وزارة التعليم العالي والبحث العلمي
الجامعة التقنية الجنوبية
المعهد التقني العمارة
قسم تقنيات المساحة

Engineering Surveying

Stage: 2nd .Surveying/ First semester

Assistant Lecturer: Athraa abbas kadhim

مفردات مادةالمسح الهندسي

المفردات	الاسبوع
مقدمة عن المسح الهندسي ومقياس الرسم المستخدم لكل حالة مع توضيح الطرق المختلفة لحساب المساحات في الحقل وتشمل: مساحات الأشكال المنتظمة، والتقسيم الى اشكال هندسية منتظمة مثل المثلثات والمربعات والمستطيل وشبه المنحرف والدوائر واجزائها.	1
اقامة الأعمدة على فترات متساوية (بطريقة شبه منحرف trapezoidal وطريقة Simpson's)، و اقامة الأعمدة على فترات غير متساوية على خط المسح لقطعة ارض وحساب مساحاتها بكافة الطرق المبينه	2
استخدام طريقة الإحداثيات في حساب المساحات ، طريقة مضاعف خط طول (D.M.D) .	3
الطرق المختلفة لحساب المساحات من الخارطة وتشمل : التقسيم الى اشكال هندسية منتظمة مثل مثلثات او المربعات أواستخدام أوراق الخطوط البيانية ، استعمال الشرائح ، استعمال البلانوميتر الإلكتروني لحساب المساحات (عندما تكون نقطة التثبيت داخل أو خارج الشكل). الطرق الحسابية والترسيمية لحساب مساحات المقاطع العرضية المختلفة الأشكال وذات الانحدارات المختلفة لسطح الأرض .	4
حساب حجوم الكميات الترابية باستعمال قانون متوسط القاعدتين وطريقة الأسفين الناقص (أوالموشوراني) والطريقة التقريبية من المقطع الطولي وحساب حجم المقلع والخزان للسدود بواسطة الخطوط الكنتورية وأجراء حسابات ورسم منحني نقل الأتربة . واستخدام الخارطة لأجراء الحسابات اللازمة للمساحات وللحجوم بطرق مختلفة .	5
التعرف على مسح الطرق : ويشمل طرق المسح الأرضي والمسح الجوي المتبعة لتعيين مسار الخط المركزي للطريق . انواع المنحنيات الرأسية المستخدمة في الطرق: الرموز والمصطلحات والقوانين الخاصة بها ولحساب المناسيب عليها (الطريقة الهندسية) ، والمنحنيات الرأسية غير المتماثلة (عناصرها وحساباتها) ، حساب الكميات الترابية لمقطع طريق يحتوي على منحنيات رأسية محدبة ومقعرة وانحدار ثابت .	6
التعرف على أنواع المنحنيات الرأسية : (المنحني المحدب و المنحني المقعر) والمعادلة الخاصة بالقطع المكافئ لحساب المنسوب (الطريقة التحليلية) وكيفية تسقيطها على الأرض – المواصفات الخاصة به من حيث علاقة طوله بمسافة الرؤية والسرعة والفرق الجبري بين الانحدارين ونصف القطر المكافئ له .	7
المنحنيات الأفقية : المنحني الأفقي الدائري البسيط ، الرموز والمصطلحات والقوانين الخاصة به ومواصفاته من حيث علاقة نصف قطره بالسرعةالمركبات ومعامل الاحتكاك للاطارات والميل الإضافي أو (الرفع الجانبي)	8
المنحنيات الأفقية الدائرية المركبة والمعكوسة وأنواعها وحساب عناصرها واستخدامها في طرق المرور السريع وفي التقاطعات ، حساب إحداثيات المحطات الرئيسية والنقاط على المنحنيات .	9
الطرق المختلفة لتسقيط المنحني الدائري البسيط وتشمل : طريقة الزوايا المماسة (أو الانحراف) باستخدام ثيودولايت وشريط أو باستخدام جهازي ثيودولايت فقط واستخدام الأجهزة الإلكترونية في تسقيط هذا المنحني أو بواسطة إحداثيات نقاط السيطرة ونقاط المنحني (طريقة تقنيات المواقع الحديثة) .	10
طريقة استخدام الأعمدة في تسقيط المنحنيات (الأعمدة على المماس والأعمدة على الوتر الكبير) وطريقة التسقيط من نقطة التقاطع – العقبات التي تعترض التسقيط وكيفية تجاوزها (علـى القوس أو في المحطات الرئيسية او عند الإنشاء) .	11
المنحنيات الانتقالية أو الحلزونية : أنواعها واستخدامها وحساباتها (الكلوثويد والقطع المكافئ التكعيبي والحلزون التكعيبي) وطرق تسقيطها باستخدام الزوايا المماسة والأوتار أو الإحداثيات ، حساب إحداثيات المحطات الرئيسية والنقاط على المنحنيات .	12

13	مشروع صغير في الطرق : أجراء الحسابات اللازمة للمنحنيات الرأسية والأفقية (تعيين المحطات والمناسيب ، كيفية رسم المخططات الأفقية والمقطع الطولي للمشروع فعلي وبيان كافة العناصر والمحطات عليها .
14-15	حساب مساحات المقاطع العرضية للمشروع وحجوم الكميات الترابية ورسم منحني نقل الأتربة وبيان عرض الحفر والردم على جانبي الخط المركزي للمشروع فعلي . المسح الإنشائي :- أعمال المسح الخاصة بإنشاء الدور والبنايات الكبيرة وتثبيت مناسيبها واستقامة الخطوط والقنوات والمجاري والأنابيب والنقل الكهربائي والخنادق الطويلة وتثبيت مناسيبها .

Course Objective

After studying this course the student should be able to

1-compute the areas of uniform and non-uniform areas and cross section .

2-compute the volumes of earth work and water .

3- setting out of all types of road curves ,sewers ,building ...etc.

Target Audience: 2nd .Surveying student

Course Description: 2hr Theoretical ,2hr Application

First to Fourth week

Area of uniform figures

مساحة الاشكال الغير منتظمة

1. Area of triangle مساحة المثلث

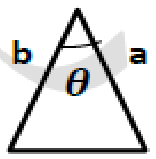
ـ اذا علمت اضلاع المثلث (a,b,c)

$$S= \frac{a+b+c}{2}$$ معدل الاضلاع

$$A= \sqrt{S(S-a)\ (S-b)\ (S-c)}$$

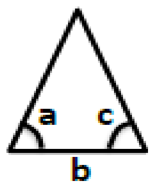
2. اذا علمت طول ضلعين والزاوية المحصورة بينهما

$$A= \frac{1}{2} a * b * \sin\theta$$



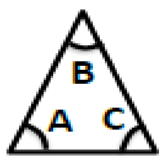
3.اذا علمت طول ضلع والزاويتين

$$A= \frac{b^2}{2} * \frac{\tan\angle A * \tan\angle c}{\tan\angle A + \tan\angle c}$$



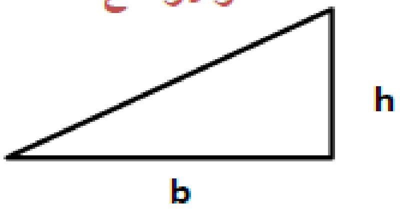
4.اذا علمت طول ضلع وثلاثة زوايا

$$A= \frac{b^2}{2} * \frac{\sin\angle A * \sin\angle C}{\sin\angle B}$$



5.اذا علمت القاعدة والارتفاع

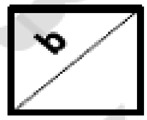
$A = \frac{1}{2} h * b$



B- Square area مساحة المربع

$A = a^2 = a=a$

$A = \frac{1}{2} b^2$



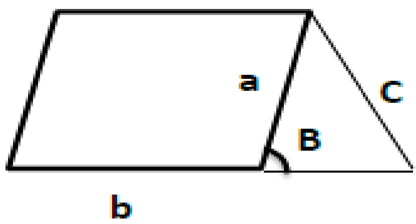
C- Rectangle area مساحة المستطيل

$A = a * b$

d- parallelogram Area مساحة متوازي الاضلاع

$A = b * c$

$A = b * a * \sin\theta$

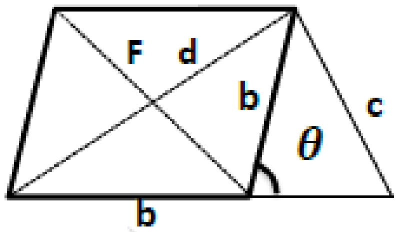


E- مساحة المعين (متوازي الاضلاع متساوي قطراها متعامدين)

A= b*c اذا علم ضلعين

A =$\frac{1}{2}$ *F*d اذا علت الاقطار

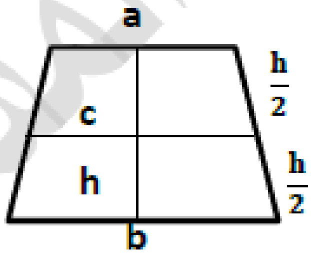
A= b^2* sin θ اذا علمت زاوية وضلع



F- Trapezoidal مساحة شبة المنحرف

A=h($\frac{a+b}{2}$)=h*c

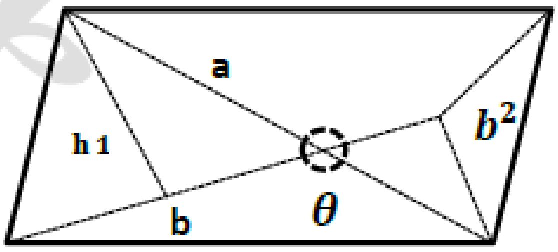
C= ($\frac{a+b}{2}$) متوسط القاعدتين



H- مساحة الشكل الرباعي

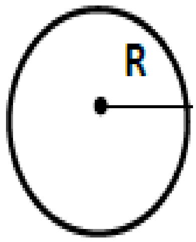
A= a*b*sin θ

A=$\frac{b}{2}$ (h 1 + h 2)



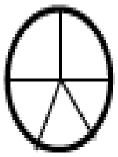
J- circde area مساحة الدائرة

1. A=πR^2 , π=3.1416

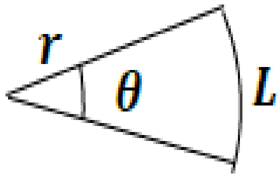


2. مساحة قطاع الدائرة

$$A=\frac{\theta^{\circ}}{360^{\circ}}*\pi*r^2$$

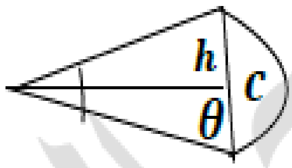


$$A=\frac{1}{2}r*h$$



3. مساحة الجزء المثلث من قطاع الدائري

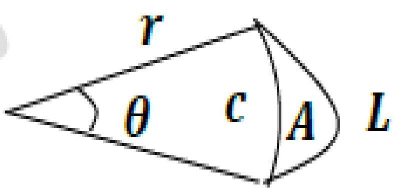
$$A=\frac{1}{2}c*h$$



$$A=\frac{1}{2}*r^2*\sin\theta$$ اذا علمت الزاوية

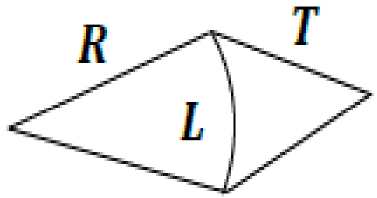
4. مساحة القطع الدائري لقطاع الدائري

$$A=\frac{1}{2}r*L-\frac{1}{2}c*h$$



5. مساحة القطعة الخارجية

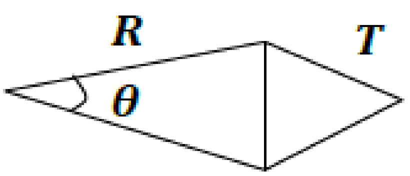
$$A=r*t-\frac{1}{2}r*L$$



6. مساحة القطاع للقطعة الخارجية

$A= r^2 * tan\ \frac{\theta}{2}$

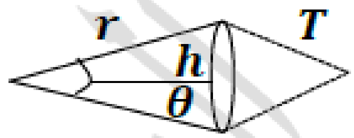
A= r*t



7. مساحة القطعة والقطة الخارجية

$A=r*t-\frac{1}{2}c*h$

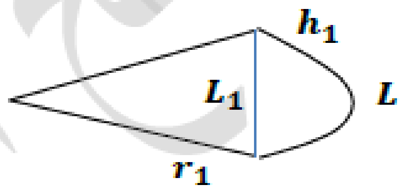
$A=tan\ \frac{\theta}{2}\ (r * sin\ \frac{\theta}{2})$



8. مساحة اجزاء من الحلقة

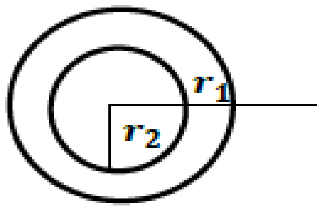
$A= (\frac{1}{2}r*L)-(\frac{1}{2}r\ 1 * L\ 1)$

$A=(L+L_2 \div 4) * L$



9. مساحة الحلقة الدائرية

$A=\pi(r_1^2 - r_2^2)$

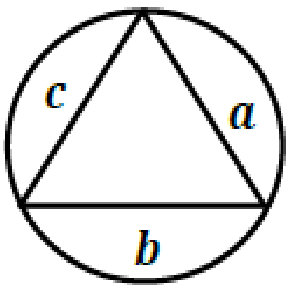


10. مساحة الدائرة المارة برؤوس المثلث

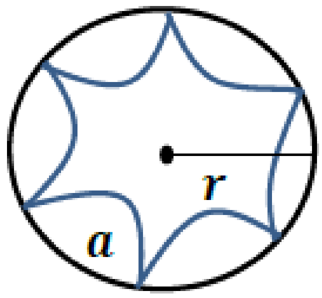
$A=\pi r^2$

$A=\sqrt{S(S-a)\ (S-b)\ (S-c)}$

$S= \frac{a+b+c}{2}$



11. مساحة الاشكال المنتظم لمتعدد الاضلاع



$A=\frac{1}{4}n*a^2*\cot\frac{180°}{n}$

$A=\frac{1}{4}n*r^2*\sin(\frac{360°}{n})$

12. مساحة الخماسي المنتظم

$A= 1.72a^2$

13. مساحة السداسي المنتظم

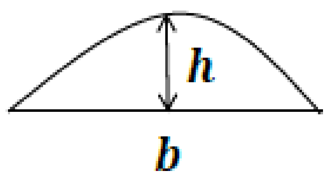
$A=2.6a^2=2.6r^2$

14. مساحة المثمن

$A=4.83a^2=2.83r^2$

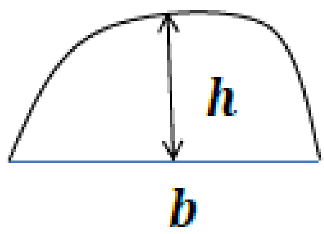
15.

$A=\frac{2}{3}b.h$



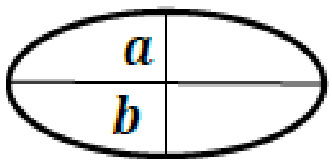
16.مساحة قطع مكافئ

$A=\frac{2}{3}b.h$



17. مساحة قطع ناقص

$A=\pi*a*b$

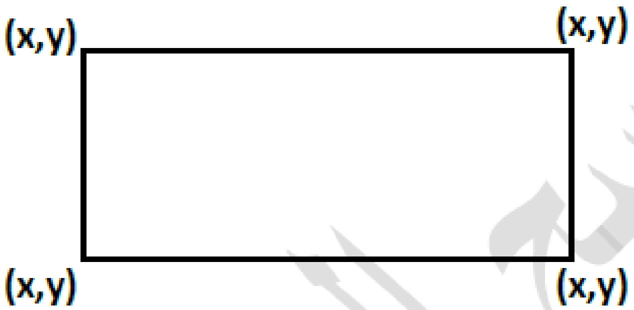


Methods of areas measurement and computation

1. Field measurement of area

1- division of triangles

2- setting out offsets



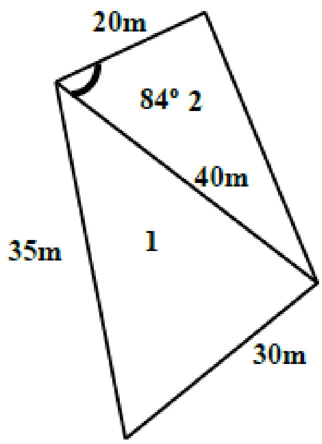
- setting out offsets at regular or equal in terval

- setting out offsets at Irregular interval

- using Goor dinates

- D.M.D (Double-Meridian-Distance).
- Map measurements.

<u>Ex</u>: measured area of a Piace of Land by division it into two triangles For First triangle was measured the length of the three ribs and For the second triangle was measured the Length of two ribs and angle between them ,Find the area of aPiace of land .



<u>Sol:</u>

$$S=\frac{a+b+c}{2}=\frac{35+30+40}{2}=52.50\ M$$

$$A_1=\sqrt{S(S-a)\ (S-b)\ (S-c)}$$

$$\sqrt{52.50(52.50-35)\ (52.50-30)\ (52.50-40)}=508.329\cong 508.33\ m^2$$

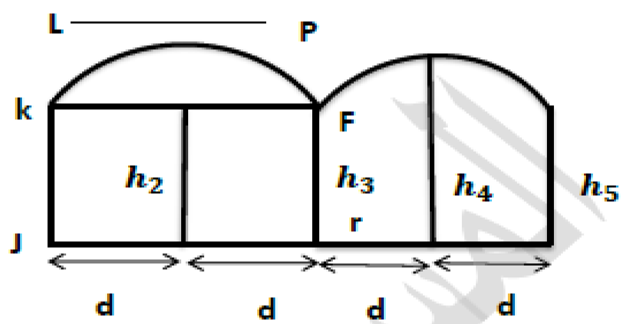
$$A_2=\frac{1}{2}a*b*\sin\theta=\frac{1}{2}20*40*\sin 84^\circ=397.808\cong 397.81\ m^2$$

$$A=A_1+A_2=508.33+397.81=906.14\ m^2$$

setting offset اقامة اعمدة

Simpson ´s method (Rule)

طريقة او قاعدة سيمسون



$A_1 = A_{LPKF} + A_{KFJr}$

$= \frac{2}{3}[2d\,(h_2 - \frac{h_1 + h_2}{2}) + 2d(\frac{h_1 + h_3}{2})]$

$= \frac{d}{3}[4h_2 - 2h_1 - 2h_3 + 3h_1 + 3h_3]$

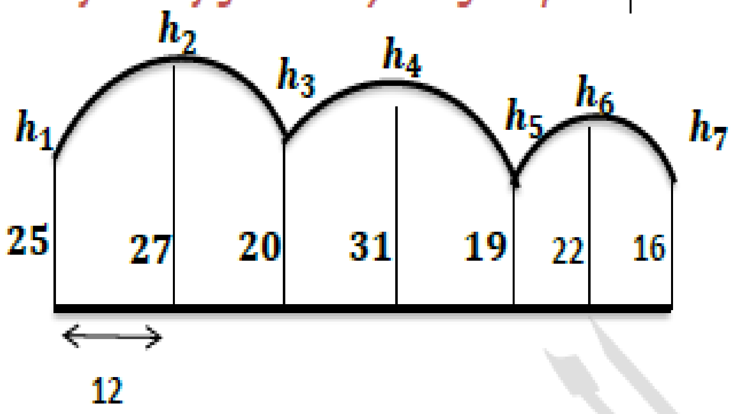
$A_{1-3} = \frac{d}{3}(h_1 + 4h_2 + h_3)$

A_{1-5} وبنفس الطريقة توجد مساحة

$A_{1-5} = \frac{d}{3}(h_1 + 4h_2 + h_3) + \frac{d}{3}(h_3 + 4h_4 + h_5)$

$A_{1-5} = \frac{d}{3}(h_1 + h_5 + 4(h_2 + h_4) + 2(h_3)$

EX: Find the area for the fig below by using Simpsons rule



Sol:

$A_1 = \frac{12}{3}$ [25+16+4(27+31+22)+2(20+19)

= 4(41+320+78)

= 1756 m^2

$A = d[(\frac{h_1 + h_7}{2} + h_2 + h_3 + h_4 + h_5 + h_6)]$

$= 12\ (\frac{25+16}{2} + 27+20+31+19+22)$

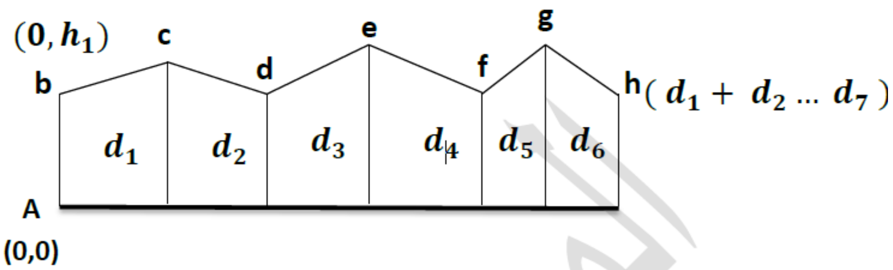
=1674 m^2

compare in the area

1756 – 1674 = 82 m^2

setting out offsets at vegulor intervals

اقامة الاعمدة على فترات غير متساوية



ملاحظة :يمكن حساب المسافات عند اقامة الأعمدة على مسافات غير متساوية من خلال طريقة الاحداثيات حيث يمكن الحصول على ضعف المساحة المطلوبة عن طريقة مجموع حاصل ضرب الاحداثي السيني(X) او احداث التشريق(E)لكل نقطة في الاحداثي الصادي(Y)أو فرق التشميل(N) (للنقطتين السابقة)

2A=$d_1\,(h_1-h_3)$+$(d_1+d_2\ )(h_{2\_}h_4)(d_1+d_2+d_3+d_4+d_5)$

$+(h_3-h_5)(d_1+d_2+d_3+d_4+d_5)((h_4-h_5)+$

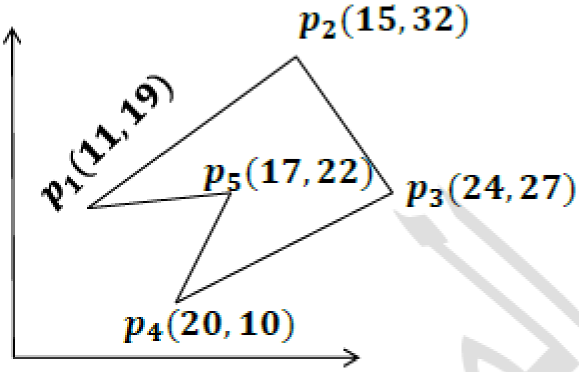
$(d_1+d_2+d_3+d_4+d_5)((h_5-h_7)+(d_1+d_2+d_3+d_4+$

$d_5+\ d_6)(h_6-h_7)=\mp$

A= $\left|\mp\frac{\text{الرقم}}{2}\right|$

2A= $\frac{N_1}{E_1}\ \frac{N_2}{E_2}\ \frac{N_3}{E_3}\ \frac{N_4}{E_4}\ \frac{N_5}{E_5}\ \frac{N_6}{E_6}=\frac{N_1}{E_1}$

***EX**: Find the area for the Following sig by using coordinates method.*



Sol:

2A=[(19*15)+(32*24)+(27*20)+(10*17)+(11*22)]-[(11*32)+(15*27)+(24*10)+(20*22)+(17*19)]

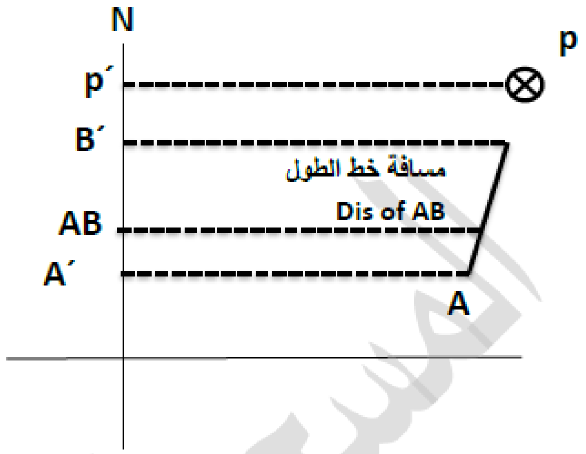
A= $\left| +\frac{245}{2} \right|$

A= 122.5 m^2

Double-meridion-Distance Method (D.M.D)

مضاعفة خط الطول (ضعف خط الطول)

$$\Delta x = (x_2 - x_1)$$
$$\Delta y = (y_2 - y_1)$$



1.Meridion ditance of Points P.P´ مسافة خط الطول لنقطة P في الشكل

2. (Merdion distance of line) ضعف خط الطول

CC´=AB

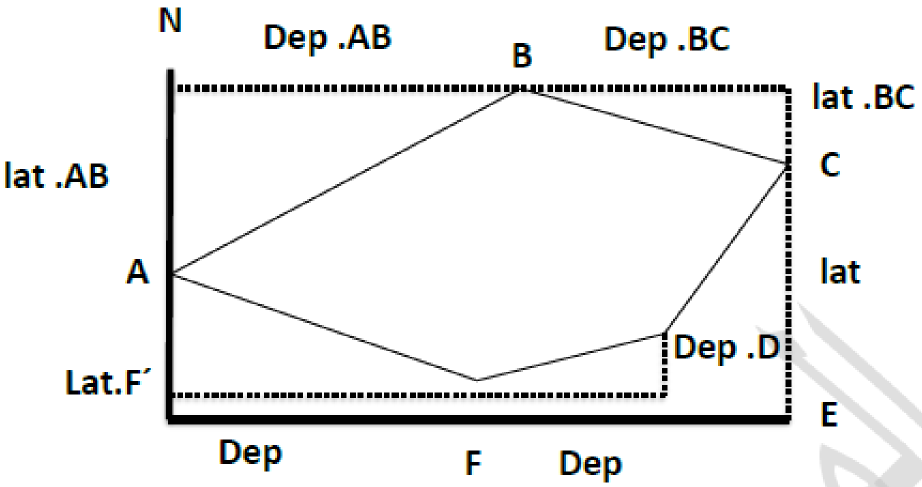
3. (Double - Meridian distance) ضعف مسافة خط الطول

AB=AA´+BB´

مساحة الشكل شبة المنحرف ABA´B´

2A=(AA´+BB´)*A´B´

المركب الرأسي للضلع A´B´=AB



١. اول ضلع = المركبة الافقية للضلع نفسة D.M.D of AB=Dep of AB(B´,B)

٢. لحسابDMDللضلع الثاني اللاحق الضلع السابق D.M.D of BC=D.M.D of AB+

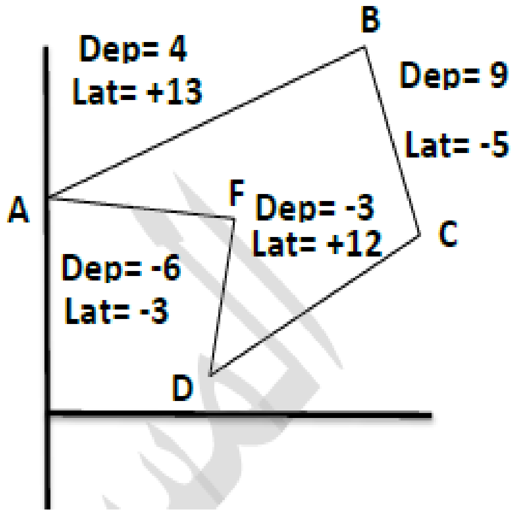
+المركبة الافقية لنفس الضلع (AB)

+المركبة الافقية للضلع اللاحق (BC)

٣. لحساب الضلع الثالث FA D.M.D of FA-Dep. of FA(F,F´)

EX :For the figure below Find the area For the Peice of land by using:
1-DMD method
2-Coordinates method

A(0,10)
B(4,23)
C(13,18)
D(9,1)
F(6,13)



SOL:

Side	Dep	D.M.D	lat	2A
AB	+4	4	+13	52
BC	+9	4+4+9=17	-5	-85
CD	-4	17+9-4=22	-17	-374
DF	-3	22-4-3=15	+12	180
FA	-6	+6	-3	-18
	∑=00		∑=00	∑=-245

$$A = \left| \frac{-245}{2} \right|$$

A=122.50 m^2

2-Coordinates method:

$$\frac{0}{10} = \frac{4}{23} = \frac{13}{18} = \frac{9}{1} = \frac{6}{13} = \frac{0}{10}$$

2A=[(0*23)+(4*18)+(13*1)+(9*13)+(6*10)]-[(10*4+(23*13)+(18*9)+(1*6)+(13*0)]

2A= 262-507

A= 122.5 m^2

Measurement Areas from a Map:

A-. Dividing into triangles and squares.
B. Using a graph (graph paper).
C. Using a planimeter.
D. Dividing the plot into slices.
Slice width = Sum of intermediate lengths.
A=(ab+cd+ef)*w
E. Calculating the area using AutoCAD
F. Using the coordinates of the corners of the plot

_Ex:_ Draw Peice of land on Graph paper with the scale 1:1000 the No of squares are 17 square Adding the parts square to each other it Found 6 squares if the area of each square. Equal to Semx5cm compute the total area in (m^2)

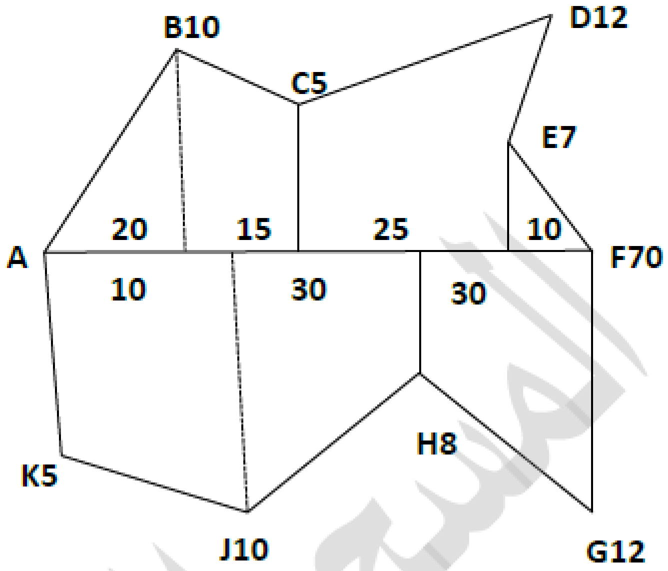
Sol:

مساحة المربع الواحد على الخارطة = 5cm * 5cm = 25 cm^2

مساحة المربع الواحد على الأرض $= \frac{25\,(1000)^2}{10\,000} = 2500\ m^2$

total area= (17+6)*2500= 57500 m^2

h.w: From the Figure below, Find the area by using D.M.D method



Dep= Δy

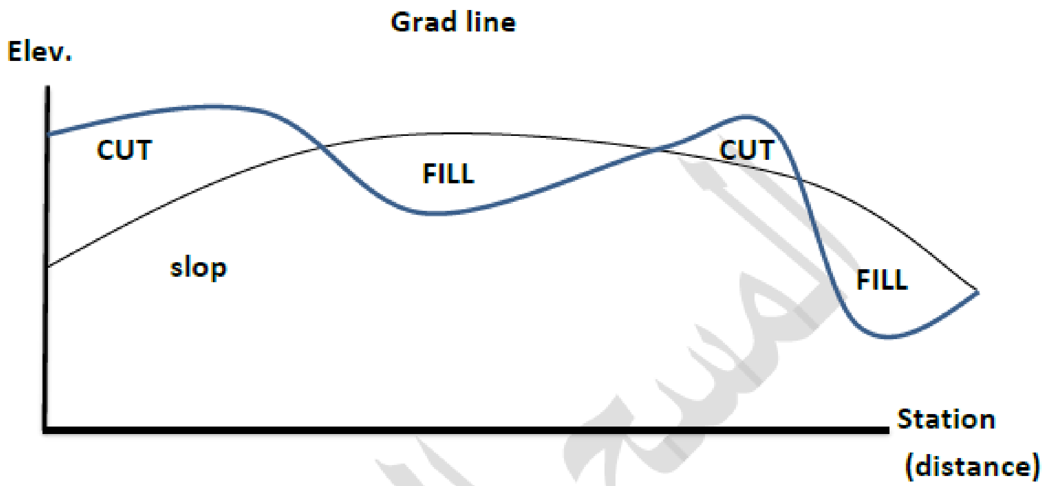
Lat= Δx

Sol:

point	Dep	lat
AB		
BC		
CD		
DE		
EF		
FG		
GH		
HJ		
JK		

Measurement area of cross section

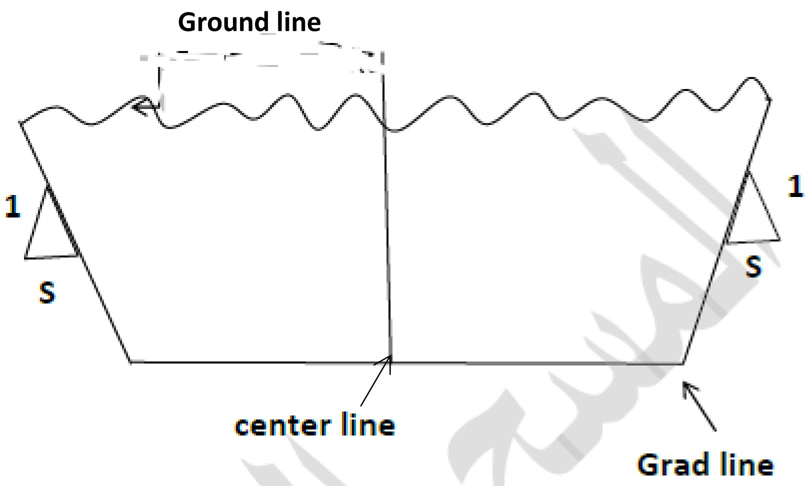
قياس المساحات للمقاطع العرضية



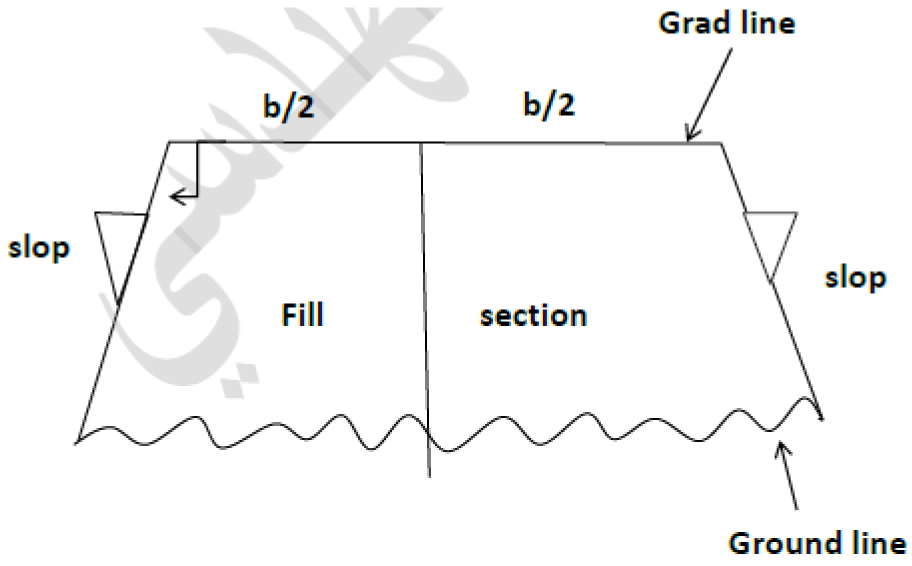
ملاحظة: الانحدار هو النسبة بين المسافة الرأسية التي عدد الوحدات للمسافة الافقية مثل $\frac{1}{3}$

types of cross-section

1. cut section

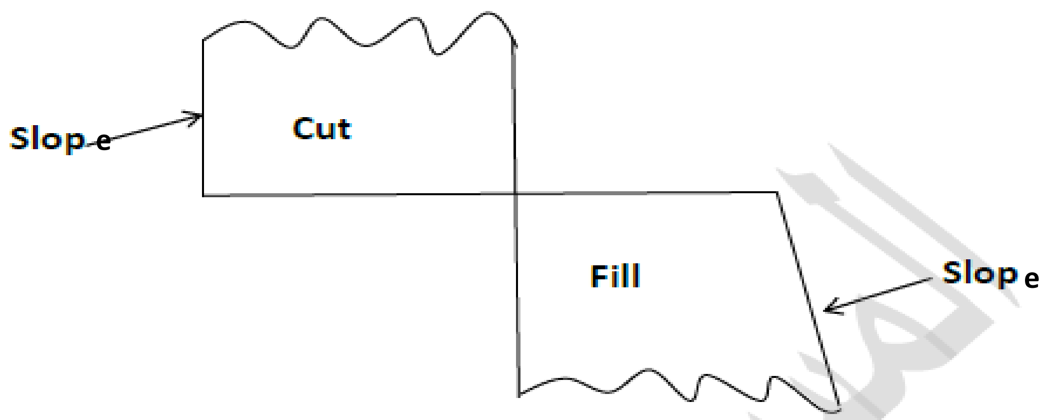


2. Fill section



3. cut and Fill section

(side-Hill section)



1.one level section

A=d(b+sd)

b= width of road

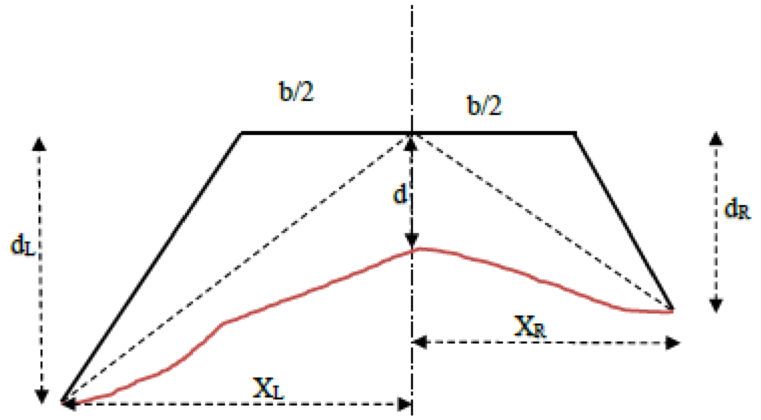
d=depth of section (cut of fill)

d= Ground elev -Grad elev

d=+depth of cut

d=-depth of fill

2. *for a Three-level section*



=مساحة المثلثين في الاسفل $[\frac{d(xR+xL)}{2}]$

=مساحة المثلثين في الاعلى $[\frac{\frac{b}{2}(dR+dL)}{2}]$

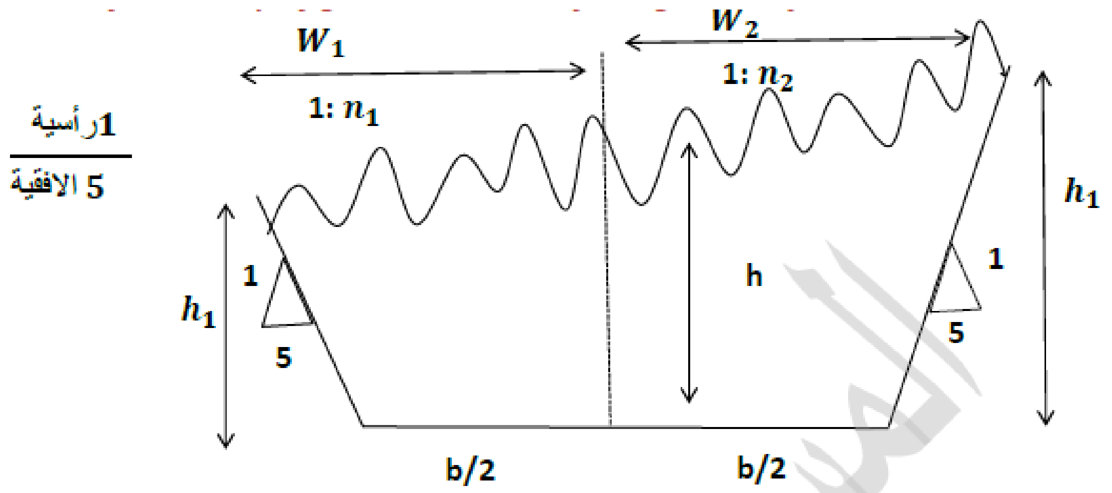
$$A=\frac{1}{2}[\frac{b}{2}(dR+dL)+d(xR+xL)]$$

3. *for a multi-level section*

ملاحظة: يتم حساب المقطع العرضي باستخدام طريقة الإحداثيات

$$2A=\frac{N_1}{E_1}=\frac{N_2}{E_2}=\frac{N_3}{E_3}=\frac{N_4}{E_4}=\frac{N_5}{E_5}=\frac{N_6}{E_6}=\frac{N_1}{E_1}$$

for the slope of ground are known for Right and left center line



$$A = \frac{w}{2}\left(h + \frac{b}{2s}\right) - \frac{b^2}{4s} \qquad , w = w_1 + w_2$$

$$w_1 = \frac{n_1 s}{n_1 s}\left(h + \frac{b}{2s}\right) \qquad , w_2 = \frac{n_2 s}{n_2 s}\left(h + \frac{b}{2s}\right)$$

$$h_1 = \frac{n_1 h - w_2}{n_1 + s} \qquad , h_2 = \frac{n_2 h - \frac{b}{2}}{n_2 - s}$$

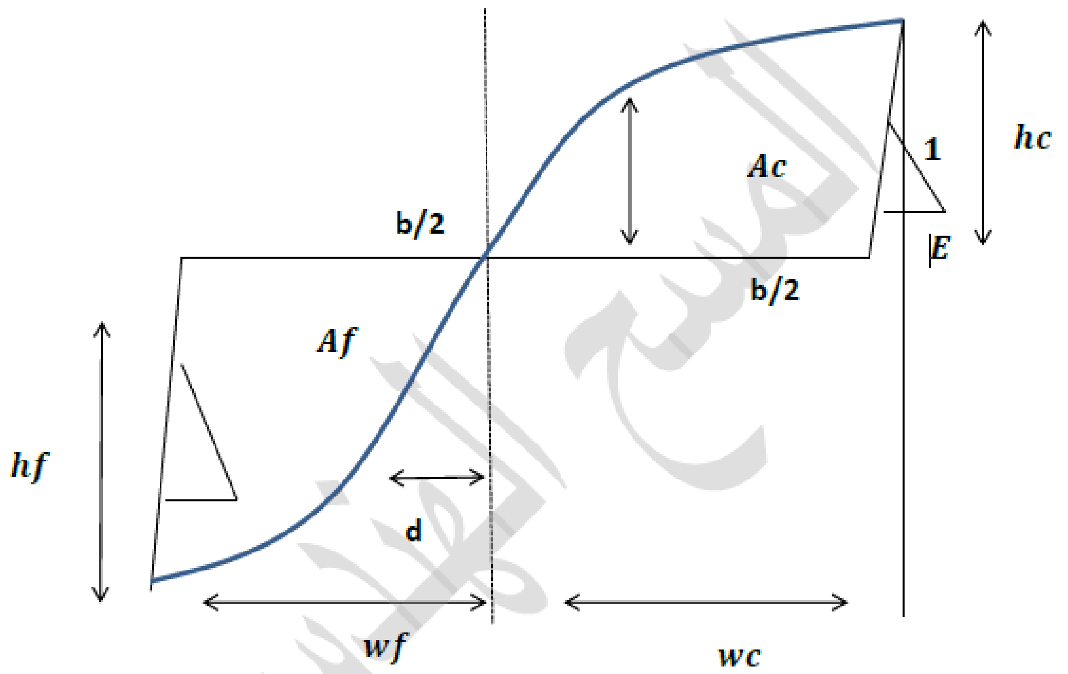
$$A = \frac{w_1}{2}\left(h + \frac{b}{2s}\right) + \frac{w_2}{2}\left(h + \frac{b}{2s}\right) - \frac{b^2}{4s}$$

اما المساحة بدلالة N,s,h,p

$$A = \frac{1}{2}\left(h + \frac{b}{2s}\right)^2\left(\frac{n_1 s}{n_1 - s} + \frac{n_2 s}{n_2 - s}\right) - \frac{b^2}{4s}$$

$$A = \frac{1}{2}\left(h + \frac{b}{2s}\right)^2\left(\frac{2n_1 n_2 + n_2 s^2 - n_1 s^2}{(n_1 + s)(n_2 - s)}\right) - \frac{b^2}{4s}$$

-If the stope for ground for extent side cross-section



مساحة القطع:

$$Ac = \frac{hc}{2}(\frac{b}{2} - d) \quad , \quad Ac = \frac{(\frac{b}{2}+nh)}{2(n-sc)}$$

مساحة الدفن او الردم:

$$Af = \frac{hf}{2}(\frac{b}{2} - d)$$

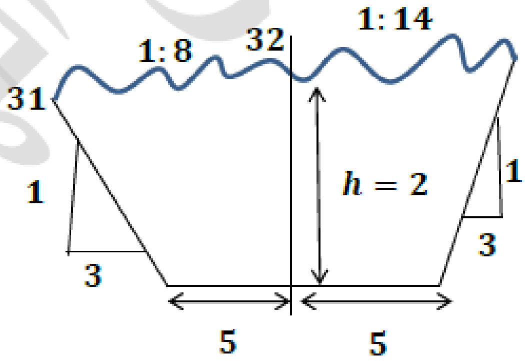
$$Af = (\frac{\frac{b}{2} - nh}{2(n - sc)})^2$$

$$w_f = \frac{n}{n - s_f}\left(\frac{b}{2sf} - h\right)$$

$$h_f = \left(\frac{\frac{b}{2}-nh}{n-sf}\right)$$

اذا كان العمق المركزي (h) في حالة الدفن فستدل (h) وفي القوانين اعلاه ب (-h)
وبالقطع (+h)

EX: Compute the Area For the cross-section



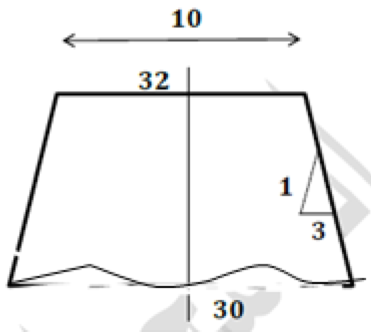
Sol:

$$A=\frac{1}{2}(h+\frac{b}{2s})^2(\frac{2n_1n_2+n_2 s^2-n_1 s^2}{(n_1+s)(n_2-s)})-\frac{b^2}{4s}$$

$$A=\frac{1}{2}(2+\frac{10}{2*3})^2(\frac{(2*8*14*3)+(14*9)-(8*9)}{(8+3)(14-3)})-\frac{100}{4*3}$$

$$A=31.99\ m^2$$

EX: Find the Area For cross-section has elevation of Grad line 32 m and G.L=30m the side slop 1:3 and road! width=10 m



Sol:

d= Ground elev - Grand elev

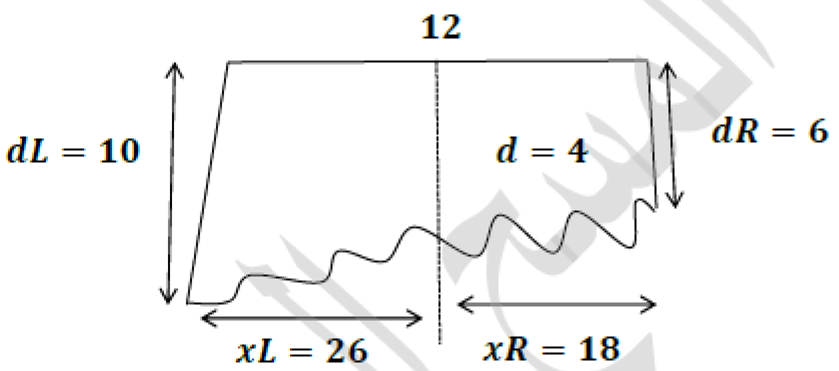
d= 30-32=-2

A=d(b+sd)

*A=2(10+3*2)*

$= 32m^2$

EX:the-level section has road width =12 depth of cut d=4m In c.L.,
depth of cut in right side dir=6m.
depth of cut in left side dir=10m
horizontal distance for right Point XR=18m
horizontal distance for left Point XL=26m
Find the area for the section



Sol:

$$A=\frac{1}{2}[\frac{b}{2}(dR + dL) + d(xR + xL)]$$

$$A=\frac{1}{2}[\frac{12}{2}(6 + 10) + 4(18 + 26)]$$

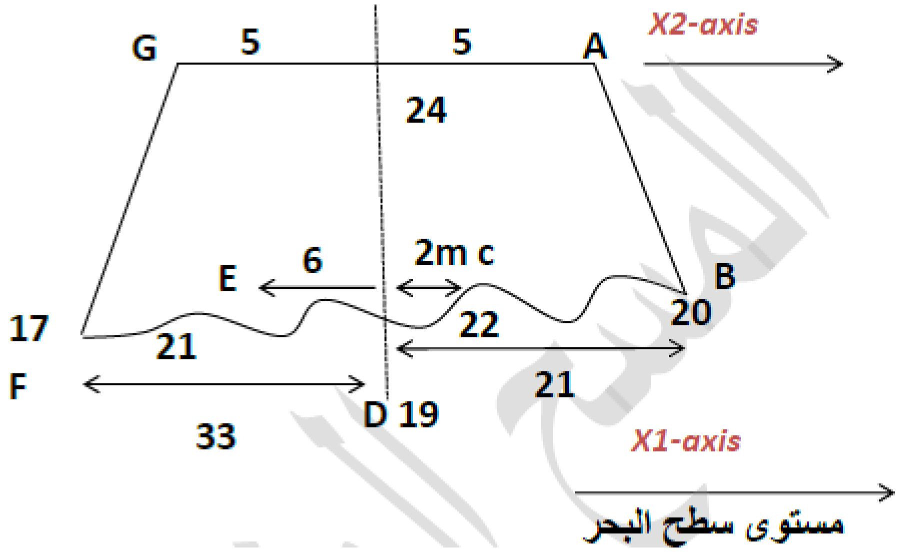
$$A=\frac{1}{2}(6 + (16)) + 4(44)$$

$$A=\frac{1}{2}(96 + 176)$$

$$A=\frac{1}{2}(272)$$

$$A=136\,m^2$$

H.W *by using coordinates rule , Find the area for the cross section below with considration the x-axis is M.S.I and another considration. that x-axis is the same Grad line*



Fifth week

Volume measurement

Average End Area Formula

This is the simplest method for determining volumes from cross sections. It closely follows the theory developed for the determination of areas; in this case instead of offsets at constant separation (resulting in areas) there are areas at constant separations (resulting in volumes).
In the figure it can be assumed that areas A1, A2 and A3 have been determined. Therefore, if A1 is the left end area, A2 the right end area and L the distance between sections, the volume is,

$$vol._{1-2} = \left(\frac{A_1 + A_2}{2}\right) * L_{1-2}$$

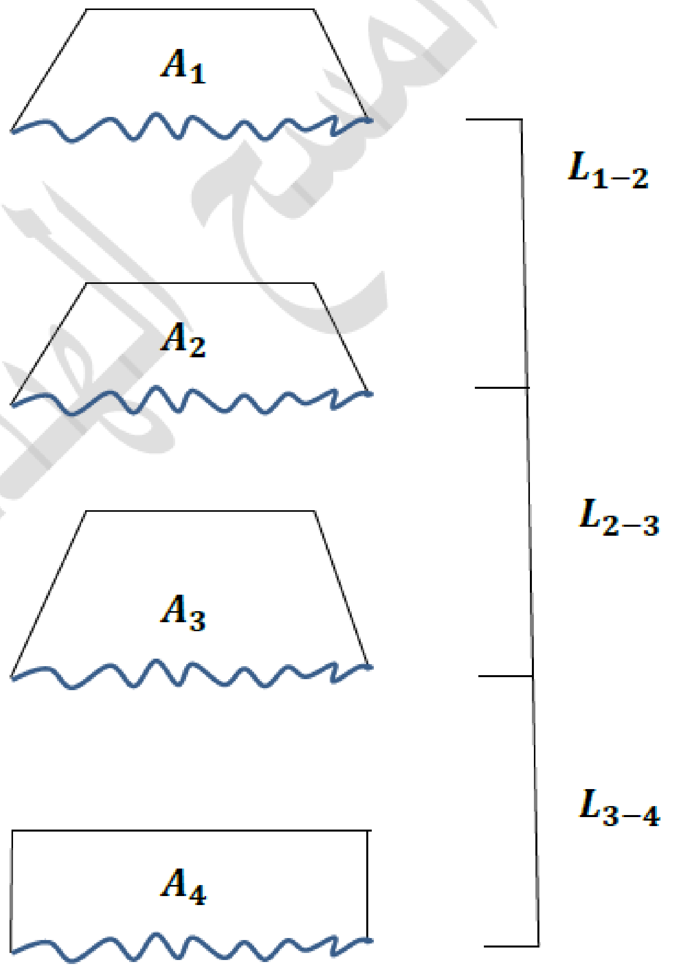
V = [First area + last area + 2Σ(all remaining areas)]

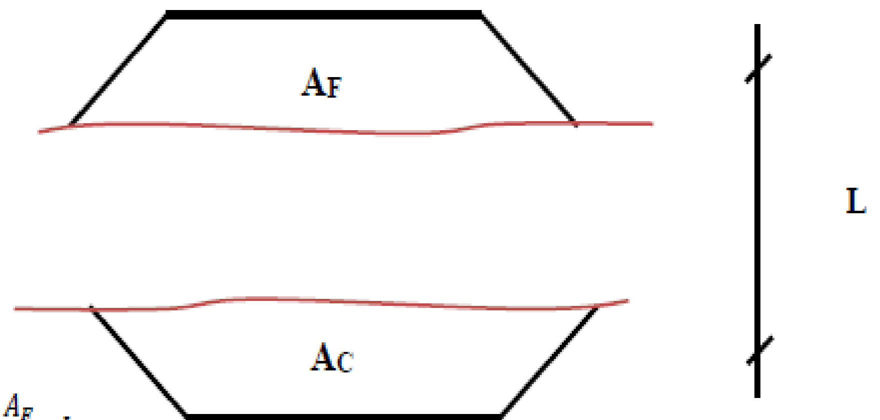
$$vol._{1-n} = L\left(\frac{A_1+A_n}{2} + A_2 + A_3 + \cdots + A_{n-1}\right)$$

$$vol._{Fill} = \frac{A_F}{3} * L$$

$$vol._{Cut} = \frac{A_c}{3} * L$$

الحسابات عندما يكون فيها قطع وردم





$$Vol_{Fill} = \frac{A_F}{3} * L$$

And $\quad Vol_{Cut} = \frac{A_C}{3} * L$

EX: *Nine sections were calculated areas Previously Fill see*
$AF1 = 12\ m2$, $AF2 = 18\ m2$, $AF3 = 12\ m2$, $AF4 = 12\ m2$, $AF5 = 4\ m2$
cut sec$Ac6 = 7\ m2$, $Ac7 = 11\ m2$, $Ac8 = 15\ m2$, $Ac9 = 23\ m2$ the distance between ea each equal to loom find the total Volfill Fill and cut.

ملاحظة: في حاله تغير نوع المقطع من الردم الى القطع او العكس فيتم استخدام القانون التالي (لعدم معرفة قيمة المقطع الحفر و الردم عندما يساوي صفر) فيتم اضافة حجم الهرم الى القانون السابق والذي مساحة قاعدتة تساوي مساحة الحفر و الردم

Sol:

$$\text{Total vol.} = L\left(\frac{A_1+A_5}{2} + A_2 + A_3 + A_4\right) + \left(\frac{A_5}{3} * L\right)$$
$$= 100\left(\frac{24+4}{2} + 18 + 21 + 12\right) + \left(\frac{4}{3} * 100\right)$$
$$= 6500 + 133.33$$
$$= 6633.33m^3$$

$$\text{Total vol.} = L\left(\frac{A_6+A_9}{2} + A_7 + A_8\right) + \left(\frac{A_9}{3} * L\right)$$
$$= 100\left(\frac{7+23}{2} + 11 + 15\right) + \left(\frac{23}{3} * 100\right)$$
$$= 4333.33m^3$$

Prismoidal Formula

قانون الموشور(الاسفين الناقص)

The Prismoidal formula is sometimes called "Simpson's Rule for Volumes", and the derivationis exactly the same as before . It is a modification of the End Areas Formula.

$$vol._{1-3} = \frac{2L}{6}(A_1 + 4A_2 + A_3)$$

$$vol._{3-5} = \frac{2L}{6}(A_3 + 4A_4 + A_5)$$

$$vol._{1-5} = \frac{2L}{6}(A_1 + A_5 + 4(A_2 + A_4) + 2(A_3)$$

$$total\ vol._{1-n} = \frac{L}{3}(A_1 + A_n + 4(A_2 + A_4 + A_6 \ldots) + 2(A_3 + A_5 \ldots)$$

Ex :

It was calculated for Four Fill sections from surveying worke the distance between each section is equal som It (A 1 ,A 2 ,A 3,A 4 ,A 5 ,A 7) then it was survey work for addational cross section betwe the section above the distance was become 25m between each cross sec. (its A 2 ,A 4 ,A 6) to increase the accuracy the total volume. Find the total volume, of fill by using (Average End-Area Formula) and Prismoidal Formula. If knowing

A F 1 =4 6 m 2 ,A F 2 =3 5 m 2 ,A F 3 =2 1 m 2 ,A F 4 =2 8 m 2 ,A F 5 =3 4 m 2 A F 6 =4 4 m 2 ,A F 7 =5 2 m 2

Sol:

$$\text{Total vol.} = L\left(\frac{A_1 + A_7}{2} + A_3 + A_5\right)$$

$$= 25\left(\frac{46+52}{2} + 21 + 34\right)$$

$$= 5200m^3$$

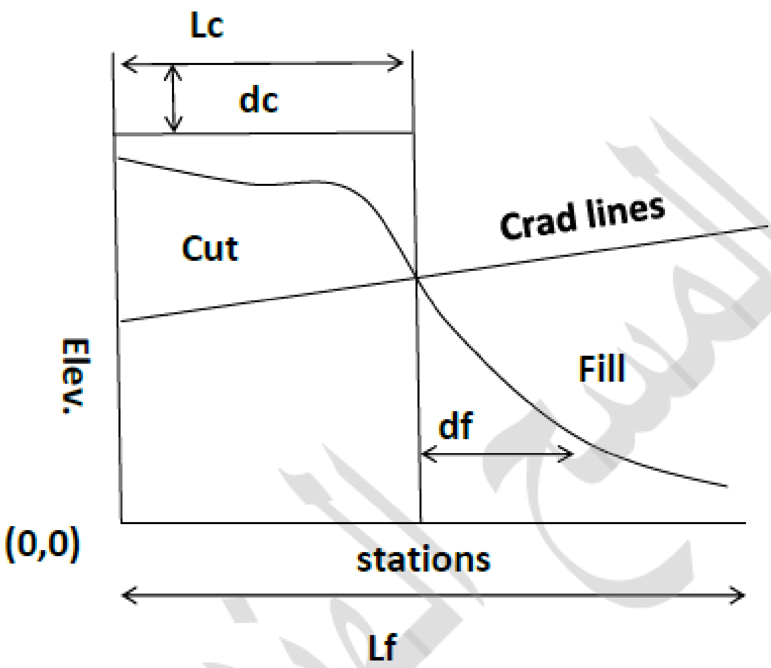
$$total\ vol \quad = \frac{L}{3}(A_1 + A_n + 4(A_2 + A_4 + A_6 \ldots) + 2(A_3 + A_5 \ldots)$$

$$total\ vol \quad = \frac{25}{3}(46 + 52 + 4(35 + 28 + 44)$$

$$= 5300m^3$$

Approximate for computing volum From the Profile

الطريقة التقريبية لحساب الحجوم من المقطع الطولي



$d_c = \frac{A_c}{L_c}$

$d_c =$ العمق المتوسط للحفر

$L_c =$ مسافة الحفر

$A_c =$ مساحة الحفر

$a_c = d_c(b_c + s_c . d_c)$

$vol._{cut} = a_c * L_c$

$d_f = \frac{A_f}{L_f}$

$d_f =$ العمق المتوسط الردم

$L_f =$ مسافة الردم

$A_f =$ مساحة الردم

$a_f = d_f(b_f + s_f . d_f)$

$vol._{fill} = a_f * L_f$

EX:

calculate the volume of cut and Fill if knowning Ac=472m² Af=318m² it was by using the Planimeter and it was found the distance of cut area and distance of Fill area. Lf= 356m. Lc=324m.ats. if knowning the width of road in case cut equal 12m and the side slope of cut 1:2 the width of Road in case fill=10 m and the side slope for fell = 1:3

Sol:

$$d_c = \frac{A_c}{L_c}$$

$$d_c = \frac{472}{324} = 1.46m$$

$$a_c = d_c(b_c + s_c.d_c)$$

$$a_c = 21.78m^2$$

$$vol._{cut} = a_c * L_c$$

$$vol._{cut} = 21.78m^2 * 324$$

$$vol._{cut} = 7057m^3$$

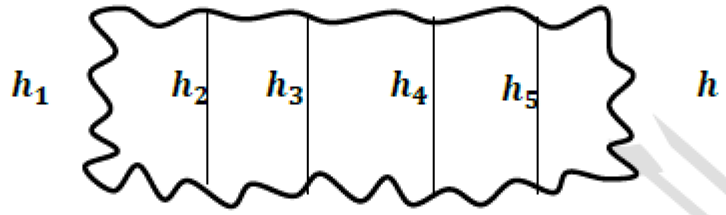
$$d_f = \frac{A_f}{L_f} = \frac{318}{356} = 0.89m$$

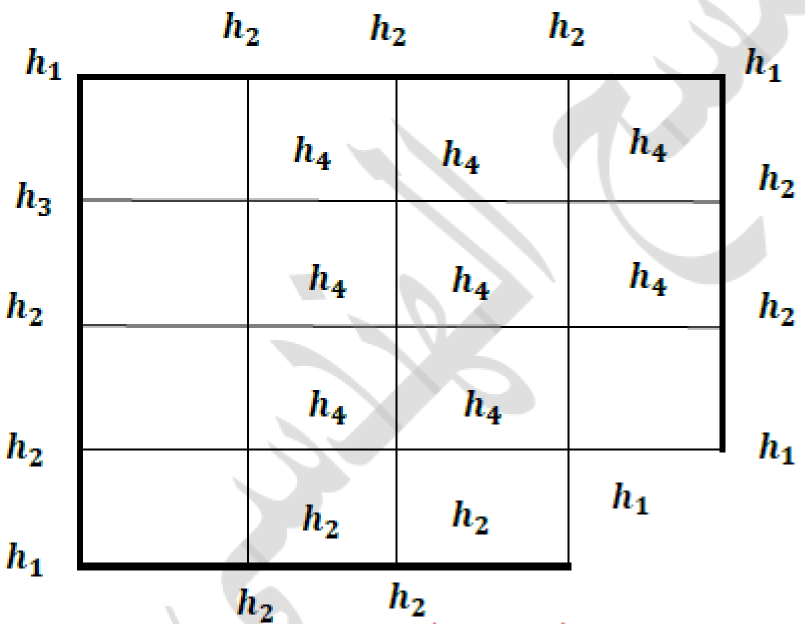
$$a_f = d_f(b_f + s_f.d_f) = 0.89(10 + 3 * 0.89) = 11.28m^2$$

$$vol._{fill} = a_f * L_f = 11.28 * 356 = 4016m^3$$

volume of Borrow Pits From spot heights

حساب الحجوم المقطع او حفرة الأعارة





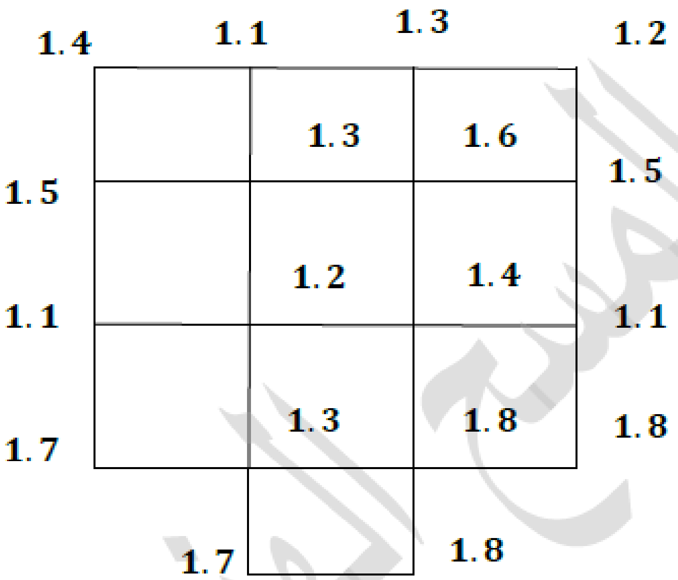
مخطط افقي لمساحة المقطع

$h = height$

A = مساحة الواحد المربع

$$vol\ of_{cut} = A\left(\frac{\sum h_1 + 2\sum h_2 + 3\sum h_3}{4}\right)$$

EX: *calculate the volume for the Following figure if the length. of squore = 20m*



Sol:

$\sum h_1 = 9.6 \quad , \sum h_2 = 7.5 \quad , \sum h_3 = 3.1 \quad , \sum h_4 = 5.5$

A=400

$$vol = A\left(\frac{\sum h_1 + 2\sum h_2 + 3\sum h_3}{4}\right)$$

$$vol = 400\left(\frac{9.6 + 15 + 9.3 + 22}{4}\right)$$

$$vol = 5590 m^3$$

Volumes from Contours

The method used is simply the end area method or the prismoidal formula, the cross section being replaced by the areas contained within successive contours (see below). The distance between sections, or in this case contours, simply becomes the contour interval. As the contained areas are usually quite irregular they are normally determined by planimeter or by computers and digitizing software. The process is laborious and is becoming less popular with the advent of digital data and digital maps. The volume of the hill shown below is,

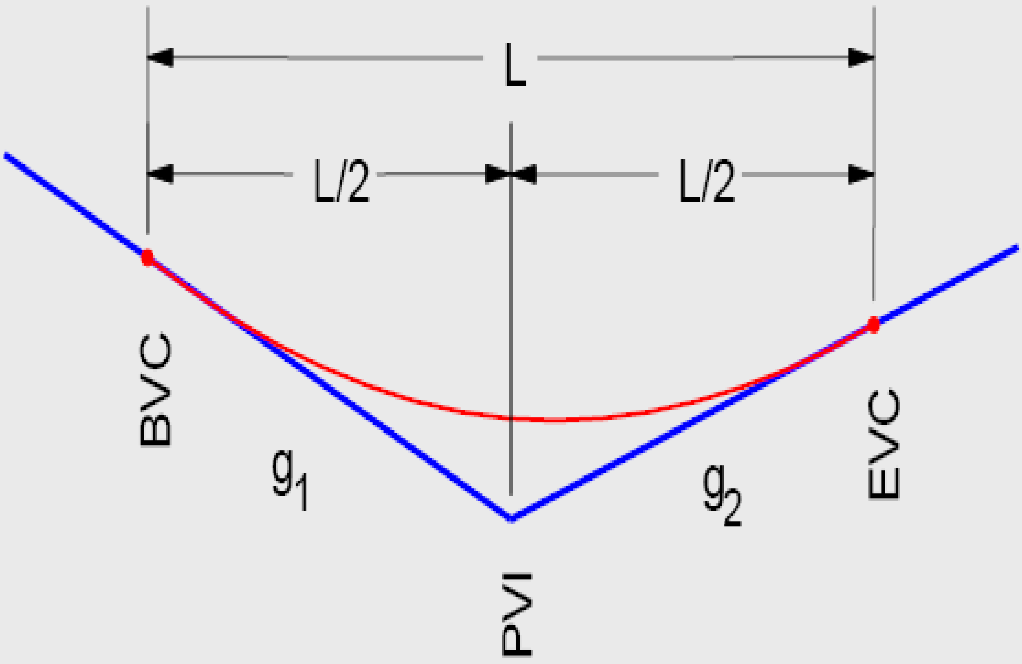
$V = c \frac{[a_1 + 2a_2 + 2a_3 + a_4]}{2}$ where c in the contour interval.

sixth to eighth week

Vertical Curves

1. Nomenclature

Equal Tangent Curve



BVC	Beginning of vertical curve; aka PVC
PVI	Point of vertical intersection; aka VPI
EVC	End of vertical curve; aka PVT
g_1	incoming grade
g_2	outgoing grade
L	curve length

2. Equations

$$Sta_{BVC} = Sta_{PVI} - L/2$$

$$Sta_{EVC} = Sta_{PVI} + L/2$$

$$Elev_{BVC} = Elev_{PVI} - \frac{g_1 L}{2}$$

$$Elev_{EVC} = Elev_{PVI} + \frac{g_2 L}{2}$$

$$k = \frac{g_2 - g_1}{L}$$

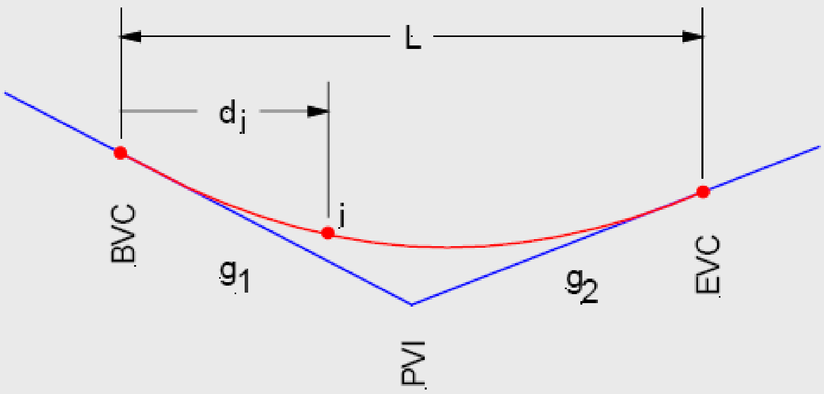
k is the grade change rate; % per station

When computing:

if g in percent, use L and distances in stations:
g=3%, L=10.00 sta

if g in ratio, use L and distances in feet
g=0.03, L=1000.00 ft

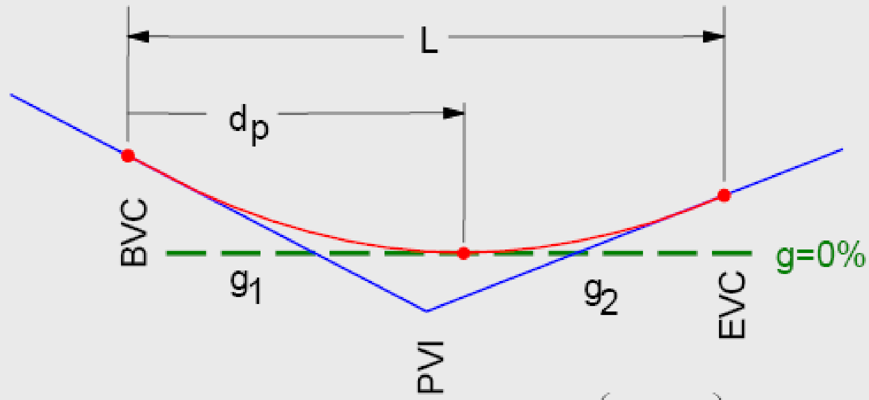
3. Elevation & Grade at any point on the curve



Elevation at station *i* $$Elev_i = Elev_{BVC} + g_1 d_i + \left(\frac{g_2 - g_1}{2L}\right) d_i^2$$

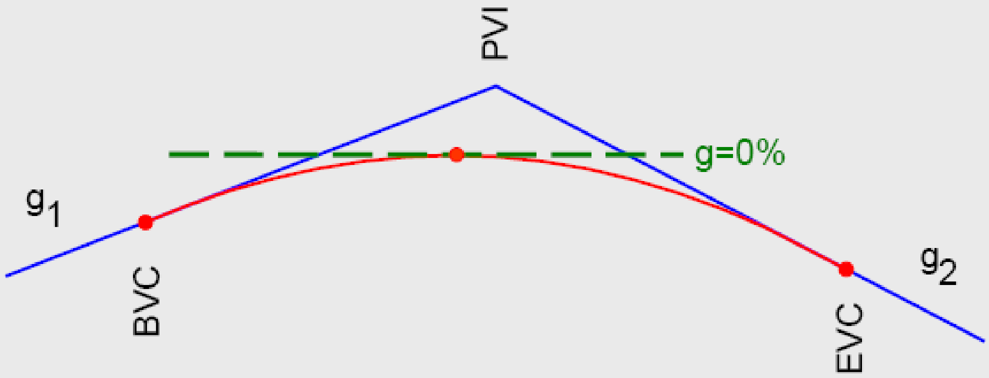
Grade at station *i* $$g_i = g_1 + d_i \left(\frac{g_2 - g_1}{L}\right)$$

5. Location of high or low point

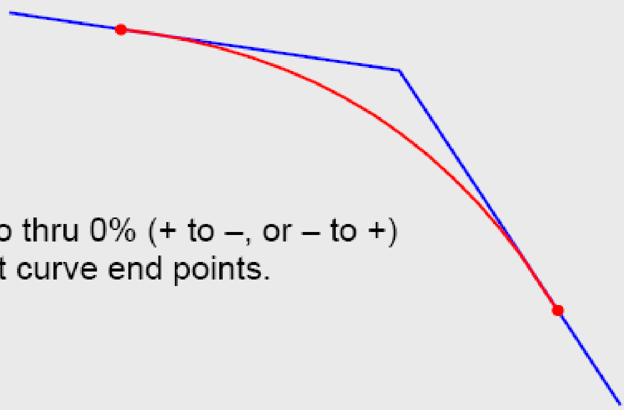


Low (or high) point occurs where the curve grade is 0%

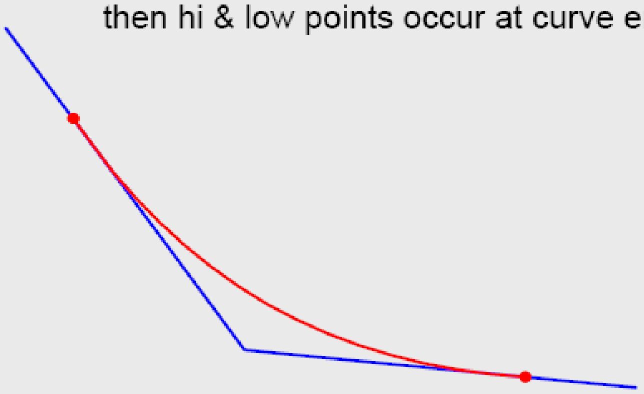
$$d_p = L\left(\frac{g_1}{g_1 - g_2}\right)$$



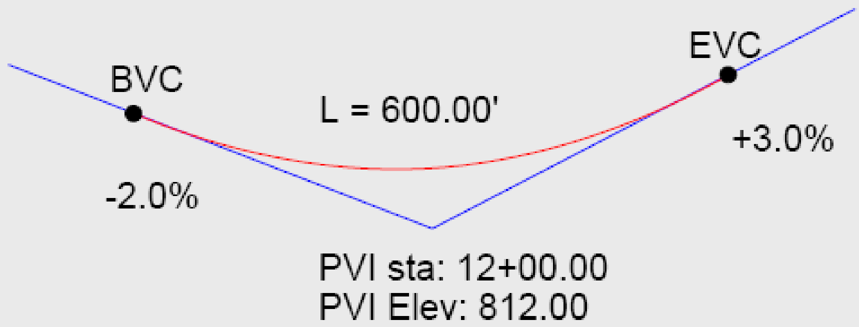
5. Location of high or low point



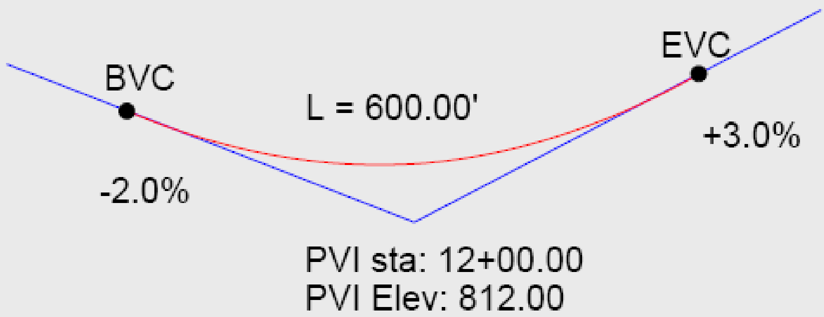
If the curve grade doesn't go thru 0% (+ to –, or – to +) then hi & low points occur at curve end points.



Example:



Example:



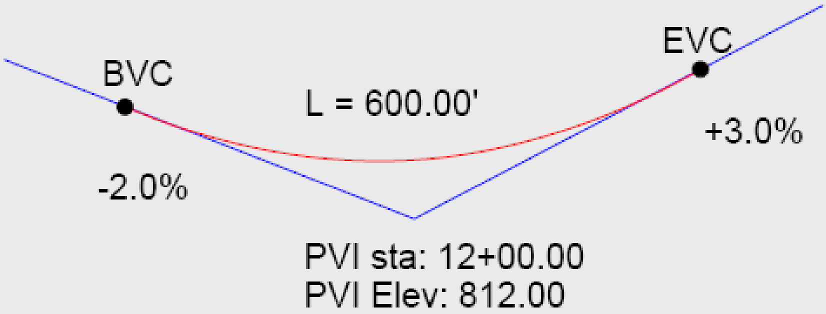
Sta_{BVC} = (1200.00-600.00/2) = 9+00.00
Sta_{EVC} = (1200.00+600.00/2) = 15+00.00

$Elev_{BVC}$ = 812.00-(-2.0)(6/2) = 818.00
$Elev_{EVC}$ = 812.00+(+3.0)(6/2)= 821.00

$$Elev_i = 818.00 + (-2.0)(d_i) + \left[\frac{3.0-(-2.0)}{2(6)}\right] d_i^2$$

$d_i = Sta_i - Sta_{BVC}$

Example:

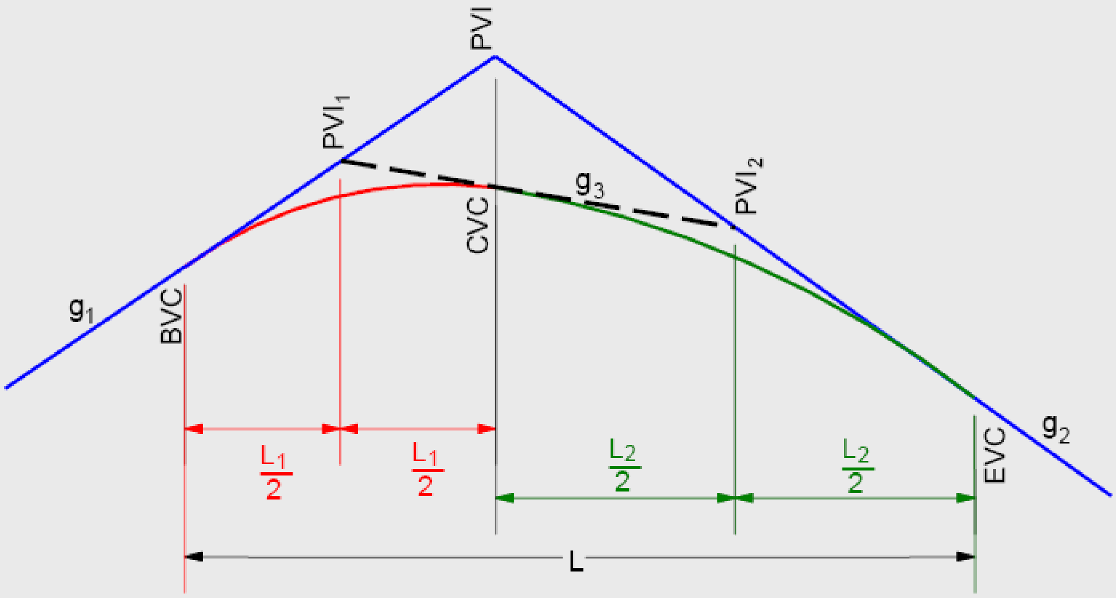


$$Elev_i = 818.00 + (-2.0)(d_i) + \left[\frac{3.0-(-2.0)}{2(6)}\right] d_i^2$$

Sta	d_i (sta)	Elev (ft)
EVC 15+00.00	6.00	821.00
14+00.00	5.00	818.42
13+00.00	4.00	816.67
12+00.00	3.00	815.75
11+00.00	2.00	815.67
10+00.00	1.00	816.42
BVC 9+00.00	0.00	818.00

Low point: sta 11+40.00; elev: 815.60'

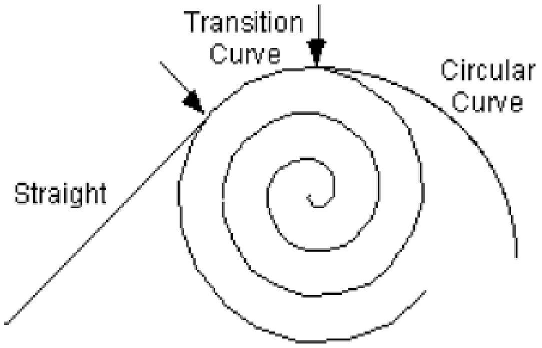
6. Unequal Tangent Curve



Two back-to-back equal tangent curves

Transition Curves

If one considers the dynamics of a vehicle of some kind travelling in a straight line and then turning into a circular curve, the vehicle changes from a state of zero acceleration into a state of full circular acceleration instantaneously. If this happened in reality the vehicle, especially a rail vehicle, would fall off the tracks (and if a road vehicle, the occupants would be thrown around and the car would wander across the road). This is obviously not acceptable. Instead a curve that starts at radius infinity (a straight line) and gradually changes to the radius of the curve is inserted at the start and end of the curve. This is known as a **transition curve** and is generally (mathematically) part of a cubic spiral.

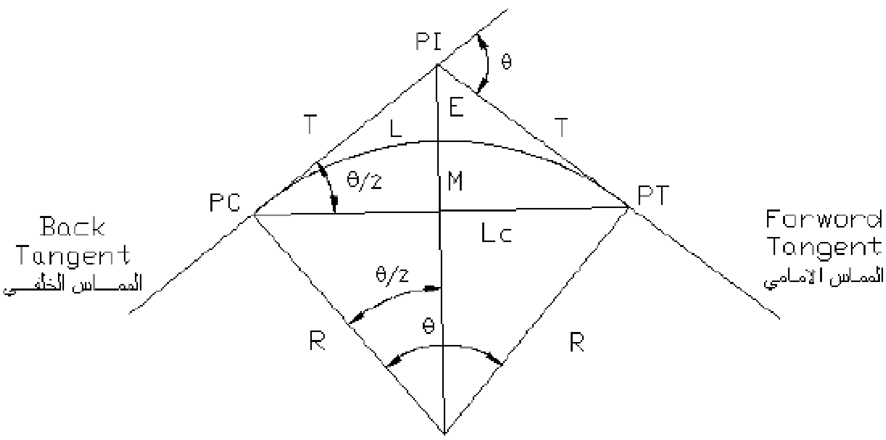


Most high speed country roads and all railway lines, conveyor systems and Sydney's monorail use transition curves as part of the curve design. The computation and layout of transition curves will be left for following chapters and later years of study.

Horizontal Curves

Introduction

The establishment of figures on the ground is an important task of the field surveyor, not only in engineering construction but also in cadastral surveying. It is a relatively easy task to peg out the boundary of a rectangular concrete slab, but considerably more difficult to establish the location of points along an elevated curved freeway.This section will look at the techniques of establishing horizontal circular curves, however more detail will be given in later subject units concerned with road design and construction

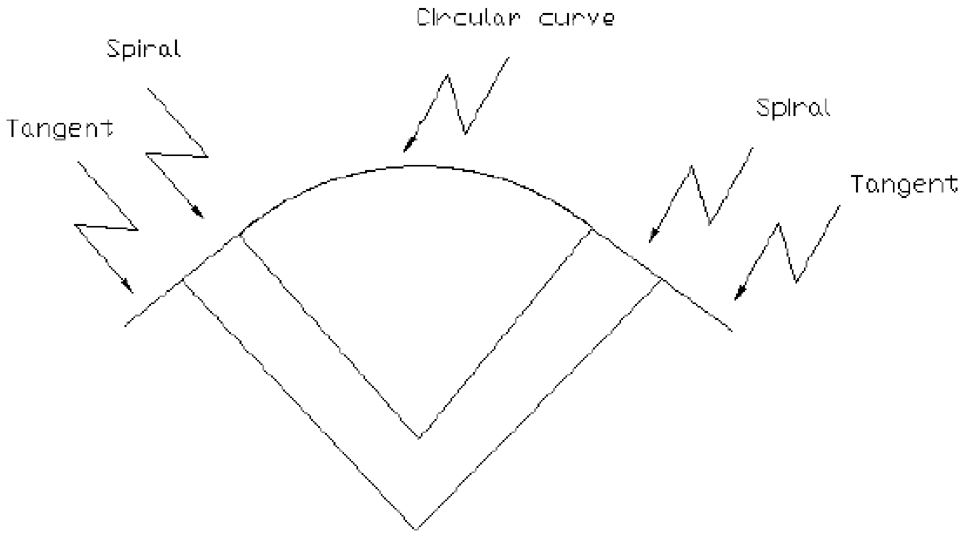


Shown above is the geometry of the horizontal circular curve, used to connect one straight line with another straight line. The two straight line segments (usually roads, rails or pipelines) would have bearings, the intersection angle being determined from the difference between the two.

Types of Horizontal Curvs

Two Types for Horizontal Curvs

1.circular curve
2.spiral curve.



The Ninth to fifteenth week

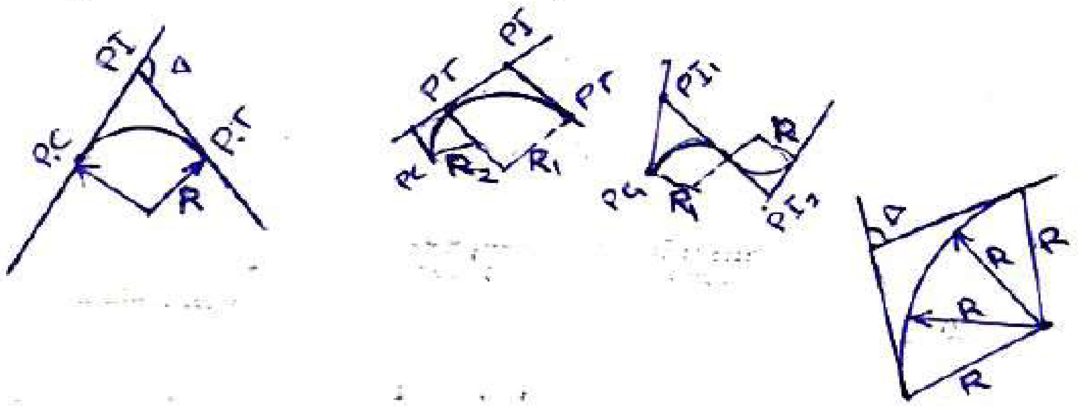
Horizontal curves

Types of Horizontal curves:

Curves may be simple compound, reverse, or spiral. Compound and reveres curves are treated a combination of two or more simple curves, where are the spiral curve is based avarying radius.

Curves of short radius (usually less than one tape length) can be established by holding one end of the tape at the ceutre of the circle and swinging the tape in an are, marking as many points as many be desired. As the radius and length of curve increases, the tape becomes impractical and the surveyer must use other methods. The common method is to measure angles and strigh-line sight distance by which selected points, know as stations, may be located on the circumference of the are.

The four types of curves are described briefly as



- Simple curve: is an acre of a circle – most often used.
- Compound curve: Frequently the terrain will mecessitate the used of compound curve.
- Reverse curve: A reverse curve consists

- Reverse curve: A reverse curve consists of two simple curves jointed together, but curving in opposited directions. For safety reason this curve is seldom used in highway construction as it would tend to send an outomobile off the road.
- Spiral curve: The spiral is a curve which has a varing radios. It is used on railroads and some modern highway. Its purpose is to provide a transition from the tangent to asimple curve or between simple curves in a compound curve:

Element of a simple curve

$P.I \rightarrow$ *Po* int *of* int *er* sec *tion*

I *or* $\Delta \rightarrow$ *The* int *er* sec *ting angle. and or central angle*

$R \rightarrow$ *radins*

$P.C \rightarrow$ *Po* int *of curvature*

$P.T \rightarrow$ *Po* int *of t* arg *ency*

$L \rightarrow$ *length of the curve*

$T \rightarrow$ *Tangent dis* tan *ce*

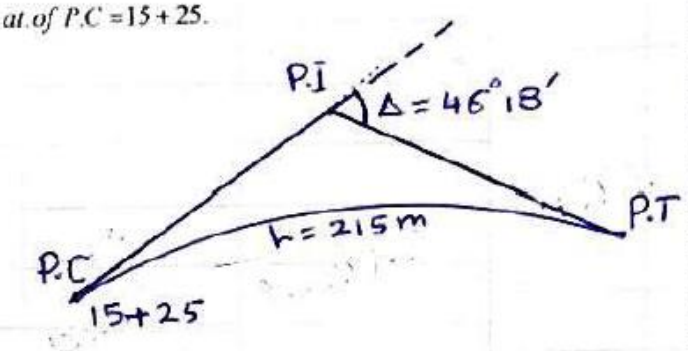
$C \rightarrow$ *The long* cov *d*

$E \rightarrow$ *External dis* tan *ce* (*from P.I to the midpo* int *of the curve*

QP 5.1 Compute the elements and stations for the following simple horizontal curve;

(A) $L = 215m$ $\Delta = 46°18'$ $at.of\ P.C = 15 + 25.$

solution:



1- Draw sketch

2- Compute station of P.T

$st.\ P.T = st.\ PC + L = 1525 + 215 = 1740m$

$= 17 + 40$

3- $T = R\tan\frac{\Delta}{2}$; *Two unknow T & R*

$L = \frac{\pi R \Delta}{180}$; $215 = \frac{\pi R 46°18'}{180}$

$R = 266.06m$

$T = 266.06 * \tan\frac{46\ 18}{2} = 113.759m$

4-

$St.\ of\ P.I = St.\ of\ P.C + T$

$= 1525 + 113.759 = 1632.759\ m$

$= 16 + 38.759$

5-

$C = 2R\sin\frac{\Delta}{2} = 2 * 266.06 * \sin 23°.15'$

$= 209.195m \equiv 209.2m$

6-

$E = R(\frac{1}{\cos\frac{\Delta}{2}} - 1) = 266.06(\frac{1}{\cos 23°15°} - 1)$

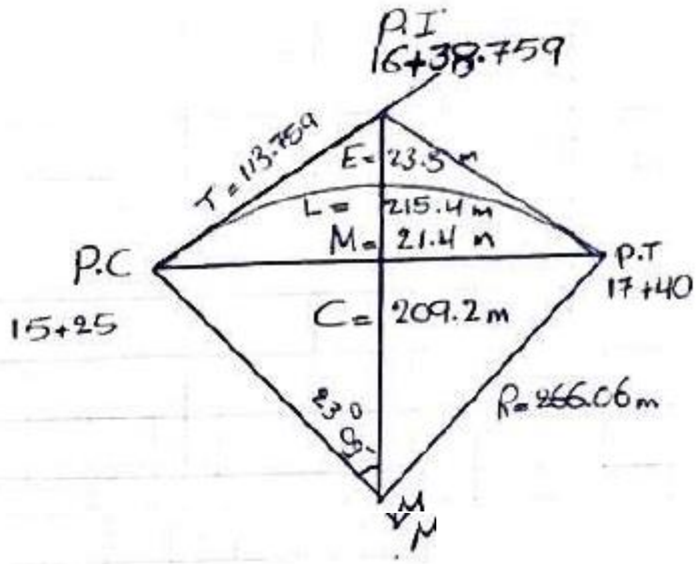
$= 23.3m$

7-

$M = R(1 - \cos\frac{\Delta}{2}) = 266.06(1 - \cos 23.15^{o})$

$= 21.424m$

8- Draw The sketch with the computed data



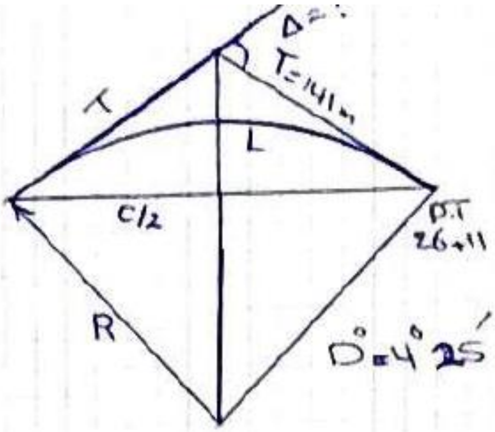
9- Great a table

table of elements

	Stations or element	Value in (m) or st
1-	P.C	15+25
2-	P.I	16+38.759
3-	P.T	17+40
4-	T	113.759
5-	C	209.200
6-	L	215
7-	R	266.06
8-	E	23.30
9-	M	21.40

$B-\quad T = 141\,m \quad D = 4°25' \quad st.of\ P.T = 26+11$

solution: 1- Draw sketch



2- Compute the element

$R=\frac{573}{D}=\frac{573}{4°25'}=129.736m$

تقرب الى ثلاث مراتب بعد الفارز

3-

$T=R\tan\frac{\Delta}{2}$; $\tan\frac{\Delta}{2}=\frac{T}{R}$; $\tan\frac{\Delta}{2}=\frac{141}{129.736}=1.08682$

$\Delta=2\tan^{-1}1.08682=94°\ 45'\ 54'' \leftarrow I''$

عادة تقرب الى ثلاث مراتب بعد الفارزة

4- $C=2R\sin\frac{\Delta}{2}=2*129.736\ \sin\frac{94\ 45\ 54}{2}=190.943m$

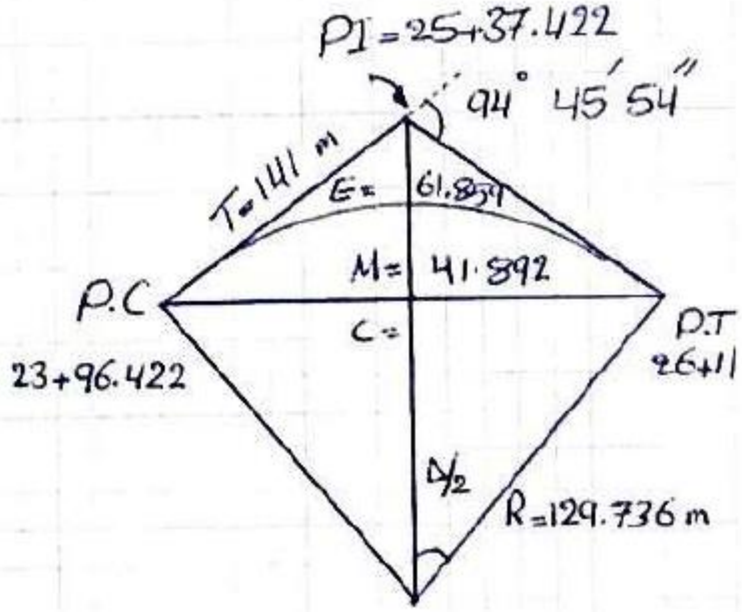
5- $L=\frac{\Pi R\Delta}{180}=\frac{\Pi*129.736*94°\ 45'\ 54''}{180}=214.678m$

6- $E=R(\frac{1}{\cos\frac{\Delta}{2}}-1)=129.739\ (\frac{1}{\cos\frac{94\ 45\ 54}{2}}-1)=61.869m$

7- $M=R(1-\cos\frac{\Delta}{2})=129.736\,(1-\cos\frac{94\ 45\ 54}{2})=41.892m$

8- $St.of\ P.C - St.of\ P.T - L = 2611 - 214.578 = 2396.422$

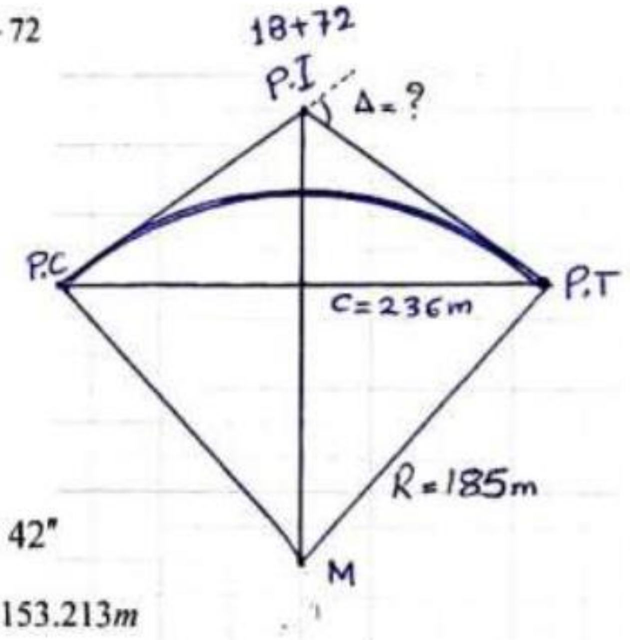
9- $St.\ of\ P.I = St.of\ P.C + T = 2396.422 + 141 = 2537.422$



EX

$C = 236m \quad R = 185m \quad St.of\ P.I = 18 + 72$

Solution: Draw sketch



1-

$D^{\circ} = \frac{573}{185} = 3^{\circ}\ 5'\ 50''$

2- Compute elements

$C = 2R\sin\frac{\Delta}{2}$

$\sin\frac{\Delta}{2} = \frac{C}{2R} = \frac{236}{2*185}$

3- $\Delta = 2\sin^{-1}0.6378 = 79^{\circ}\ 15'\ 42''$

4- $T = R\tan\frac{\Delta}{2} = 185\tan\frac{79\ 15\ 42}{2} = 153.213m$

5- $L = \frac{\Pi * R\Delta}{180} = \frac{\Pi * 185 * 79^{\circ}\ 15'\ 42''}{180} = 255.924m$

6- $E = R(\frac{1}{\cos\frac{\Delta}{2}} - 1) = 185(\frac{1}{\cos\frac{79\ 15\ 42}{2}} - 1) = 55.206m$

7- $M = R(1 - \cos\frac{\Delta}{2}) = (1 - \cos\frac{79\ 15\ 42}{2}) = 42.518m$

8- $St.of\ P.C = 1872 - 153.213 = 1718.787$ m

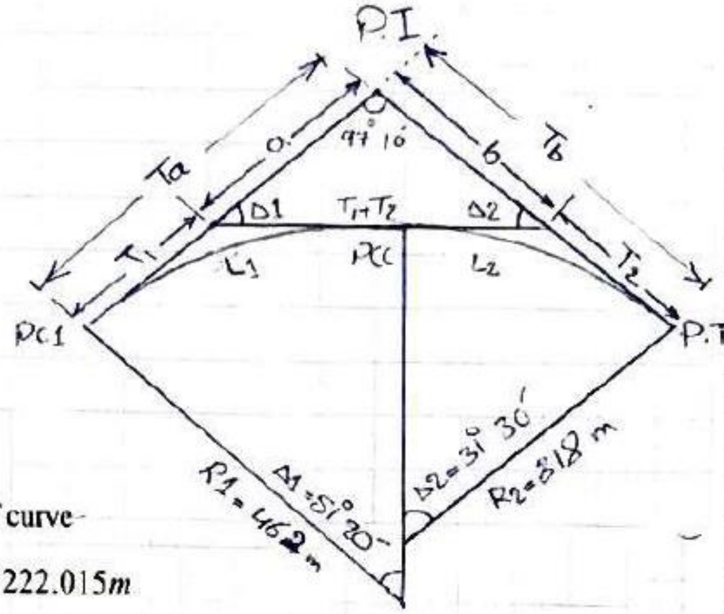
9- $St.of\ P.T = 1718.787 + 255.924 = 1974.711$ m

EX

Compute the stations of the sompound curves

A) $P.I = 56 + 21$ $R_1 = 462m$ $R_2 = 318m$

Sketch the curve $\Delta_1 = 51° \ 20'$ $\Delta_2 = 31° \ 30'$



Compute the elements stat of curve

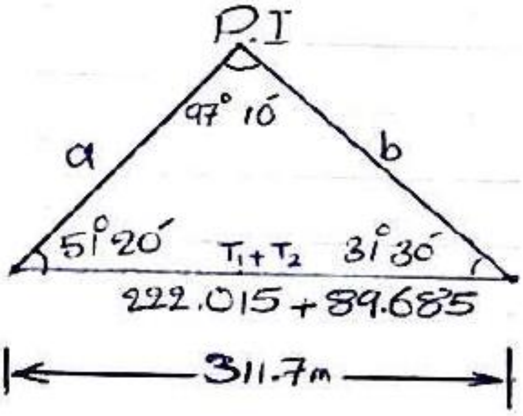
- $T_1 = R_1 \tan\frac{\Delta_1}{2} = 452 \ \tan\frac{5120}{2} 222.015m$
- $L_1 = \frac{\Pi R_1 \Delta_1}{180} = \frac{\Pi * 462 * 51° \ 20'}{180} = 413.922m$
- $T_2 = R_2 \tan\frac{\Delta_2}{2} = 318 \tan\frac{31\ 30}{2} = 89.685m$
- $L_2 = \frac{\Pi R_2 \Delta_2}{180} = \frac{\Pi * 318 * 31° \ 30'}{180} = 174.830m$

(مفتاح الحل في المنحنيات المركبة هو المثلث) (قانون الجيوب)

In Triangle shown (show the triangle using sine law)

$$\frac{a}{\sin 31\ 30} = \frac{b}{\sin 51\ 20} = \frac{222.015 + 89.685}{\sin 97° \ 10'}$$

a = 164.15m
b = 245.29m



$a = 164.15m$

$b = 245.29m$

$T_a = T_1 + a = 222.015 + 164.150 = 386.165m$

$St.\ of\ P.C = 5621 - 386.165 = 5234.835 \rightarrow 52+34.835$

$St.\ of\ P.C.C = PC + L_1$

$= 5234.835 + 413.922$

$= 5658.757 \qquad = 56+58.757$

$St.\ of\ P.T = P.C.C + L_2$

$= 5658.757 + 174.830$

$= 5833.587$

$= 58 + 33.587$

EX:

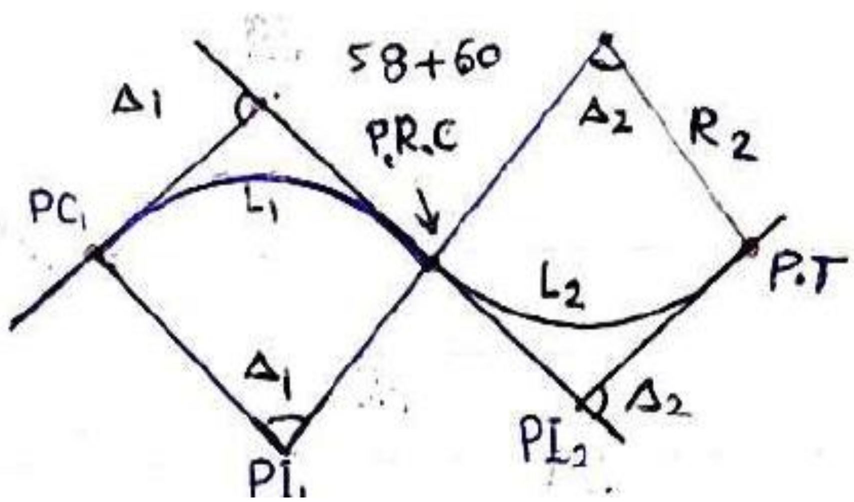
Compute the stations of the following reverse curve

Compute the stations of the following reverse curve

$St.\ of\ PRC = 58+60$

$R_1 = 200m \qquad \Delta_1 = 25° \ 32'$

$R_2 = 350m \qquad \Delta_2 = 35° \ 40'$



Solution

$$T_1 = 200 \tan 12^\circ \; 46' = 45.32$$

$$L_1 = \frac{\Pi * 200 * 25.5333}{180} = 89.12$$

$$T_2 = 350 \tan 17^\circ \; 50' = 112.6m$$

$$L_2 = \frac{\Pi * 350 * 35667}{180} = 217.9m$$

$St.\ of\ P.C = PRC - L_1 = 5860 - 89.12 = 5770.88 = 57+70.88$

$St.\ of\ P.I_1 = PC + T_1 = 5770.88 + 45.32 = 2816.2 = 58+16.2$

$St.\ of\ PI_2 = PRC + T_2 = 5860 + 112.6 = 59+72.60$

$St.\ of\ PT = PRC + L_2 = 5860 + 217.9 = 60+77.9$

الحالات التي ينشأ فيها المنحني المعكوس

١- وجود عائق مثل بناية على نفس الاتجاه.

٢- التقاطع مع نهر او سكة حديد ،

Methods of setting out the horizontal curve

1- method using offsets from the long chord .

2- method using offset on the tangent .

3- method using of deflection angle.

4- Setting out from point of intersection.

1- Using offset from long chord :

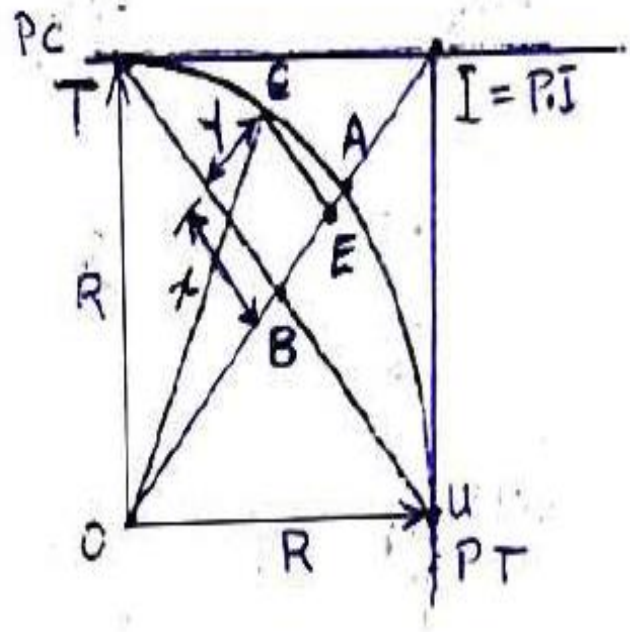
Derive the formula

$$y = \sqrt{R^2 - X^2} - \sqrt{R^2 - (\frac{C}{2})^2}$$

AB = AO = OB

$= AO - \sqrt{OU^2 - UB^2}$

$= R2 - \sqrt{R^2 - (\frac{C}{2})^2}$



Draw CE parallel to TU

Y= EB = EB = EO – BO

$EO^2 = CO^2 - CE^2$ $\quad EO = \sqrt{R^2 - X^2}$

$$y = \sqrt{R^2 - X^2} - \sqrt{R^2 - (\frac{C}{2})^2}$$

Derive Data for setting out the curb line shown the former shape , if the radius be 12 m and $T\hat{O}U = 90^\circ$ offset , are required at 2m intervals .

$TU^2 = TO^2 + OU^2 = 12^2 + 12^2 = 288$

Therefore TU = C = 16.97 m

$\sqrt{R^2 - (\frac{C}{2})^2} = 8.49\ m$

Point	x	X^2	R^2-x^2	$\sqrt{R^2 - X^2}$	Y (m) offset
1	0	0	144	12	3.51
2	2	4	140	11.83	3.34
3	4	16	128	11.31	2.82
4	6	36	108	10.93	1.9
5	8	64	80	9.94	0.45

Point T & U would be located be measuring IT(= IU) from the intersection point (P.V.I)

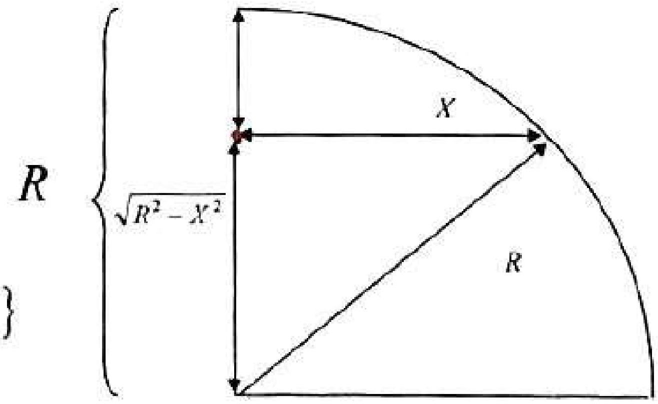
2 – **Tangent – offsets method:**

Depends one the formula $Y = R\left[1-\sqrt{1-(\frac{x}{R})^2}\right]$

$$R = y - \sqrt{R^2 - X^2}$$

$$y = R - \sqrt{R^2 - X^2}$$

$$y = R\left\{1 - \sqrt{1-(\frac{x}{R})^2}\right\}$$



Point	**X**	$y = R\left\{1 - \sqrt{1-(\frac{x}{R})^2}\right\}$
1	x_1	Y_1
2	x_2	Y_2
3	x_3	Y_3
4	x_4	Y_4
.	.	.
.	.	.

setting out a horizontal circular curve with $\Delta = 43^\circ - 24$; $D = 4^\circ 30$ st. of P. I

=38 + 20ssss; using 4 different method

(1) Tangential angle method (2) offset on tangent (3) off-set on long chord (4) off-set from point of intersection .

solution : compute the curve elements

$$R = \frac{573}{\Delta} = \frac{573}{4.5} = 127.33\ m$$

$$T = R.\ \tan\frac{\Delta}{2} = 127.33\ \tan\frac{4324}{2} = 50.67\ m$$

$$L = \frac{TR\Delta}{180} = \frac{T * 127.33 * 43.4}{180} = 96.45\ m$$

$C = 2\,R\,\sin\frac{\Delta}{2} = 2*127.33*\sin 21\ 42 = 9.416m$

$C/2 = \frac{94.16}{2} = 47.08\ m$

$E = R\,(\frac{1}{\cos\frac{\Delta}{2}} - 1) = 127.33\ (\frac{1}{\cos 21\ 42} - 1) = 9.71\ m$

$M = R\,(1 - \cos\frac{\Delta}{2}) = 127.33\ (1 - \cos 21\ 42) = 9.02\ m$

St.of P.c = st.of P.I – T = 3820 -50.67 = 3769.33 m

37+ 69.33 m

st. of P.I = st. of. P.C + L = (37 +69.33) + (96.54) = 38 +65.78

setting out:

1) using deflection angle method:

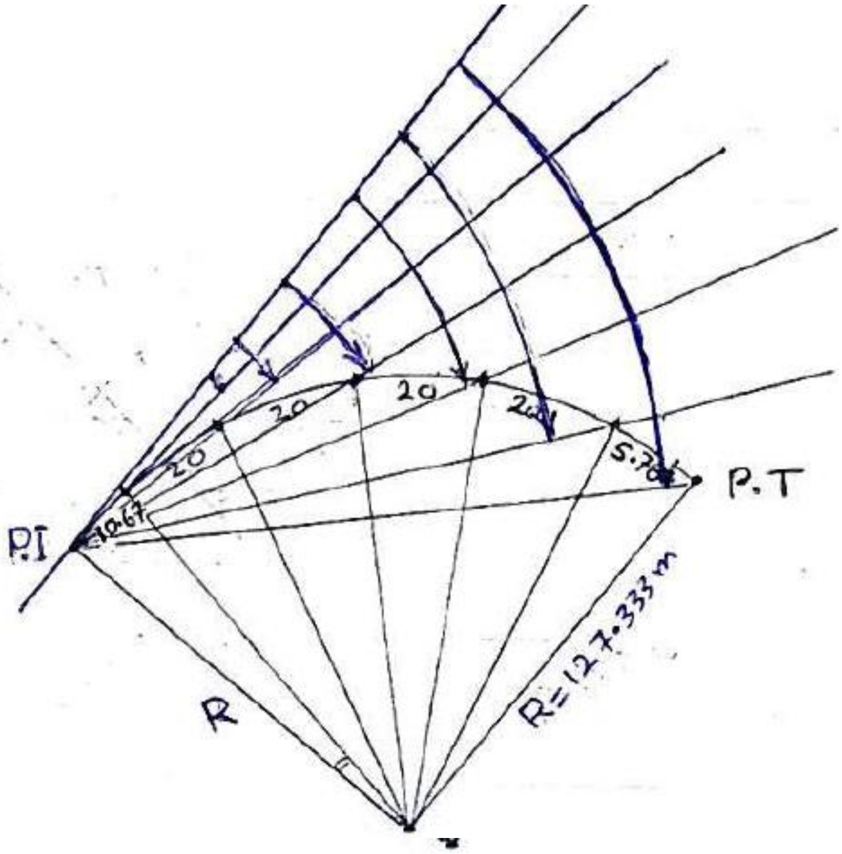
- depending on the L = 96.46 m and the interval =20 m, st. of P.c = 37 +69 .33 the staking out will be:

37 + 69.33	⟶	The st. of P.C
37 + 80	⟶	1 st
38 +00	⟶	2 nd
38 + 20	⟶	3 rd
38 + 40	⟶	4 th
38 + 60	⟶	5 th
38 + 65.57	⟶	6 th st .of P.T

$$L = \frac{\pi R \Delta}{180}$$

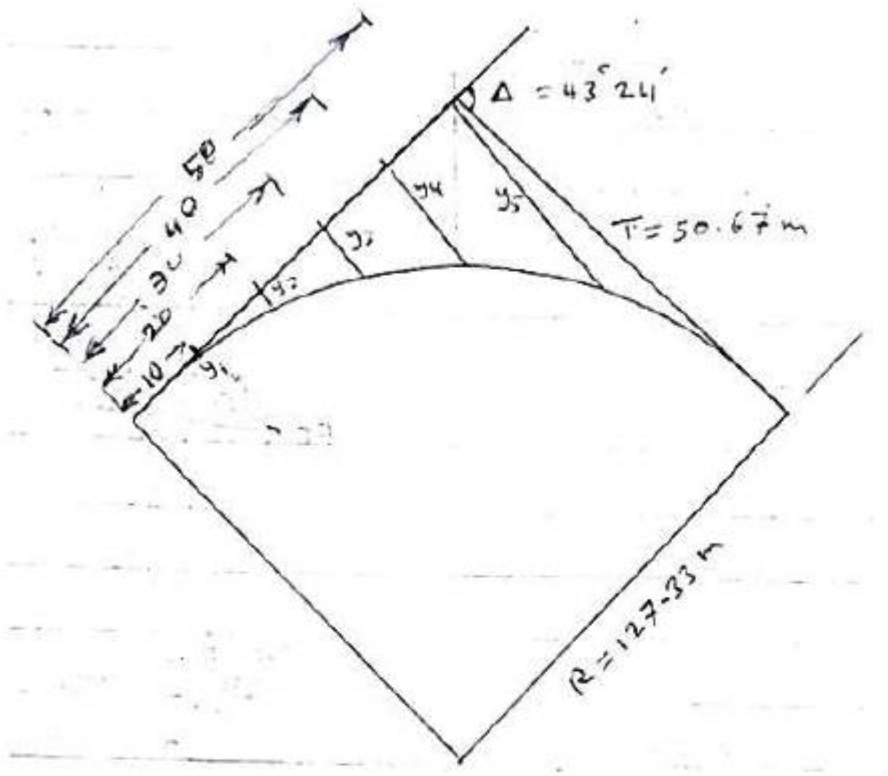
$$\ell = \frac{\pi R \alpha}{90}$$

$$\alpha = \frac{90 \ell}{\pi R}$$



Stations	ℓ (m)	$\alpha = \frac{90 \ell}{\pi R}$	Total α	C= 2 R sin
P. C 37 + 69.33	0.0	0 00	0.00	0.00
37 + 80	10.67	2 24	2 24	10.66
38 +00	20	4 30	6 54	29.00
38 + 20	20	4 30	11 24	50.34
38 + 40	20	4 30	15 54	68.23
38 + 60	20	4 30	20 24	88.77
P. T 38 + 65.57	5.78	1 18	21 42	94.16= C

2) Tangent off- set Method:

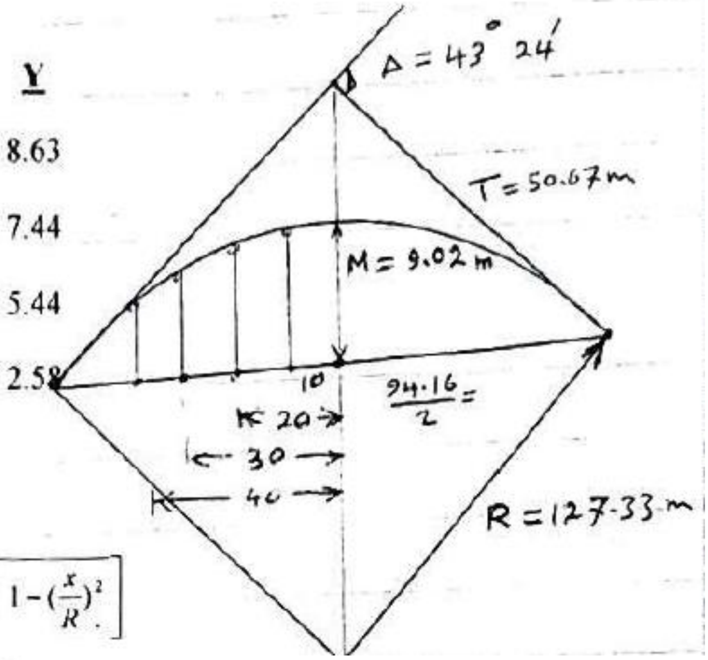


Point	**xm**	**Y**
1	10	0.39
2	20	1.58
3	30	3.58
4	40	6.45
5	50	10.23

$$Y = R\left[1-\sqrt{1-(\frac{x}{R})^2}\right]$$

3) off-set on long chord:

Point	xm	Y
1	10	8.63
2	20	7.44
3	30	5.44
4	40	2.58



$$y = R\left[\sqrt{1-(\frac{x}{R})^2} - \sqrt{1-(\frac{x}{R})^2}\right]$$

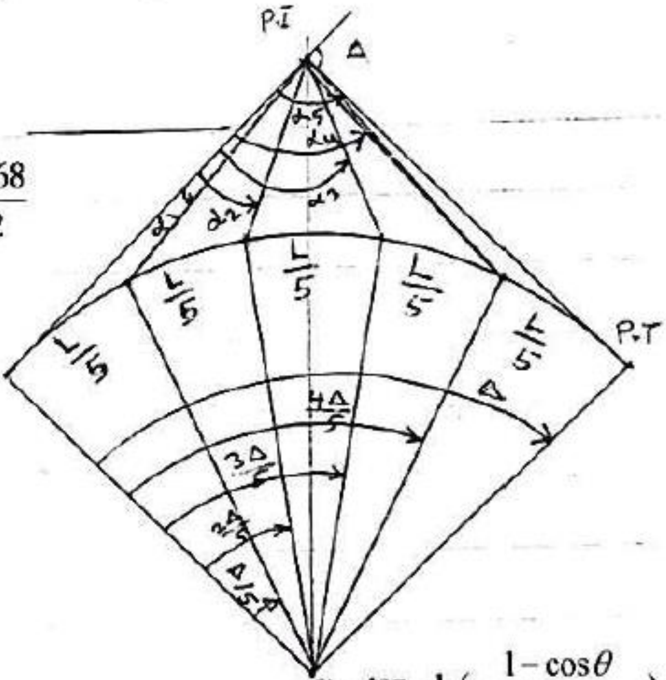
4) from point of intersection

$$\frac{L}{5} = \frac{96.45}{5} = 19.29\ m$$

$$C = 2R\sin\alpha = 2*127\sin\frac{0.68}{2}$$

C= 19.27

Point	θ	α
1	8.68	2 39
2	17.36	24 35
3	26.04	112 01
4	34.72	133 57
5	43.40	136 36



$$\alpha = \tan-1\ (\frac{1-\cos\theta}{\tan\frac{\Delta}{2} - \sin\theta})$$

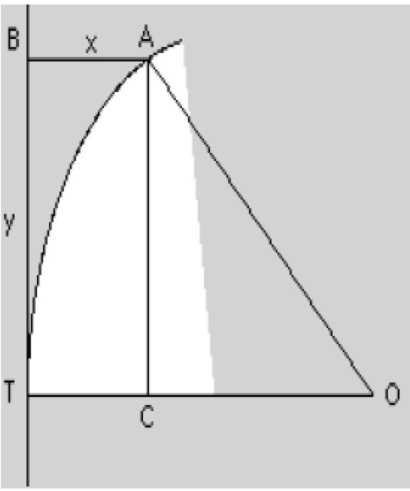
$\theta_1 = \frac{\Delta}{5}$ حيث ان ، θ هي القيمة المتغيرة لـــ Δ

Setting Out

There are several methods available for establishing the location of points along the centre line of the engineering curve. Some of these are rarely used these days, the system is generally dominated by the use of coordinates as the method of computation, so the use of radiations from control points is common. In any case, all pegs and marks placed must be checked, and the preferred method for that is to use a different method to check from that used to peg.

Setting Out - Offsets From The Tangent

When the tangent points have been located, the curve may be set out by means of offsets from the tangents. Consider the circular arc illustrated below with centre O and one of the tangent points, T. It is necessary to calculate the length of the offset BA(c) at distance TB(g) along the tangent. Let radius of arc be R.



Applying Pythagoras Theorem to triangle OAC, we have:

$$OA^2 = OC^2 + AC^2 = (TO - TC)^2 + AC^2$$

or

$$OA^2 = (TO - BA)^2 + TB^2$$

Substituting for x, y, and R in this equation:

$$R^2 = (R - x)^2 + y^2$$

or

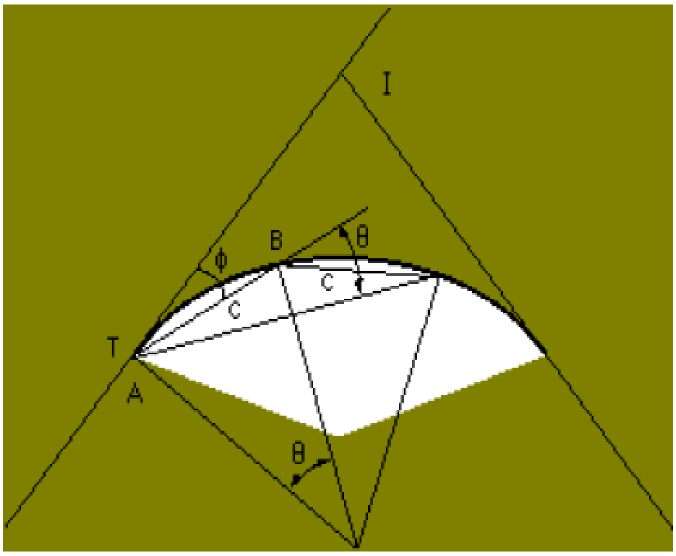
$$(R - x)^2 = (R^2 - y^2)$$

$$\therefore\ x = \sqrt{(R^2 - y^2)}$$

Setting out - Deflection Angles

The use of deflection angles (the angle deflected by a chord) is considerable more rigourous than either of the two previous methods. The method also follows the centreline of the curve, unlike the previous two which require access to the chord and centreline.

The method is based on the following geometry:



It will be remembered that the angle subtended at the circumference by a chord is one half of the angle subtended at the centre (in this case ϕ and θ). The first angle through which the chord being used for pegging is deflected is therefore half the angle subtended by that chord at the centre. The next angle through which the next chord is deflected is the equal to twice this value that is the same as the angle subtended at the centre. A typical application of the method is as follows:

i. Set the instrument up at the tangent point, sight along the tangent and turn off the first deflection angle ϕ ($=\frac{\theta}{2}$).
ii. fix one end of tape at A, measure off 'c' metres, and swing tape until it aligns with the line of sight. Put in peg B.
iii. Turn theodolite a further $\theta°$. Fix one end of tape at B, measure off 'c' meters, and swing tape until that point on the tape crosses the line of sight. Put in peg C.
iv. Repeat step (iii) until you peg the curve. If the line of sight becomes obstructed, then simply set up on any peg on the curve, sight back along the chord to the previous peg and continue to establish the deflection angles.

Construction Surveys

INTRODUCTION

Construction is one of the largest industries in the United States, and thus surveying, as the basis for it, is extremely important. It is estimated that 60 *% of all* hours spent in surveying are on location-type work, giving line and grade. Nevertheless, insufficient attention is frequently given to this type of survey.

An accurate topographic survey and site map are the first requirement! signing streets, sewer and water lines, and structures. Surveyors then lay o position these facilities according to the design plan. A final "as-built" map incorporating any modifications made to the design plans, is prepared during after construction, and filed. Such maps are extremely important, especially underground utilities are involved, to assure that they can be located qui trouble develops, and that they will not be disturbed by later improvemen[1]

Construction surveying involves establishing both *line* and *grade* by of stakes and reference lines which are placed on the construction site. These the contractor so that proposed facilities are constructed according to a placement of the stakes is most often done by making the fundamental measuring of horizontal distances, horizontal and vertical angles, and differences in ele using the basic equipment and methods described in earlier chapters of the However, the global positioning system (GPS) is also being used with in a frequency for construction surveys (see Section 23-10). Other specialized equipment, including laser alignment devices and reflectorless electronic distant surveying equipment, (see Section 23-2) have also been developed which greatly facilitates construction surveying.

All surveyors, engineers, and architects who may be involved with pb designing and building constructed facilities should be familiar with the mental procedures involved in construction surveying. This chapter describes procedures *i* applicable for some of the more common types of construction projects. ters 24.25, and 26 cover the subjects of horizontal curves, vertical curves, and computations, respectively. These topics are all pertinent to construction eys. particularly those for transportation routes.Construction surveying is perhaps best learned on the job, and consists in ting fundamental principles to the undertaking at hand. Since each project F involve unique conditions, and present individual problems, coverage in this t is limited to a discussion of the fundamentals.

|23-2 SPECIALIZED EQUIPMENT FOR CONSTRUCTION SURVEYS

looted above, the placement of stakes for line and grade to guide construction ns accomplished using the surveyor's standard equipment— . tapes, total station instruments and GPS receivers. Recent advances in mod-: technology, however, have produced some additional new instruments that : improved, simplified, and greatly increased the speed with which certain types ^construction surveying can be accomplished. *Visible laser-beam* alignment in-aents and *pulsed laser EDM* instruments (total stations equipped with re-torless electronic distance measuring devices) are among the new innovations. ; are described briefly in the subsections that follow.

-2.1 Visible Laser Beam Instruments:

Fundamental purpose of laser instruments is to create a visible line of known enation or a plane of known elevation, from which measurements for line and ie can be made. Two general types of lasers are described here: *Single-beam lasers,* as shown in Figures 23-1 and 23-2, project visible refer-; lines ("string lines" or "plumb lines") that are utilized in linear and vertical alignment applications such as tunneling, sewer pipe placement, and 1 struction.The instrument shown in Figure 23-1 is a single-beam type 1 been combined with a total station instrument. This combination pr bilities that are convenient for a variety of construction layout applic laser beam is projected collinear with the instrument's line of sight, a fe facilitates aligning it in prescribed horizontal alignments and/or along] grade lines. The instrument can be used to project string lines for dist about 1000 m. With the zenith angle set to either 90° or 270°, if the total < strument is rotated about its vertical axis, the laser will generate a horizonui| Also if it is turned about its horizontal axis, the laser will define a vertical The instrument shown in Figure 23-2 projects a visible laser beam a < of 5 m below and 100 m above the instrument along the plumb line. These i ments are useful for alignment of objects in vertical structures. A similar tyj single-beam laser projects a visible laser-beam at a selected grade—a device I is especially useful in aligning pipelines.*Rotating-beam lasers* are merely single-beam lasers with spinning optics 1 rotate the beam in azimuth, thereby creating planes of reference. They expedite 1 placement of grade stakes over large areas such as airports, parking lots, and« divisions, and are also useful for topographic apping.Figure 23-3 shows a rotating-beam type laser. It projects a beam up to **350i** while rotating at 600 rpm. The laser signal can be picked up by one or more i ceivers attached to grade rods or staffs. The instrument is self-leveling and quicfchrl set up. If somehow bumped out of level, the laser beam shuts off and does not come back on until it is releveled. It can be operated with the laser plane oriented horizontally for setting footings, floors, etc., or the beam can be turned 90° and used vertically for plumbing walls or columns. Because laser beams are not readily visible to the naked eye in bright sunlit, special detectors attached to a hand-held rod are often used. To lay out hor-ital planes with either

of these devices, the height of the instrument above i, *HI,* must be established. Then the height on a graduated rod that a refer-: mark or detector must be set is the difference between the *HI* and the plane's auired elevation.

STAKING OUT A PIPELINE ics are used to carry water for human consumption, storm water, sewage, oil, I gas, and other fluids. Pipes which carry storm runoff are called *storm sew-*: those which transport sewage, *sanitary sewers*. Flow in these two types of sew-> is usually by gravity, and therefore their alignments and grades must be care-ly set. Flow in pipes carrying city water, oil, and natural gas is generally under sure, so usually they need not be aligned to as high an order of accuracy. In pipeline construction, trenches are usually opened along the required lent to the prescribed depth (slightly below if pipe bedding is required), the : is installed according to plan, and the trench backfilled. Pipeline grades are I by a variety of existing conditions, topography being a critical one. A profile : that of Figure 5-12 is usually used to analyze the topography and assist in de-ig the grade line for each pipe segment. To minimize construction difficulties : costs, excavation depths are minimized, but at the same time a certain mini-hum cover over the pipeline must be maintained to protect it from damage by heavy loading from above and to prevent freezing in cold climates. Minimum f shades also become an important design factor for pipes under gravity flow. Ac-i accordingly, a grade of at least 0.5 percent is recommended for storm sewers, but slightly higher grades are needed for sanitary sewers. In designing pipe grade lines, other existing underground elements often must be avoided, and due regard must also be given to the grades of connecting lines and the vertical clearances needed to construct manholes, catch basins, and outfalls.

Prior to staking a pipeline, the surveyor and contra tails of he project. An understanding must be reached trench width, where the installation equipment will be pla the excavated

material will be stockpiled. Then a reference < appropriately established that will (1) meet the contractor's i destruction, and (3) not interfere with operations.

The alignment and grade for the pipeline are taken ; set reference line parallel to the required centerline is estab or 50-ft stations when the ground is reasonably uniform.. together on horizontal and vertical curves than on straight: large diameter, stakes may be placed for each pipe length—say.1 surfaces where stakes cannot be driven, points are marked by) scratch marks.

Precise alignment and grade for pipe placement are guided! *boards* or laser beams. Figure 23-5 shows one arrangement of a I sewer line. It is constructed using 1 X 4 in., 1 X 6 in., or 2 X 4 in! 2 x 4 in. posts which have been pointed and driven into the grc of the trench. Depending upon conditions, these may be placed at.' other convenient distance along the sewer line. The top of the 1 erally placed a full number of feet above the *invert* (flow line or I face) of the pipe. Nails are driven into the board tops so a string« between them will define the pipe centerline. A graduated pole -often called a *story pole,* is used to measure the required distance: to the pipe invert. Thus, the string gives both line and grade. It can bel hanging a weight on each end after wrapping it around the nails.

STAKING PIPELINE GRADESI

pipeline grades is essentially the reverse of running profiles, although in ations the centerline must first be marked and stationed in horizontal lo-tlhe actual profiling and staking are on an offset line, formation conveyed to the contractor on stakes for laying pipelines usu-sts of two parts: (1) giving the depth of cut (or fill), normally only to the 10.1 ft, to enable a rough trench to be excavated; and (2) providing precise : information, generally "to the nearest 0.01 ft, to guide in the actual place-lof the pipe invert at its planned elevation. Cut (or fill) values for the first : vertical distances from ground elevation at the offset stakes to the pipe inter the pipe's grade line has been computed and the Set up the level and get an *HI* by reading a plus sight on a BS *HI* = 2.11 + 100.65 = 102.76 (see Plate B-6 and Figure 25-^ Obtain the elevation at each station from a rod reading at every stake (column 4) — for example, 4.07 at station I - i B-6 and Figure 23-6) — and subtract it from the ///(column 5l 102.76 - 4.07 = 98.69 at station 1 + 00.

5. Subtract the pipe elevation from the ground elevation to get < (-) (column 7); for example. 98.69 - 95.34 = C 3.35 (see Piaiel ure 23-6).
6. Mark the cut or fill (using a permanent marking felt pen or 1 set stake facing the centerline; the station number is written < side.In another variation, which produces the same results, *grade i* between *HI* and pipe invert) is computed, and *ground rod* (reading i at stake) is subtracted from it to get cut or fill. For station 1 + 00.! 102.76 - 95.34 = 7.42, and 7.42 - 4.07 = C 3.35.After the trench has been excavated based on cuts and fills i stakes, batter boards are set. Marks needed to place them can be made i cil or felt pen on the offset stakes during the same leveling operation i tain cut and fill information. Figure 23-6 also illustrates the process.'. at station 1 + 00, the batter board will be set so its top is exactly 5.00 ft i pipe invert. The rod reading necessary to set the batter board is obt trading the pipe invert elevation plus 5.00 ft from the *HI*; thus 102.76 — < 5.00) = 2.42 ft (see Figure 23-6). The rod is held at the stake and adjt tical position by commands from the level operator until a rod reading! is obtained; then a mark is made at the rod's base on the stake. (To fa process, a rod target or a colored rubber band can be placed on the rod *i* quired reading.) The board is then fastened to the stake with its top at 1 using nails or C clamps, and a carpenter's level is used to align it horizont the trench. A nail marking the pipe centerline is set by measuring the • set distance along the board.If a laser is to be employed, this same leveling procedure can be usedl tablish the elevation of the laser beam at some desired vertical offset dist the pipe's in vert. The procedure is used to establish the height of the laser i ment, and also to set another identical offset elevation at a station forward* Then the laser beam is aimed at that target to establish the required grade 1

• 23-6 STAKING OUT A BUILDING

The first task in staking out a building is to locate it properly on the correct 1 making measurements from the property lines. Most cities have an ordina tablishing setback lines from the street and between houses to improve app and provide fire protection.Stakes may be set initially at the exact building corners as a visual check* the positioning of the structure, but obviously such points are lost immed when excavation is begun on the footings. A set of batter boards and refer

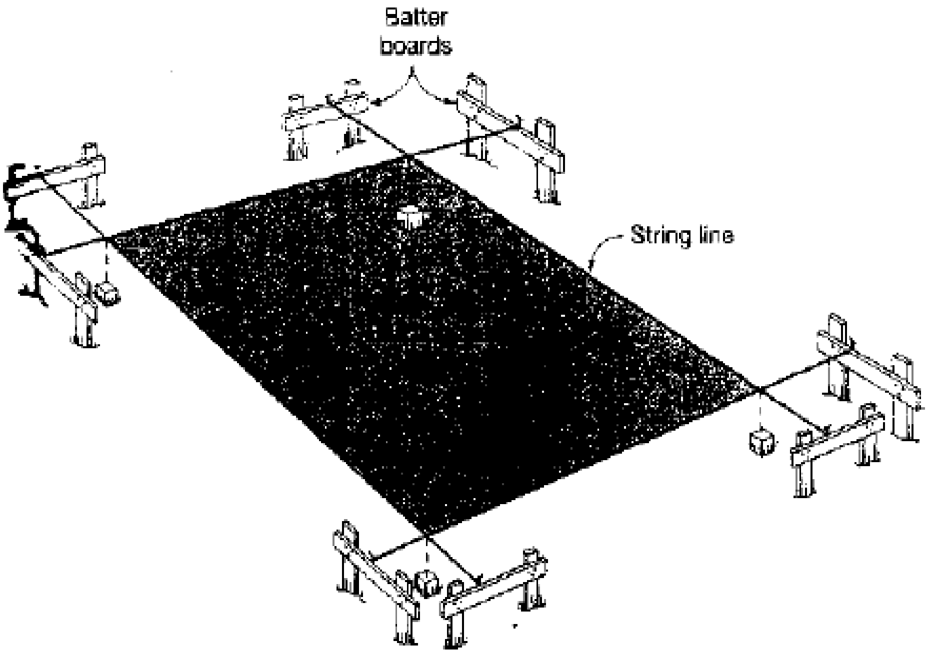


Figure 23-7

Batter boards for building layout., placed as shown in Figure 23-7, is therefore erected near each corner, but I of the way of construction. The boards are nailed a full number of feet above t footing base, or at first-floor elevation. (The procedure of setting boards at a ed elevation was described in the preceding section.) Nails are driven into shatter board tops so that strings stretched tightly between them define the out-: wall or form line of the building. The layout is checked by measuring diago- »and comparing them with each other (for symmetric layouts) or to their com-l values. Figure 23-8 illustrates the placement on a lot and staking of a slightly : complicated building. The following are recommended steps in the procedure:

1. Set hubs *A* and *B* 5.00 ft inside the east lot line, with hub *A* 20.00 ft from the south lot line and hub *B* 70.00 ft from *A*. Mark the points precisely with nails.
2. Set a total station instrument over hub *A*, backsight on hub *B*, and turn a clockwise angle of 270° to set batter board nails 1 and 2 and stakes *C* and *D*.
3. Set the instrument over hub *B*, backsight on hub *A*, and turn a 90° angle. Set batter board nails 3 and 4 and stakes *E* and *F*.
4. Measure diagonals *CF* and *DE* and adjust if the error is small or restake if large.
5. Set the instrument over *C* backsight on *E*, and set batter-board nail 5. Plunge the instrument and set nail 6.
6. Set the instrument over D, backsight on *F*, and set nail 7. Plunge and set nail 8.
7. Set batter board nails 9,10,11,12,13, and 14 by measurements from established points.
8. Stretch the string lines to create the building's outline, and check all diagonals.

As an alternative to this building stakeout procedure, radial i scribed in Section 9-9) can be used. This can substantially reduce the i strument setups and stakeout time required. In the radial method. (all building corners are computed in the same coordinate system as the 1 Then the total station instrument is set on any convenient control] ented in azimuth by sighting another intervisible control point. Angles *t* tances, computed from coordinates, are then laid off to mark each bu The layout is checked by measuring the distances between adjacent j also the diagonals. (An example illustrating radial stakeout of a circular i given in Section 24-11.) After constructing the batter boards and setting i pieces at the desired elevations, the alignment nails on the batter boards (by pulling taut string lines across established corners. In Figure 23-8, for < with corners *D* and *F* marked, a line stretched across these two points i placing nails 7 and 8 on the boards. With the strings in place after setting I board nails, diagonals between corners should again be checked.

Another method of laying out buildings, is to stake two points on the \ ing, occupy one of them with the total station instrument, take a backsight < other, and stake all (or many) of the remaining points from that setup using] calculated angles and distances. In some cases, advantage can be taken of i metrical layouts to save considerable time. Figure 23-9 shows an unusual metrical building shape which was laid out rapidly using only two setups (at j A and O). With this choice of stations, half the corners could be set from •. setup, and the same calculated angles and distances could be used (see the :

220.00 ft	Rt	0°00'	*0*
98.00 ft	Rt	90°00'	F
135.00ft	Rt	90°00'	G
169.74ft	Rt	120°00'	E
196.00ft	Rt	150°00'	D
169.74ft	Rt	180°00'	C
98.00 ft	Rt	210°00'	B
7K @ Point O			
220.00 ft	Lt	0°00'	*A*
98.00 ft	Lt	90°00'	J
135.00ft	Lt	90°00'	H
169.74ft	Lt	120°00'	K
196.00ft	Lt	150°00'	L
169.74ft	Lt	180°00'	M
98.00 ft	Lt	210°00'	N

structures, such as retaining walls, offset lines are necessary[1] because 1 face is obstructed. Positions of such things as interior footings.; columns, and special piping or equipment can first be marked by 23 with tacks. Survey disks, scratches on bolts or concrete surfaces. 3 also be used. Batter boards set inside the building dimensions for < have to be removed as later construction develops.

On multistory buildings, care is required to ensure vertical; construction of walls, columns, elevator shafts, structural steel, etc.! checking plumbness of constructed members is to carefully aim a • of sight on a reference mark at the base of the member. The line • raised to its top. For an instrument that has been carefully leveled! proper adjustment, the line of sight will define a vertical plane as i should not be assumed that the instrument is in good adjustment. 1 line should be raised in both the direct and reversed positions. It a check plumbness in two perpendicular directions when using this | guide, construction of vertical members in real-time, two instr up with their lines of sight oriented perpendicular to each other.; monitored as construction progresses. Alternatively, lasers can be : and monitor vertical construction.

If the surveyor does not give sufficient forethought to the bask *t* required, the best method to establish them, and the most efficient; staking out a building, the job can be a time-consuming and difficuji] number of instrument setups should be minimized to conserve time.j tions made in the office if possible, rather than in the field while a : waits.

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