
<th>Corrected Azimuth ($\alpha_{ij}$)</th>
<th>Distance $d_{ij}$ (m)</th>
<th>Departure $\Delta x = d_{ij} \sin \alpha_{ij}$</th>
<th>Latitude $\Delta y = d_{ij} \cos \alpha_{ij}$</th>
<th>Preliminary coordinates</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>209° 37' 30&quot;</td>
<td>773.61</td>
<td>-382.41</td>
<td>-672.48</td>
<td>5000.00 5000.00</td>
</tr>
<tr>
<td>B</td>
<td>96° 00' 35&quot;</td>
<td>1195.95</td>
<td>1189.38</td>
<td>-125.21</td>
<td>4017.39 4327.52</td>
</tr>
<tr>
<td>C</td>
<td>357° 46' 15&quot;</td>
<td>1515.93</td>
<td>-58.96</td>
<td>1514.78</td>
<td>5806.97 4202.31</td>
</tr>
<tr>
<td>D</td>
<td>269° 26' 15&quot;</td>
<td>1127.31</td>
<td>-1127.26</td>
<td>-11.01</td>
<td>5748.01 5717.09</td>
</tr>
<tr>
<td>E</td>
<td>151° 43' 35&quot;</td>
<td>801.63</td>
<td>379.72</td>
<td>-705.99</td>
<td>4620.75 5706.08</td>
</tr>
<tr>
<td>A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5000.47 5000.09</td>
</tr>
</tbody>
</table>

\[ \sum d_{ij} = 5414.43 \text{ m} \]

Closure error: $\varepsilon_y = +0.47 \text{ m}$  
\[ \varepsilon_x = +0.09 \text{ m} \]

Linear error of closure $= \sqrt{(0.47)^2 + (0.09)^2} = 0.48 \text{ m}$
**Position correction step**

<table>
<thead>
<tr>
<th>Station</th>
<th>Cumulative Distance</th>
<th>y-coordinate</th>
<th>x-coordinate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Preliminary</td>
<td>Correction</td>
<td>Final</td>
</tr>
<tr>
<td>A</td>
<td>0</td>
<td>5000.00</td>
<td>0</td>
</tr>
<tr>
<td>B</td>
<td>773.61</td>
<td>4617.59</td>
<td>-0.07</td>
</tr>
<tr>
<td>C</td>
<td>1969.56</td>
<td>5806.97</td>
<td>-0.17</td>
</tr>
<tr>
<td>D</td>
<td>3485.49</td>
<td>5748.01</td>
<td>-0.30</td>
</tr>
<tr>
<td>E</td>
<td>4612.80</td>
<td>4620.75</td>
<td>-0.40</td>
</tr>
<tr>
<td>A</td>
<td>5414.43</td>
<td>5000.47</td>
<td>-0.47</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Line</th>
<th>Final Distance</th>
<th>Final Azimuth</th>
<th>Final Reduced Bearing</th>
</tr>
</thead>
<tbody>
<tr>
<td>A – B</td>
<td>773.65</td>
<td>209° 37' 45&quot;</td>
<td>S 29° 37' 45&quot; W</td>
</tr>
<tr>
<td>B – C</td>
<td>1195.86</td>
<td>96° 00' 39&quot;</td>
<td>S 83° 59' 21&quot; E</td>
</tr>
<tr>
<td>C – D</td>
<td>1515.90</td>
<td>357° 45' 57&quot;</td>
<td>N 2° 14' 03&quot; W</td>
</tr>
<tr>
<td>D – E</td>
<td>1127.41</td>
<td>269° 26' 22&quot;</td>
<td>S 89° 26' 22&quot; W</td>
</tr>
<tr>
<td>E – A</td>
<td>801.60</td>
<td>151° 43' 52&quot;</td>
<td>S 28° 16' 08&quot; E</td>
</tr>
</tbody>
</table>
Thank You !!!!!