## Surveying Engineering



## Lecturer: Dr. Israa Rahman Ghanim

Technical College of Engineering, Najaf - middle Euphrates, Technical University
Building and Construction Engineering Department

## Deflection angles

- Deflection angles : are observed from an extension of the back line to the forward station. They are used principally on the long linear alignments of route surveys. As illustrated in the figure, deflection angles may be observed to the right (clockwise) or to the left (counterclockwise) depending on the direction of the route. Clockwise angles are considered plus, and counterclockwise ones minus, as shown in the figure.



## Deflection angles

Deflection angles are always smaller than $180^{\circ}$ and appending an R or L to the numerical value identifies the direction of turning. Thus the angle at B in Figure is $(\mathrm{R})$, and that at C is $(\mathrm{L})$. Deflection angles are the only exception where counterclockwise observation of angles should be made.

Deflection angles $=$ FW of AB- FW of BC
Forward Az. (لاحّ) = Forward Az. (لابّة) + Deflection Angle to right

or Forward Az. (لادق) = Forward Az. (سابق) - Deflection Angle to left

- Example1: the following polygon was survey by using deflection angle method, if you know that the line $A B=45^{\circ} 00^{\prime}$ and the value of the angles values was as follow $A B C=122^{\circ} \mathrm{R}, \mathrm{BCA}=133^{\circ} \mathrm{R}, \mathrm{CAB}=105^{\circ} \mathrm{R}$. find the direction of line CA.
Solution :

$$
\begin{aligned}
& \mathrm{AB}=45^{\circ} 00^{\prime} \\
& \mathrm{BC}=\mathrm{AB}+\text { Def. Angle to } \mathrm{R} .=45^{\circ}+122^{\circ}=167^{\circ} \\
& \mathrm{CA}=\mathrm{BC}+\text { Def. Angle to } \mathrm{R} .=167^{\circ}+133^{\circ}=300^{\circ} \\
& \mathrm{AB}=\mathrm{CA}+\text { Def. Angle to } \mathrm{R} .=300^{\circ}+105^{\circ}=405^{\circ} \\
& \therefore \mathrm{AB}=405^{\circ}-360=45^{\circ} 00^{\prime} \quad \therefore \text { O.K }
\end{aligned}
$$



- Example2 : the following angles were measured by using deflection method :

| Station | From | To | Deflection angle |
| :---: | :---: | :---: | :---: |
| A | E | B | $142^{\circ} 25^{\prime} \mathrm{L}$ |
| B | A | C | $135^{\circ} 40^{\prime} \mathrm{L}$ |
| C | B | D | $105^{\circ} 35^{\prime} \mathrm{R}$ |
| D | C | F | $48^{\circ} 30^{\prime} \mathrm{R}$ |

If the direction of line $E A=320^{\circ}$, find the other lines directions?. Solution:
$\mathrm{EA}=320^{\circ} \rightarrow \mathrm{AB}=\mathrm{EA}-$ Deflection angle to left $=320^{\circ}-142^{\circ} 25^{\prime}$

$$
\mathrm{AB}=177^{\circ} 35^{\prime}
$$

$\mathrm{BC}=\mathrm{AB}-$ Deflection angle to left $=177^{\circ} 35^{\prime}-135^{\circ} 40^{\prime}=41^{\circ} 55^{\prime}$

$$
\begin{aligned}
& C D=B C+\text { Deflection angle to right }=41^{\circ} 55^{\prime}+105^{\circ} 35^{\prime}=147^{\circ} 30^{\prime} \\
& D A=C D+\text { Deflection angle to right }=147^{\circ} 30^{\prime}+48^{\circ} 30^{\prime}=196^{\circ} 00^{\prime}
\end{aligned}
$$

- Example3 : in the polygon $\operatorname{ABCDEF}$ shown below if the direction of line $D E=50^{\circ} 10^{\prime}$, find the directions of the lines $A B, C D, E F$ ?.

Solution : the angle $65^{\circ} 14^{\prime}$ is a left deflection angle from the extension of the previous line DE to the next line EF. While the angle $105^{\circ} 23^{\prime}$ is aright angle from the previous line CD to the next line DE with clockwise and its considered as interior angle .

Find the interior angle $\theta$ value by using sine law as follow :
$25^{2}=20^{2}+12^{2}-2 * 20^{*} 12 * \cos \theta \rightarrow \theta=99^{\circ} 42^{\prime} 54^{\prime \prime} \approx 99^{\circ} 43^{\prime}$
$\mathrm{EF}=\mathrm{DE}-$ deflection angle to left $=50^{\circ} 10^{\prime}-65^{\circ} 14^{\prime}=-15^{\circ} 4^{\prime}+360$
$\therefore \mathrm{EF}=344^{\circ} 56^{\prime}$
$\mathrm{DC}=\mathrm{DE}+$ External angle at $\mathrm{D}=50^{\circ} 10^{\prime}+(360-$ Internal angle at D$)$
$\mathrm{DC}=50^{\circ} 10^{\prime}+\left(360-105^{\circ} 23^{\prime}\right)=304^{\circ} 47^{\prime}=\mathrm{DG}$
$\mathrm{GD}=\mathrm{DG}-180=304^{\circ} 47^{\prime}-180=124^{\circ} 47^{\prime}=\mathrm{CD}$
$\mathrm{GB}=\mathrm{GD}+\theta=124^{\circ} 47^{\prime}+99^{\circ} 43^{\prime}=224^{\circ} 30^{\prime}=\mathrm{BA}$

$\mathrm{AB}=\mathrm{BA}-180=224^{\circ} 30^{\prime}-180=44^{\circ} 30^{\prime}$

Example 4 : from the survey line $A B$ the linear measurements was taken (offsets) to setting a rectangular fence CDEF, if you know that the line $A B=170^{\circ} 05^{\prime}$, what is the direction of lines $C D$ and $D E$.

$$
\begin{aligned}
& \theta=\tan ^{-1} \frac{15.612}{13.1}=50^{\circ} \quad \text { G which is right-angled at G. } \\
& \alpha=180-(90+\theta)=40^{\circ}
\end{aligned}
$$



اتجاه FG = اتجاه $170^{\circ} 05^{\prime}=$ (لأن FG يوازي AB)
$\mathrm{FC}=\mathrm{FG}+\alpha=170^{\circ} 05^{\prime}+40^{\circ}=210^{\circ} 05^{\prime} \rightarrow \mathrm{CF}=\mathrm{FC}-180=30^{\circ} 05^{\prime}$
الز اوية FCD زاوية قائمة = $90^{\circ}$ (لان زو ايا المستطيل قائمة)

$$
\text { الز اوية الخارجية = } 270^{\circ}=90^{\circ}-360^{\circ} \text { (زاوية من اليمين من CF إلى CD) }
$$

$\mathrm{CD}=\mathrm{CF}+$ Ext. angle to right $=30^{\circ} 05^{\prime}+270^{\circ}=300^{\circ} 05^{\prime} \rightarrow \mathrm{DC}=120^{\circ} 05^{\prime}$
$\mathrm{DE}=\mathrm{DC}-$ Internal angle to left $=120^{\circ} 05^{\prime}-90=30^{\circ} 05^{\prime}$

## The interior and exterior angles of polygons

- Enclosed polygon : known as the enclosed polygon on its self, its that type of polygons that start with a point and end in the same point and used for control on the error chances and try to prevent it or minimize it as possible.
- The summation of the interior and exterior angles in the polygon
$\sum$ internal standard angles $=(n-2) * 180$
$\sum$ external standard angles $=(n+2) * 180$

Where n represent the number of polygon sides or number of angles


## Enclosed polygon

- Each side of the polygon have an interior and exterior angles so :

For each side of the polygon (the interior angles + the exterior angles $=360^{\circ}$ ).
Example : if the directions of the polygon (ABCDA) sides as follow :

$$
\mathrm{AB}=130^{\circ} 14^{\prime}, \mathrm{BC}=50^{\circ} 20^{\prime}, \mathrm{CD}=305^{\circ} 15^{\prime}, \mathrm{DA}=220^{\circ} 10^{\prime}
$$

Find the interior angles of the polygon ?.
Solution :
The first step we should draw the polygon in an approximate form according to the given directions.
From the forward given directions we calculate the backward directions as follow :

| Line | Forward Dir. | Backward Dir. |
| :---: | :---: | :---: |
| AB | $130^{\circ} 14^{\prime}$ | $310^{\circ} 14^{\prime}$ |
| BC | $50^{\circ} 20^{\prime}$ | $230^{\circ} 20^{\prime}$ |
| CD | $305^{\circ} 15^{\prime}$ | $125^{\circ} 15^{\prime}$ |
| DA | $220^{\circ} 10^{\prime}$ | $40^{\circ} 10^{\prime}$ |



- From the definition of the horizontal angle (is the range that enclosed between two lines from the same point ), we notice that each point from the polygon will have two points for observation, the difference between the two directions will give an angle may be interior or exterior according to the draw above.

| Point | خطوط الرصد | اتجاه خط الرصد | الزاوية الداخلية = أمامي - خلفي |
| :---: | :---: | :---: | :---: |
| A | أمامي L | $130^{\circ} 14^{\prime}$ | $130^{\circ} 14^{\prime}-40^{\circ} 10^{\prime}=90^{\circ} 4^{\prime}$ |
|  | خلف大يAD | $40^{\circ} 10^{\prime}$ |  |
| B | 6مامكيBC | $50^{\circ} 20^{\prime}$ | $\begin{gathered} 50^{\circ} 20^{\prime}-310^{\circ} 14^{\prime}=-259^{\circ} 54^{\prime} \\ +360=100^{\circ} 6^{\prime} \end{gathered}$ |
|  | خلفה-BA | $310^{\circ} 14^{\prime}$ |  |
| C | أماميCD | $305^{\circ} 15^{\prime}$ | $305^{\circ} 15^{\prime}-230^{\circ} 20^{\prime}=74^{\circ} 55^{\prime}$ |
|  | خلف | $230^{\circ} 20^{\prime}$ |  |
| D | أمامئDA | $220^{\circ} 10^{\prime}$ | $220^{\circ} 10^{\prime}-125^{\circ} 15^{\prime}=94^{\circ} 55^{\prime}$ |
|  | فلف DC | $125^{\circ} 15^{\prime}$ |  |

To check the calculations we should addition all angles according to the below relation: $\left.\left.\left[(n-2)^{*} 180=360^{\circ}\right)\right]=\left[(4-2)^{*} 180\right]=360^{\circ}\right]$

Angles summation $=94^{\circ} 55^{\prime}+74^{\circ} 55^{\prime}+100^{\circ} 6^{\prime}+90^{\circ} 4^{\prime}=360^{\circ} \therefore$ ok

- Example : If the exterior angles for the polygon ABCDA was as follow :
$\triangle \mathrm{A}=201^{\circ}, \not \mathbb{B}=315^{\circ}, \quad \angle \mathrm{C}=232^{\circ}, \quad \mathbb{D}=331^{\circ}$,
and the forward direction of line $A B=29^{\circ} 10^{\prime}$, find the value of forward and backward directions for the polygon lines ?.
Solution :
The first step we should check the exterior angle of the polygon

$$
\begin{gathered}
\angle \mathrm{A}=201^{\circ}+\angle \mathrm{B}=315^{\circ}+\angle \mathrm{C}=232^{\circ}+\angle \mathrm{D}=331^{\circ}=1080^{\circ} \\
(\mathrm{n}+2)^{*} 180=(4+2)^{*} 180=1080^{\circ} \therefore \mathrm{O} . \mathrm{K}
\end{gathered}
$$

Draw the polygon approximately depending on the exterior angle and the forward given direction.

- The next forward direction= previous backward direction - the angle to the right (exterior )
$\mathrm{AB}=29^{\circ} 10^{\prime} \rightarrow \mathrm{BA}=209^{\circ} 10^{\prime}$
$\mathrm{BC}=\mathrm{BA}+$ Angle to right $=209^{\circ} 10^{\prime}+315^{\circ} 40^{\prime}$
$\mathrm{BC}=524^{\circ} 50^{\prime}-360^{\circ}=164^{\circ} 50^{\prime} \rightarrow \mathrm{CB}=344^{\circ} 50^{\prime}$
$\mathrm{CD}=344^{\circ} 50^{\prime}+232^{\circ} 20^{\prime}=577^{\circ} 10^{\prime}-360=217^{\circ} 10^{\prime} \rightarrow \mathrm{DC}=37^{\circ} 10^{\prime}$
$\mathrm{DA}=\mathrm{DC}+$ angle to right $=37^{\circ} 10^{\prime}+331^{\circ} 00^{\prime}=368^{\circ} 10^{\prime}-360=8^{\circ} 10^{\prime}$
$\rightarrow \mathrm{AD}=188^{\circ} 10^{\prime} \rightarrow \mathrm{AB}=188^{\circ} 10^{\prime}+201^{\circ} 00^{\prime}=389^{\circ} 10^{\prime}-360=29^{\circ} 10^{\prime}$
$\therefore$ O.K.

- Example: in the below figure if the line EF direction $=40^{\circ} 30^{\prime}$ and the angle to the right $\mathrm{AEF}=100^{\circ} 20^{\prime}$. Find the direction of lines $B C, D C, A N D A E$.
- Solution : from the given figure we find the line $A E$ direction :

$$
\begin{aligned}
& =360-100^{\circ} 20^{\prime}=259^{\circ} 40^{\prime} \\
& \mathrm{EA}=\mathrm{EF}+\mathrm{AEF}_{\text {(الخاريبة) }}=40^{\circ} 30^{\prime}+259^{\circ} 40^{\prime} \\
& \mathrm{EA}=300^{\circ} 10^{\prime} \rightarrow \mathrm{AE}=120^{\circ} 10^{\prime}
\end{aligned}
$$

Now find DC direction

$$
\mathrm{DE}=\mathrm{AE}=120^{\circ} 10^{\prime}
$$


$\mathrm{DC}=\mathrm{DE}+90=210^{\circ} 10^{\prime}$

- Find line $B C$ direction :

$$
\mathrm{BD}=\sqrt{(\mathrm{AB})^{2}+(\mathrm{AD})^{2}}=\sqrt{(30)^{2}+(40)^{2}}=50 \mathrm{~m}
$$

- In the triangle $A B D$ which its right angle at A, calculate angle $\alpha$ in point $B$ and angle $\theta$ in point $D$.

$$
\alpha=\cos ^{-1} \frac{30}{50}=53^{\circ} 7^{\prime} 48^{\prime \prime}, \quad \theta=\sin ^{-1} \frac{30}{50}=36^{\circ} 52^{\prime} 12^{\prime \prime}
$$



- In the triangle BCD calculate angle $\beta$ in point $B$ and angle $\gamma$ in point $D$.

$$
\begin{aligned}
& \gamma=180-90-\theta=53^{\circ} 7^{\prime} 48^{\prime \prime} \\
& \mathrm{BC}=\sqrt{(\mathrm{DB})^{2}+(\mathrm{DC})^{2}-2(\mathrm{DB})(\mathrm{DC}) \cos \gamma} \\
& =\sqrt{(50)^{2}+(70)^{2}-2(50)(70) \cos 53^{\circ} 7^{\prime} 48^{\prime \prime}}=56.57 \mathrm{~m} \\
& \frac{\mathrm{BC}}{\sin \gamma}=\frac{70}{\sin \beta} \Rightarrow \beta=81^{\circ} 52^{\prime} 12^{\prime \prime}
\end{aligned}
$$

$$
\begin{aligned}
& \mathrm{DB}=\mathrm{DE}+90+\gamma=120^{\circ} 10^{\prime}+90+53^{\circ} 7^{\prime} 48^{\prime \prime}=263^{\circ} 17^{\prime} 48^{\prime \prime} \\
& \mathrm{BD}=263^{\circ} 17^{\prime} 48^{\prime \prime}-180=83^{\circ} 17^{\prime} 48^{\prime \prime} \\
& \mathrm{BC}=\mathrm{BD}+\beta=83^{\circ} 17^{\prime} 48^{\prime \prime}+81^{\circ} 52^{\prime} 12^{\prime \prime}=165^{\circ} 10^{\prime}
\end{aligned}
$$



