2012

Highway Engineering

4th year Civil

1,25

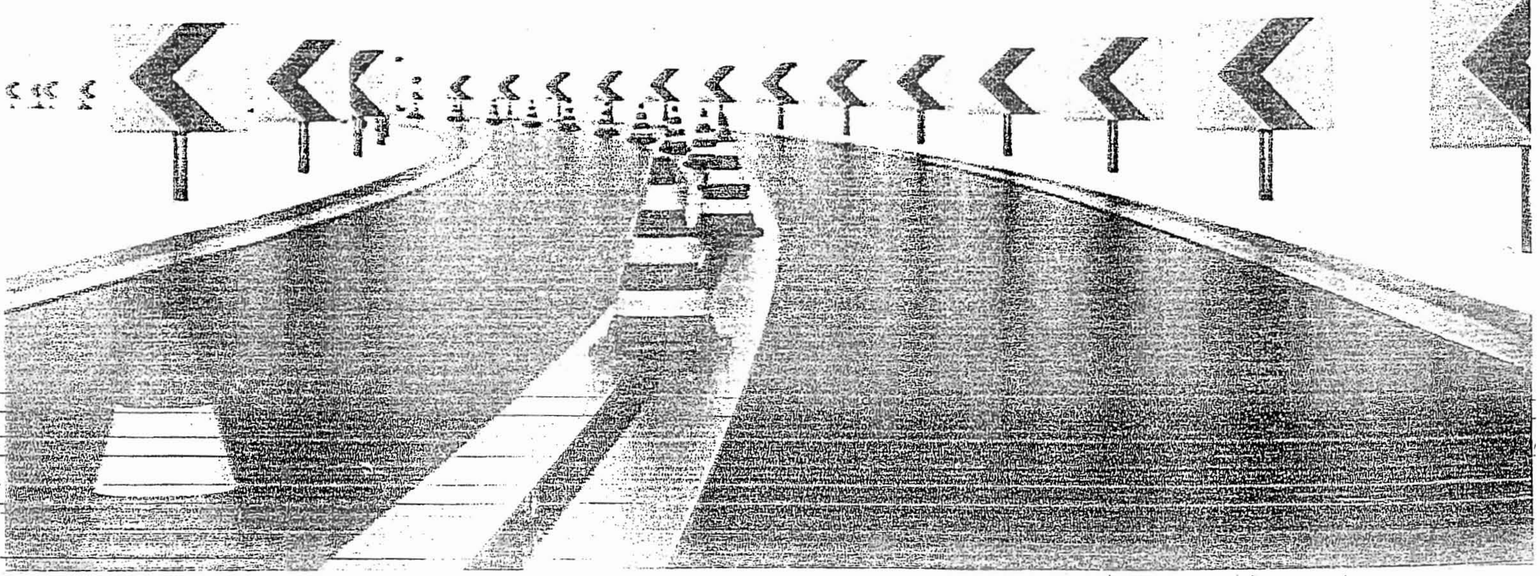
HORIZONTAL ALIGNMENT (2)

5p y-2!!

9p ?!!

8p

13p ?!!



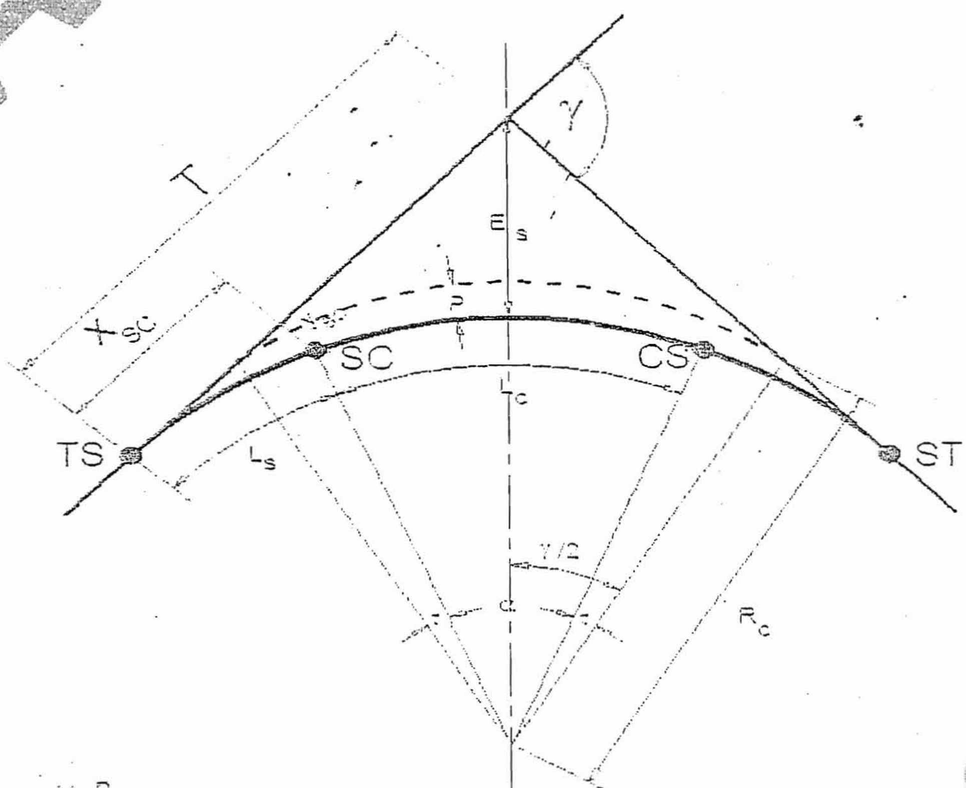
Coefficient of Side Friction (f_s) Versus Speed on Curve (V_c)

V_c (km/hr)	30	50	60	80	90	100
f_s (m)	0.16	0.15	0.14	0.13	0.12	0.10

Minimum Spiral Curve Constant (A_{min}) of Clotoide Type Versus Speed on Curve (V_c)

V_c (km/hr)	40	60	80	100	120	140
A_{min}	50	100	150	200	350	500

Elements of Circular & Transition Curves



$$L_s = 2\tau_{rad} \times R_c$$

$$\gamma^\circ = 2\tau^\circ + \alpha^\circ$$

$$P = Y_{sc} + R_c \times [\cos\tau^\circ - 1]$$

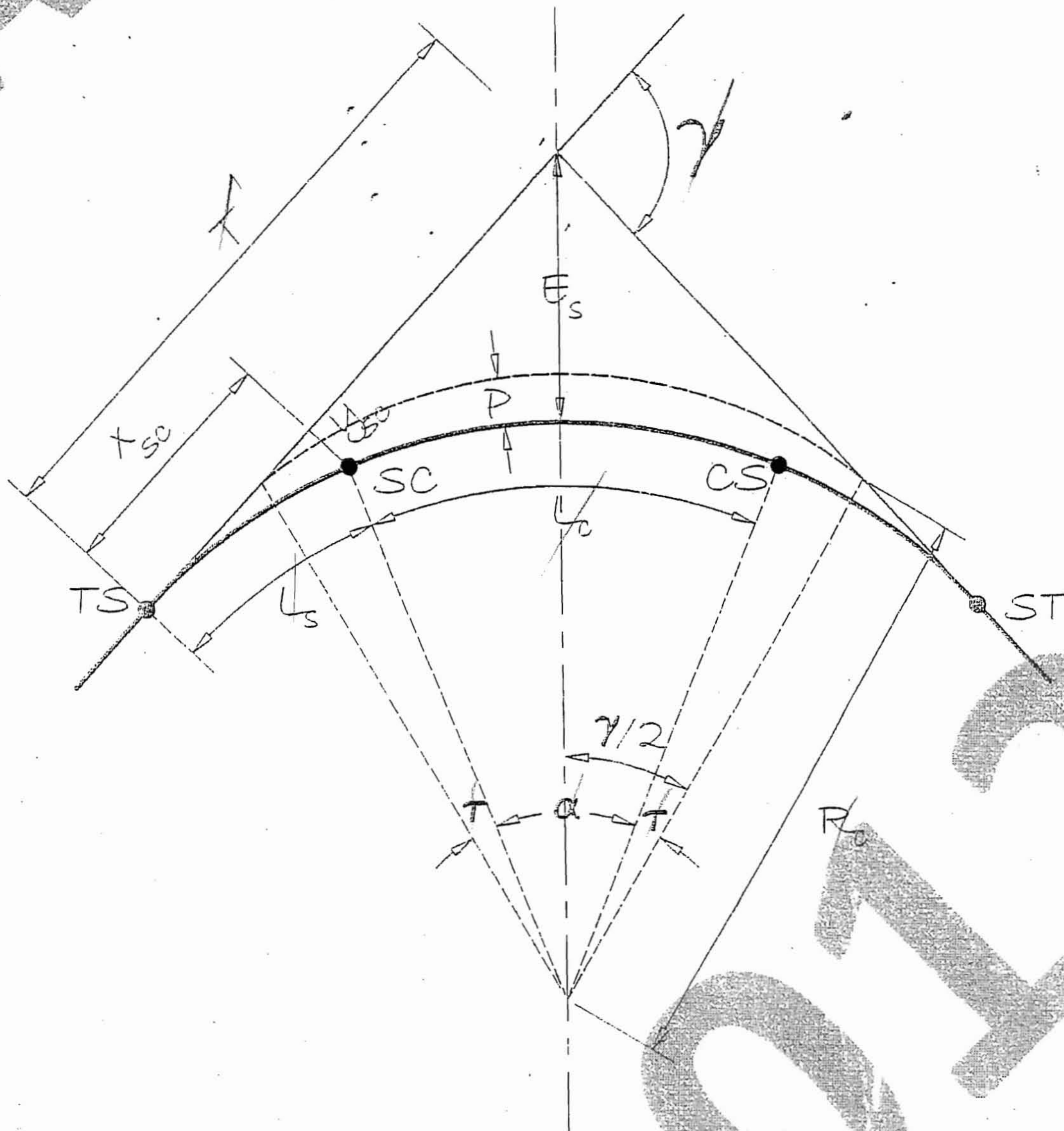
$$L_c = \alpha_{rad} \times R_c$$

$$T = X_{sc} + [P + R_c] \times \tan\left(\frac{\gamma^\circ}{2}\right) - R_c \times \sin\tau$$

$$E_s = [P + R_c] \times \sec\left(\frac{\gamma^\circ}{2}\right) - R_c$$

Coordinates of Transition Curves:

توقيع المنحنيات الأفقية



بالنسبة للجزء الدائري :

1 Find (T)

$$L_s = 2T\, R_c \longrightarrow \frac{\pi}{180} \times T = \checkmark^{\circ}$$

2 Find (α)

$$\gamma = 2T + \alpha \longrightarrow \alpha = \checkmark^{\circ}$$

3 Find (P)

$$P = y_{sc} + R_c * [\cos T - 1]$$

4 Find (L_c, T, E_s)

$$L_c = \alpha_{rad} * R_c \quad , \quad \alpha_{rad} = \alpha^{\circ} * \frac{\pi}{180}$$

$$T = X_{sc} + (P + R_c) * \tan\left(\frac{\gamma}{2}\right) - R_c * \sin T$$

$$E_s = (P + R_c) * \sec\left(\frac{\gamma}{2}\right) - R_c$$

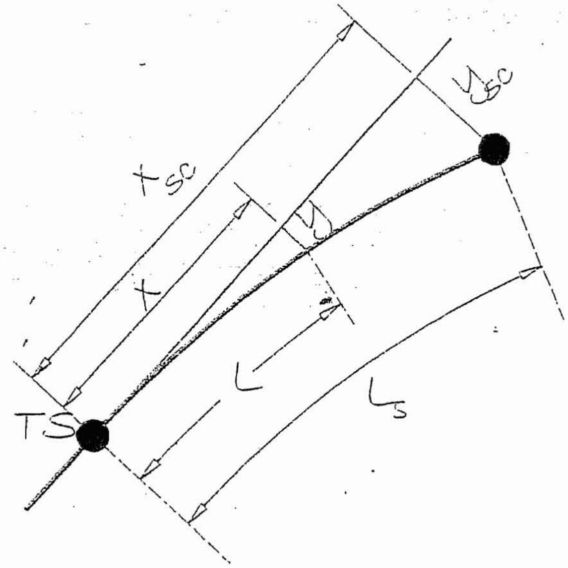
$$\sec \rightarrow \frac{1}{\cos}$$

بالنسبة للـ Transition curve

لحساب إحداثيات المنحني الانتقالي ... يتم التعويض في المعادلات التالية

$$x = L * \left[1 - \frac{L^4}{40\,A^4}\right]$$

$$y = \frac{L^3}{6A^2} * \left[1 - \frac{L^4}{56\,A^4}\right]$$



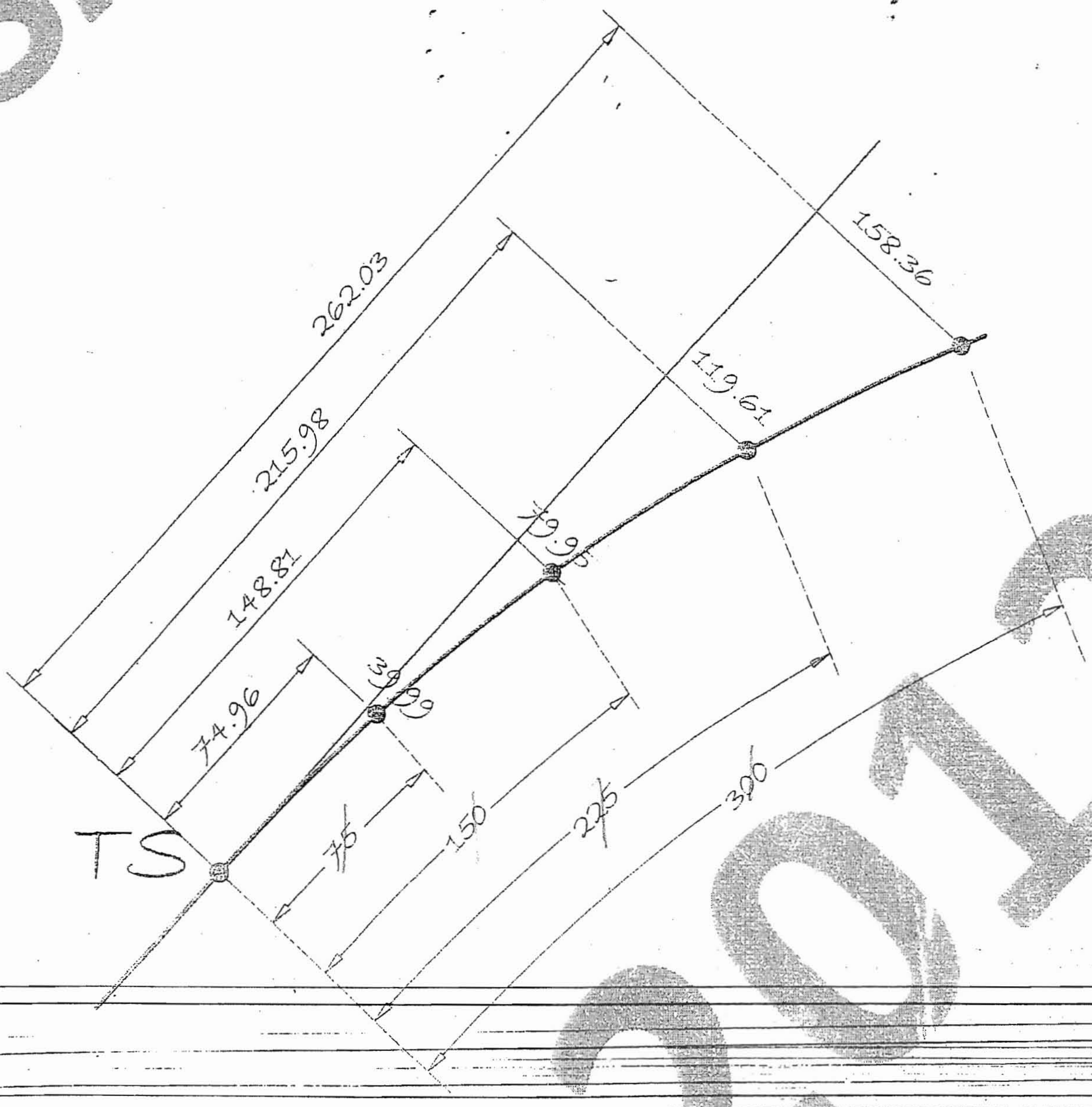
حيث L جزء من الطول الكلي للمنحني الانتقالي L_s حسب عدد النقط المطلوب حساب إحداثياتها ... فمثلا لو كان مطلوب حساب الإحداثيات عند كل ربع من الطول الكلي للمنحني الانتقالي يكون حساب ذلك كما يلي

تقسيم L_s إلي عدة أقسام ثم لكل طول L نحسب x & y

Ex:

Calculate four coordinates on a spiral curve which length is 300 m long and A = 200

L	$1/4\,L_s = 75$	$1/2\,L_s = 150$	$3/4\,L_s = 225$	$L_s = 300$
$x = L * \left[1 - \frac{L^4}{40A^4}\right]$	74.96	148.81	215.98	262.03
$y = \frac{L^3}{6A^2} * \left[1 - \frac{L^4}{56A^4}\right]$	39.99	79.95	119.61	158.36



Ex: 7

The centerline of a 2-lane road 7.5 m wide with a design speed of 80 km/hr. runs along a horizontal curve consisting of a circular curve and two transition curves. the road has a cross slope of 1.5 % and longitudinal slope = - 1%.The tangent spiral point (T.S.) has a station [215+00] and an elevation = 50.0 m. along the centerline. The circular curve has a degree of curve = 8 degree and external angle = 80 degree. It is required to :

- Determine the length of the transition curve and the length of the circular curve.
- Draw a neat sketch showing the attainment of superelevation along the curve, by rotation about the inner edge, f = 0.17
- Calculate the station and elevation of the controlling points of the horizontal curve, T.S., S.C., C.S. and S.T. at the centerline as well as the inside and outside edges of the pavement.

ls / le

$lc * Rc = A^2$

lc

Solution

1 Curve Raduis :

$$R = \frac{1746}{D^\circ} = \frac{1746}{8^\circ} = 218.25\ m$$

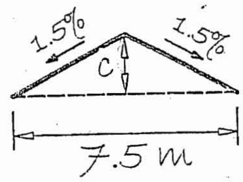
Superelevation :

$$e + f_s = \frac{V^2}{127\,R} \longrightarrow e + 0.14 = \frac{80^2}{127 * 218.25}$$

$$\therefore e = 0.06$$

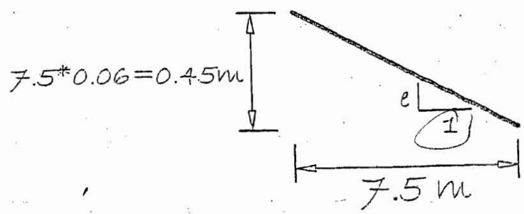
② S & C :

In straight parts



$$c = \frac{7.5}{2} * \frac{1.5}{100} = 0.056 \text{ m}$$

In circular parts



Request#1 $\quad L_s = ?? \qquad L_c = ??$

$\boxed{L_s}$ The max. of :

@ V = 80 km/hr. $\longrightarrow$ A = 150

$\boxed{1}$ $L_s = \frac{A^2}{R} = \frac{150^2}{218.25} = 103.09$ m

$\boxed{2}$ $L_s = \frac{V^3}{28 R} = \frac{80^3}{28 * 218.25} = 83.78$ m

$\boxed{3}$ $L_{s_{min}} = 50$ m

$\boxed{4}$ $L_s = 200 * S = 200 * S = 200 * 0.45 = 90$ m

$\therefore \boxed{L_s = 103.09 \text{ m}}$

$\because$ <u>From data sheet equations:</u>

$$L_s = 2T\ R_c$$

$$103.09 = 2T * 218.25 \longrightarrow T = \frac{103.09}{2 * 218.25} * \frac{180}{\pi} = 13.35^{\circ}$$

$$\gamma = 2T + \alpha$$

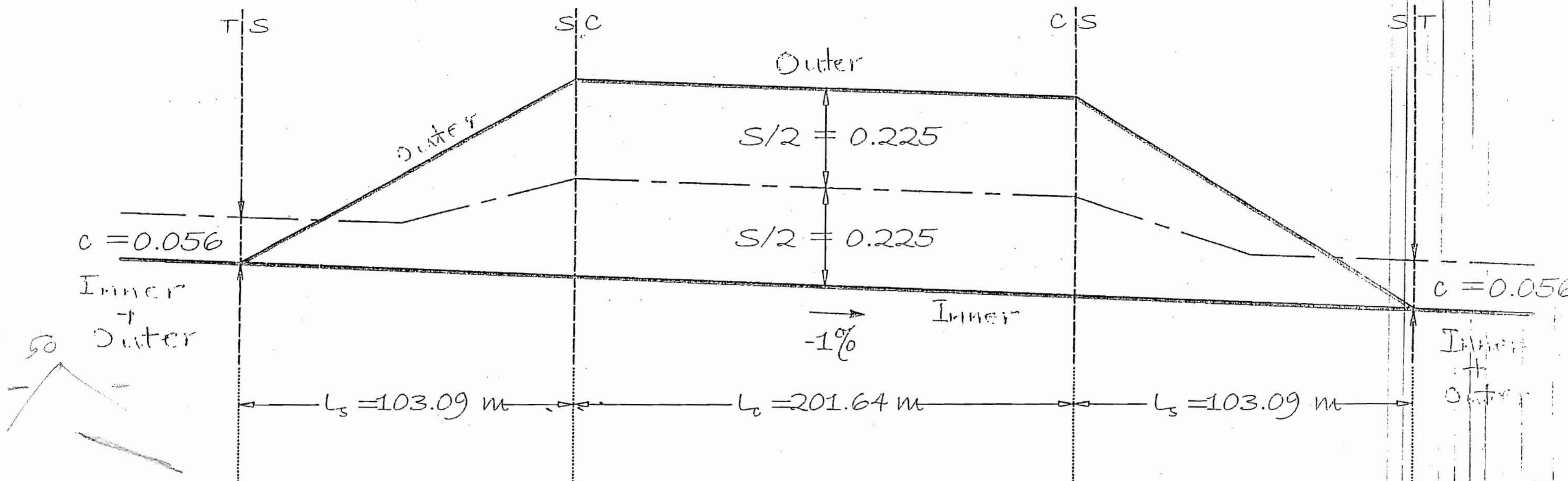
$$80^{\circ} = 2 * 13.35^{\circ} + \alpha \longrightarrow \alpha = 52.94^{\circ}$$

$$L_c = \alpha_{rad} * R_c \quad \because \alpha_{rad} = \alpha^{\circ} * \frac{\pi}{180}$$

$$\therefore L_c = 52.94^{\circ} * \frac{\pi}{180} * 218.25 = 201.64\ m$$

Request#2 & 3

$$y = \frac{L^3}{6A^2}\left\{1 - \frac{L^4}{56A^2}\right\}$$



	STA.	[215+00]	[216+03.09]	[218+04.73]	[219+07.82]
Elevation	Outer	49.944	49.363	47.122	45.866
	℄	50.00	49.138	47.122	45.922
	Inner	49.944	48.913	46.897	45.866

يتم حساب المناسيب لعناصر الطريق المختلفة عن طريق تحديد مناسيب الـ Inner

لأنه الثابت ثم حساب باقي المناسيب بالنسبة له عن طريق إضافة أو طرح S/2 or c

Ex:

A curved 2-lane road 3.5 m lane width for a design speed of 100 km/hr and superelevation of 0.09 which equals 3/2 the coefficient of side friction, it is required to :

i) Draw a neat sketch showing the development of superelevation about the centerline if the road cross slope is 2% & longitudinal slope of 2%

ii) The alignment of horizontal and transition curve, if you know that the external angle = 45 degrees , it is required four coordinates

Solution

1 Curve Raduis :

$$\text{Given } e = 0.09 = \frac{2}{3} * f_s$$

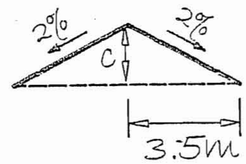
$$\therefore f_s = \frac{3}{2} * 0.09 = 0.135$$

$$e + f = \frac{V^2}{127 R}$$

$$0.09 + 0.135 = \frac{100^2}{127 * R} \longrightarrow R = 350 \text{ m}$$

2 S & c :

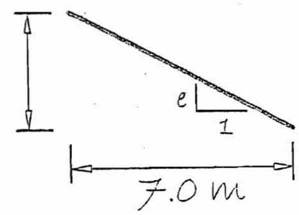
In straight parts



$$c = 3.5 * \frac{2}{100} = \underline{\underline{0.07 \ m}}$$

In circular parts

$$7 * 0.09 = 0.63 m$$



Request#1

$\boxed{L_s}$ The max. of :

1. $L_s = \frac{A^2}{R} = \frac{200^2}{350} = 114.28 \ m$

2. $L_s = \frac{V^3}{28 R} = \frac{100^3}{28 * 350} = 102 \ m$

3. $L_{s_{min}} = 50 \ m$

4. $L_s = 200 * (S/2 + c) = 200 * (0.315 + 0.07) = 77 \ m$

$$\therefore \boxed{L_s = 114.28 \ m}$$

For Circular curve :

data sheet باستخدام الـ

1 Find (T)

$$L_s = 2T\,R_c$$

$$114.28 = 2T * 350 \longrightarrow T = 0.163 \text{ rad}$$

$$= 0.163 * \frac{180}{\pi} = 9.354^{\circ}$$

2 Find (α)

$$\gamma = 2T + \alpha$$

$$45^{\circ} = 2 * 9.354^{\circ} + \alpha \longrightarrow \alpha = 26.292^{\circ}$$

3 Find (P)

$$P = y_{sc} + R_c * [\cos T - 1]$$

$$= 6.21 + 350 * [\cos 9.354 - 1] = 1.556 \text{ m}$$

4 Find (L_c , T , E_s)

$$\alpha_{rad} = \alpha^{\circ} * \frac{\pi}{180} = 26.292^{\circ} * \frac{\pi}{180} = 0.459 \text{ rad}$$

$$L_c = \alpha_{rad} * R_c = 0.459 * 350 = 160.61 \text{ m}$$

$$T = X_{sc} + (P + R_c) * \tan\left(\frac{\gamma}{2}\right) - R_c * \sin T$$

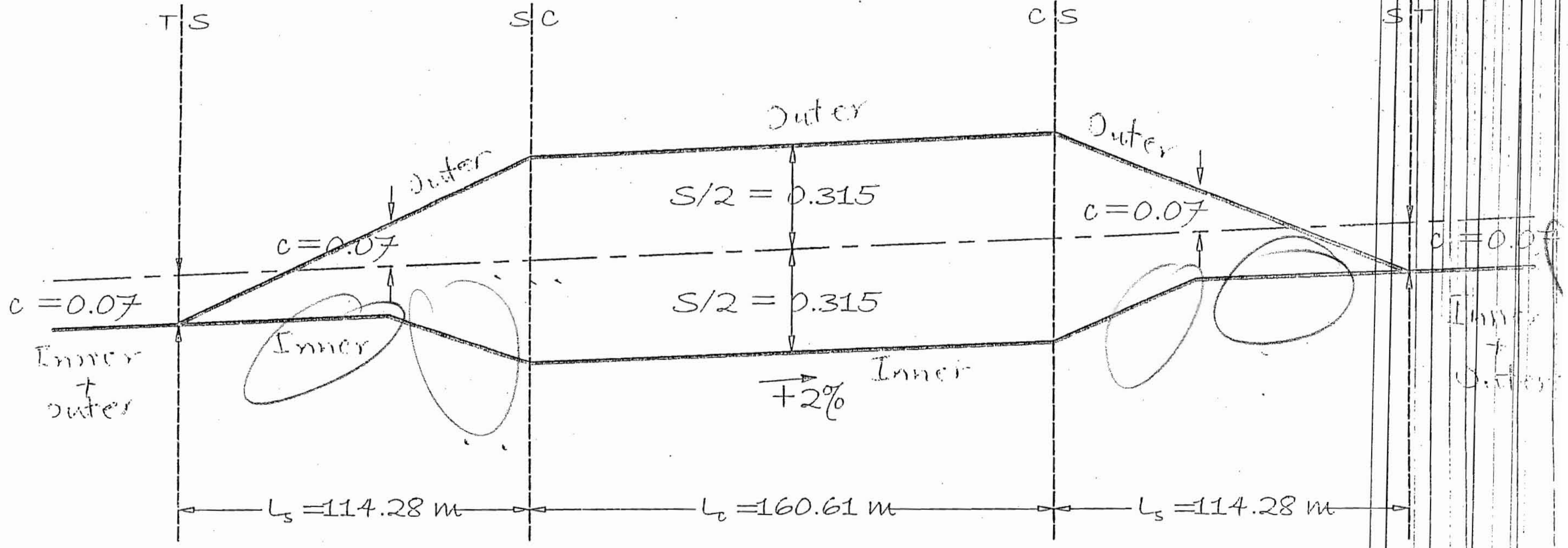
$$= 113.98 + (1.556 + 350) * \tan\left(\frac{45}{2}\right) - 350 * \sin 9.354$$

$$= 202.71 \text{ m}$$

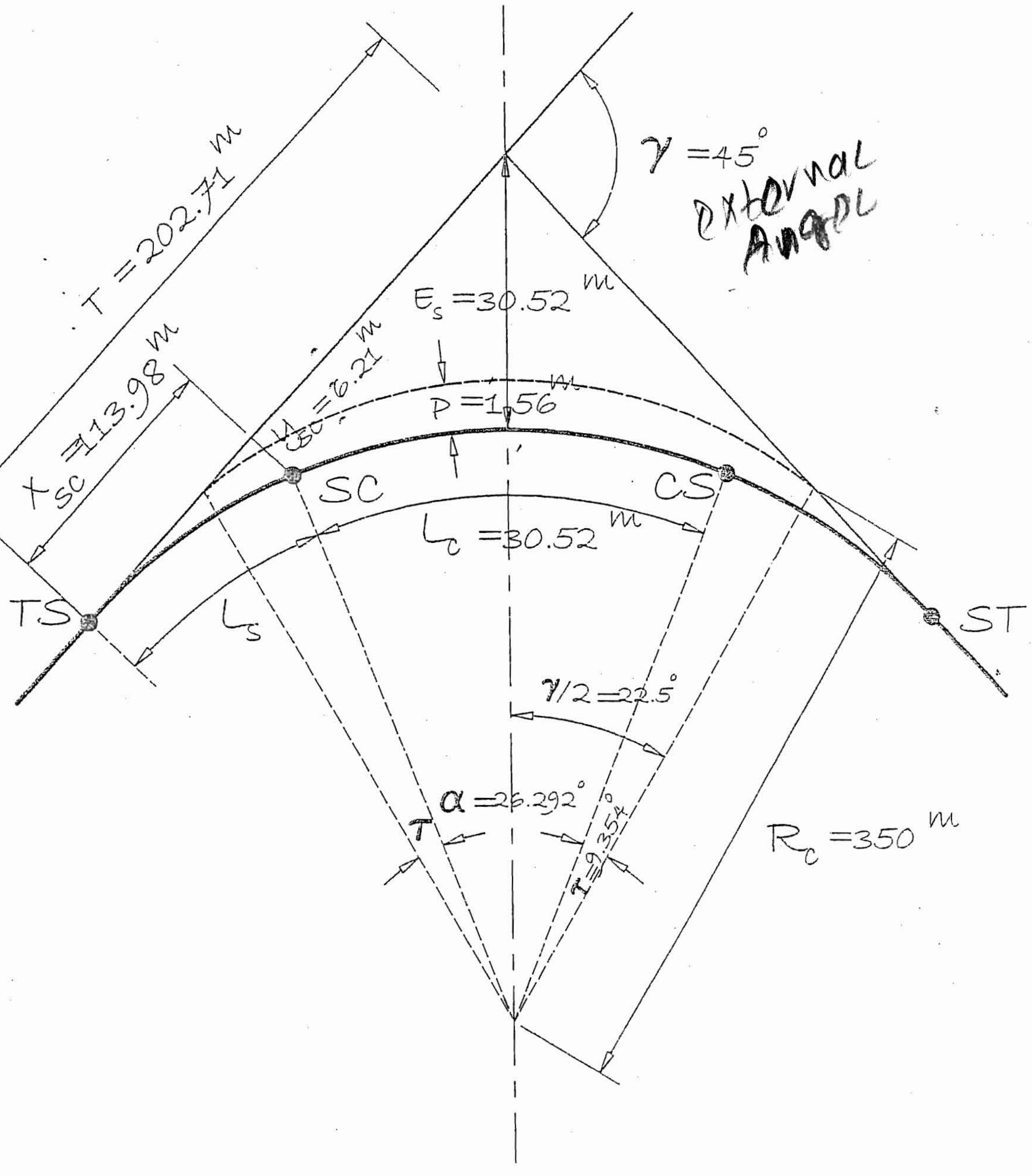
$$E_s = (P + R_c) * \sec\left(\frac{\gamma}{2}\right) - R_c$$

$$= (1.556 + 350) * \sec\left(\frac{45}{2}\right) - 350 = 30.52 \text{ m}$$

Request#2 & 3



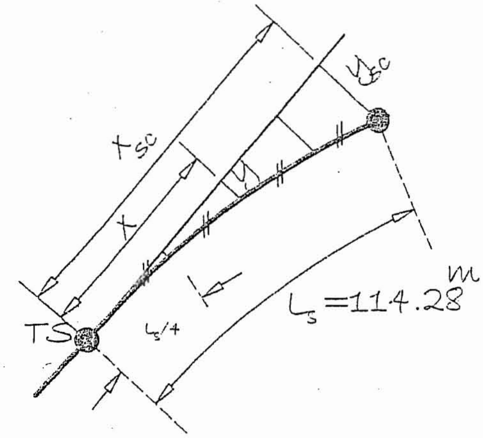
TS
SC
CS
ST
Outer
Outer
Outer
S/2 = 0.315
S/2 = 0.315
c = 0.07
c = 0.07
c = 0.07
Inner
Inner
Inner + outer
+2%
Ls = 114.28 m
Lc = 160.61 m
Ls = 114.28 m



T =202.71 m
X_SC =113.98 m
Y_SC =6.21 m
E_s =30.52 m
P =1.56 m
γ =45°
external Angel
SC
CS
TS
ST
L_c =30.52 m
L_s
γ/2 =22.5°
α =26.292°
τ
τ =9.354°
R_c =350 m

For Transition curve :

(4 points)



$$x = L * \left[1 - \frac{L^4}{40\,A^4}\right]$$

$$y = \frac{L^3}{6A^2} * \left[1 - \frac{L^4}{56\,A^4}\right]$$

@ $L = \frac{1}{4} L_s = 28.57$ m $\longrightarrow$ $x \cong 28.57$ m & $y = 0.1$ m

@ $L = \frac{1}{2} L_s = 57.14$ m $\longrightarrow$ $x = 57.13$ m & $y = 0.78$ m

@ $L = \frac{3}{4} L_s = 85.71$ m $\longrightarrow$ $x = 85.64$ m & $y = 2.62$ m

@ $L = L_s = 114.28$ m $\longrightarrow$ $x_{sc} = 113.98$ m & $y_{sc} = 6.21$ m

HOME WORK

Draw a neat sketch showing the development of superelevation about the inner edge of 2-lane, 3.75 m lane width, $D = 10^{\circ}$, cross slope 3%, long. slope 4%, $V = 85$ km/h, $f = 0.16$. Compute four coordinates on spiral curve if $\gamma = 85^{\circ}$; $A = 200$. Draw sketches to show the application of extra widening.