KURSUS SIASATAN FORENSIK KEMALANGAN

-ELEMEN REKABENTUK-

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BAHAGIAN KEJURUTERAAN FORENSIK JALAN
CAWANGAN JALAN JKR MALAYSIA

Elemen Rekabentuk

- Jarak Penglihatan
- Jajaran Mendatar
  - Kadar Kesendengan (Superelevation)
  - Jejari (Radius)
- Kamber

KEPENTINGAN KESERAGAMAN DALAM REKABENTUK JALAN

01

Untuk memberikan keseragaman dalam reka bentuk jalan raya mengikut keperluan prestasi

02

Untuk menyediakan kemudahan jalan raya yang konsisten, selamat & boleh dipercayai untuk pergerakan trafik

03

Untuk memberi panduan & mengurangkan keputusan yang kurang subjektif dalam reka bentuk jalan

ELEMEN REKABENTUK

1.0 SIGHT DISTANCE

- Stopping Sight Distance
- Passing Sight Distance

2.0 HORIZONTAL ALIGNMENT (JAJARAN MENDATAR)

- Superelevation
- Minimum radius
- Type of Curves – Transitional Curves and Circular Curves
- Pavement widening on curves
- Sight distance on horizontal curves
- Overtaking lane

3.0 VERTICAL ALIGNMENT(JAJARAN MENEGAK)

- Gradient
- Critical Grade Length
- Maximum grades
- Minimum grades
- Climbing lane

4.0 CROSS SECTION ELEMENTS

- Surface type
- Normal cross slope
- Lane widths and marginal strips
- Width of shoulders
- Shoulder cross slope
- Kerbs
- Traffic barriers - Medians
- Pedestrian crossings
- U-Turns
- Bus laybyes
- Minimum reserve width

KAWALAN UMUM BAGI JAJARAN MENDATAR (HORIZONTAL ALIGNMENT)

Jajaran mendatar seharusnya konsistan dengan topografi & mengekalkan pembangunan sedia ada serta nilai komuniti.

Jajaran yang bengkang-bengkok (winding) dengan lengkung yang kecil perlu dielakkan.

Jajaran lurus yang terlalu panjang juga perlu dielakkan (max. 2 minit traveling time). Contoh untuk halaju 90km/hr = 3km/2minit

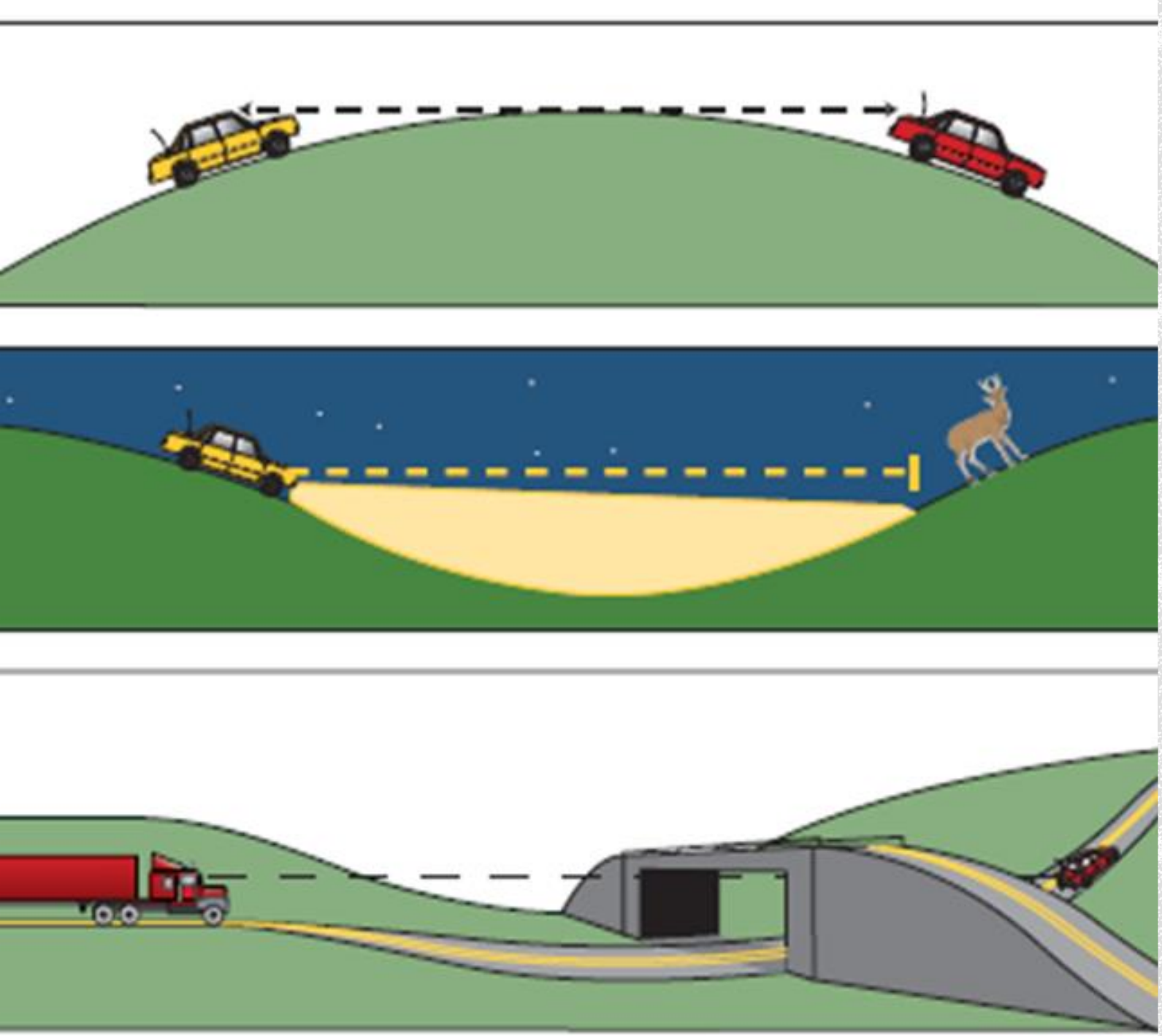
KAWALAN UMUM BAGI JAJARAN MENDATAR (HORIZONTAL ALIGNMENT)

Penggunaan radius minimum bagi sesuatu halaju rekabentuk seharusnya dielakkan

Jajaran yang konsisten adalah perlu. Elak dari menggunakan lengkung yang tajam pada tangen yang panjang

Bagi ‘deflection angle’ yang kecil, lengkung perlu cukup panjang untuk mengelakkan wujudnya ‘kink’. Minimum 150m.

JARAK PENGLIHATAN



PENGENALAN

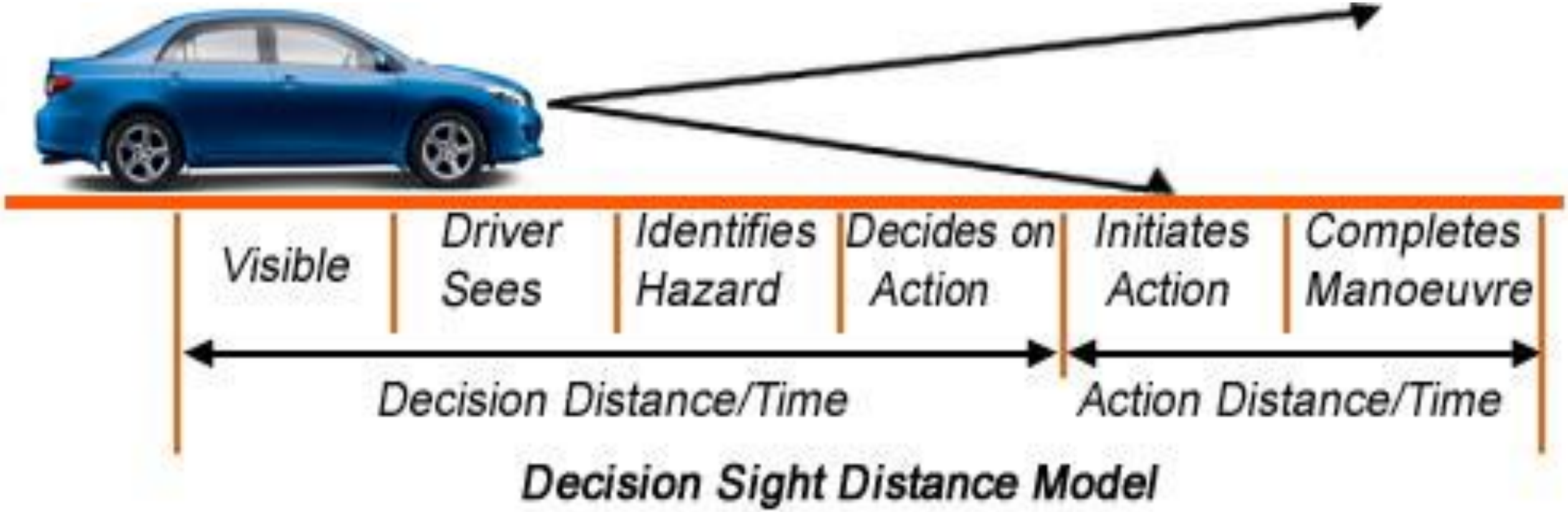
- Jarak penglihatan? Apa tu..?
- Jarak jalan yang pemandu boleh melihat dengan jelas jika terdapat halangan
- Kalau dah lihat, apa boleh buat?
- Jarak penglihatan yang mencukupi memberi ruang kepada pemandu untuk bertindak dengan efisyen dan selamat

PENGENALAN (SAMB..)

Efisyen?? Selamat???

- Jarak penglihatan mencukupi -> masa yang cukup-> pemandu berfikir/bertindak -> mengelak/membrek -> efisyen & selamat -> berjaya!!!

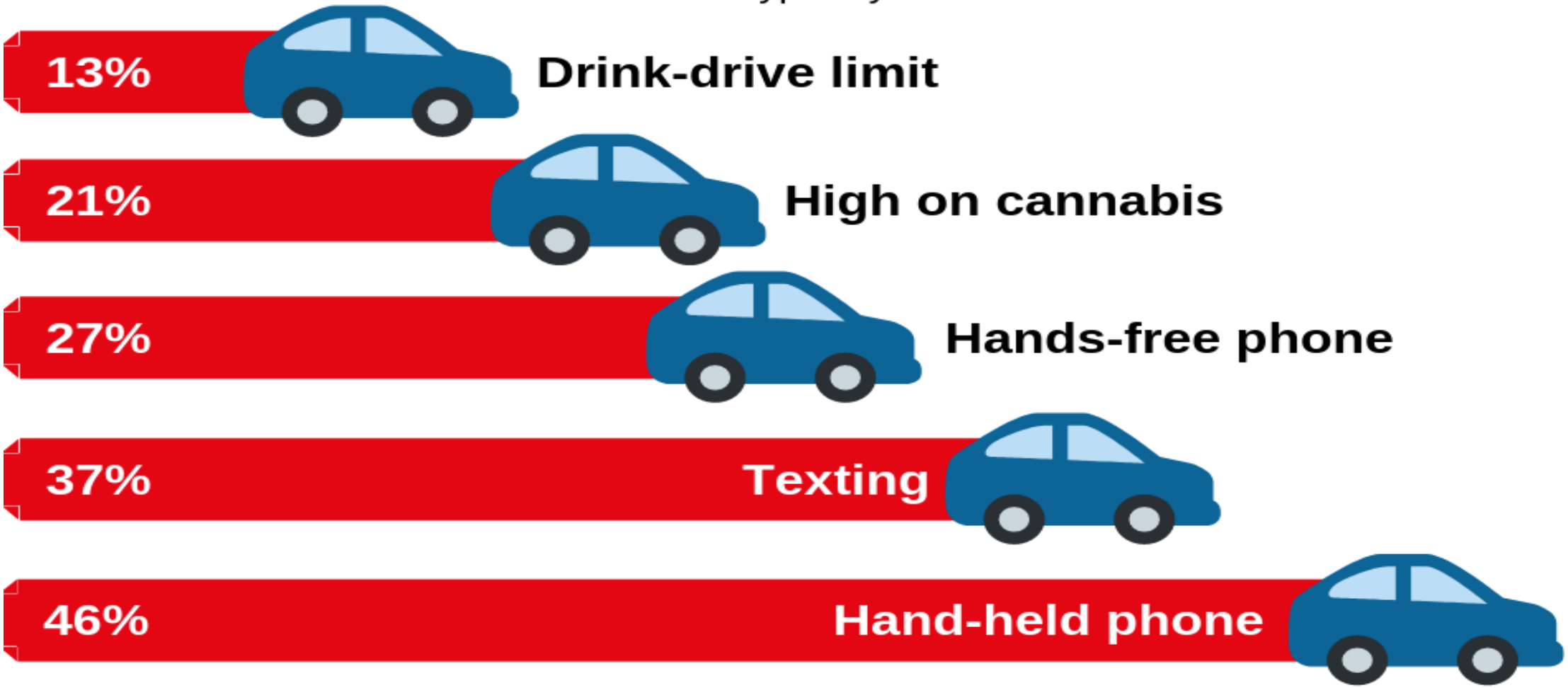
- Jarak penglihatan tidak cukup ->masa juga ->pemandu tiada masa berfikir/bertindak-> kemalangan -> gagal!!!



Decision Sight Distance Model

How Our Reactions Slow

This chart shows the percentage increase in distracted drivers' response times.
An undistracted driver typically reacts in 1 second



Driving at 56mph the stopping distance for a driver using a hand-held phone increases by 13.1m compared to an alert driver.

Source: Transport Research Laboratory

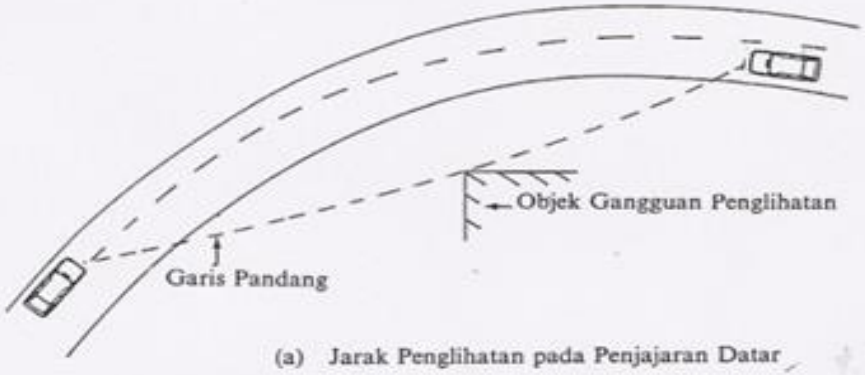
JENIS – JENIS JARAK PENGLIHATAN

- Stopping sight distance
- Decision sight distance
- Passing sight distance

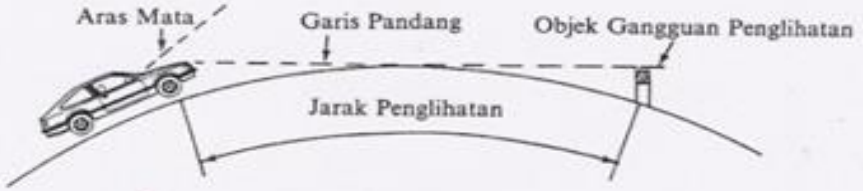
JARAK PENGLIHATAN
1. Jarak penglihatan berhenti

(Stopping Sight Distance, SSD)

- Jarak penglihatan yang memuaskan untuk pemandu memberhentikan kenderaan sebelum melanggar sesuatu objek yang muncul secara tiba-tiba
- Jarak tersebut merangkumi jarak yang ditempuh dalam sela masa berikut:
  i. Jumlah masa tanggapan dan tindak balas
  ii. Masa membrek



(a) Jarak Penglihatan pada Penjajaran Datar

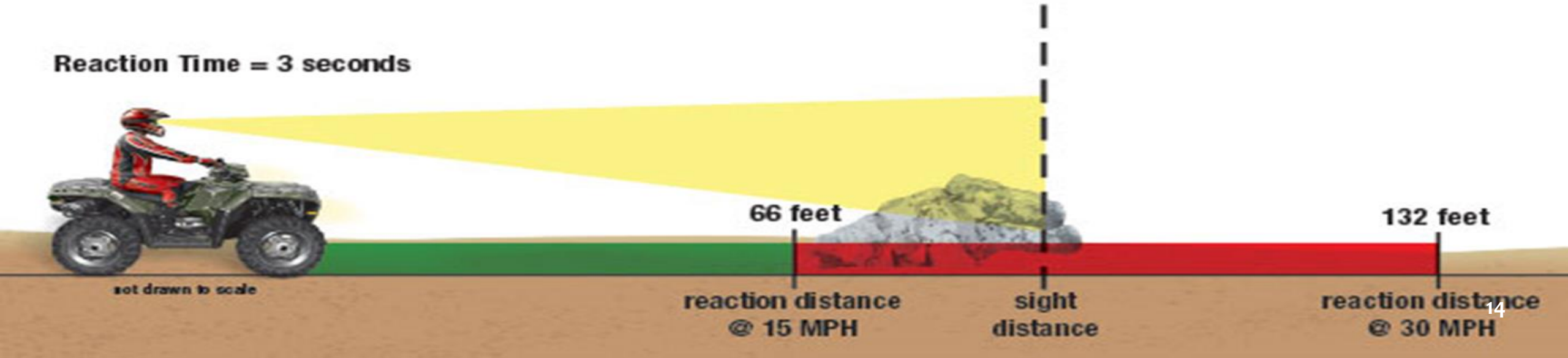


(b) Jarak Penglihatan pada Penjajaran Tegak

(c) Jarak Penglihatan pada Persilangan Searas

JARAK PENGLIHATAN
1. Jarak penglihatan berhenti (Samb..)

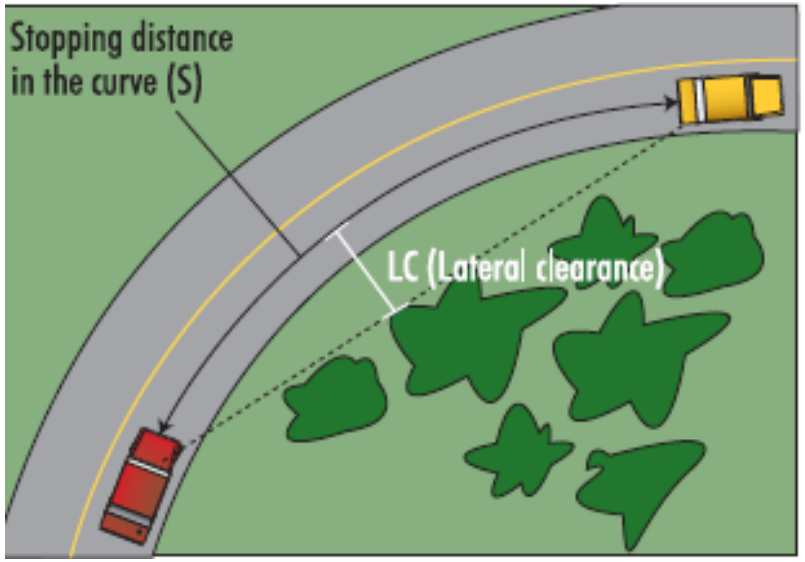
- Jumlah 2 jarak:
  - Reaction distance
  - Braking distance



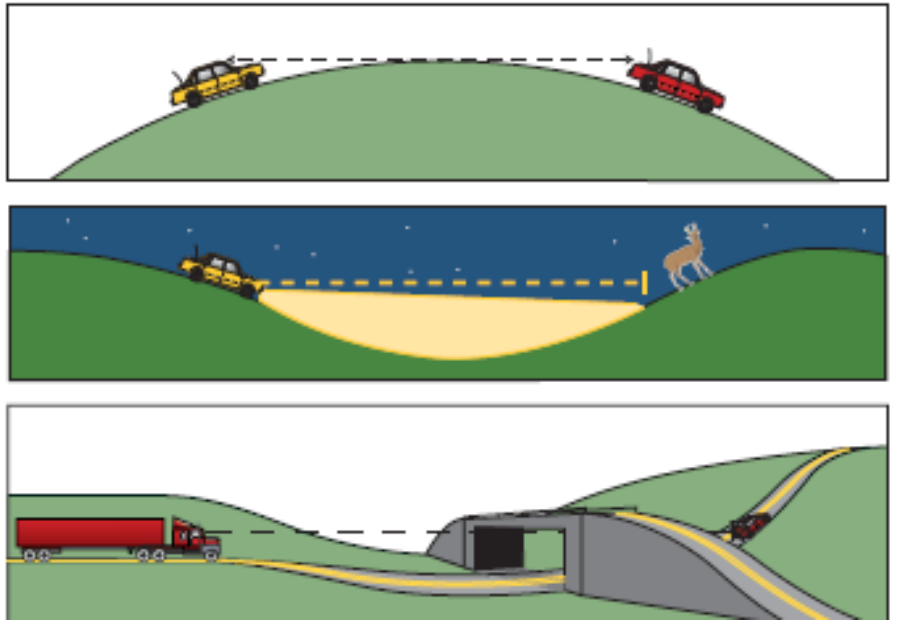
JARAK PENGLIHATAN

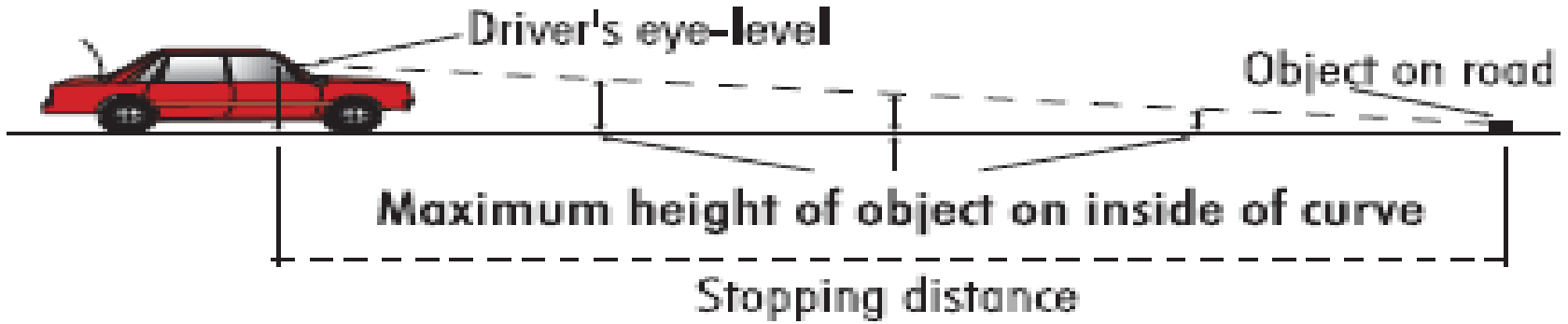
1. Jarak penglihatan berhenti (Samb..)

- Jajaran mendatar



- Jajaran pugak





JARAK PENGLIHATAN
2. Decision Sight Distance

- Panjang jalan yang diperlukan bagi pemandu untuk mengawal kenderaan (safety maneuver) setelah mengesan bahaya (potential hazard)

- Jarak adalah lebih jauh daripada stopping sight distance

JARAK PENGLIHATAN
2. Decision Sight Distance

- Dimana ia digunakan?

- Lokasi kritikal yang tidak diduga pergerakan kenderaan
  - Interchange & intersection

- Lokasi di mana perubahan cross section jalan
  - Plaza tol

JARAK PENGLIHATAN
3. Passing Sight Distance, PSD

- Jarak terpendek yang diperlukan oleh kenderaan untuk keluar dari lorong asal seterusnya memecut untuk memotong kenderaan di hadapannya & kemudian masuk semula ke dalam lorong asalnya dengan selamat & tidak mengganggu kenderaan yang dipotong/di hadapan

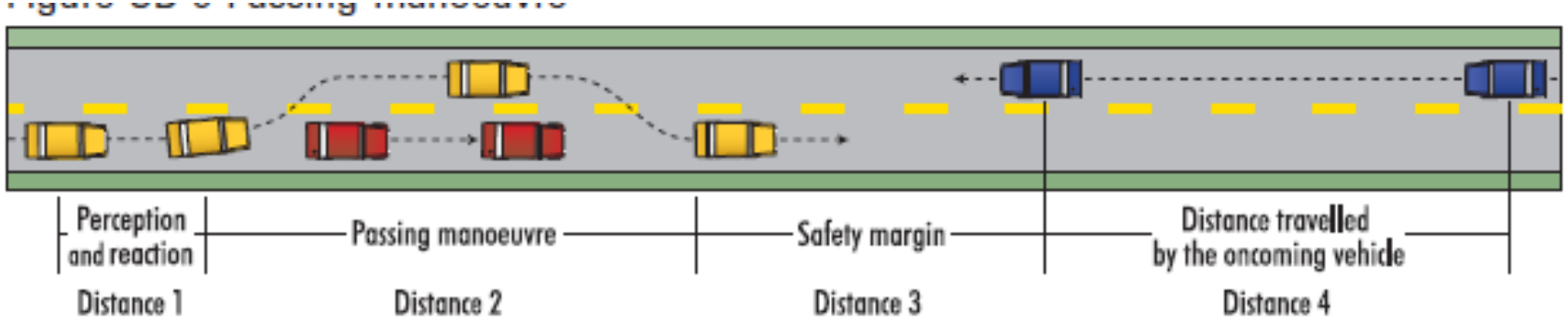
Table 4.4 Minimum passing sight distances (2-Lanes - 2 Way)

Design speed (km/hr)	Minimum passing sight distance (m)
110	730
100	670
90	610
80	550
70	490
60	410
50	350
40	290

JARAK PENGLIHATAN
3. Passing Sight Distance, PSD (Samb..)

Road section:

- Jarak penglihatan memotong



KRITERIA JARAK PENGLIHATAN D KAWASAN PERSIMPANGAN

- Approach sight distance
- Pemandu yang menghampiri persimpangan perlu dapat melihat;
- Keadaan pavemen di Kawasan konflik
- Susunan kedudukan traffic island
- Garisan jalan & Garisan Berhenti

Table 1 : Approach Sight Distance (ASD)

Speed (km/h)	d	Stopping Sight Distance (m) Rural Normal R_t=2.5s	Rural Alerted R_t=2.0s	Urban R_t=1.5s
40	0.56		35	30
50	0.52		45	40
60	0.48		65	55
70	0.45		85	70
80	0.43	115	105	95
90	0.41	140	130	
100	0.39	170	160	
110	0.37	210	190	
120	0.35	250	230	

Table 2 : Grade Corrections to ASD

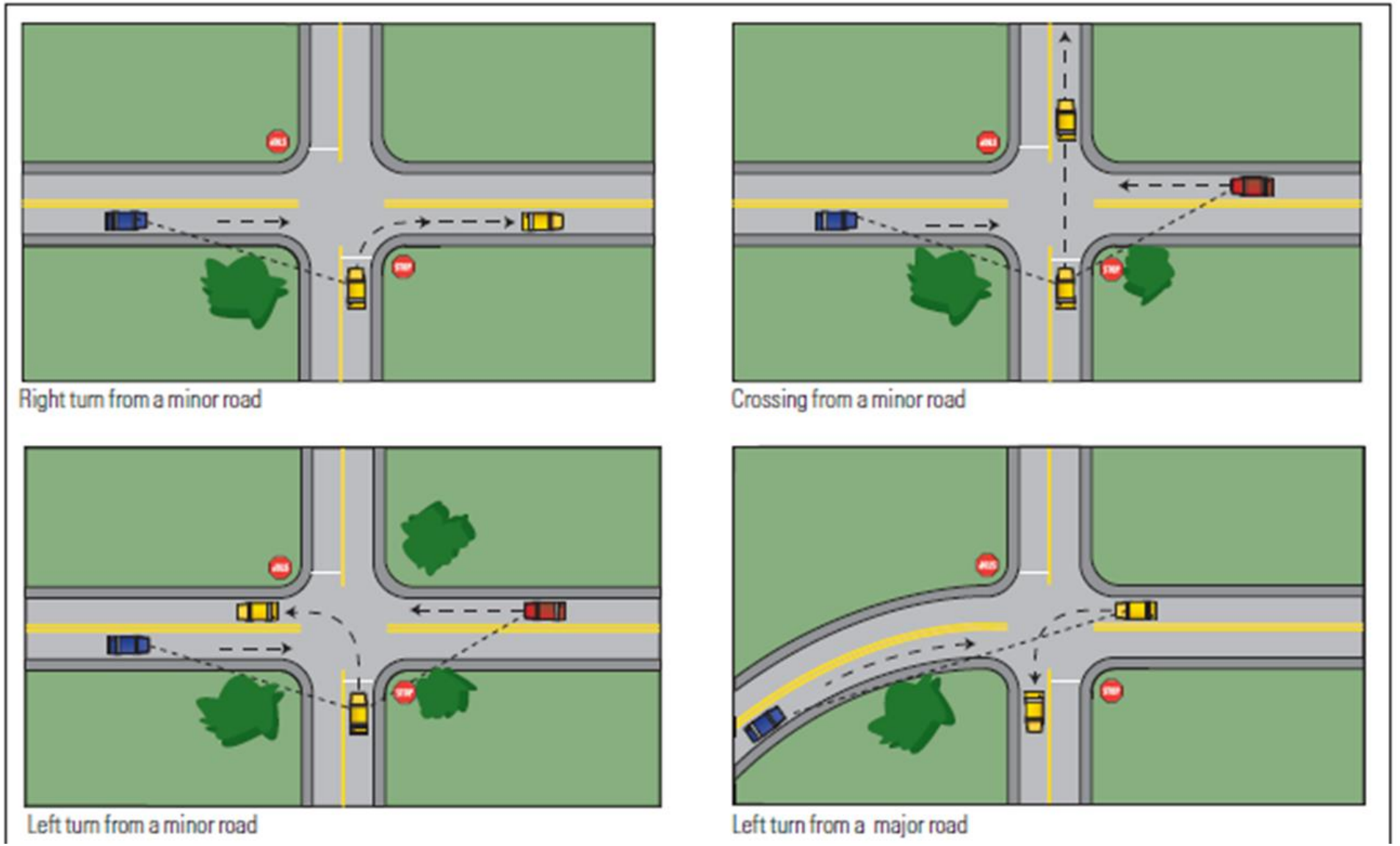
Design Speed (km/h)	Correction (m)* Upgrade 4%	Upgrade 8%	Upgrade 12%	Down Grade 4%	Down Grade 8%	Down Grade 12%
40	-	-	-	-	-	5
50	-	-	5	-	5	5
60	-	5	5	-	5	10
70	-	10	10	5	10	15
80	5	10	15	5	10	25
90	10	15	20	10	20	30
100	10	20	25	10	25	45
110	15	25	30	15	35	60
120	20	30	40	20	50	85

* Correction to be added to ASD for downgrade and sub-tracted for upgrade. Ignore grades of 2% or less.

JARAK PENGLIHATAN DI PERSIMPANGAN

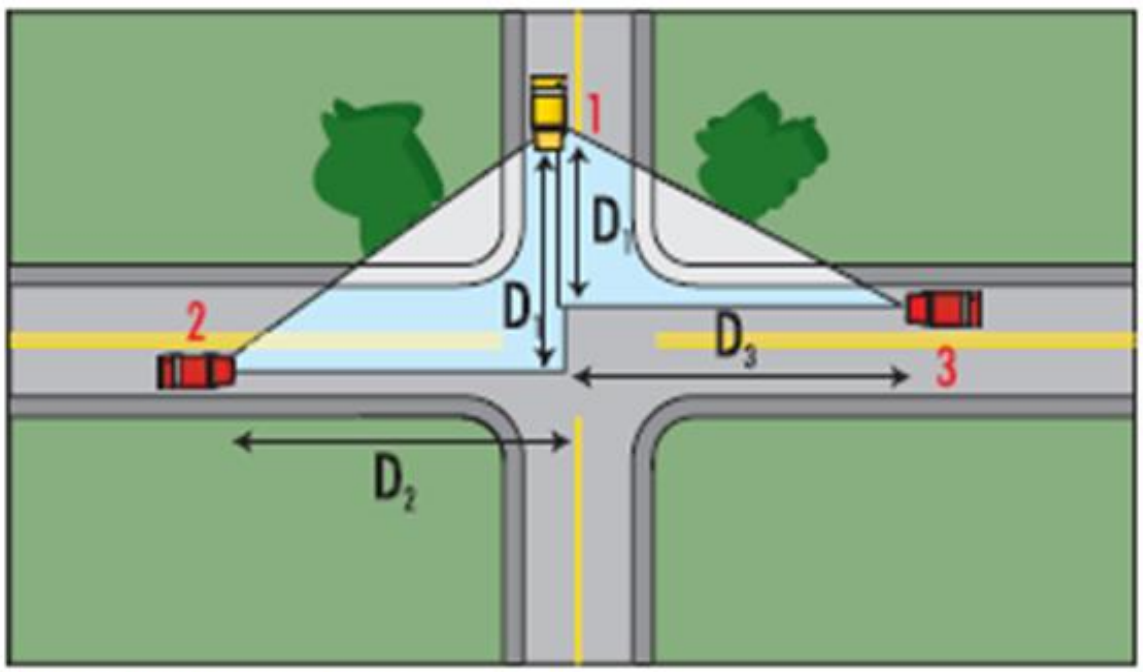
- Jarak penglihatan di simpang adalah terhad sekiranya terletak di kawasan selekoh

JARAK PENGLIHATAN DI PERSIMPANGAN



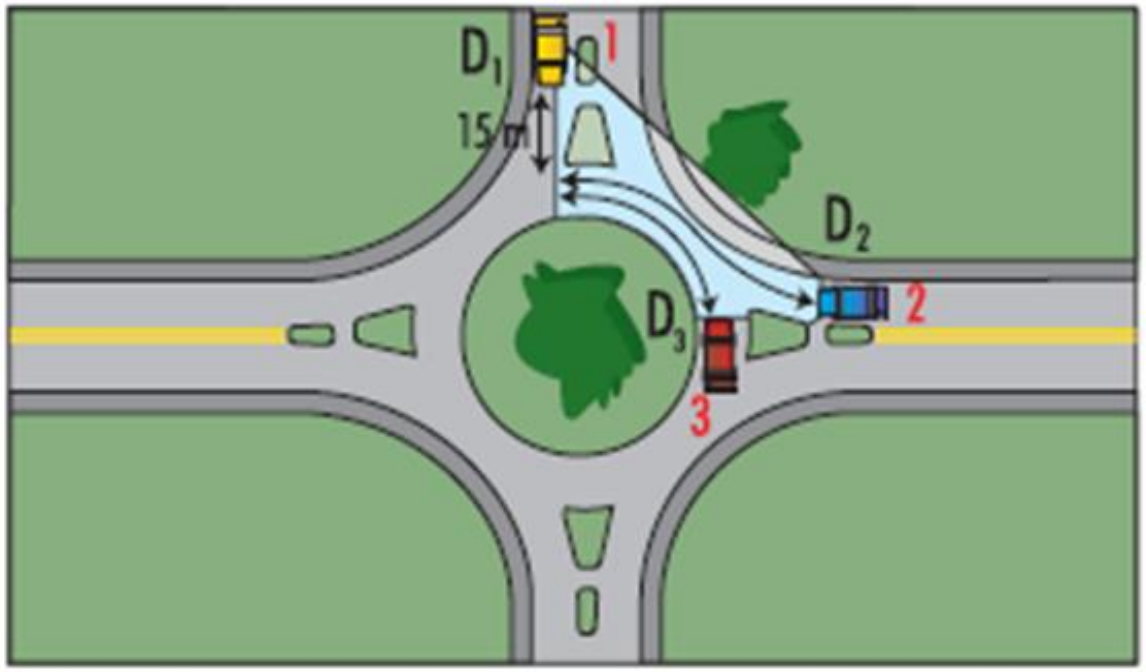
JARAK PENGLIHATAN DI PERSIMPANGAN

- Jarak penglihatan segitiga



Conventional intersection:

The driver of vehicle 1 should see vehicles approaching the intersection in both adjacent legs (vehicles 2 and 3) sufficiently in advance.



Roundabout:

The driver of vehicle 1 must see the vehicles approaching from the left adjacent leg (vehicle 2) and the vehicles traveling in the circle (vehicle 3) sufficiently in advance.

TUJUAN CERAPAN JARAK PENGLIHATAN

- Untuk mendapatkan jarak penglihatan di tapak
- Jarak penglihatan > spesifikasi → masa yang cukup → pemandu berfikir/bertindak → mengelak/membrek → efisyen & selamat → berjaya!!!
- Jarak penglihatan < spesifikasi → masa tidak cukup → pemandu tiada masa berfikir/bertindak→ kemalangan → gagal!!!

PERALATAN MENCERAP JARAK PENGLIHATAN

TRU-PULSE/ TRU-METER

KRITERIA UNTUK MENGUKUR JARAK PENGLIHATAN

- Ketinggian mata pemandu
  - Purata pemandu dalam kenderaan penumpang – 1070mm di atas permukaan jalan
- Ketinggian objek
  - 150mm untuk pengukuran jarak penglihatan berhenti
  - 1.30m untuk pengukuran jarak penglihatan memotong
  - Ketinggian diukur dari permukaan jalan

PIAWAIAN BERKAITAN JARAK PENGLIHATAN

Design Speed (kph)	Min. Passing Sight Distance (m)
120	775
110	730
100	670
90	615
80	540
70	485
60	410
50	345
40	270
30	200

Design Speed (kph)	Min. Stopping Sight Distance (m)
120	250
110	220
100	185
90	160
80	130
70	105
60	85
50	65
40	50
30	35

Design Speed (kph)	Decision Sight Distance for Avoidance Maneuver (meters)			
	A	B	C	D
50	70	155	145	195
60	95	195	170	235
70	115	235	200	275
80	140	280	230	315
90	170	325	275	360
100	200	370	315	400
110	235	420	330	430
120	265	470	360	470

ISU-ISU BERKAITAN JARAK PENGLIHATAN

Jarak penglihatan tidak mencukupi disebabkan terlindung oleh pokok/bukit/bangunan dll.

Geometrik jalan yang tidak mematuhi standard minimum

JARAK PENGLIHATAN

Apa yang akan berlaku jika...

Sight distance tidak mencukupi?

Kemalangan

Rawatan??

JARAK PENGLIHATAN

- Jarak penglihatan tidak mencukupi

	Dicerap (m)	REAM-GL 2/2002 (m)
Jarak Penglihatan	104	170 (90 km/j)

LENGKUNG/JEJARI (RADIUS) SELEKOH

PENGENALAN

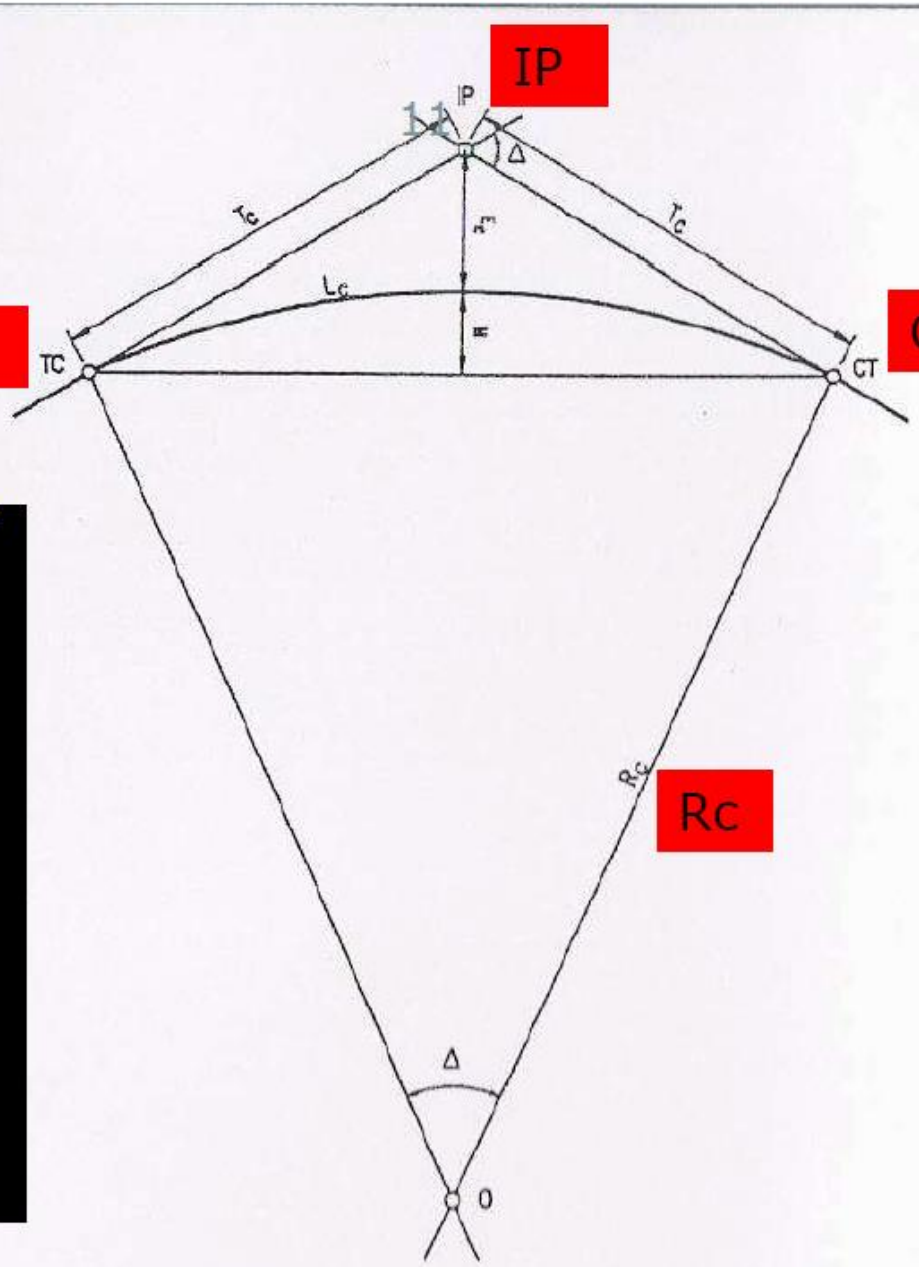
- Lengkung/ Jejari/ Selekoh/ Curves
- Salah 1 elemen bagi horizontal curve yang mana mempunyai nilai minimum berdasarkan halaju yang direkabentuk

- Kenapa minimum???
  - Supaya kenderaan melalui selekoh dengan selamat pada kelajuan yang ditetapkan
- Rekabentuk lengkung bergantung kepada:
  - Halaju rekabentuk
  - Kadar sendengan (Superelevation rates)
  - Jejari (Radius)
  - Lengkung peralihan

JENIS LENGKUNG

1. Lengkung mudah (Simple curve)
   - Sesuai digunakan untuk kawalan lengkung yang besar & nilai radius melebihi2000m
2. Lengkung peralihan (Transition/Spiral curve)
   1. Kenderaan mengikut laluan peralihan sebelum memasuki lengkung bulat (circular curve) & selepasnya
   2. Lebih selamat dan selesa

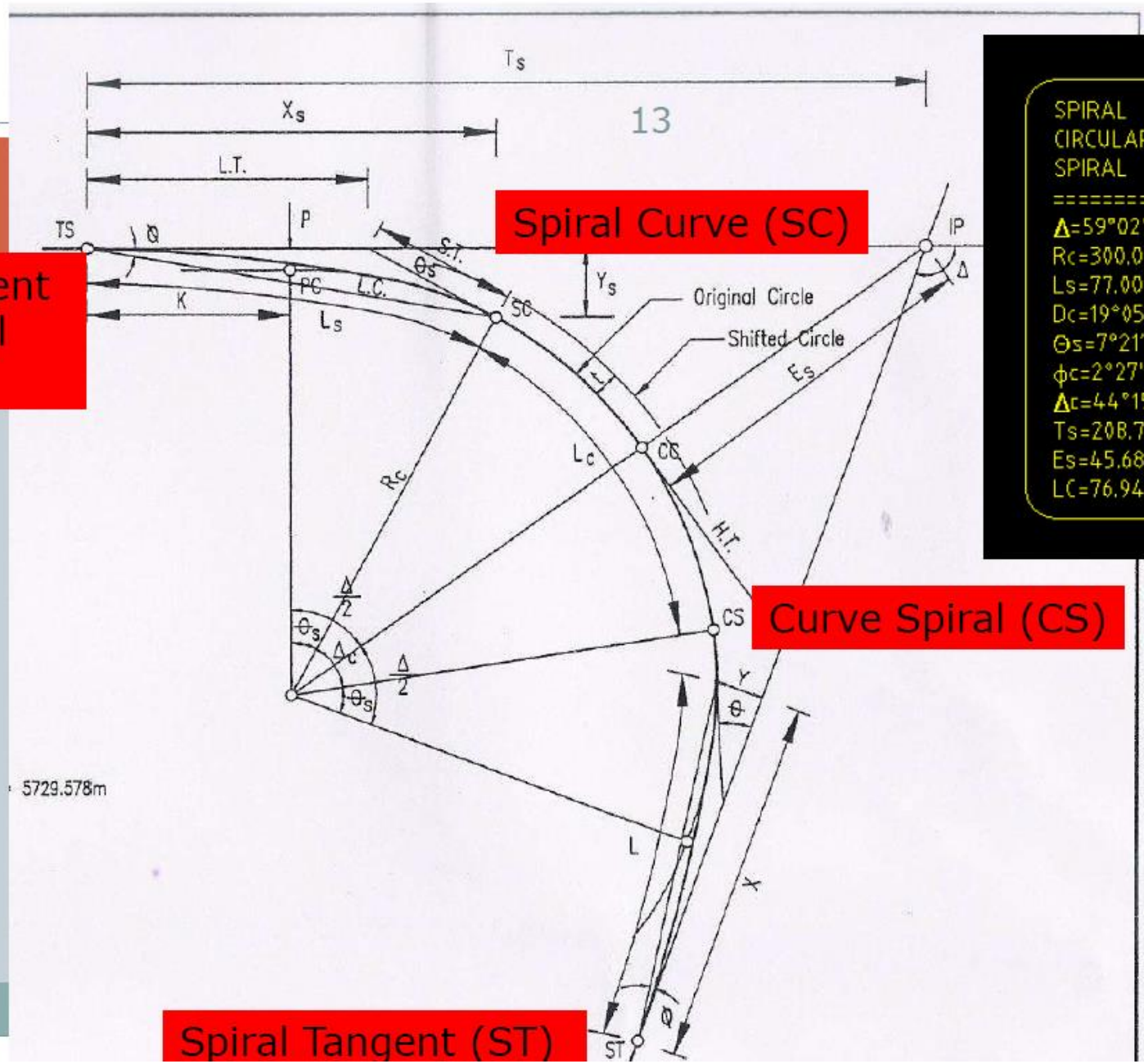
Lengkung mudah (berjejari tunggal)



IP-4

E=-18,365.729m
N=1,641.895m
CH=1,581.790m
=========
Δ=7°29'52"
Rc=2,500.000m
T=163.808m
Dc=2°17'31"
Lc=327.149m
E=5.361m

Lengkung peralihan (berjejari berubah)



13

Tangent Spiral (TS)

Spiral Curve (SC)

Curve Spiral (CS)

Spiral Tangent (ST)

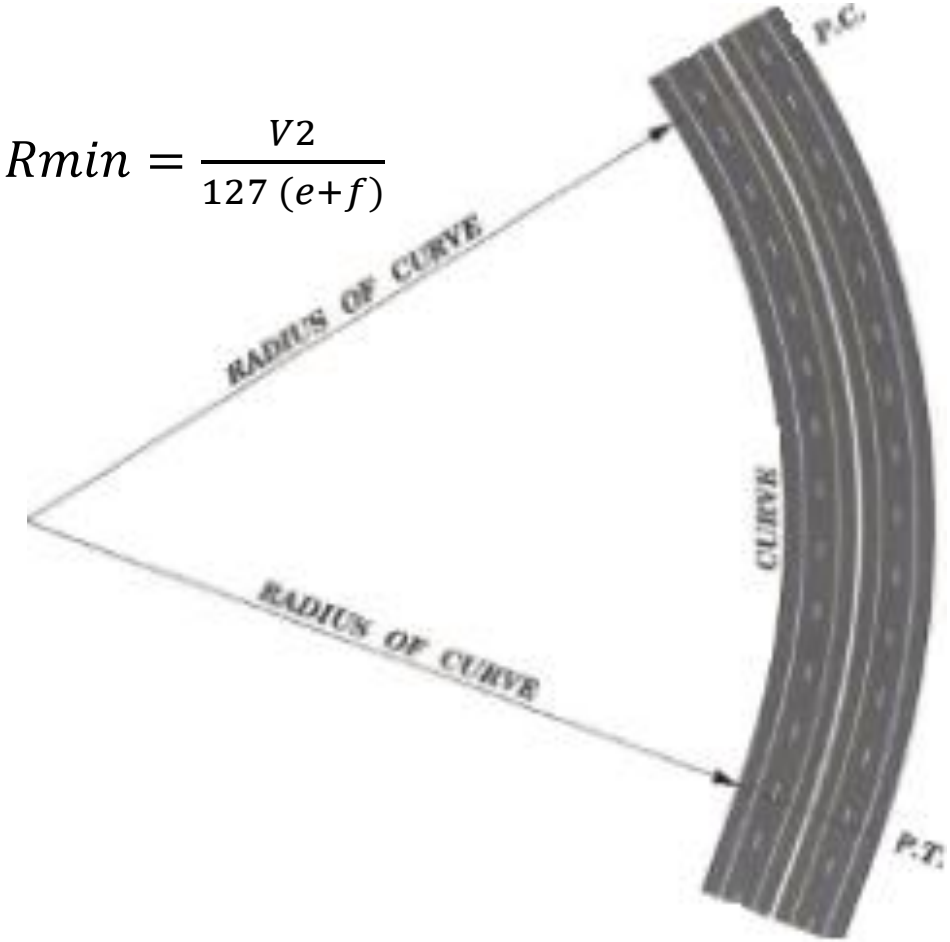
IP-2

SPIRAL	E=-19,240.536m
CIRCULAR	N=2,160.321m
SPIRAL	CH=547.005
Δ=59°02'00"	xs=76.873m
Rc=300.000m	ys=3.290m
Ls=77.000m	LT=51.378m
Dc=19°05'55"	ST=25.707m
Θs=7°21'11"	Lc=232.098m
ϕc=2°27'02"	p=0.823m
Δc=44°19'39"	k=38.479m
Ts=208.792m	
Es=45.689m	
LC=76.944m	

PENGENALAN (SAMB..)

- Jejari lengkung berkait rapat dengan
  - Nilai maksimum superelevation, e
  - Nilai maksimum geseran (side friction) yang dibenarkan, f
  - Halaju rekabentuk, V
- Oleh itu, nilai jejari selamat boleh dikira dengan menggunakan persamaan di bawah:

- $Rmin = \frac{V2}{127\ (e+f)}$

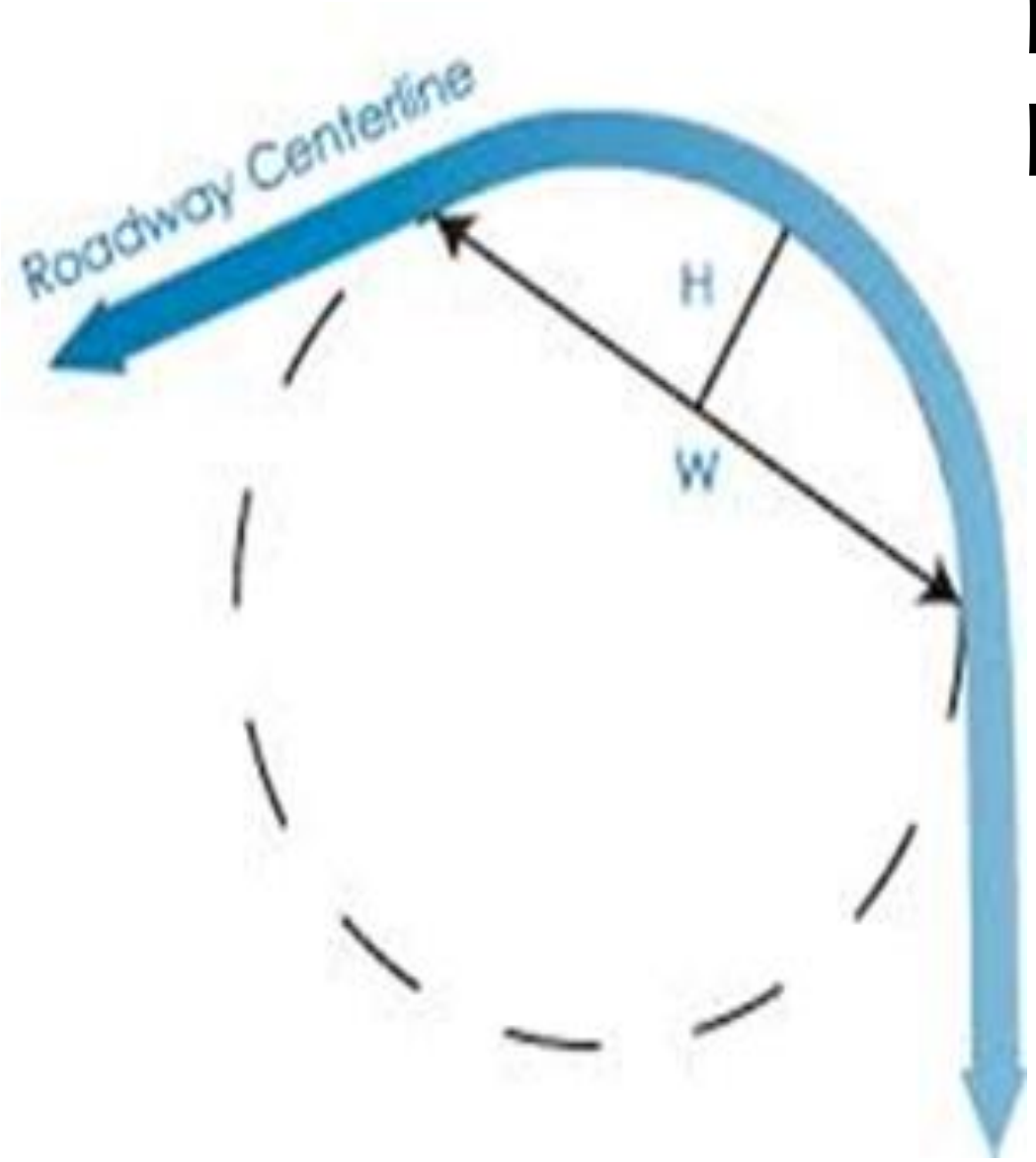


TUJUAN MENCERAP LENGKUNG SELEKOH

1. Untuk mendapatkan nilai sebenar lengkung di tapak - > *design speed* bagi sesuatu lokasi
2. Untuk kajian *speed differential* -> Untuk penilaian *sub standard curves* (keperluan minimum)
3. Untuk *pavement widening* di selekoh

- Lengkung di tapak < lengkung minima piawai → lengkung sub-standard → risiko kemalangan terbabas

KAEDAH-KAEDAH PENENTUAN RADIUS



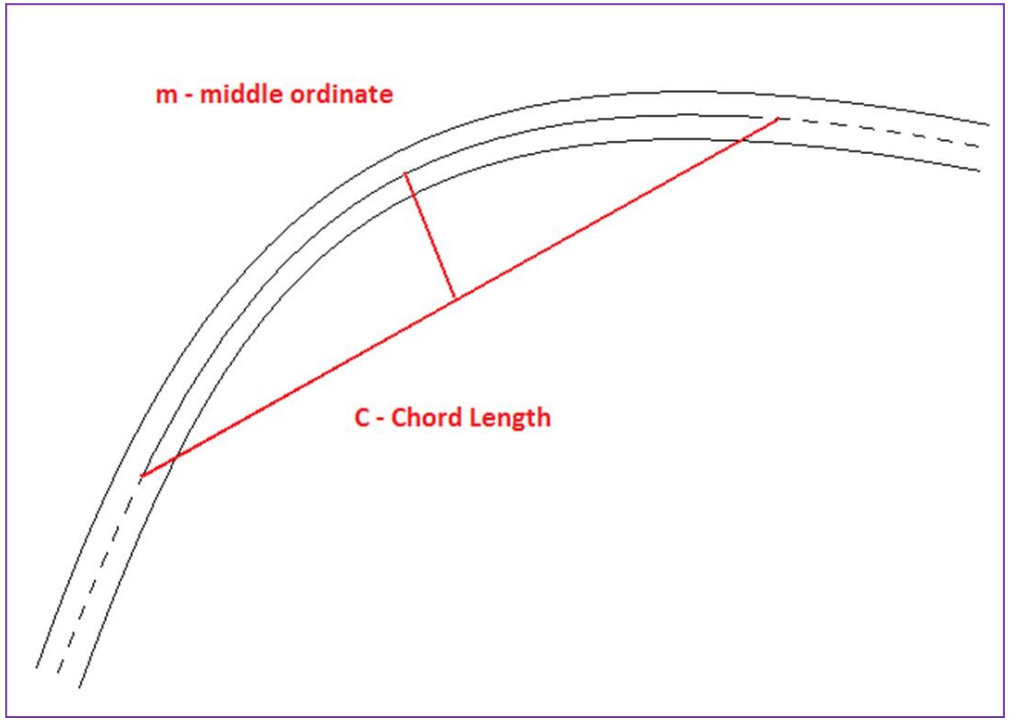
- Chord-offset method
- Compass method
- Google Earth
- Global Positioning Systems (GPS)

1. CHORD – OFFSET METHOD

Menggunakan tape - ukur yang dipegang pada setiap hujung selekoh jalan untuk mengukur panjang chord.

Dengan mengguna bahagian tengah tape - ukur tersebut, ukuran pula dibuat daripada titik tengah sehingga ketengah / tepi jalan berkenaan untuk mendapatkan nilai middle - ordinate.

1. CHORD – OFFSET METHOD (SAMB..)



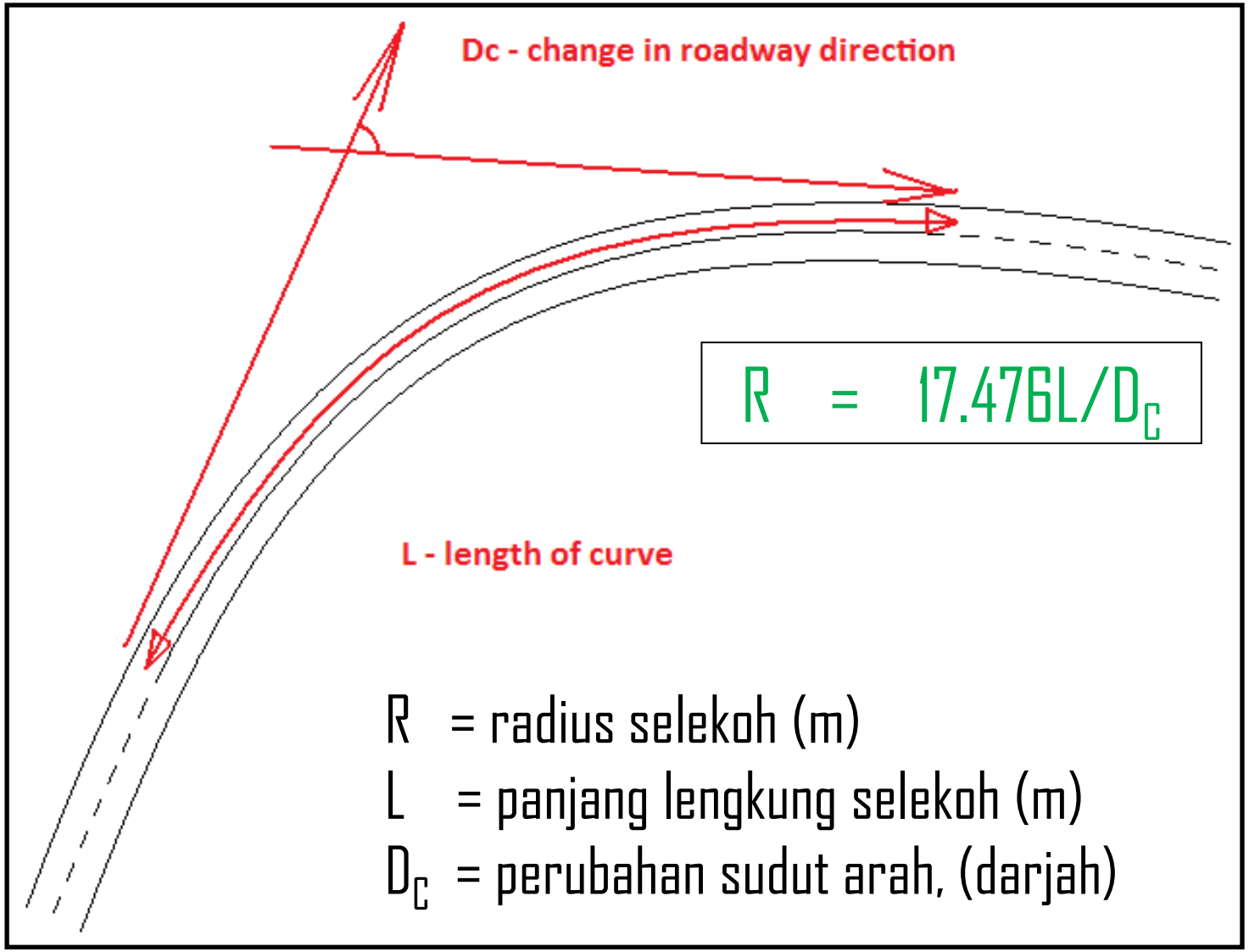
$$R = \frac{4m^2 + C^2}{8m}$$

2. COMPASS METHOD

Kaedah ini melibatkan pengukuran panjang lengkung selekoh dan perubahan sudut arah (total change in direction).

Lengkung selekoh boleh diukur dengan trumeter (measuring wheel) manakala perubahan sudut arah pula boleh menggunakan kompas.

Perbezaan sudut tunjuk arah kedua - dua tangent akan member nilai berkenaan.



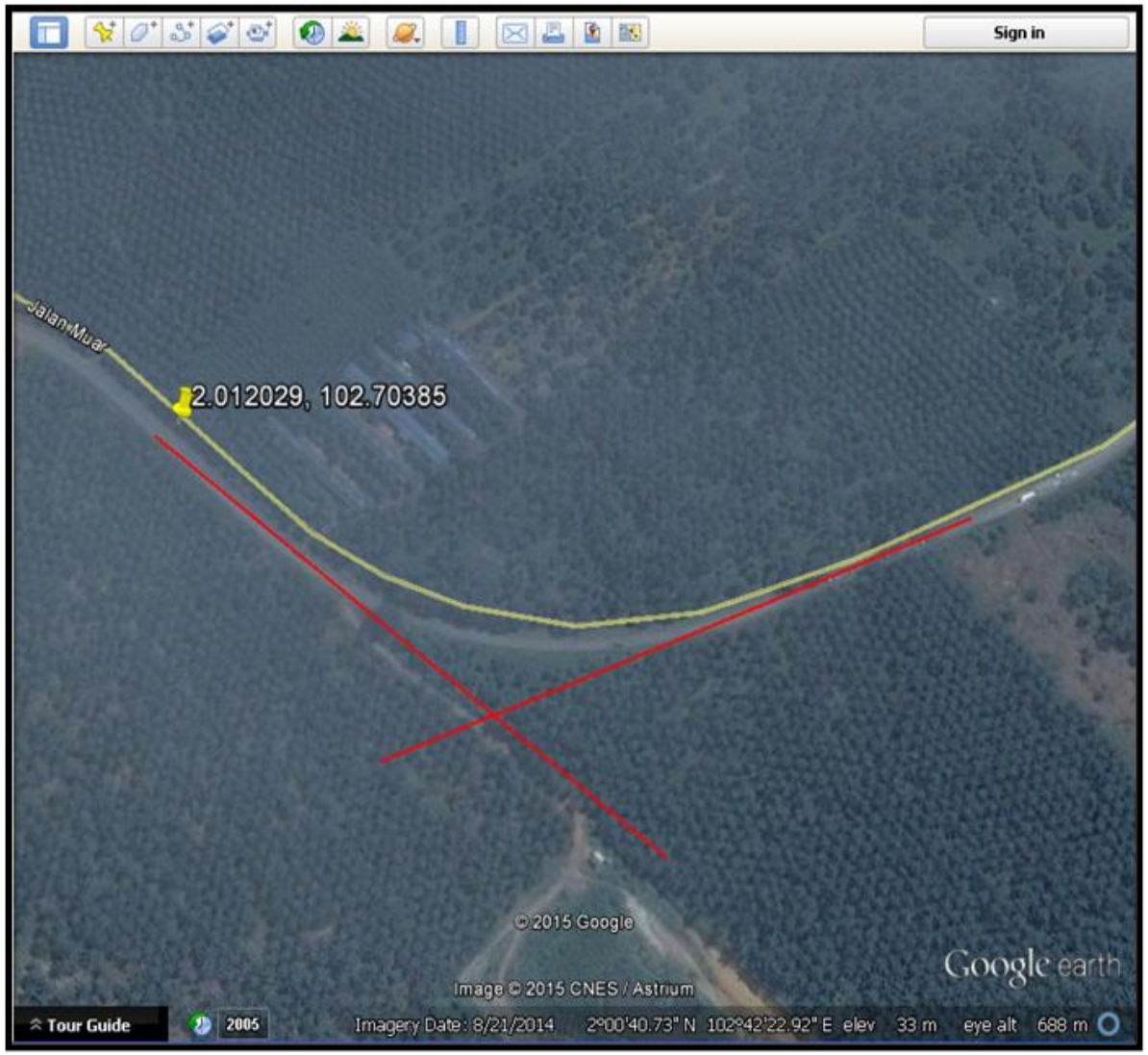
$$R = 17.476L/D_C$$

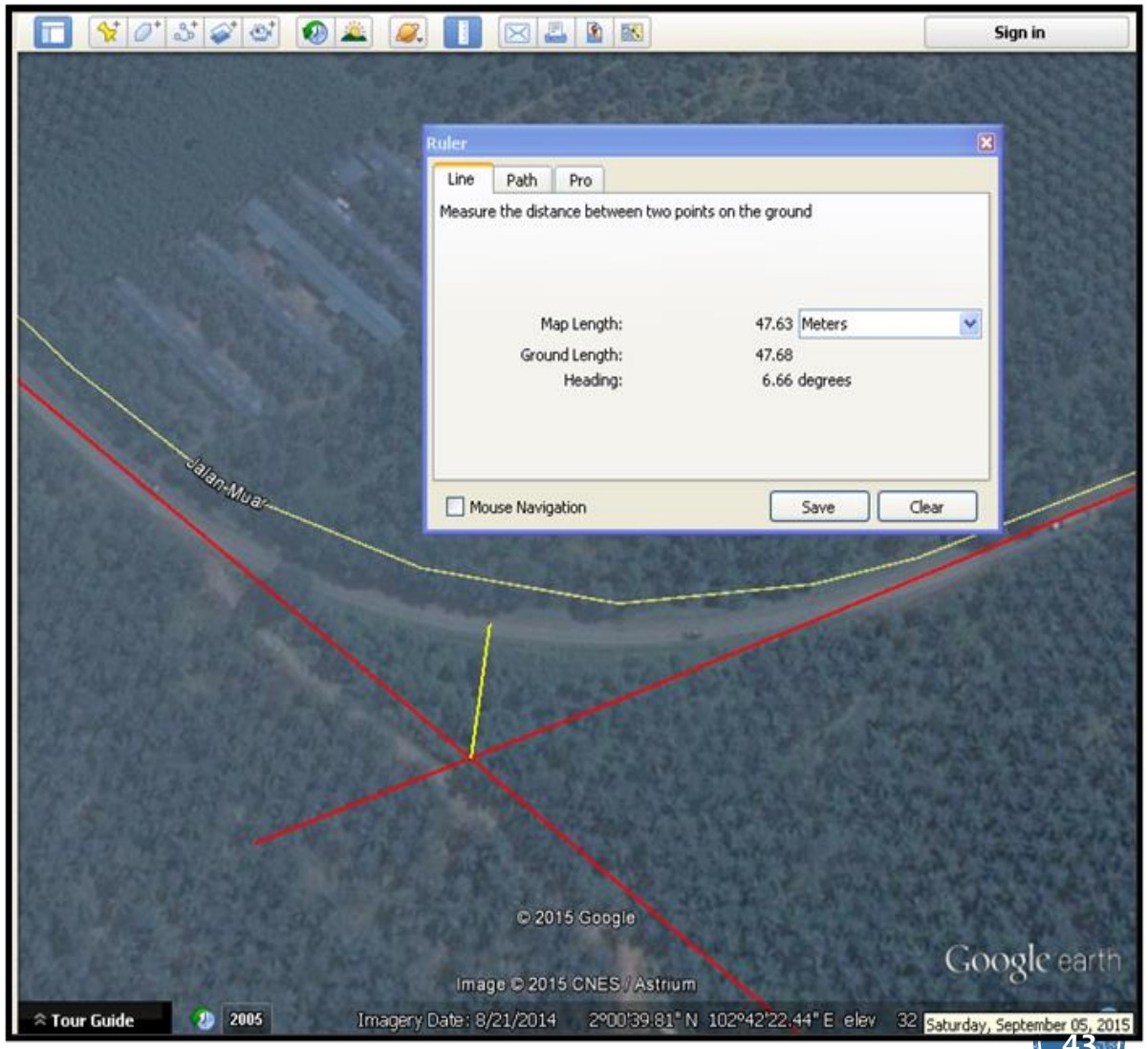
R = radius selekoh (m)

L = panjang lengkung selekoh (m)

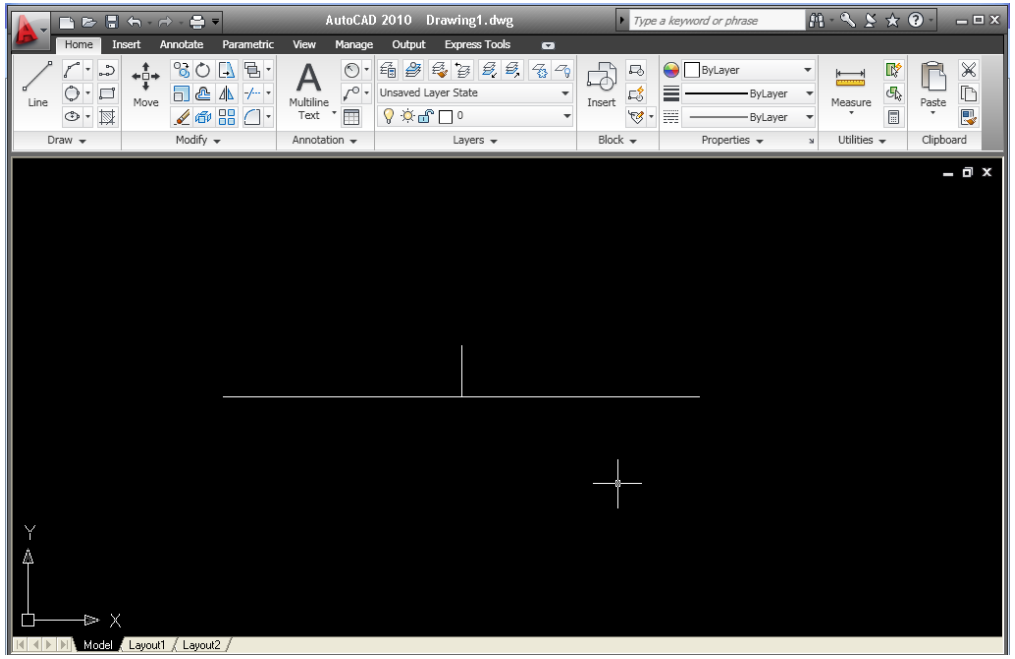
D_C = perubahan sudut arah, (darjah)

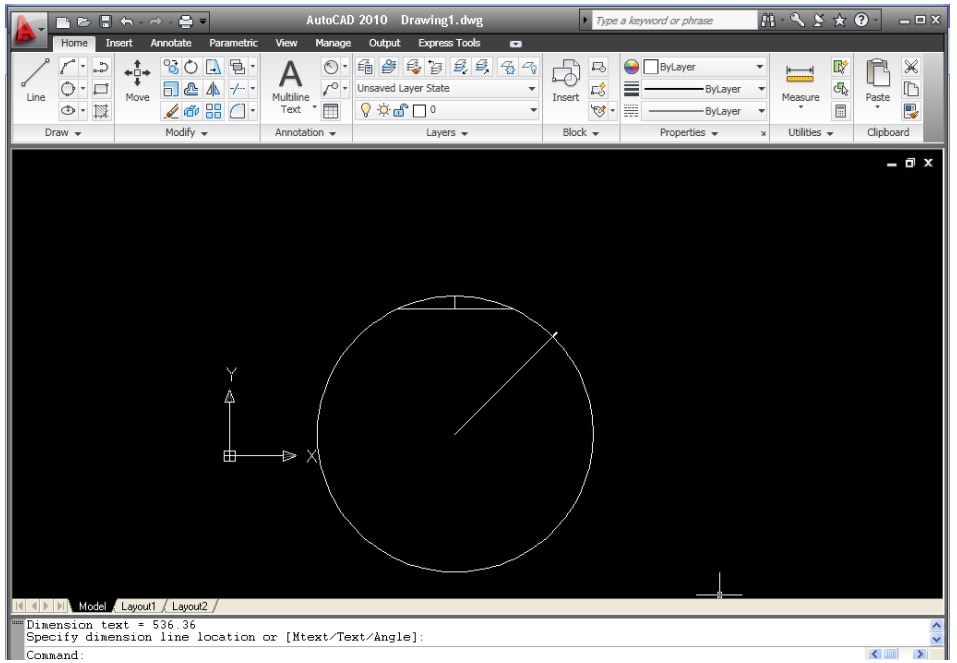
3. GOOGLE EARTH

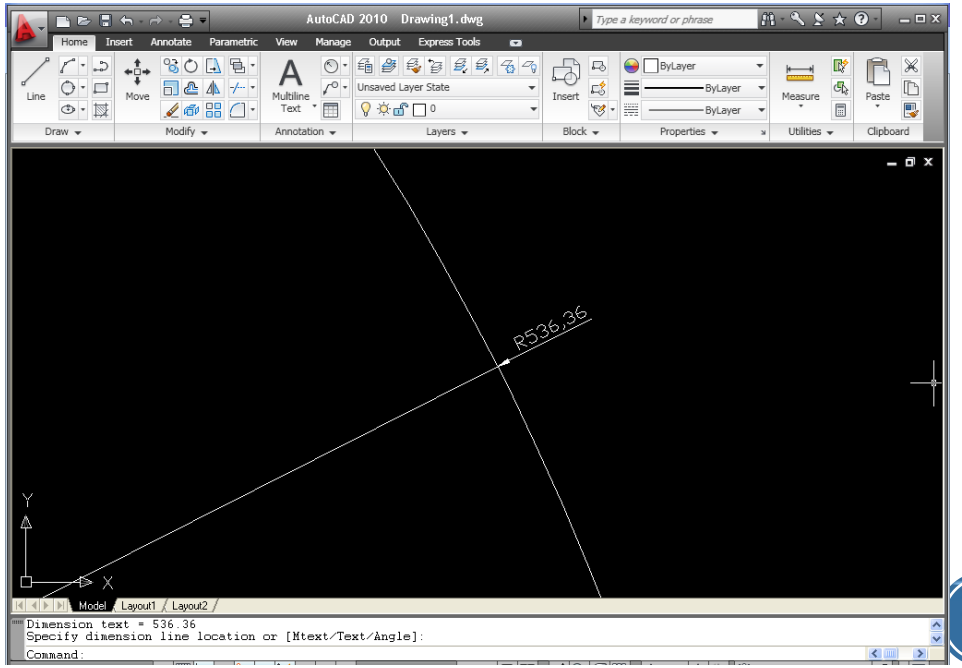




3. GOOGLE EARTH (SAMB..)







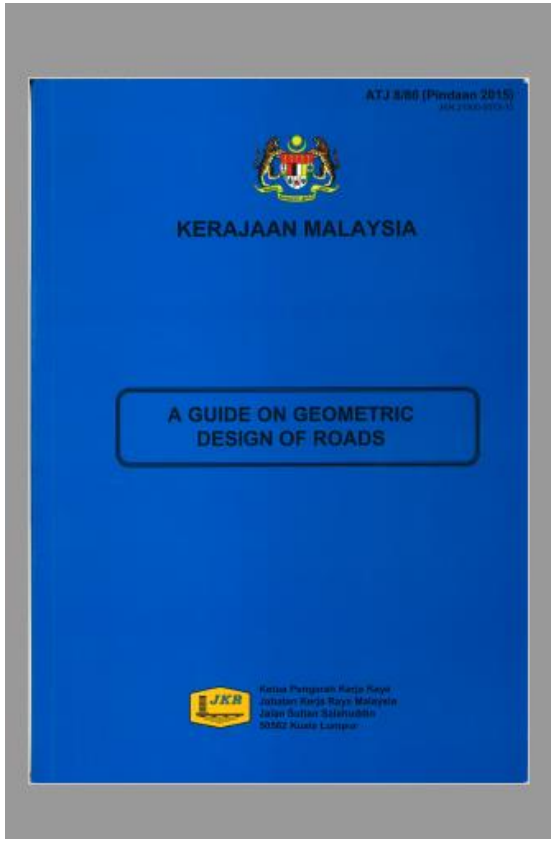
4. MENGGUNAKAN GPS

Buka menu utama, tetapkan pada tracking mode dan klik tracking.

Klik pada setup untuk mengubah cerapan data mengikut masa seperti setiap 15 saat, 30 saat, 1 minit sehingga setiap 24 jam. Setelah selesai, klik pasa save dan mulakan cerapan.

Berjalan mengikut jajaran jalan sehingga tamat selekoh yang dicerap.

PIAWAIAN BERKAITAN LENGKUNG



Design Speed (kph)	Minimum Radius (m)		
	e = 0.06	e = 0.08	e = 0.10
120	755	665	595
110	560	500	455
100	435	395	360
90	335	305	275
80	250	230	210
70	195	175	160
60	135	125	115
50	90	80	75
40	55	50	45
30	30	30	25

LENGKUNG MINIMUM

- Had nilai radius lengkung ufuk bagi halaju rekabentuk yang ditetapkan, ditentukan dari nilai sendengan maksimum & faktor geseran sisi maksimum yang dibenarkan.

- R min = V2 / [127(e + f)]
  - V= Halaju Rekabentuk
  - e = Nilai sendengan maksimum
  - f = Nilai faktor geseran sisi yang dibenarkan

- **Radius yang lebih besar daripada nilai radius minimum perlu digunakan untuk mendapatkan lebih keselesaan & selamat.**

Table 4-5: Minimum radius

Design speed (km/h)	Minimum radius (m)		
	e=0.06	e=0.08	e=0.10
120	755	665	595
110	560	500	455
100	435	395	360
90	335	305	275
80	250	230	210
70	195	175	160
60	135	125	115
50	90	80	75
40	55	50	45
30	30	30	25

JEJARI

Apa yang akan berlaku jika...

Jejari yang diperoleh kurang daripada jejari minimum

→ Pemanduan di selekoh sub standard adalah bahaya dan berpotensi untuk berlakunya kemalangan

Rawatan??

CADANGAN PENAMBAHBAIKAN - PELEBARAN KAWASAN SELEKOH

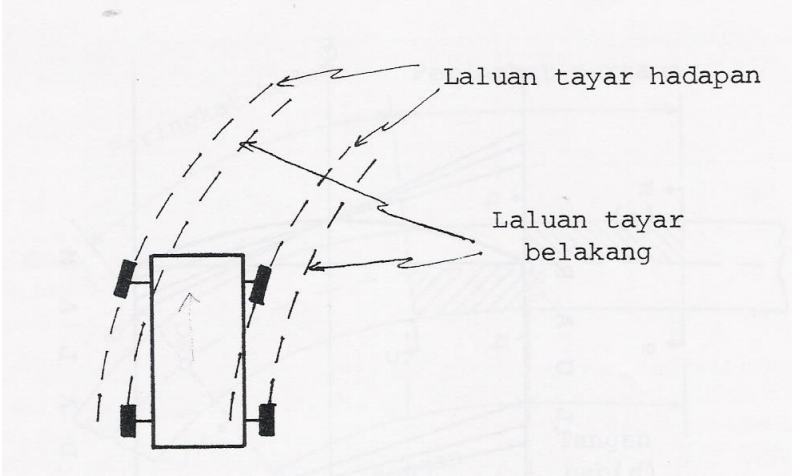
- Pelebaran turapan di kawasan selekoh amat diperlukan kerana:

i. Keluasan laluan tayar kenderaan di atas selekoh lebih lebar daripada keluasannya di atas tangen. Ruang ini diperlukan kerana arah laluan tayar belakang dan tayar depan kenderaan tidak sama

ii. Apabila berselisih diselekoh, pemandu cenderung untuk mengelak dengan menjauhkan kenderaan daripada kenderaan lawan sejauh mungkin untuk mengelak kemalangan

iii. Pemandu akan mengelakkan kenderaannya daripada merapat dekat dengan sisi jalan

iv. Pemandu yang tidak berpengalaman menghadapi kesulitan mengemudi kenderaannya supaya benar-benar berada di pertengahan lorong ketika membelok



KESENDENGAN (SUPER ELEVATION)

SUPER-E

PENGENALAN

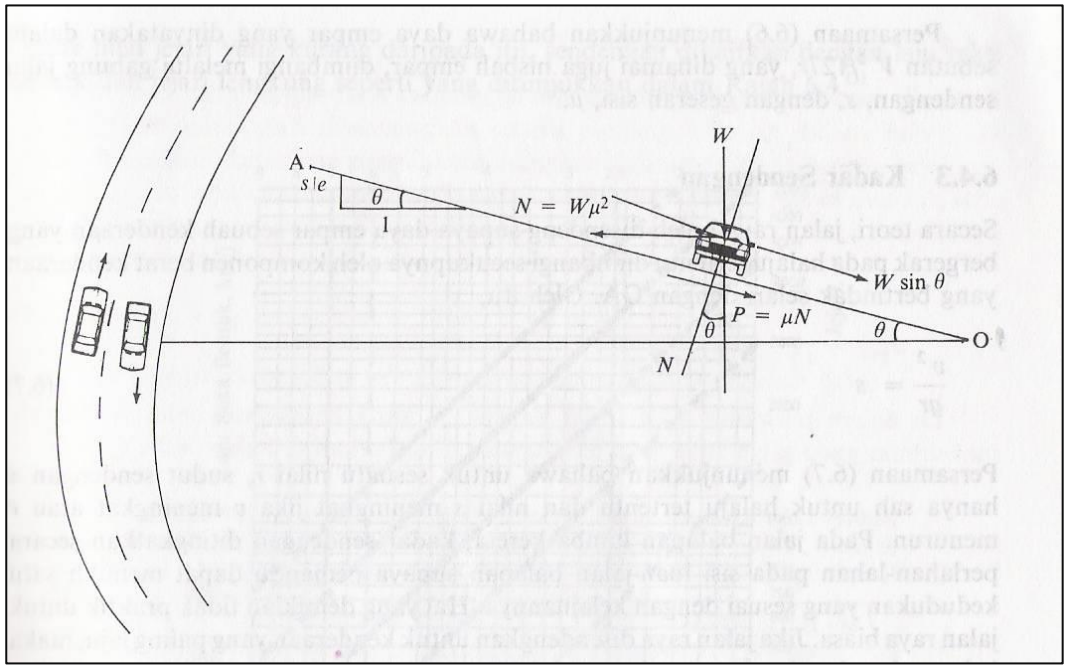
Sendengan (superelevation) di perkenalkan di kawasan selekoh peralihan adalah untuk mengimbangi dan mengelakkan kenderaan daripada terbalik atau tergelincir serta memberi keselesaan kepada pemanduan,

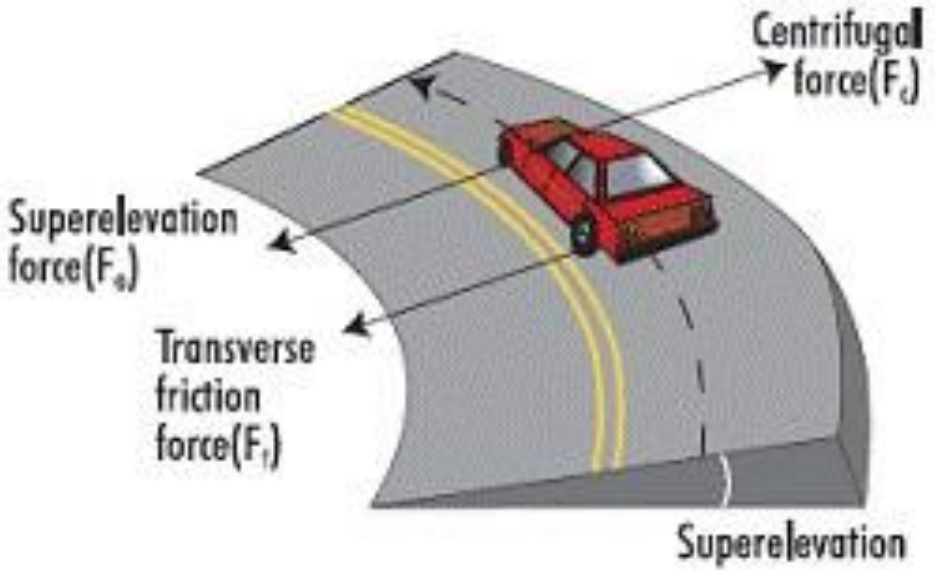
- Mengambilkira perkara berikut:
  - Halaju rekabentuk di lengkung (curve)
  - Kemungkinan kenderaan yang bergerak perlahan menghala ke tengah jalan
  - Kestabilan kenderaan berat melalui lengkung
  - Nilai maksimum sendengan:
    - Rural Roads: 0.1 (10%)
    - Urban Roads: 0.06 (6%)

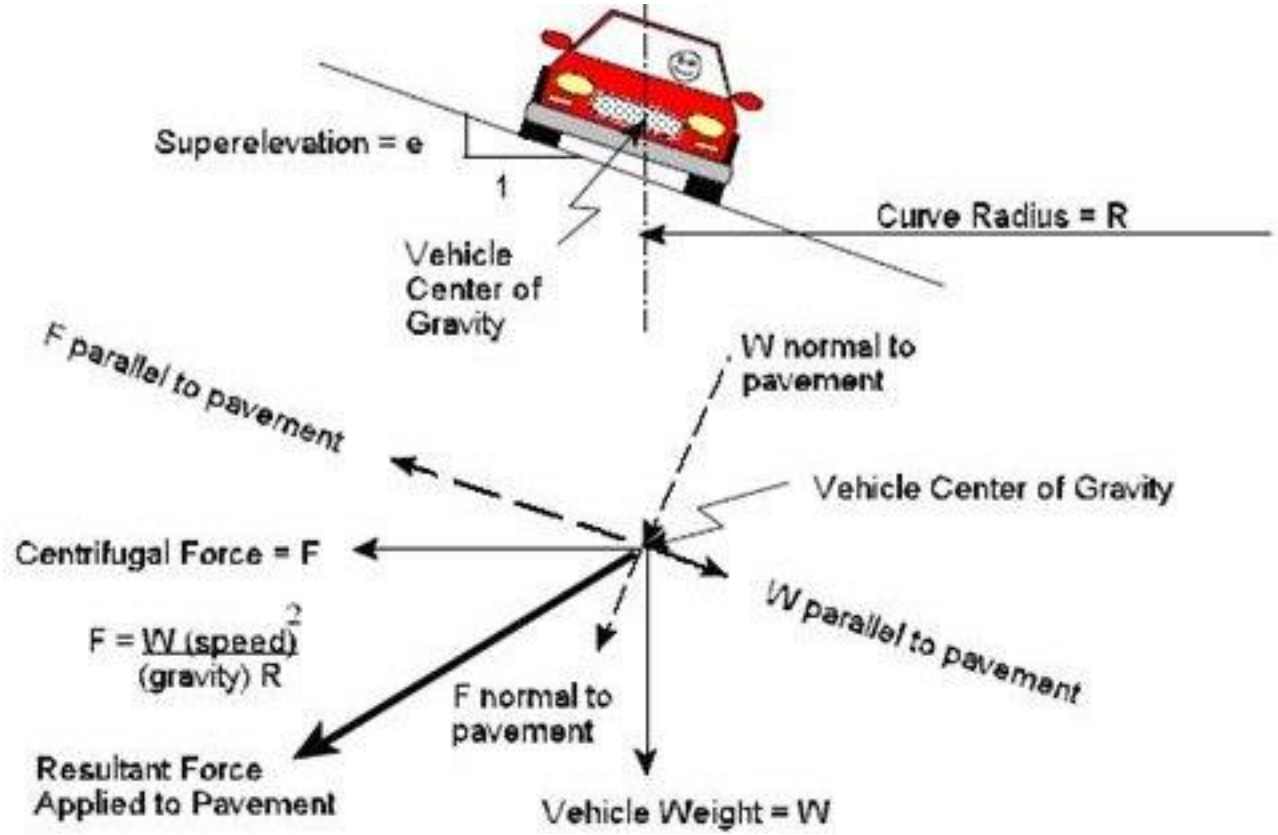
KESENDENGAN (SUPERELEVATION)

- Apabila sebuah kenderaan yang bergerak dari jalan lurus dan seterusnya menyelekoh, terdapat tiga daya yang bertindak terhadap kenderaan tersebut, iaitu:

  - Daya empar (centrifugal force) - yang bertindak melintang keluar
  - Komponen berat kenderaan - yang bertindak ke bawah
  - Geseran sisi pada antara muka tayar dan jalan raya.

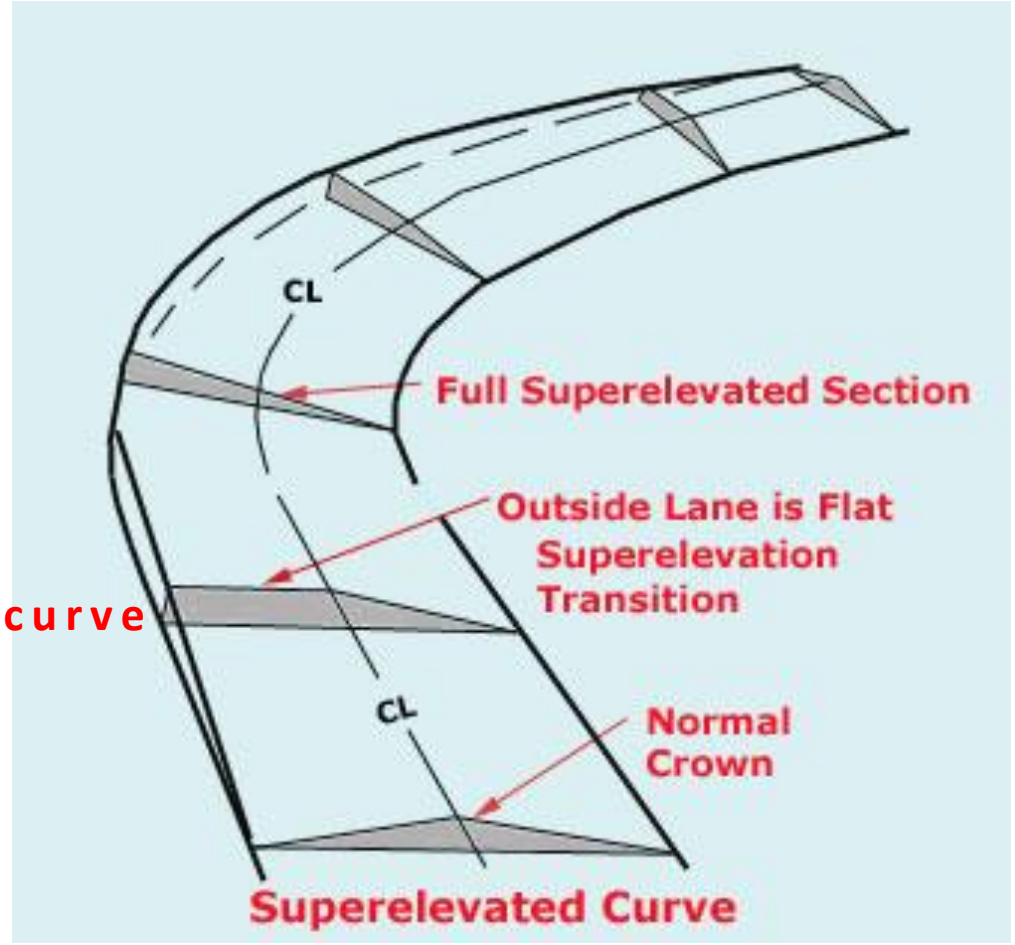



Centrifugal force(F_c)
Superelevation force(F_e)
Transverse friction force(F_f)
Superelevation


Superelevation = e
1
Curve Radius = R
Vehicle Center of Gravity
F parallel to pavement
W normal to pavement
Vehicle Center of Gravity
Centrifugal Force = F
$F = \frac{W (speed)^2}{(gravity) R}$
W parallel to pavement
F normal to pavement
Resultant Force Applied to Pavement
Vehicle Weight = W

BAGAIMANA IA DIBINA???

Transition curve

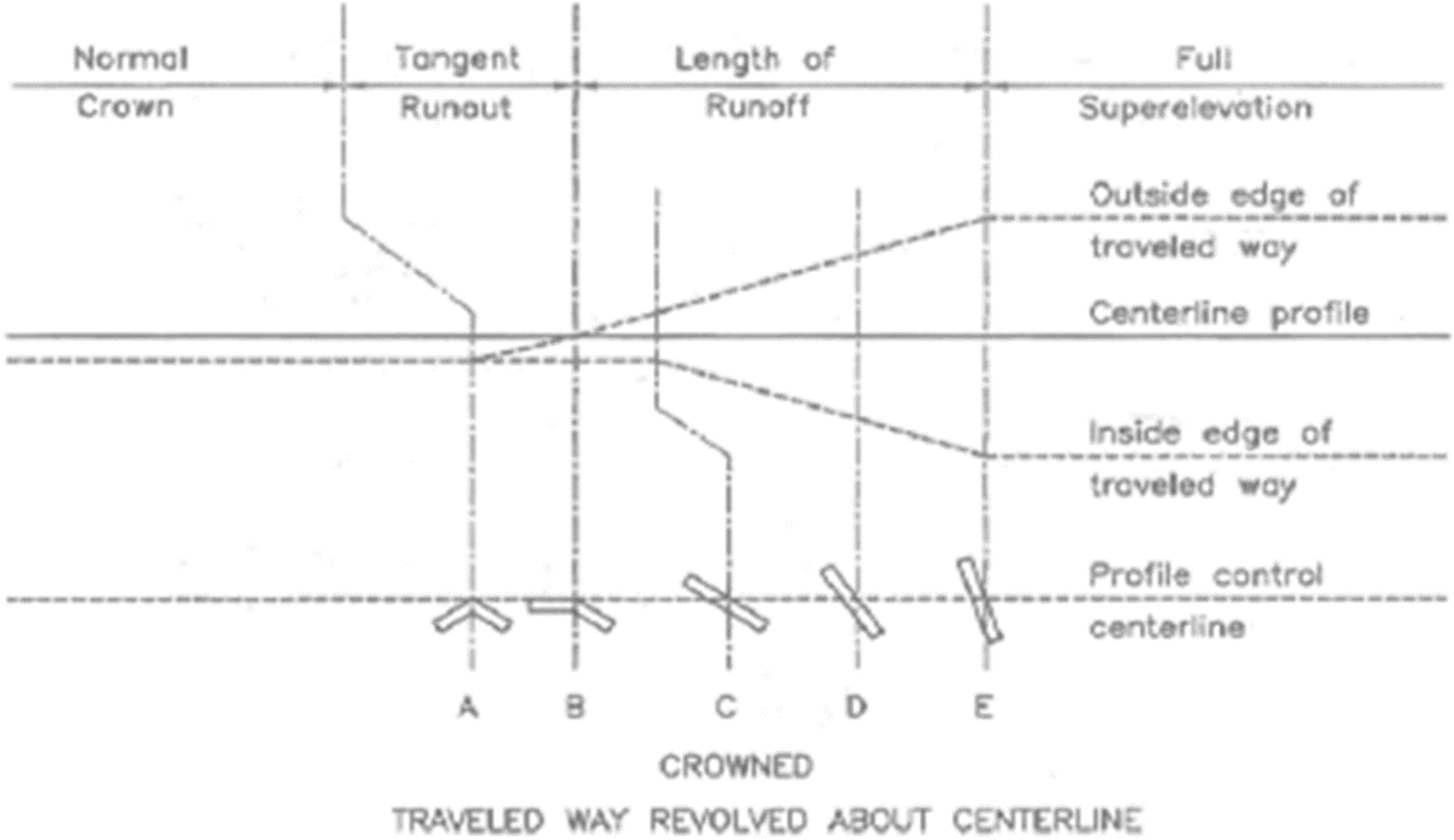


Max super-e

6% (urban)
10% (rural)

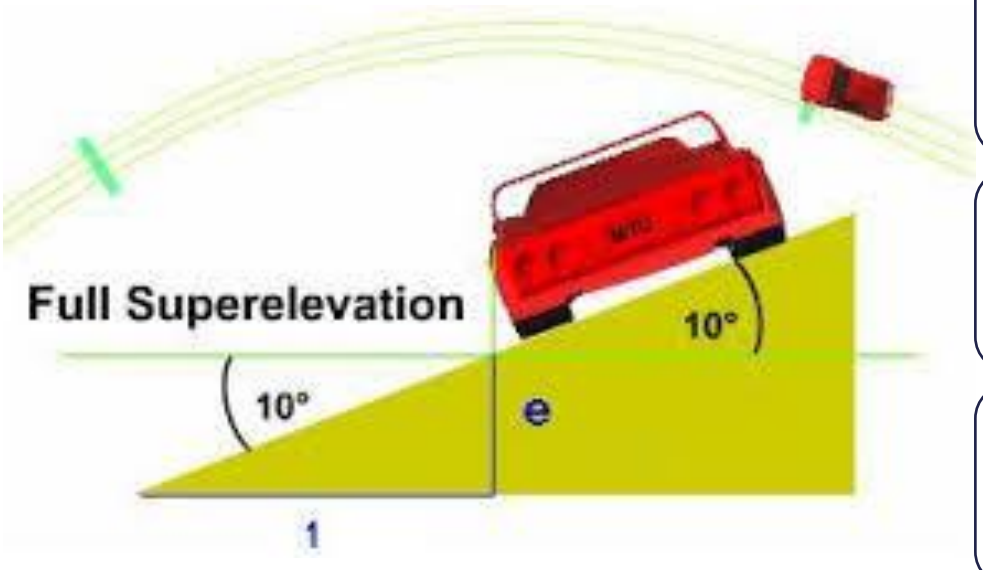
animation

PERALIHAN (TRANSITION) SUPER-E



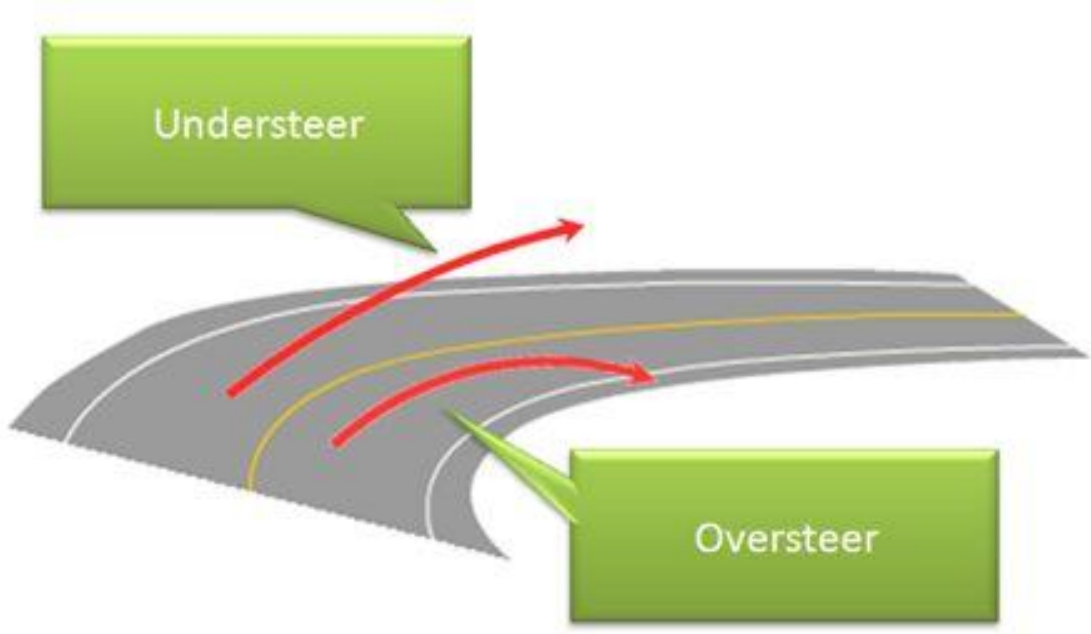
from AASHTO's *A Policy on Geometric Design of Highways and Streets 2001*

TUJUAN CERAPAN SUPER –E



- Mendapatkan nilai sebenar super – e di lokasi
- Menyemak kesesuaian super-e bagi selekoh
- Menentukan kesesuaian super-e dengan had laju
- Digunakan untuk mendapatkan jejari minima selekoh

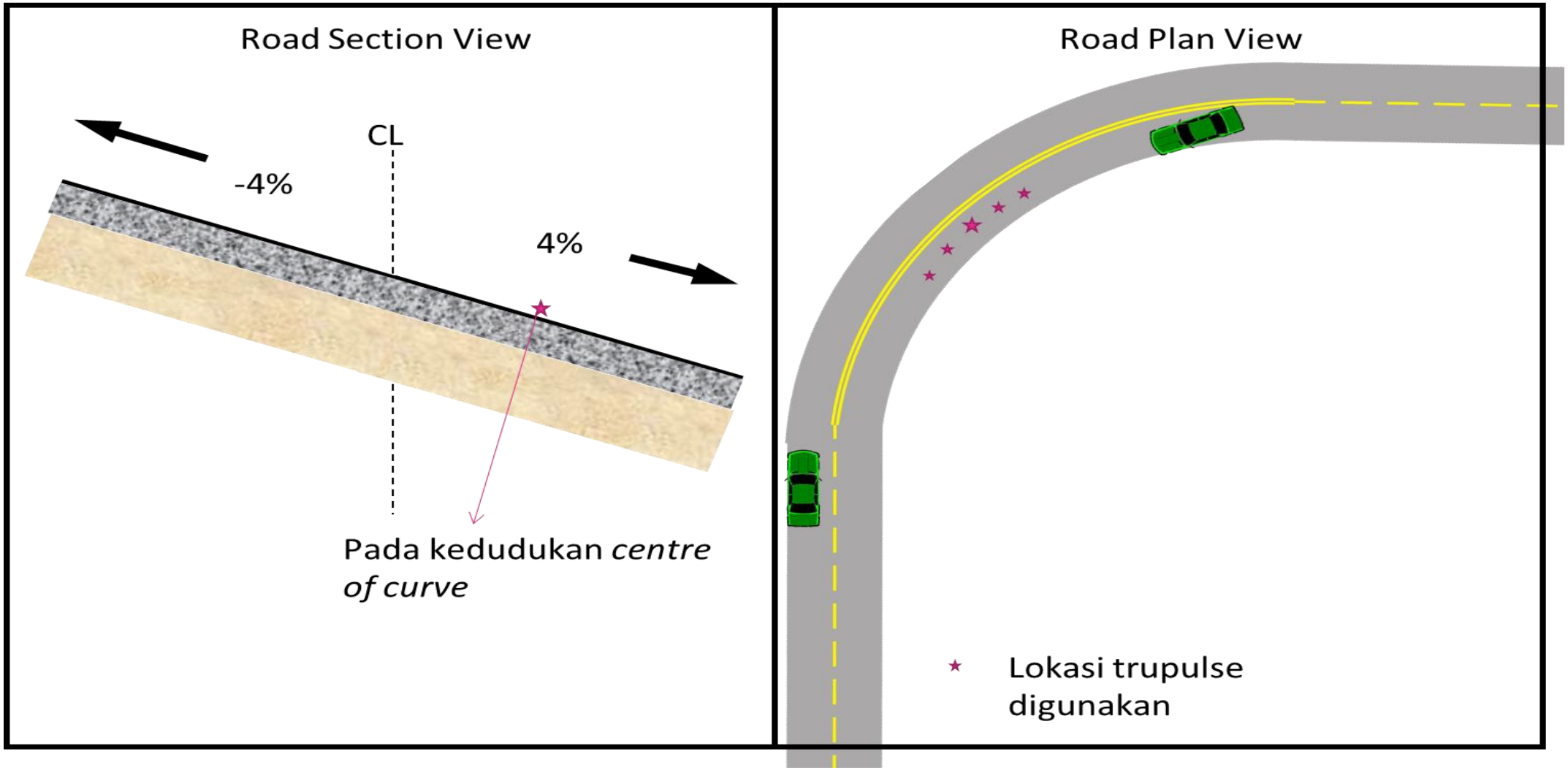
- Jika kesendengan < e_{maks} → understeer → risiko kemalangan terbabas ke kiri jalan
- Jika kesendengan > e_{maks} → oversteer → risiko kemalangan terbabas ke kanan jalan



PERALATAN MENCERAP KESENDENGAN

- Kayu pengukur
- Tru-pulse

KEDUDUKAN TRUPULSE SEMASA MENCERAP SUPER- E



MENCERAP KESENDENGAN DI TAPAK

Ukuran diambil di sepanjang selekoh untuk dapatkan Full Super-e

MENCERAP KESENDENGAN DI TAPAK


S.E = 2.5 – 4.5 %

PIAWAIAN BERKAITAN KESENDENGAN

Table 4-7A: Design Superelevation Table – ATJ 8/86 (Pindaan 2015)

TABLE 4-7A : DESIGN SUPERELEVATION TABLE

R (m)	V = 30kph				V = 40kph				V = 50kph				V = 60kph				V = 70kph				V = 80kph				V = 90kph				V = 100kph				V = 110kph				V = 120kph			
	e (%)	2 L(m)	4 L(m)	6 L(m)	e (%)	2 L(m)	4 L(m)	6 L(m)	e (%)	2 L(m)	4 L(m)	6 L(m)	e (%)	2 L(m)	4 L(m)	6 L(m)	e (%)	2 L(m)	4 L(m)	6 L(m)	e (%)	2 L(m)	4 L(m)	6 L(m)	e (%)	2 L(m)	4 L(m)	6 L(m)	e (%)	2 L(m)	4 L(m)	6 L(m)	e (%)	2 L(m)	4 L(m)	6 L(m)	e (%)	2 L(m)	4 L(m)	6 L(m)
7000	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0
5000	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0
3000	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	RC	20	31	40	RC	23	34	46	RC	24	37	48
2500	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	RC	19	28	38	RC	20	31	40	RC	23	34	46	2.7	26	38	52
2000	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	RC	18	27	36	RC	19	28	38	RC	20	31	40	2.8	25	37	50	3.3	31	47	62
1500	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	RC	17	26	34	RC	18	27	36	2.7	21	31	42	3.1	25	38	50	3.6	32	47	64	4.2	40	60	80
1400	NC	0	0	0	NC	0	0	0	NC	0	0	0	RC	15	23	30	RC	17	26	34	RC	18	27	36	2.8	21	32	42	3.3	27	41	54	3.8	33	50	66	4.4	42	63	84
1300	NC	0	0	0	NC	0	0	0	NC	0	0	0	RC	15	23	30	RC	17	26	34	2.7	19	29	38	3	23	34	46	3.5	29	43	58	4	35	53	70	4.7	45	67	90
1200	NC	0	0	0	NC	0	0	0	NC	0	0	0	RC	15	23	30	RC	17	26	34	3.1	22	33	44	3.2	25	37	50	3.7	30	45	60	4.2	37	55	74	5	47	71	94
1000	NC	0	0	0	NC	0	0	0	RC	14	21	28	RC	15	23	30	2.6	17	26	34	3.4	24	37	48	3.6	28	41	56	4.2	34	52	68	4.8	42	63	84	5.6	53	80	106
900	NC	0	0	0	NC	0	0	0	RC	14	21	28	RC	15	23	30	2.8	18	27	36	3.6	26	39	52	3.9	30	45	60	4.5	37	55	74	5.1	45	67	90	5.8	55	82	110
800	NC	0	0	0	NC	0	0	0	RC	14	21	28	RC	15	23	30	3.1	20	30	40	4	29	43	58	4.2	32	48	64	4.9	40	60	80	5.4	47	71	94	6	57	85	114
700	NC	0	0	0	RC	13	19	26	RC	14	21	28	2.8	17	25	34	3.4	22	33	44	4.3	31	46	62	4.6	35	53	70	5.2	43	64	86	5.8	51	76	102	R min = 755			
600	NC	0	0	0	RC	13	19	26	RC	14	21	28	3.1	19	28	38	3.8	25	37	50	4.8	35	52	70	5	38	57	76	5.6	46	69	92	6	53	79	106				
500	NC	0	0	0	RC	13	19	26	2.8	15	23	30	3.5	21	32	42	4.2	27	41	54	5.3	38	57	76	5.4	41	62	82	5.9	48	72	96	R min = 560							
400	RC	10	14	20	RC	13	19	26	3.3	18	27	36	4	24	36	48	4.7	31	46	62	5.9	42	64	84	5.9	45	68	90	R min = 435											
300	RC	10	14	20	3.1	16	24	32	3.9	22	32	44	4.6	28	41	56	5.4	35	53	70	6	43	65	86	R min = 335															
250	RC	10	14	20	3.5	18	27	36	4.2	23	35	46	5	30	45	60	5.8	38	57	76	R min = 250																			
200	2.8	13	20	26	3.9	20	30	40	4.7	26	39	52	5.5	33	50	66	6	39	59	78																				
175	3	14	22	28	4.1	21	32	42	5	28	42	56	5.8	35	52	70	R min = 195																							
150	3.3	16	24	32	4.4	23	34	46	5.3	29	44	58	6	36	54	72																							
140	3.5	17	25	34	4.5	23	35	46	5.4	30	45	60	6	36	54	72																							
130	3.6	17	25	34	4.6	24	35	48	5.6	31	47	62	R min = 135																											
120	3.8	18	27	36	4.8	25	37	50	5.7	32	47	64																											
110	3.9	19	28	38	5	26	39	52	5.8	32	48	64																											
100	4.1	20	30	40	5.2	27	40	54	6	33	50	66																											
90	4.2	20	30	40	5.4	28	42	56	6	33	50	66																											
80	4.5	22	32	44	5.6	29	43	58	R min = 90																														
70	4.7	23	34	46	5.8	30	45	60																															
60	5	24	36	48	6	31	46	62																															
50	5.4	26	39	52	R min = 55																																		
40	5.8	28	42	56																																			
30	6	29	43	58																																			
	R min = 30																																						

Notes:-
The RC row presents minimum radii for a compute
The row NC designates a travel way cross section
For curve radii falling between NC and RC, a plane

e max	=	6%
R	=	Radius of curve
Vd	=	Design speed
L	=	Minimum length of runoff (excluding tangent runout)
		length are for 3.6m lane width and the respective
		maximum relative slope for each design speed

Source: Adapted from AASHTO – A Policy on Geome

Halaju = 80km/h
Radius = 800m
Superelevation = 0.040 (4.0%)
Ls = 29m (2 lanes)
43m (4 lanes)

Table 4-7B: Design Superelevation Table –ATJ 8/86 (Pindaan 2015)

TABLE 4-7B : DESIGN SUPERELEVATION TABLE

R (m)	V = 30kph				V = 40kph				V = 50kph				V = 60kph				V = 70kph				V = 80kph				V = 90kph				V = 100kph				V = 110kph				V = 120kph			
	e (%)	2 L(m)	4 L(m)	6 L(m)	e (%)	2 L(m)	4 L(m)	6 L(m)	e (%)	2 L(m)	4 L(m)	6 L(m)	e (%)	2 L(m)	4 L(m)	6 L(m)	e (%)	2 L(m)	4 L(m)	6 L(m)	e (%)	2 L(m)	4 L(m)	6 L(m)	e (%)	2 L(m)	4 L(m)	6 L(m)	e (%)	2 L(m)	4 L(m)	6 L(m)	e (%)	2 L(m)	4 L(m)	6 L(m)	e (%)	2 L(m)	4 L(m)	6 L(m)
7000	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0
5000	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0
3000	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	RC	21	32	42	RC	22	33	44	RC	24	36	48
2500	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	RC	19	29	38	RC	21	32	42	RC	22	33	44	2.9	27	41	54
2000	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	RC	18	27	36	RC	19	29	38	2.6	21	32	42	3.0	26	40	52	3.5	33	50	66
1500	NC	0	0	0	NC	0	0	0	NC	0	0	0	RC	15	23	30	RC	17	25	34	RC	18	27	36	2.8	21	32	42	3.4	28	42	56	3.9	34	51	68	4.6	44	65	88
1400	NC	0	0	0	NC	0	0	0	NC	0	0	0	RC	15	23	30	RC	17	25	34	RC	18	27	36	3.0	23	34	46	3.6	29	44	58	4.1	36	54	72	4.9	46	70	92
1300	NC	0	0	0	NC	0	0	0	NC	0	0	0	RC	15	23	30	RC	17	25	34	2.7	19	29	38	3.2	25	37	50	3.8	31	47	62	4.4	39	58	78	5.2	49	74	98
1200	NC	0	0	0	NC	0	0	0	NC	0	0	0	RC	15	23	30	RC	17	25	34	2.9	21	31	42	3.4	26	39	52	4.1	34	50	68	4.7	41	62	82	5.6	53	80	106
1000	NC	0	0	0	NC	0	0	0	RC	14	21	28	RC	15	23	30	2.8	18	27	36	3.4	24	37	48	4.0	31	46	62	4.8	39	59	78	5.5	48	72	96	6.5	62	92	124
900	NC	0	0	0	NC	0	0	0	RC	14	21	28	RC	15	23	30	3.1	20	30	40	3.7	27	40	54	4.4	34	51	68	5.2	43	64	86	6.0	53	79	106	7.1	67	101	134
800	NC	0	0	0	NC	0	0	0	RC	14	21	28	RC	15	23	30	3.4	22	33	44	4.1	30	44	60	4.8	37	55	74	5.7	47	70	94	6.6	58	87	116	7.6	72	108	144
700	NC	0	0	0	RC	13	20	26	RC	14	21	28	2.7	15	23	30	3.8	25	37	50	4.5	32	49	64	5.3	41	61	82	6.3	52	77	104	7.2	63	95	126	8.0	76	114	152
600	NC	0	0	0	RC	13	20	26	2.6	14	21	28	3.0	18	27	36	4.3	28	42	56	5.1	37	55	74	6.0	46	69	92	6.9	55	85	110	7.7	68	101	136	R min = 665			
500	NC	0	0	0	RC	13	20	26	3.0	17	25	34	3.4	20	31	40	4.9	32	48	64	5.8	42	63	84	6.7	51	77	102	7.6	62	93	124	8.0	70	105	140				
400	RC	12	18	24	2.7	14	21	28	3.6	20	30	40	3.9	23	35	46	5.7	37	56	74	6.6	48	71	96	7.5	57	88	114	8.0	65	98	130	R min = 500							
300	RC	12	18	24	3.4	17	26	34	4.5	25	37	50	4.7	28	42	56	6.7	44	66	88	7.6	55	82	110	R min = 396															
250	2.5	12	18	24	4.0	21	31	42	5.1	26	42	52	5.6	34	50	68	7.4	48	73	96	7.9	57	85	114																
200	3.0	14	22	28	4.6	24	35	48	5.8	32	48	64	6.2	37	56	74	7.9	52	78	104	R min = 305																			
175	3.4	16	24	32	5.0	26	39	52	6.2	34	52	68	7.0	42	63	84	8.0	52	79	104																				
150	3.8	18	27	36	5.4	28	42	56	6.7	37	56	74	7.4	44	67	88	R min = 230																							
140	4.0	19	29	38	5.6	29	43	58	6.9	38	57	76	7.3	47	70	94																								
130	4.2	20	30	40	5.8	30	45	60	7.1	39	59	78	7.9	47	71	94																								
120	4.4	21	32	42	6.0	31	46	62	7.4	41	61	82	8.0	48	72	96																								
110	4.7	23	34	46	6.3	32	49	64	7.6	42	63	84	R min = 175																											
100	5.0	24	36	48	6.6	34	51	68	7.8	43	65	86																												
90	5.2	25	37	50	6.9	35	53	70	7.9	44	66	88																												
80	5.5	26	40	52	7.2	37	56	74	8.0	44	66	88																												
70	5.9	28	42	56	7.5	39	58	78	R min = 80																															
60	6.4	31	46	62	7.8	40	60	80																																
50	6.9	33	50	66	8.0	41	62	82																																
40	7.5	36	54	72	R min = 50																																			
30	8	38	58	76																																				
	R min = 30																																							

Notes:-
The RC row presents minimum radii for a computed SE rate
The row NC designates a travel way cross section used on cu
For curve radii falling between NC and RC, a plane slope acr

e max	=	8%
R	=	Radius of curve
Vd	=	Design speed
L	=	Minimum length of runoff (excluding tangent runout) length are for 3.6m lane width and the respective maximum relative slope for each design speed
NC	=	Normal crown 2.5%

Source: Adapted from AASHTO – A Policy on Ge

Halaju = 80km/h
Radius = 800m
Superelevation = 0.041 (4.1%)
Ls = 30m (2 lanes)
44m (4 lanes)

Table 4-7C: Design Superelevation Table –ATJ 8/86 (Pindaan 2015)

TABLE 4-7C : DESIGN SUPERELEVATION TABLE

R (m)	V = 30kph				V = 40kph				V = 50kph				V = 60kph				V = 70kph				V = 80kph				V = 90kph				V = 100kph				V = 110kph				V = 120kph			
	e (%)	2 L(m)	4 L(m)	6 L(m)	e (%)	2 L(m)	4 L(m)	6 L(m)	e (%)	2 L(m)	4 L(m)	6 L(m)	e (%)	2 L(m)	4 L(m)	6 L(m)	e (%)	2 L(m)	4 L(m)	6 L(m)	e (%)	2 L(m)	4 L(m)	6 L(m)	e (%)	2 L(m)	4 L(m)	6 L(m)	e (%)	2 L(m)	4 L(m)	6 L(m)	e (%)	2 L(m)	4 L(m)	6 L(m)	e (%)	2 L(m)	4 L(m)	6 L(m)
7000	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0
5000	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0
3000	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	RC	20	30	40	RC	22	33	44	RC	24	36	48
2500	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	RC	19	28	38	2.7	22	33	44	3.1	27	41	54	3.6	34	51	68
2000	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	NC	0	0	0	RC	17	26	34	RC	19	28	38	3.5	29	43	58	4.1	36	54	72	4.8	46	68	92
1500	NC	0	0	0	NC	0	0	0	NC	0	0	0	RC	15	23	30	RC	17	26	34	RC	17	26	34	2.9	22	33	44	3.8	31	47	62	4.3	38	57	76	5.1	48	72	96
1400	NC	0	0	0	NC	0	0	0	NC	0	0	0	RC	15	23	30	RC	17	26	34	2.6	19	28	38	3.1	24	36	48	4	33	49	66	4.6	40	61	80	5.5	52	78	104
1300	NC	0	0	0	NC	0	0	0	NC	0	0	0	RC	15	23	30	RC	17	26	34	2.8	20	30	40	3.3	25	38	50	4.3	35	53	70	5	44	66	88	5.9	56	84	112
1200	NC	0	0	0	NC	0	0	0	NC	0	0	0	RC	15	23	30	RC	17	26	34	3	22	32	44	3.6	28	41	56	5.1	42	63	84	5.9	52	78	104	7	66	99	132
1000	NC	0	0	0	NC	0	0	0	RC	15	22	30	RC	15	23	30	2.9	19	28	38	3.5	25	38	50	4.2	32	48	64	5.6	46	69	92	6.4	55	84	110	7.7	73	109	146
900	NC	0	0	0	NC	0	0	0	RC	15	22	30	2.6	15	23	30	3.2	21	31	42	3.9	28	42	56	4.6	35	53	70	6.2	51	76	102	7.1	62	94	124	8.5	81	121	162
800	NC	0	0	0	NC	0	0	0	RC	15	22	30	2.7	16	24	32	3.5	23	34	46	4.3	31	46	62	5.1	39	59	78	6.9	56	85	112	8	70	105	140	9.5	90	135	180
700	NC	0	0	0	RC	14	22	28	RC	15	22	30	3.1	19	28	38	4	26	39	52	4.8	35	52	70	5.8	44	67	88	7.8	64	95	128	9	79	119	158	10	95	142	190
600	NC	0	0	0	RC	14	22	28	2.7	15	22	30	3.6	22	32	44	4.5	29	44	58	5.5	40	59	80	6.5	50	75	100	8.9	73	109	146	9.9	87	130	174	R min = 595			
500	NC	0	0	0	RC	14	22	28	3.1	17	26	34	4.2	25	36	50	5.3	35	52	70	6.4	46	69	92	7.6	58	87	116	9.8	80	120	160	R min = 455							
400	RC	12	19	24	2.8	14	22	28	3.8	21	32	42	5	30	45	60	6.3	41	62	82	7.5	54	81	108	8.8	67	101	134	R min = 360											
300	RC	12	19	24	3.6	19	28	38	4.8	27	40	54	6.3	38	57	76	7.8	51	77	102	9	65	97	130	9.9	76	114	152												
250	2.6	12	19	24	4.2	22	32	44	5.6	31	47	62	7.1	43	64	86	8.7	57	85	114	9.7	70	105	140	R min = 275														
200	3.1	15	22	30	5	26	39	52	6.6	37	55	74	8.2	49	74	98	9.6	63	94	126	R min = 210																		
175	3.5	17	25	34	5.6	29	43	58	7.1	39	59	78	8.8	53	79	106	9.9	65	97	130																				
150	4	19	29	38	6.2	32	48	64	7.8	43	65	86	9.4	56	85	112	R min = 160																							
140	4.3	21	31	42	6.4	33	49	66	8.1	45	67	90	9.7	58	87	116																								
130	4.5	22	32	44	6.7	34	52	68	8.5	47	71	94	9.8	59	88	118																								
120	4.8	23	35	46	7	36	54	72	8.8	49	73	98	10	60	90	120																								
110	5.1	24	37	48	7.4	38	57	76	9.1	50	76	100	R min = 115																												
100	5.5	26	40	52	7.7	40	59	80	9.5	53	79	106																												
90	5.9	28	42	56	8.2	42	63	84	9.8	54	81	108																												
80	6.4	31	46	62	8.6	44	66	88	10	55	83	110																												
70	6.9	33	50	66	9.1	47	70	94	R min = 75																															
60	7.5	36	54	72	9.6	49	74	98																																
50	8.2	39	59	78	10	51	77	102																																
40	9.1	44	65	88	R min = 45																																			
30	9.9	48	71	96																																				
	R min = 25																																							

Notes:-
The RC row presents minimum radii for a computed SE rate
The row NC designates a travel way cross section used on c
For curve radii falling between NC and RC, a plane slope ac

e max	=	10%
R	=	Radius of curve
Vd	=	Design speed
L	=	Minimum length of runoff (excluding tangent runout) length are for 3.6m lane width and the respective maximum relative slope for each design speed
NC	=	Normal crown 2.5%

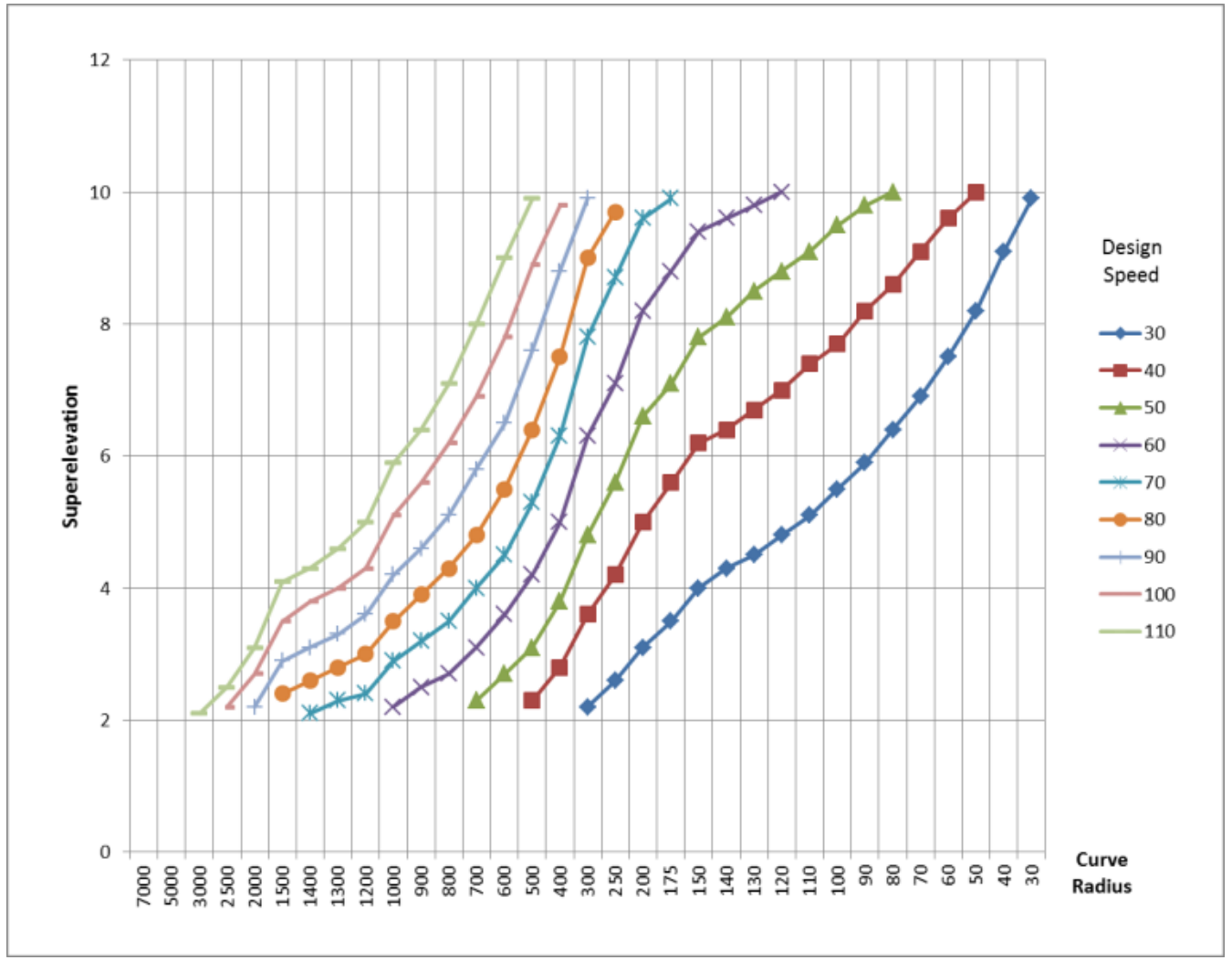
Source: Adapted from AASHTO – A Policy on Ge

Halaju = 80km/h
Radius = 800m
Superelevation = ? %
Ls = ? m (2 lanes)
? m (4 lanes)

SUPERELEVATION

Hubungan antara super-e, radius & halaju

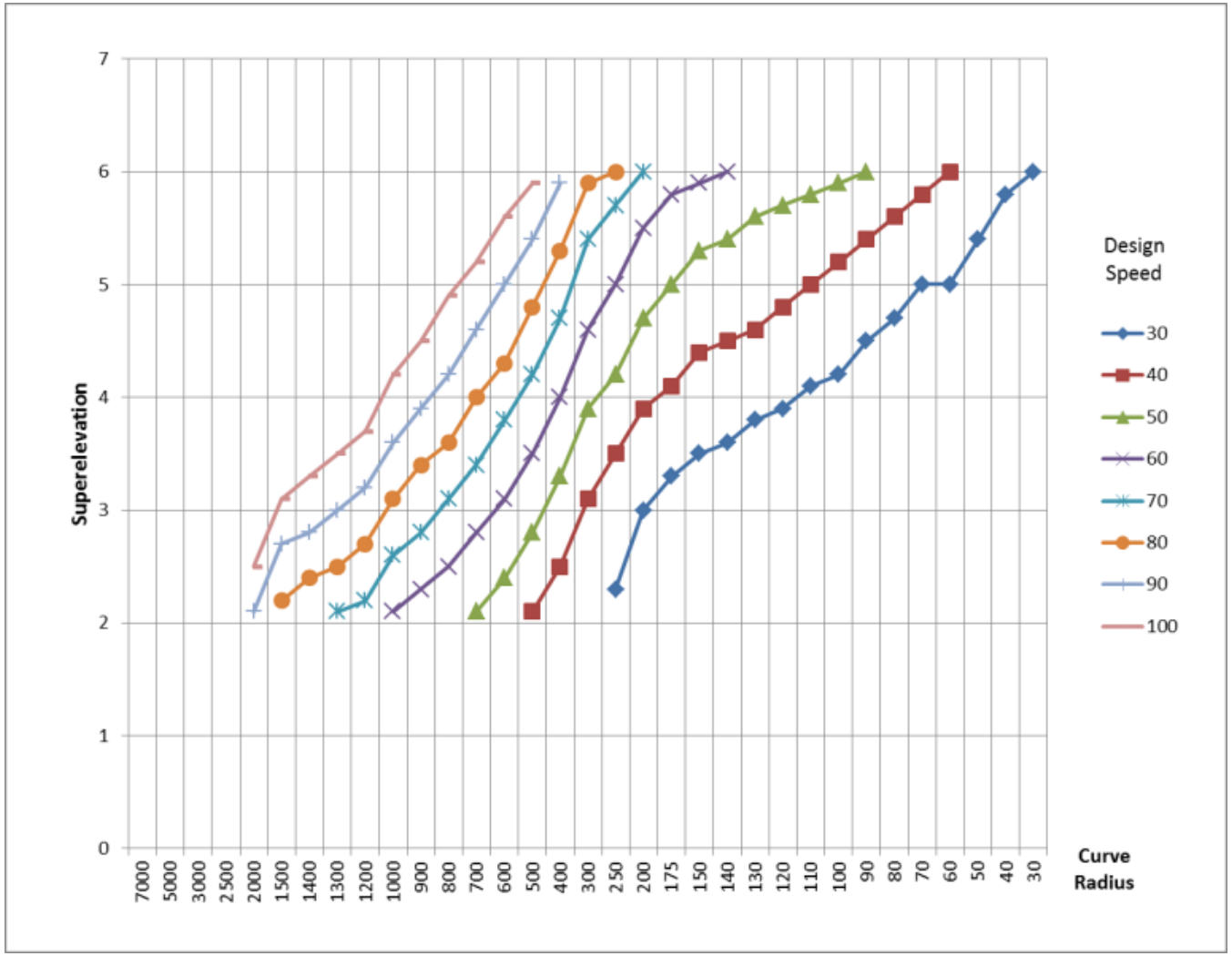
Rural



SUPERELEVATION

Hubungan antara super-e, radius & halaju

Urban



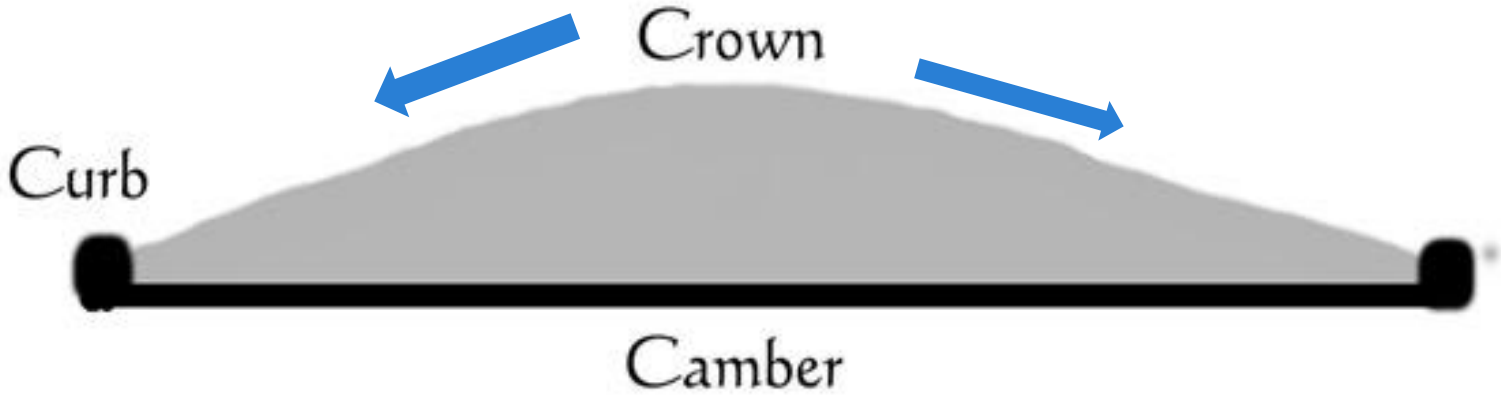

KAMBER

Apa itu kamber...?

- A.K.A cerun silang (cross slope)
- Lengkungan pada permukaan jalan di mana bahagian tengah jalan lebih tinggi dari sisinya
- Untuk mengalirkan air hujan ke sisi jalan serta mengelakkan terjadinya air bertakung

KAMBER

Road rises from Curb to Crown of road
and falls back to curb again.
This runs water off the road and into gutter



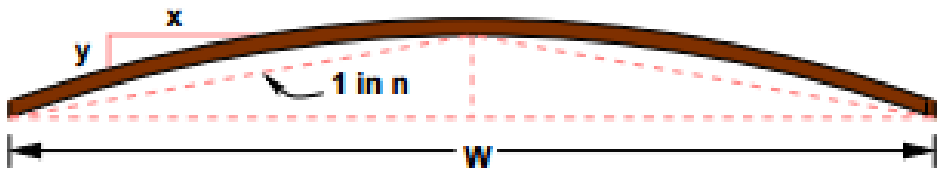
KAMBER

Objektif kamber??

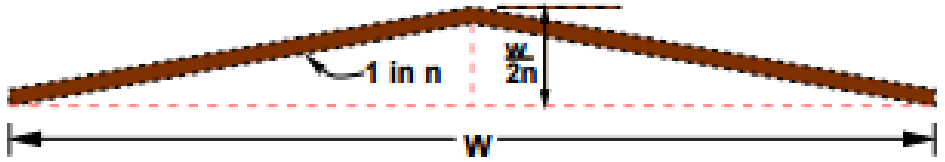
- Melindungi permukaan jalan terutamanya permukaan berbitumin
- Melindungi sub-grade
- Pengaliran air yang baik -> turapan cepat kering -> lebih geseran -> keselamatan meningkat

KAMBER

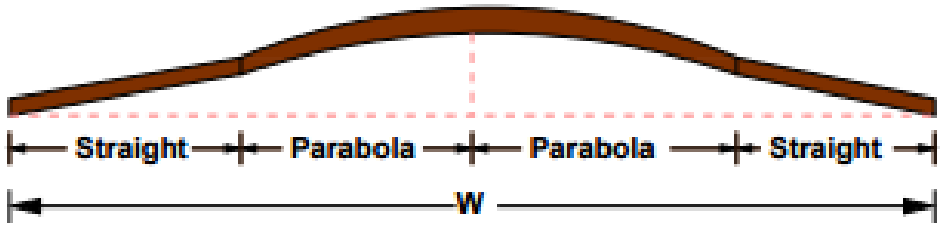
Jenis – jenis kamber



a. Parabolic camber $y=2x^2/nw$



b. Straight line camber



c. Combination of straight and parabolic camber

TUJUAN MENCERAP KAMBER

- Untuk mendapatkan nilai kamber di tapak
- Kamber < piawaian → air sukar mengalir ke pinggir jalan → risiko kemalangan tinggi

KAMBER

Bagaimana ia diukur di tapak?

True-pulse

PROSEDUR MENCERAP KAMBER

1. Letakkan kayu pengukur di atas jalan
2. Letakkan tru-pulse di atas kayu pengukur
3. 3 bacaan kamber diambil di kiri dan kanan jalan

MENCERAP KAMBER DI TAPAK

PIAWAIAN BERKAITAN KAMBER

Cross slopes are an important element in the cross-section design and a reasonably steep lateral slope is desirable to minimise water ponding on flat sections of unkerbed pavements due to pavement imperfections or unequal settlements and to control the flow of water adjacent to the kerb on kerbed pavements. The range of cross slopes for various pavement types varies from 2.5% - 6.0%.

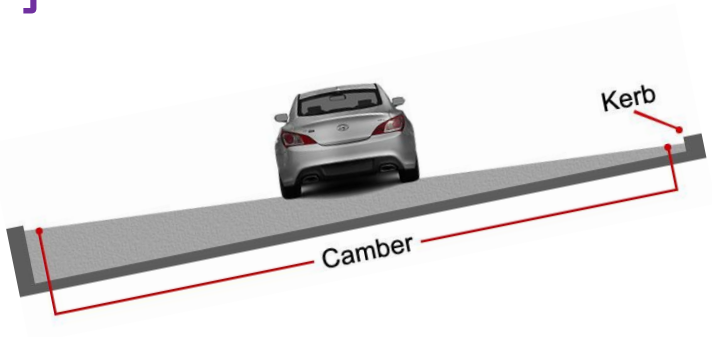
KAMBER

Apa yang akan berlaku jika...

Kamber melebihi piawaian

Rawatan??

→ Pemanduan boleh terganggu akibat kenderaan akan mudah menghala ke sisi jalan



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PENEMUAN DI TAPAK

Jenis Kemalangan	Hilang kawalan (*out of control)* di kedudukan selekoh

Punca Kemalangan

1) Tiada *advisory speed* di selekoh
2) Tiada penyediaan bahu jalan berturap yang seragam di lokasi kemalangan
3) *Clear zone juga adalah tidak mencukupi iaitu hanya 2.5m.*
4) Jarak penglihatan terhad kerana ditutupi tebing bukit
5) Tiada penyediaan garisan *double line* di kedudukan selekoh

Jenis Kemalangan	*Out of control, head on* di selekoh

Punca Kemalangan

1) Tiada bahu jalan berturap untuk tujuan *road widening* di selekoh
2) Tiada penyediaan *double line* di selekoh di jarak penglihatan terhad
3) *Clear zone* tidak mencukupi iaitu hanya 2.8m sahaja

Jenis Kemalangan	*Out of control* dan melanggar rumah di kawasan tebing bukit

Punca Kemalangan

1) Had laju yang ada terletak jauh sebelum kawasan kemalangan.
2) Had laju tersebut adalah salah (70km/h) berbanding kelajuan selamat (*advisory speed*) di selekoh (45km/h sahaja)
3) Pada umumnya jajaran dilaluan ini adalah tidak sekata (inconsistent) dan ini terbukti dengan adanya selekoh yang substandard (differentialspeed 25 > 20km/h)
4) Jajaran berbentuk 'S-curve' dengan jarak antara lengkung (jarak tangent 28 m) yang dekat, perubahan superelevation yang cepat juga disyaki mengganggu keseimbangan lori minyak tersebut.
5) Tiada penyediaan bahu jalan berturap sebagai treatment untuk pelebaran jalan di selekoh.
6) Penghadang jalan yang salah (TL2) dipasang kerana selekoh dikategorikan sebagai high risk area kerana terdapatnya kediaman di bawah tebing bukit setinggi 5m.

Jenis Kemalangan	*Out of control* dan melanggar rumah di kawasan tebing bukit

COMBINATION OF HORIZONTAL AND VERTICAL ALIGNMENT

Horizontal and vertical alignments are among the most important of the permanent design elements and should be designed concurrently.

Their designs complement each other and poorly designed combinations can reduce the quality of both.

Quality in their design and in their combined design increases usefulness and safety, encourages uniform speed, and improves appearance.

Coordination can be achieved by plotting the location of the horizontal curves on the working profile to help visualize the highway in three dimensions.

Coordinate the horizontal and vertical alignment to obtain safety, uniform speed, pleasing appearance, and efficient traffic operation.

POOR DESIGN PRACTICE

Alignment change behind crest

Sharp horizontal curves should not be introduced at or near the top of a crest vertical curve. The change in alignment may be very difficult to see at night.

If the crest curve restricts the driver's view of the start of the horizontal curve, a driver may be confuse and turn incorrectly.

This is particularly dangerous when sharp horizontal curves are located near the crest of vertical curves.

POOR DESIGN PRACTICE

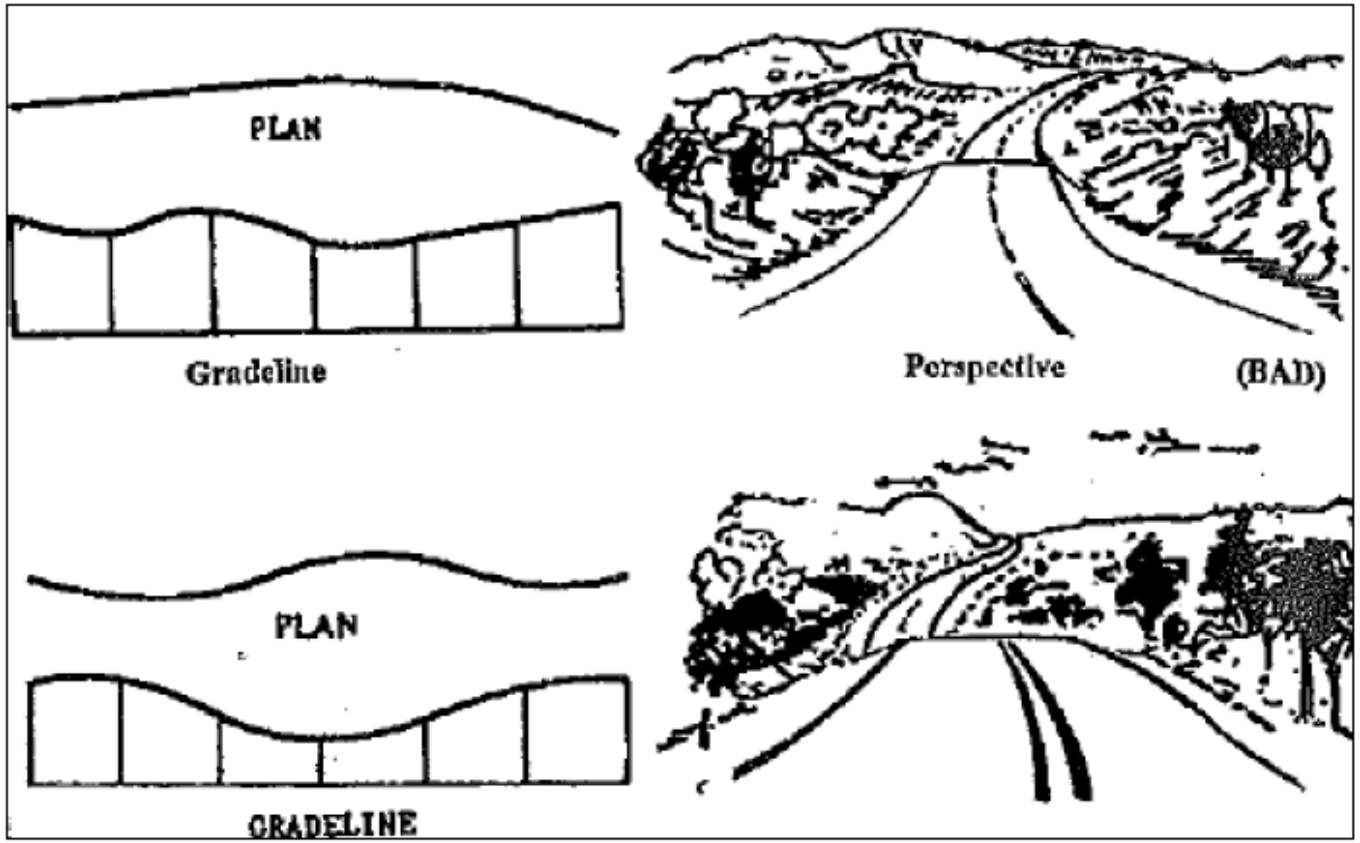


Figure 1 : Alignment change behind crest

GOOD DESIGN PRACTICE

Horizontal curve longer than vertical curve

For good design, the horizontal curve shall indicate the change in direction before introduction of the vertical curve in both directions of travel.

That is, the horizontal curve must be longer than vertical curve as shown in Figure 2.

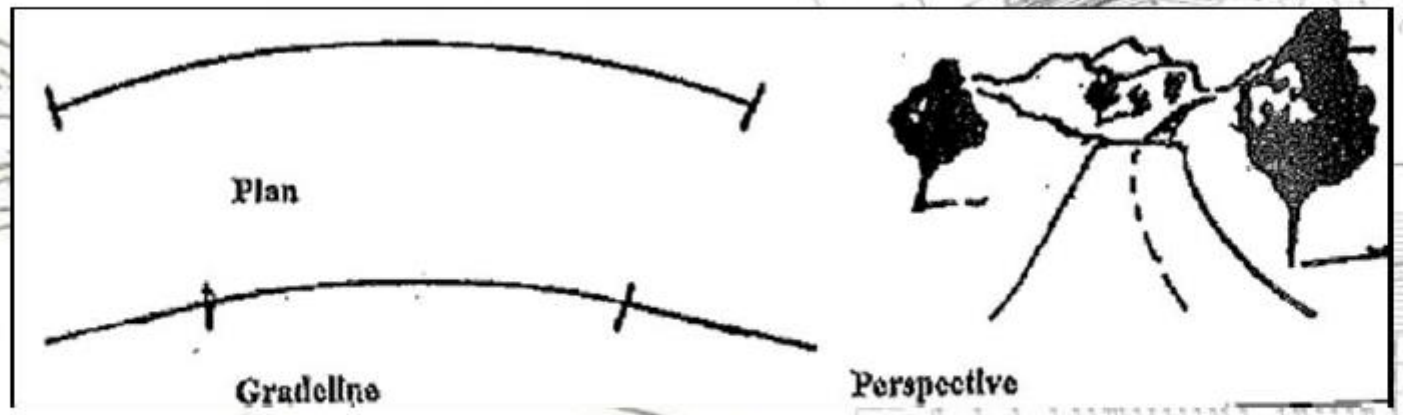


Figure 2 : Horizontal curve longer than vertical curve

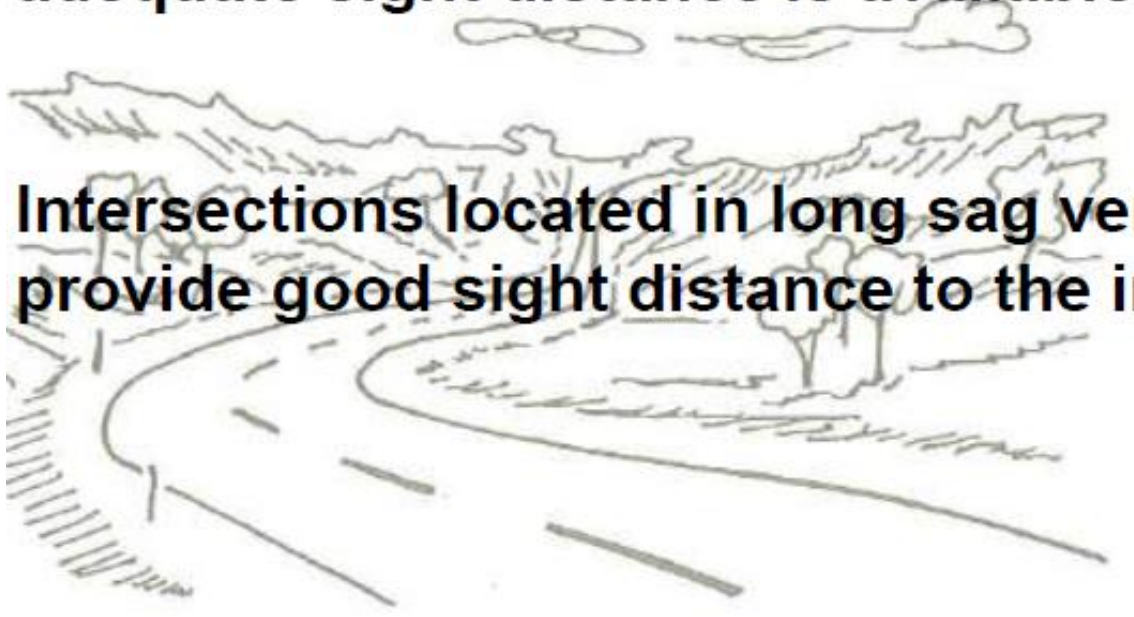
POOR DESIGN PRACTICE

Intersection hidden behind a crest

Intersections shall not be hidden behind a crest as shown in Figure 3.

Intersections should be located with care to ensure that adequate sight distance is available on each approach.

Intersections located in long sag vertical curves generally provide good sight distance to the intersection area.



POOR DESIGN PRACTICE

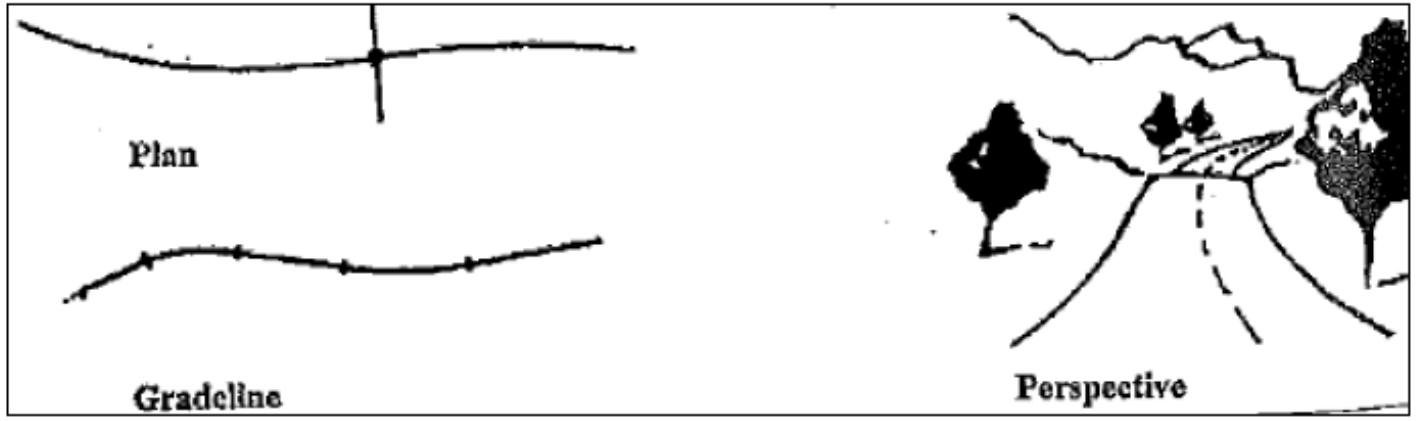


Figure 3: Intersection hidden behind a crest

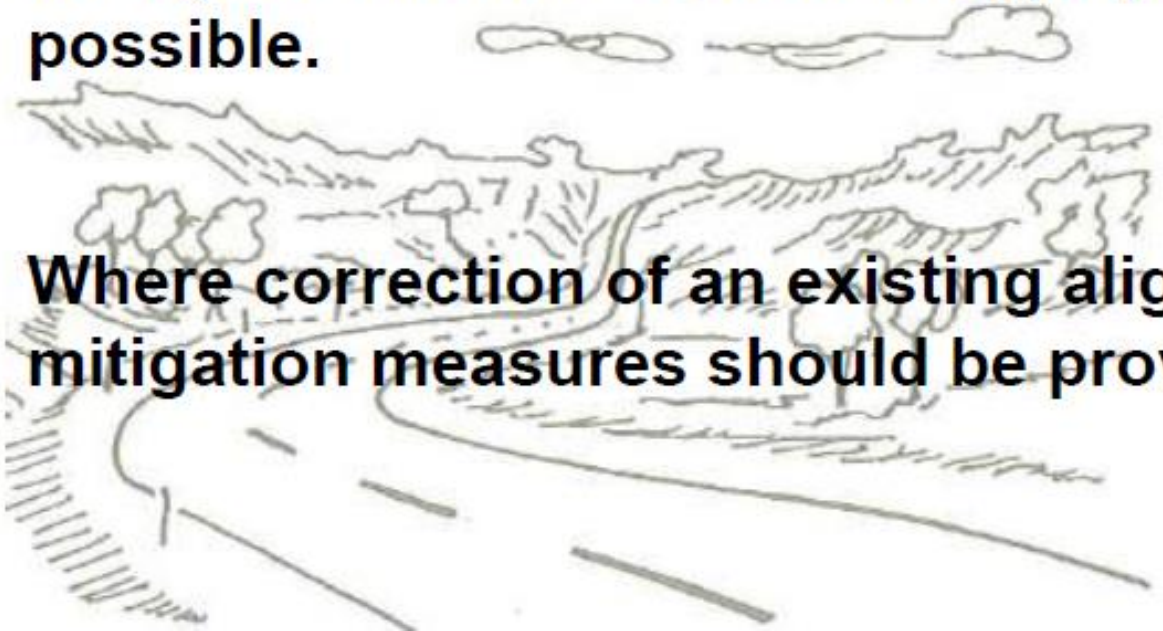
POOR DESIGN PRACTICE

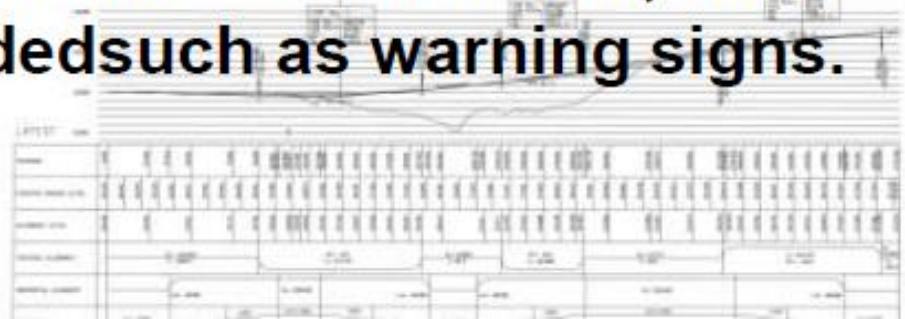
Hidden dips

Minimisation of earthworks on new construction, which create dips in the road may reduce overall safety.

Designer should avoid creating dips in vertical alignments where possible.

Where correction of an existing alignment is uneconomic, other mitigation measures should be providedsuch as warning signs.





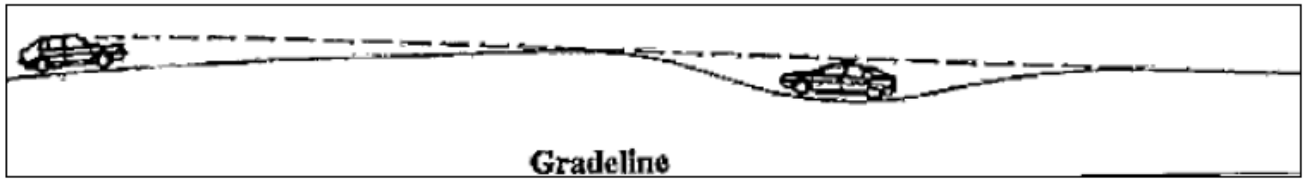


Figure 4: Hidden dip

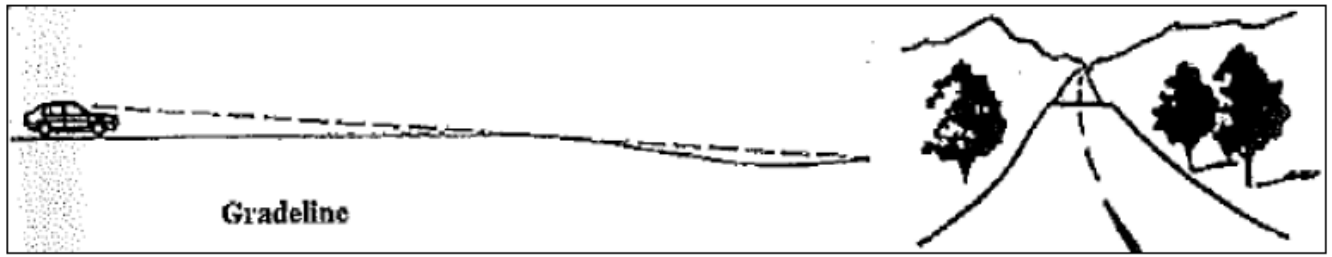


Figure 5: Shallow dip

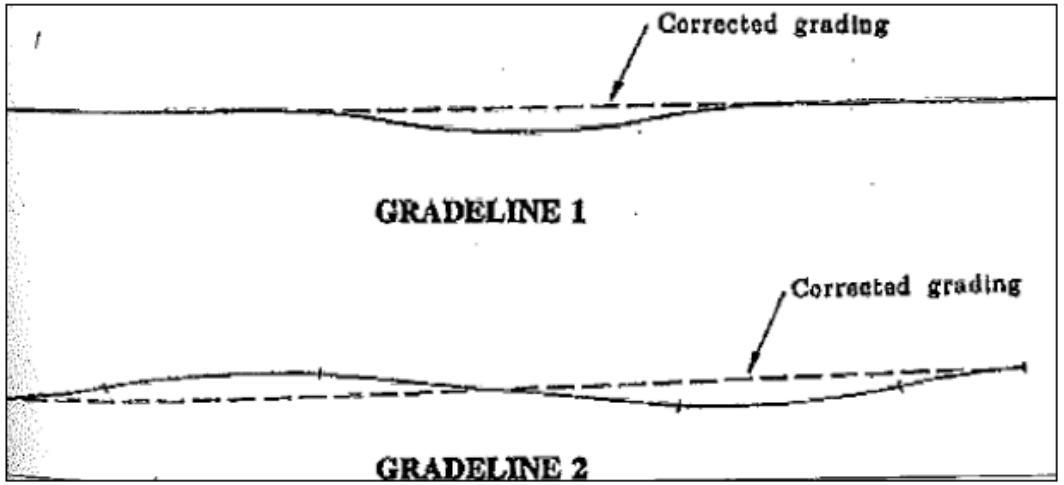


Figure 6: Measures to correct dips in long uniform grades

EXAMPLES OF POOR COMBINATION

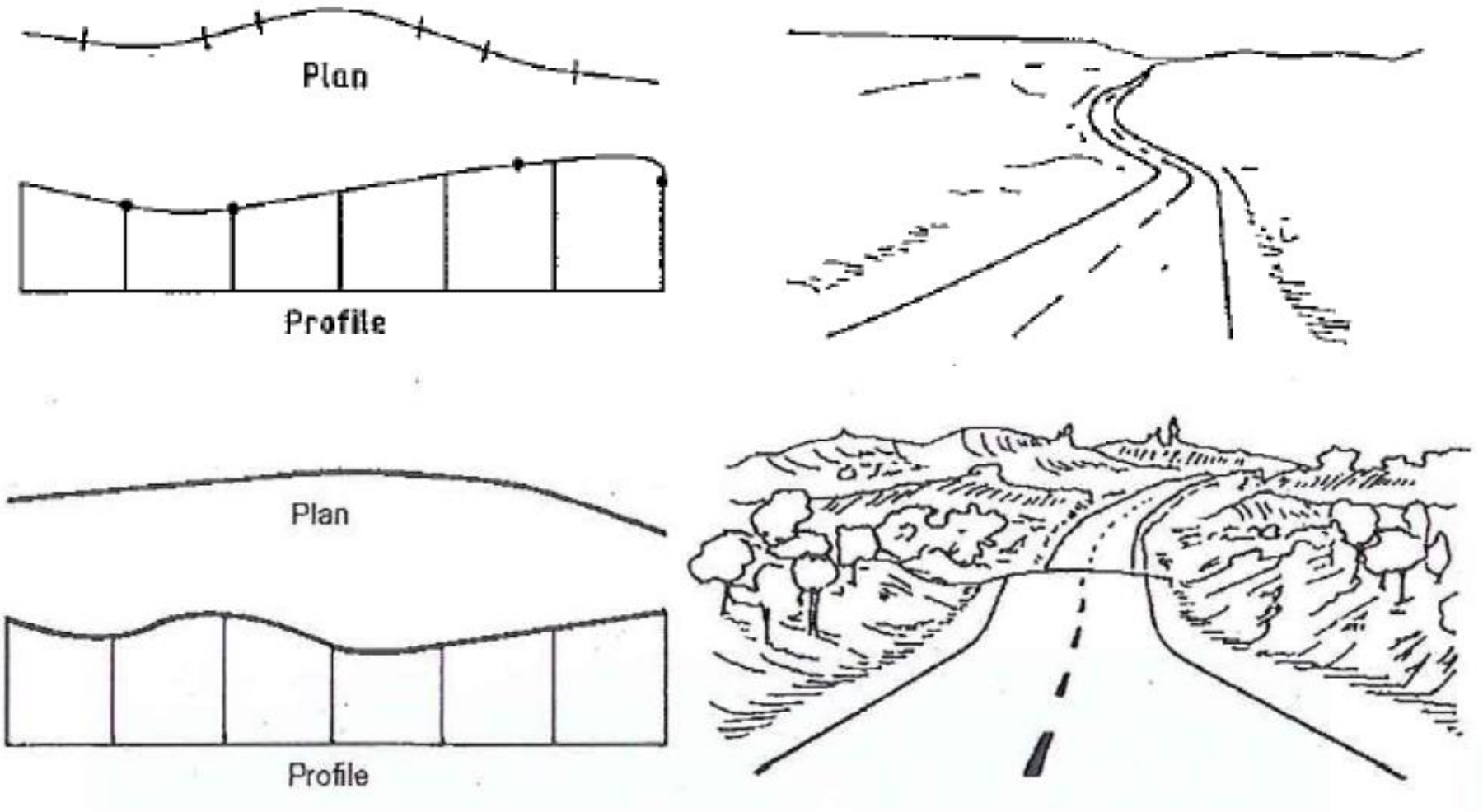


Figure 7: Both examples have visually poor alignment with unrelated horizontal and vertical curves and broken backed horizontal curves

EXAMPLES OF POOR COMBINATION

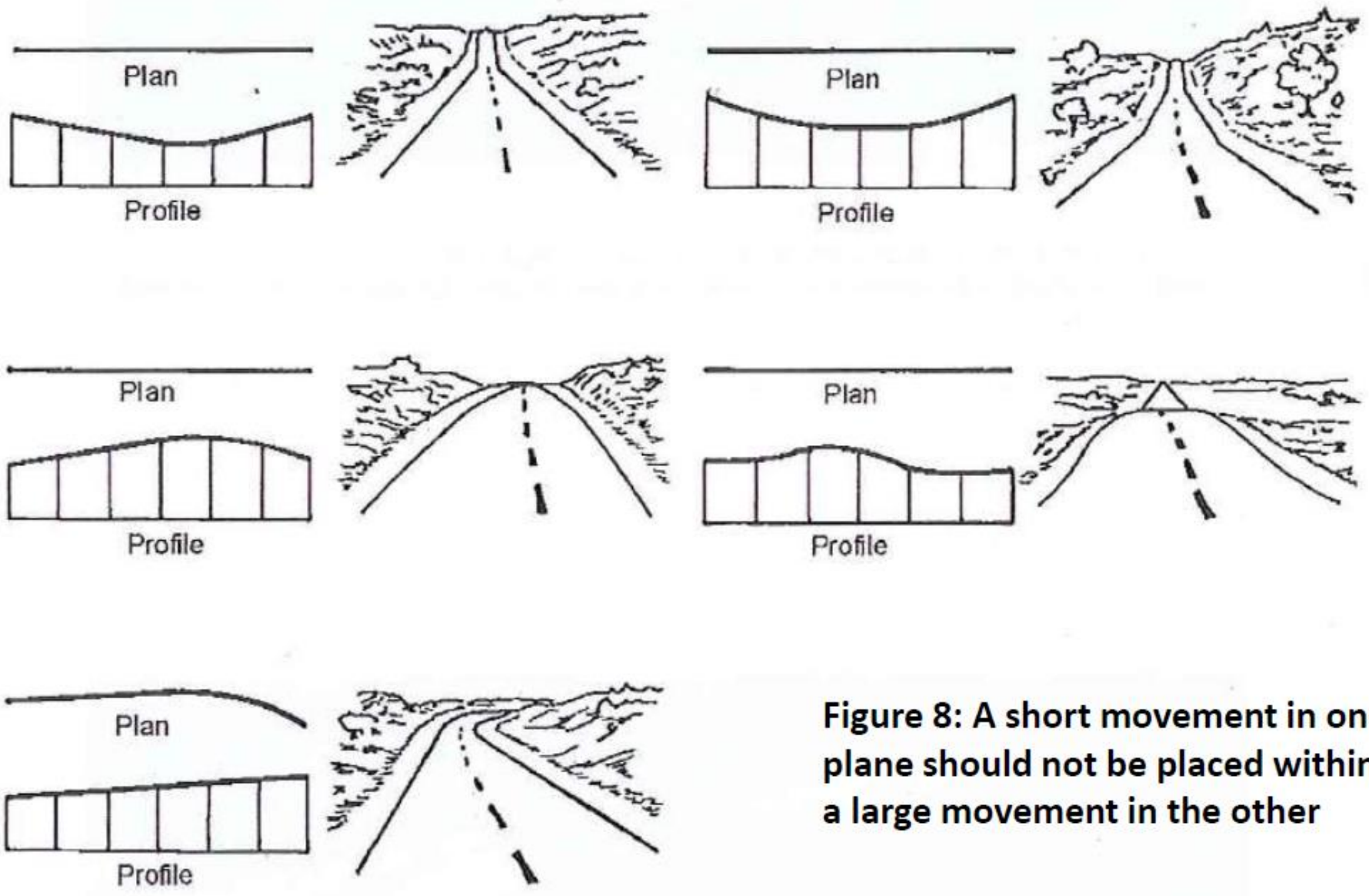


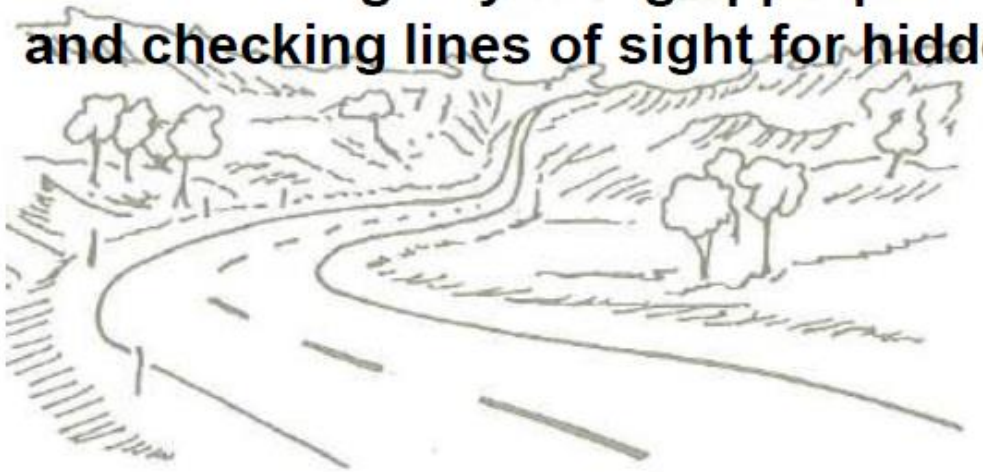
Figure 8: A short movement in one plane should not be placed within a large movement in the other

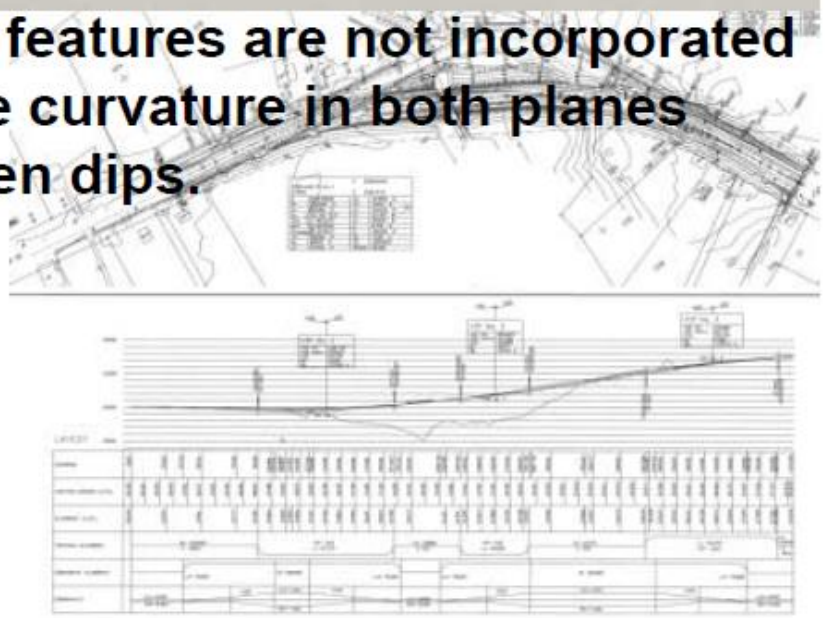
POOR DESIGN PRACTICE

Roller Coaster Grading

Long straight sections are prone to roller coaster grading with the added potential for hidden dips.

Designers should take care that the features are not incorporated into the design by using appropriate curvature in both planes and checking lines of sight for hidden dips.





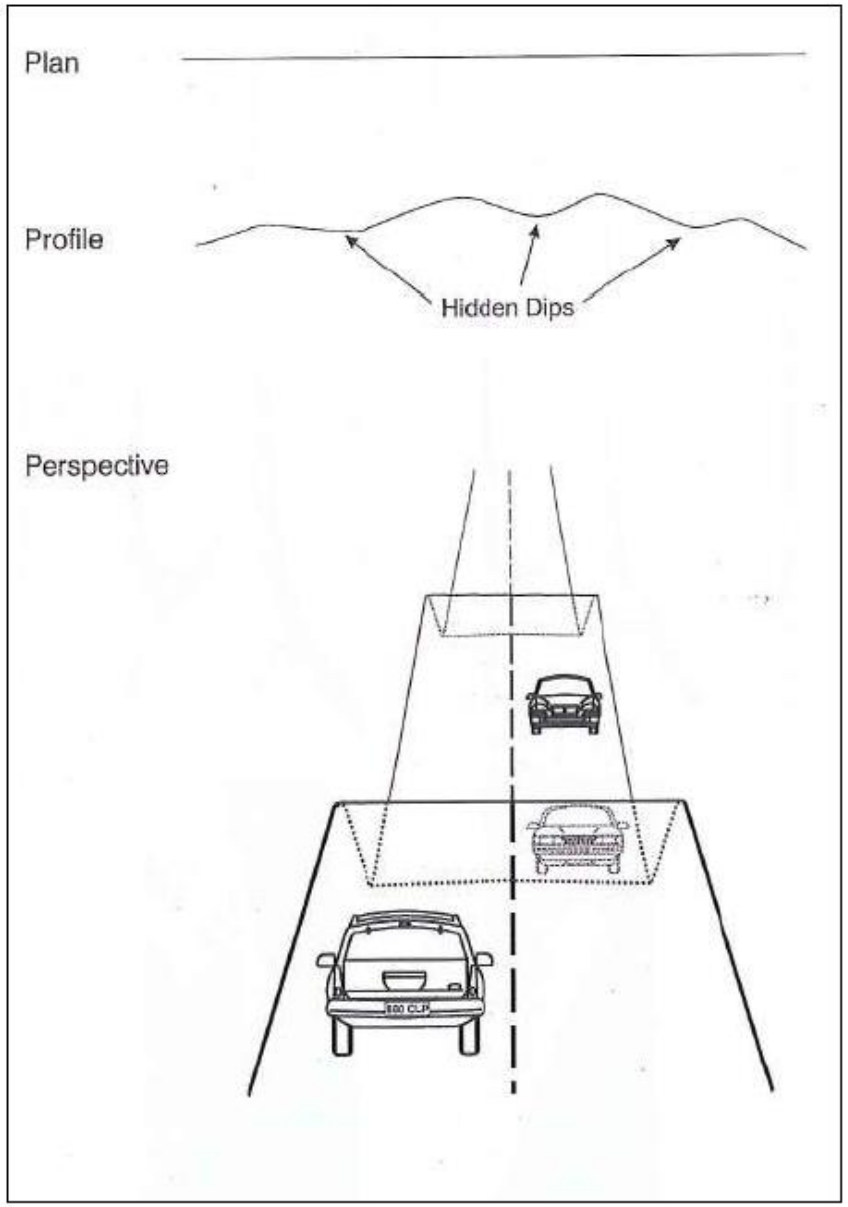


Figure 9 : Roller coaster grading resulting in hidden dips

RUMUSAN

- Rekabentuk jalan perlu mematuhi piawaian
- Pembinaan jalan perlu mematuhi spesifikasi
- Penyenggaraan jalan perlu dilaksanakan segera jika terdapat kerosakan/kehilangan
- Oleh yang demikian, salah satu perkara **4E's (Education, Engineering, Enforcement and Environment)** di dalam Pelan Keselamatan Jalan 2010-2020 iaitu Engineering perlu diberi perhatian agar kemalangan jalanraya di Malaysia dapat dikurangkan

SEKIAN
TERIMA KASIH..

END OF TRAINING / COURSE DAY 1