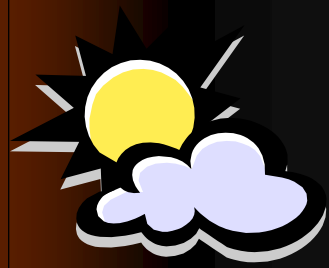
TRAFFIC ENGINEERING





INTRODUCTION TO TRAFFIC ENGINEERING

TRAFFIC ENGINEERING

DEFINIITON

The phase of transportation engineering that deal with the planning, geometric design and traffic operation of road, streets and highways, their networks, terminals, abutting lands and relationships with other modes of transportation

TRAFFIC ENGINEERING

PURPOSE

1) Safety of the public

2) Efficient use transportation resources

3) Mobility of people and goods

TRAFFIC ENGINEERING

People – for a variety of reasons of an economic or personal in nature

Goods – on the needs of further manufacture or processing or of ultimate consumption or use

TRAFFIC ENGINEERING

RELATIONSHIP WITH FUNCTION TRAFFIC ENGINEERING

1) Collect and analysis traffic data
2) Plan traffic system and transportation
3) Design traffic system
4) Manage operation traffic system
5) Control traffic safety program

TRAFFIC ENGINEERING

Component of traffic system

Driver

Vehicle

Road

Pedestrian



DRIVER



DRIVER

Driver Characteristics

Driver Tasks

Driver Errors

Driver Characteristics

Physical characteristics

(age, gender, physical condition)

Processing **ability**

(mental capabilities, skill perception-reaction time and expectancy)

Tolerable Accelerations/Decelerations

–Longitudinal (along roadway)

–Lateral (around curves)

–Vertical (comfort)

Perception-Reaction Process

- Perception
- Identification



- Emotion
- Reaction (volition)



PIEV

Used for Signal Design and Braking Distance

Perception-Reaction Process

- Perception
  - Sees or hears situation (sees deer)
- Identification
  - Identify situation (realizes deer is on road)
- Emotion
  - Decides on course of action (swerve, stop, change lanes, etc)
- Reaction (volition)
  - Acts (time to start events in motion but not actually do action)

Foot begins to hit brake

Perception-Reaction Time (PRT)

Time from Perception to Initial Reaction to Stimulus

Typical PRT range is:

0.5 to 7 seconds

Perception-Reaction Time Factors

Environment:

- Urban vs. Rural
- Night vs. Day
- Wet vs. Dry

Age

Physical Condition:

- Fatigue
- Drugs/Alcohol

Age

Older drivers

- May perceive something as a hazard but not act quickly enough
- More difficulty seeing, hearing, reacting
- Drive slower

Age

Younger drivers

- Able to act quickly but not have experience to recognize things as a hazard or be able to decide what to do
- Drive faster
- Are easily distracted by conversation and others inside the vehicle
- Poorly developed risk perception
- Feel invincible, the "Superman Syndrome”

Alcohol

- Affects each person differently
- Slows reaction time
- Increases risk taking
- Dulls judgment
- Slows decision-making
- Presents peripheral vision difficulties

Perception/Reaction Applications

- Stopping sight distance
- Passing sight distance
- Placement of signs/traffic control devices
- Design of horizontal/vertical curves

Driver Tasks

CONTROL

(steering and speed control)

GUIDANCE

(lane choice, road following, car following, passing, merging, response to traffic control)

NAVIGATION

(trip planning and route following)

Driver Errors

Drivers' deficiencies including

–limited drivers capabilities (elders, limited experience)

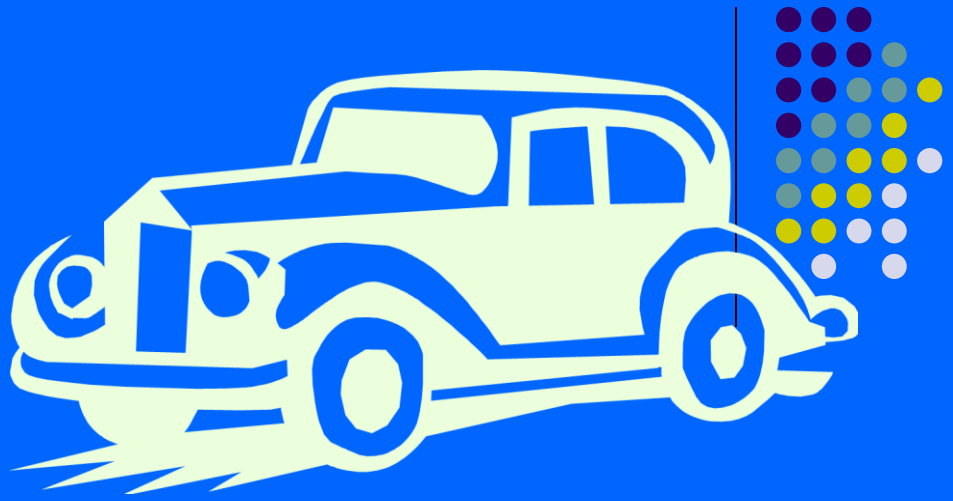
–temporal impairments (alcohol, drugs, fatigue).

Difficult situations including

–highly complex tasks in urban areas

–surprising, new elements in rural areas.



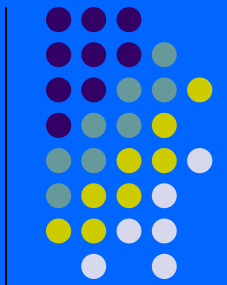


Vehicle





VEHICLE



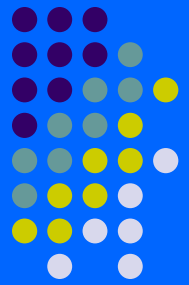
Moving people and goods from one Node to another along the link

Link – roadway / tracks connecting 2 or more points

VEHICLE CHARACTERISTICS

- Physical
- Operating
- Environmental

PHYSICAL CHARACTERISTICS



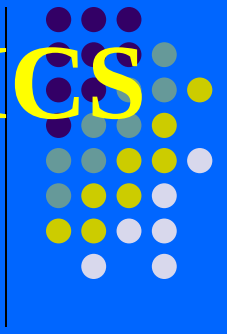
Type (GB defines 15 design vehicle types)

- Passenger Car
- Motorcycle
- Truck

Size (Several examples)

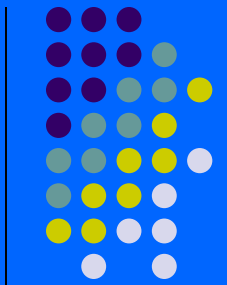
- Length
- Height
- Weight
- Width

OPERATING CHARACTERISTICS



- Acceleration
- Deceleration and braking
- Power/weight ratios
- Turning radius
- Headlights

ENVIRONMENTAL CHARACTERISTICS

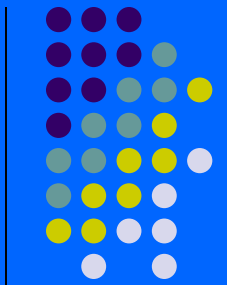


Noise

Exhaust

Fuel Efficiency

VEHICLE VARIABLE



Design vehicle

Minimum turning path

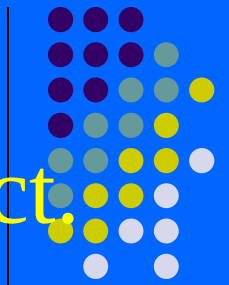
Vehicle performance

DESIGN VEHICLE

A design vehicle represents an individual class in a conservative manner.

- ***passenger cars*** (compact, subcompact, light delivery trucks),
- ***trucks*** (single-unit, tractor-semitrailer combinations, trucks with full trailers),
- ***buses/recreational vehicles*** (single-unit, school buses, motor homes, passenger cars pulling trailers or boats).

The dimensions of motor vehicles influence the design of a roadway project.



- Vehicle Width affects width of traffic lane
- Vehicle length has a bearing on roadway capacity and affects the turning radius
- Vehicle height affects the clearance of various structures
- Vehicle weight affects the structural design of the roadway (pavement)

AASHTO recommends using 15 design vehicles

Design Vehicle

Metric

Design Vehicle Type	Symbol	Dimensions (m)											
		Overall			Overhang								Typical Kingpin to Center of Rear Axle
		Height	Width	Length	Front	Rear	WB_1	WB_2	S	T	WB_3	WB_4	
Passenger Car	P	1.3	2.1	5.8	0.9	1.5	3.4	–	–	–	–	–	–
Single Unit Truck	SU	3.4-4.1	2.4	9.2	1.2	1.8	6.1	–	–	–	–	–	–
Buses													
Inter-city Bus (Motor Coaches)	BUS-12	3.7	2.6	12.2	1.8	1.9[a]	7.3	1.1	–	–	–	–	–
	BUS-14	3.7	2.6	13.7	1.8	2.6[a]	8.1	1.2	–	–	–	–	–
City Transit Bus	CITY-BUS	3.2	2.6	12.2	2.1	2.4	7.6	–	–	–	–	–	–
Conventional School Bus (65 pass.)	S-BUS 11	3.2	2.4	10.9	0.8	3.7	6.5	–	–	–	–	–	–
Large School Bus (84 pass.)	S-BUS 12	3.2	2.4	12.2	2.1	4.0	6.1	–	–	–	–	–	–
Articulated Bus	A-BUS	3.4	2.6	18.3	2.6	3.1	6.7	5.9	1.9[a]	4.0[a]	–	–	–
Trucks													
Intermediate Semitrailer	WB-12	4.1	2.4	13.9	0.9	0.8[a]	3.8	8.4	–	–	–	–	8.4
Intermediate Semitrailer	WB-15	4.1	2.6	16.8	0.9	0.6[a]	4.5	10.8	–	–	–	–	11.4
Interstate Semitrailer	WB-19*	4.1	2.6	20.9	1.2	0.8[a]	6.6	12.3	–	–	–	–	13.0
Interstate Semitrailer	WB-20**	4.1	2.6	22.4	1.2	1.4-0.8[a]	6.6	13.2-13.8	–	–	–	–	13.9-14.5
"Double-Bottom"-Semitrailer/Trailer	WB-20D	4.1	2.6	22.4	0.7	0.9	3.4	7.0	0.9[b]	2.1[b]	7.0	–	7.0
Triple-Semitrailer/ Trailers	WB-30T	4.1	2.6	32.0	0.7	0.9	3.4	6.9	0.9[c]	2.1[c]	7.0	7.0	7.0
Turnpike Double-Semitrailer/Trailer	WB-33D*	4.1	2.6	34.8	0.7	0.8[a]	4.4	12.2	0.8[d]	3.1[d]	13.6	–	13.0
Recreational Vehicles													
Motor Home	MH	3.7	2.4	9.2	1.2	1.8	6.1	–	–	–	–	–	–
Car and Camper Trailer	P/T	3.1	2.4	14.8	0.9	3.1	3.4	–	1.5	5.8	–	–	–
Car and Boat Trailer	P/B	–	2.4	12.8	0.9	2.4	3.4	–	1.5	4.6	–	–	–
Motor Home and Boat Trailer	MH/B	3.7	2.4	16.2	1.2	2.4	6.1	–	1.8	4.6	–	–	–
Farm Tractor[f]	TR	3.1	2.4-3.1	4.9[g]	–	–	3.1	2.7	0.9	2.0	–	–	–

Note: Since vehicles are manufactured in U.S. customary dimensions and to provide only one physical size for each design vehicle, the values shown in the design vehicle drawings have been soft converted from numbers listed in feet, and then the numbers in this table have been rounded to the nearest tenth of a meter.

* = Design vehicle with 14.63 m trailer as adopted in 1982 Surface Transportation Assistance Act (STAA).

** = Design vehicle with 16.16 m trailer as grandfathered in with 1982 Surface Transportation Assistance Act (STAA).

a = Combined dimension is 5.91 m and articulating section is 1.22 m wide.

b = Combined dimension is typically 3.05 m.

c = Combined dimension is typically 3.05 m.

d = Combined dimension is typically 3.81 m.

e = This is overhang from the back axle of the tandem axle assembly.

f = Dimensions are for a 150-200 hp tractor excluding any wagon length.

g = To obtain the total length of tractor and one wagon, add 5.64 m to tractor length. Wagon length is measured from front of drawbar to rear of wagon, and drawbar is 1.98 m long.

- WB_1, WB_2, and WB_4 are the effective vehicle wheelbases, or distances between axle groups, starting at the front and working towards the back of each unit.
- S is the distance from the rear effective axle to the hitch point or point of articulation.
- T is the distance from the hitch point or point of articulation measured back to the center of the next axle or center of tandem axle assembly.

Exhibit 2-1. Design Vehicle Dimensions

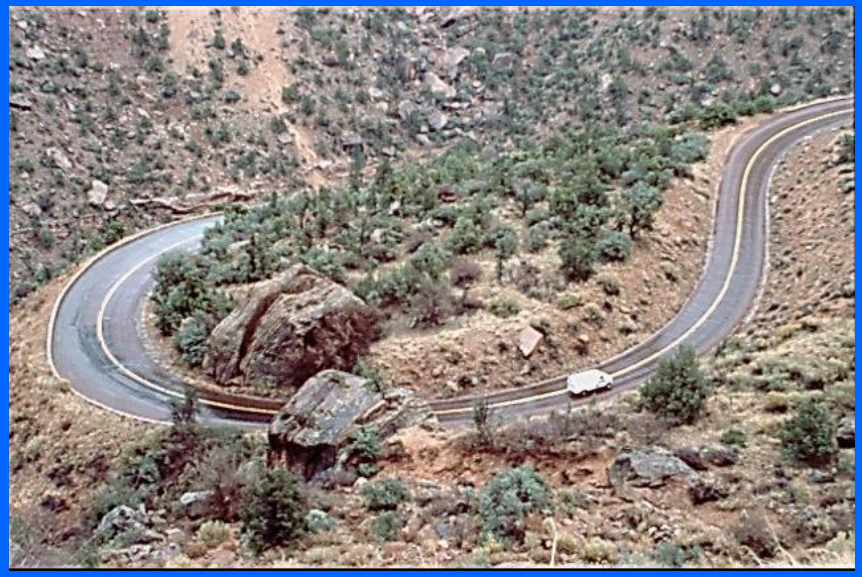
DESIGN VEHICLE DIMENSIONS

(PWD – with Refer to AASHTO 1984)

Design Vehicle		Dimension in meter						Turning Radius (m)
Type	Symbol	Wheel Base	Overhang		Overall Length	Overall Width	Height	
			Front	Rear				
Passenger Car	P	3.4	0.9	1.5	5.8	2.1	1.3	7.3
Single Unit Truck	SU	6.1	1.2	1.8	9.1	2.6	4.1	12.8
Truck Combination	WB-50	7.9	0.9	0.6	16.7	2.6	4.1	13.7

L A u

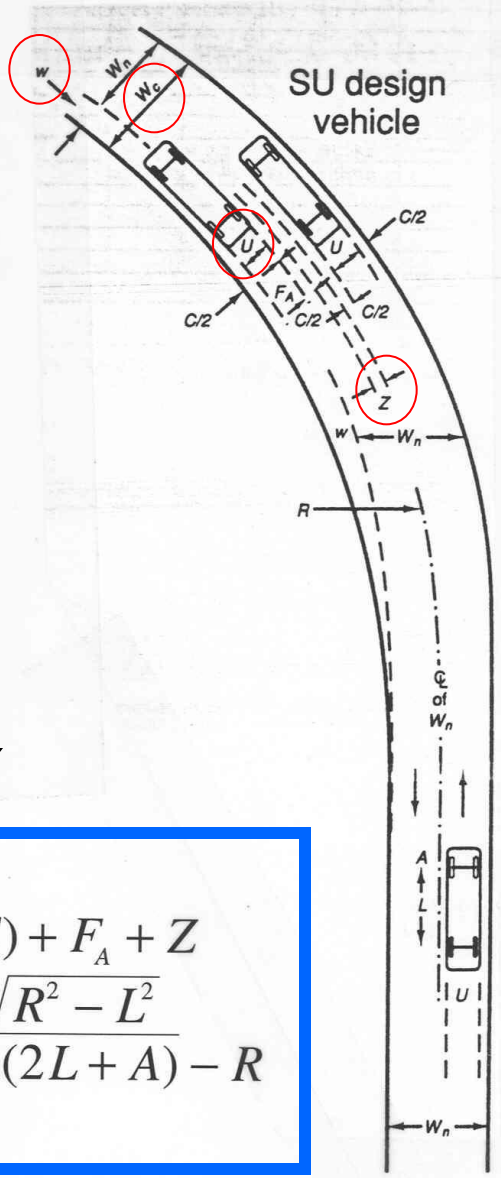
CURVES



A traffic lane on a curve must be widened because:

- The rear wheels do not track the front wheels
- Vehicle's front overhang requires an additional lateral space
- Difficulty of driving on curves justifies wider lateral clearance

CURVES



$$w = W_c - W_n$$
$$W_c = 2(U + C) + F_A + Z$$
$$U = u + R - \sqrt{R^2 - L^2}$$
$$F_A = \sqrt{R^2 + A(2L + A)} - R$$
$$Z = V / \sqrt{R}$$

(ft) W_n	C (ft)
20	2.0
22	2.5
24	3.0

$u = 8.5$ ft (typically)

w = two-lane roadway widening (ft), W_c = roadway width on curve (ft), W_n = roadway width on tangent (ft), U = track width of vehicle on curve (ft), C = lateral clearance per vehicle (ft), F_A = width of front overhang (ft), Z = extra clearance for driving difficulty on curves (ft), u = track width on tangent (ft), R = radius (ft), L = wheelbase (ft), A = front overhang (ft), v = design speed of highway (mi/h).

Example

Calculate the widening required for passenger cars on a curve with radius R =570 ft. and design speed v = 40 mph. The roadway has two lanes and is 22 ft wide on the tangent section.

$W_n = 22\ \text{ft},\ C = 2.5\ \text{ft},\ u = 7\ \text{ft},\ L = 11\ \text{ft},\ A = 3\ ft$

$$W_c = 2(U + C) + F_A + Z$$

$$U = u + R - \sqrt{R^2 - L^2}$$

$$U = 7 + 570 - \sqrt{570^2 - 11^2}$$

$$U = 7.11\ \text{ft}$$

$$F_A = \sqrt{R^2 + A(2L + A)} - R$$

$$F_A = \sqrt{570^2 + 3(2 \cdot 11 + 3)} - 570$$

$$F_A = 0.07\ \text{ft}$$

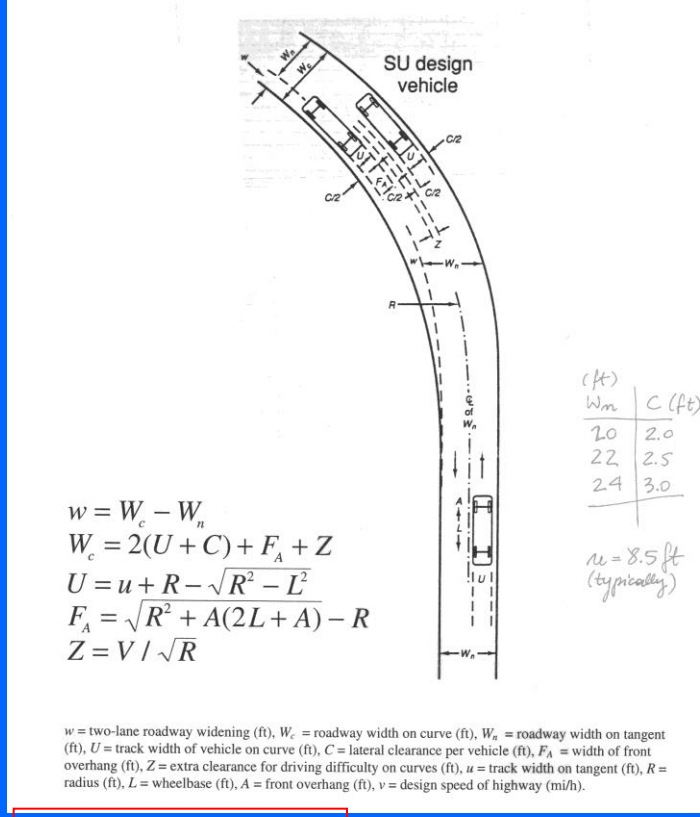
$$Z = \frac{v}{\sqrt{R}}$$

$$Z = \frac{40}{\sqrt{570}} = 1.68\ \text{ft}$$

$$W_c = 2(U + C) + F_A + Z$$

$$W_c = 2(7.11 + 2.5) + 0.07 + 1.68 = 20.1\ \text{ft}$$

$W_c < W_n \rightarrow$ no widening is needed for passenger cars



w = two-lane roadway widening (ft), W_c = roadway width on curve (ft), W_n = roadway width on tangent (ft), U = track width of vehicle on curve (ft), C = lateral clearance per vehicle (ft), F_A = width of front overhang (ft), Z = extra clearance for driving difficulty on curves (ft), u = track width on tangent (ft), R = radius (ft), L = wheelbase (ft), A = front overhang (ft), v = design speed of highway (mi/h).

SYMBOL

W_n = width of pavement on tangent, ft
U = track width of vehicle (out-to-out tires), ft
C = lateral clearance per vehicle; assumed 2,2.5 and 3 ft for W_n of 20, 22 and 24 ft, respectively
F_A = width of front overhang, ft
Z = extra width allowance for difficulty of driving on curves, ft
u = track width on tangent (out-to-out) 8.5 ft
R = radius on centerline of two-lane pavement, ft
L = wheelbase
A = front overhang
V = design speed of highway, mi/h

EXERCISE

- Given that R = 175 m, V = 65 km/h, W_n = 6.7 m, C = 0.8 m, u = 2.1 m, L = 3.4 m, A = 0.9 m (Passenger Cars)
- Determine W_c, do you think that you need to widen on this curve if only passenger cars use this facility!
- Now, with the same R&V, check for truck, whether this facility need to be widened on the curve!

PWD STANDARD - CURVE

Pavement Width (m)	7				6.5				5.5				Required Widening (m)
Design Speed (kph)	80	60	50	40	60	50	40	30	50	40	30	20	
	R ≥ 470	R ≥ 340	R ≥ 280	R ≥ 230	R ≥ 1100	R ≥ 880	R ≥ 680	R ≥ 520	R ≥ 100	R ≥ 68	R ≥ 52	R ≥ 39	None
	470 > R ≥ 280	340 > R ≥ 180	280 > R ≥ 150	230 > R ≥ 130	1100 > R ≥ 340	880 > R ≥ 280	670 > R ≥ 230	520 > R ≥ 190		68 > R ≥ 60	52 > R ≥ 35	39 > R ≥ 27	0.50
		180 > R ≥ 150	150 > R ≥ 100	130 > R ≥ 130	340 > R ≥ 180	280 > R ≥ 150	230 > R ≥ 130	190 > R ≥ 110				27 > R ≥ 20	0.75
				86 > R ≥ 64	180 > R ≥ 150	150 > R ≥ 100	130 > R ≥ 86	110 > R ≥ 74				20 > R ≥ 16	1.00
				64 > R ≥ 60			86 > R ≥ 65	57 > R ≥ 45				16 > R ≥ 15	1.25
							65 > R ≥ 60	57 > R ≥ 45					1.50
								45 > R ≥ 38					1.75
								38 > R ≥ 35					2.00

Note:
R = radius in metre

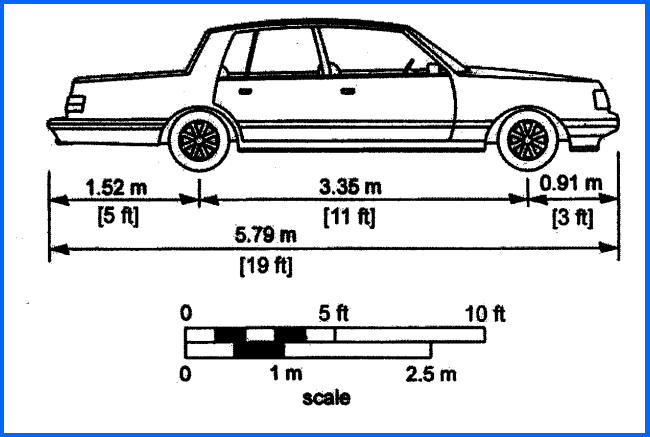
TURN PATHS

Key variables in turn paths

- Centerline turn radius
- Out-to-out track
- Wheelbase
- Path of inner tire

MINIMUM TURNING PATH

Passenger Car



Minimum turning path is defined by the outer trace of the front overhang and the path of the inner rear wheel.

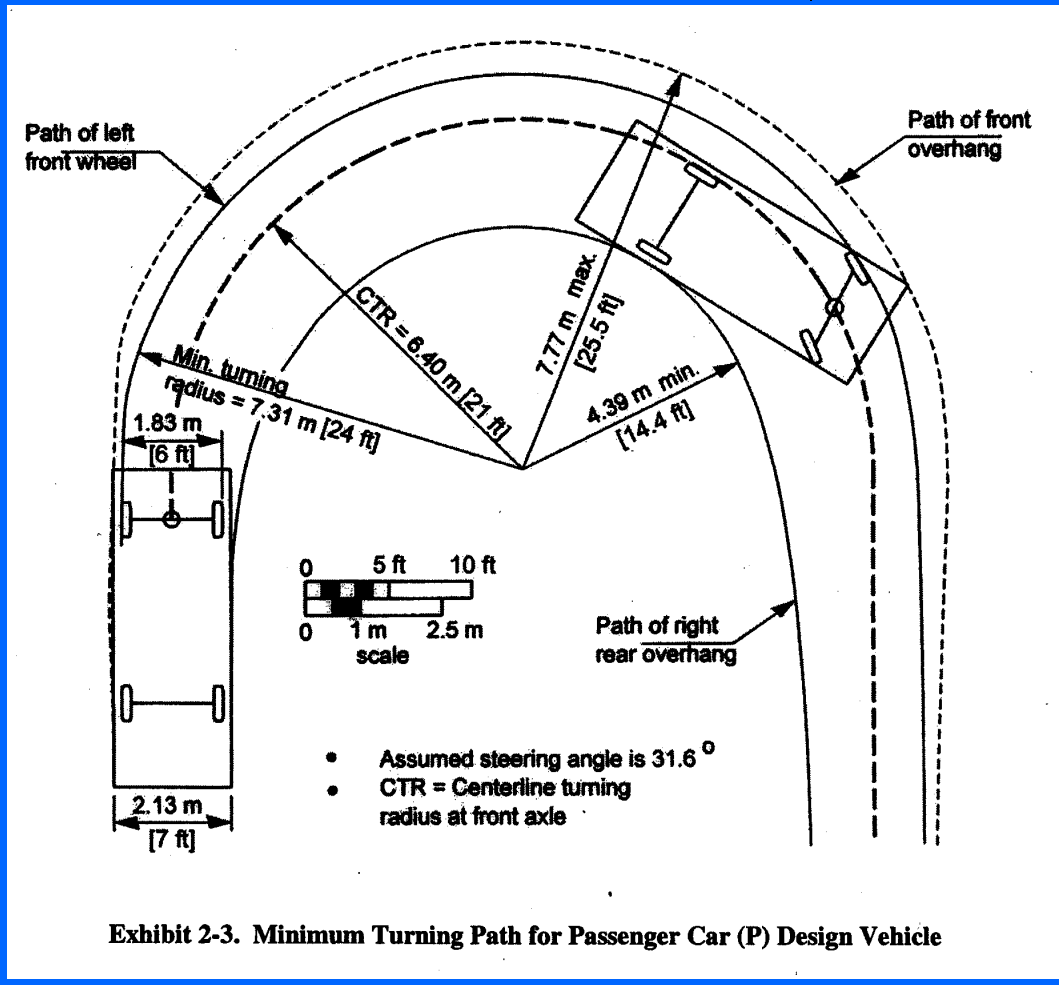
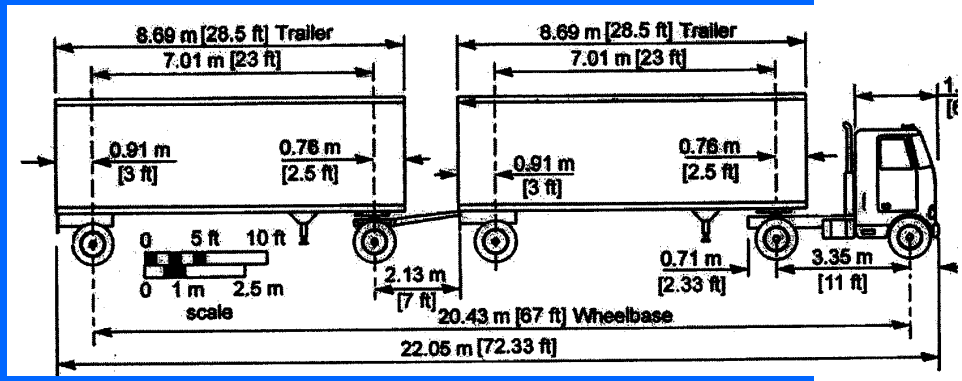


Exhibit 2-3. Minimum Turning Path for Passenger Car (P) Design Vehicle

MINIMUM TURNING PATH

Double-Trailer Combination



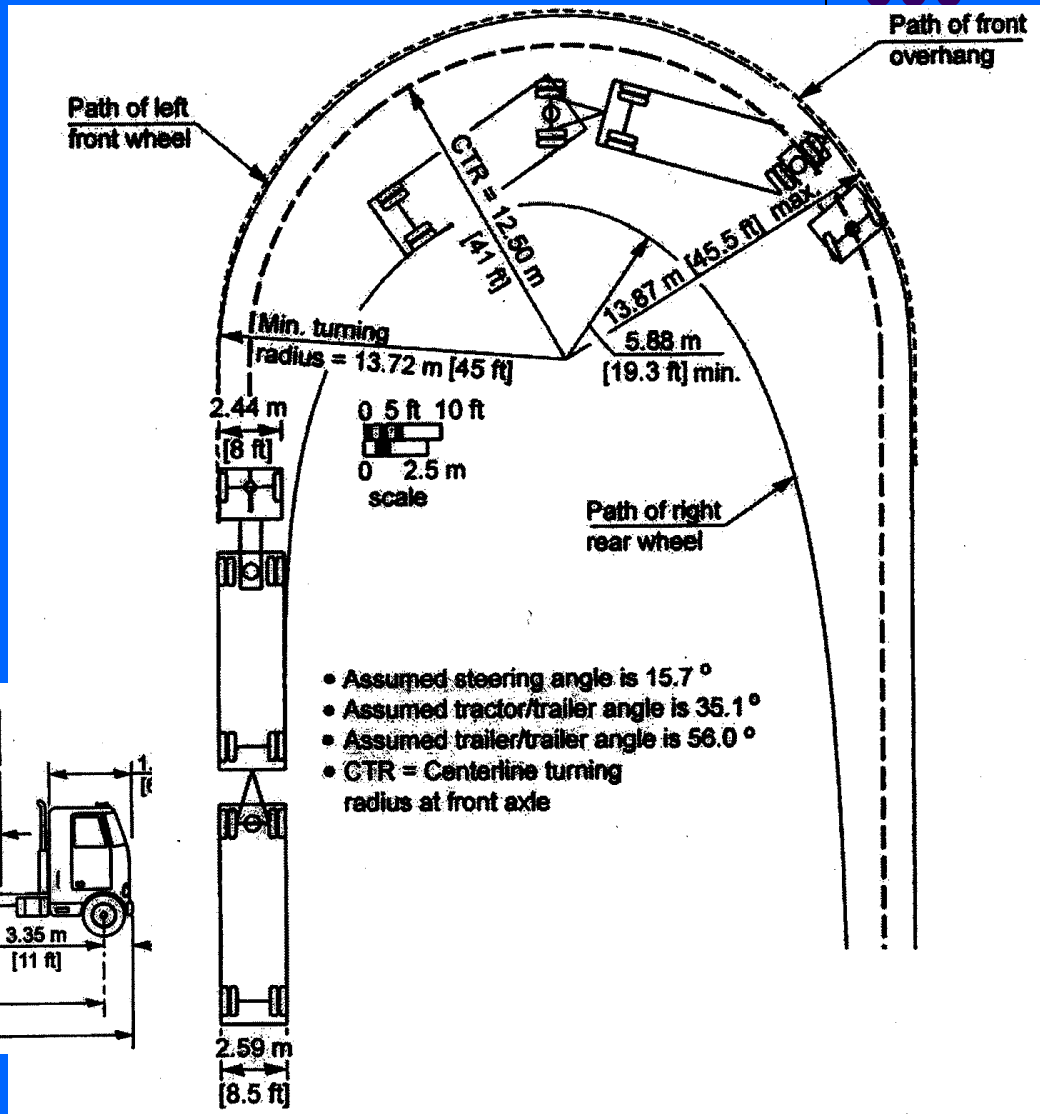


Exhibit 2-17. Minimum Turning Path for Double-Trailer Combination (WB-20D [WB-67D]) Design Vehicle

VEHICLE PERFORMANCE

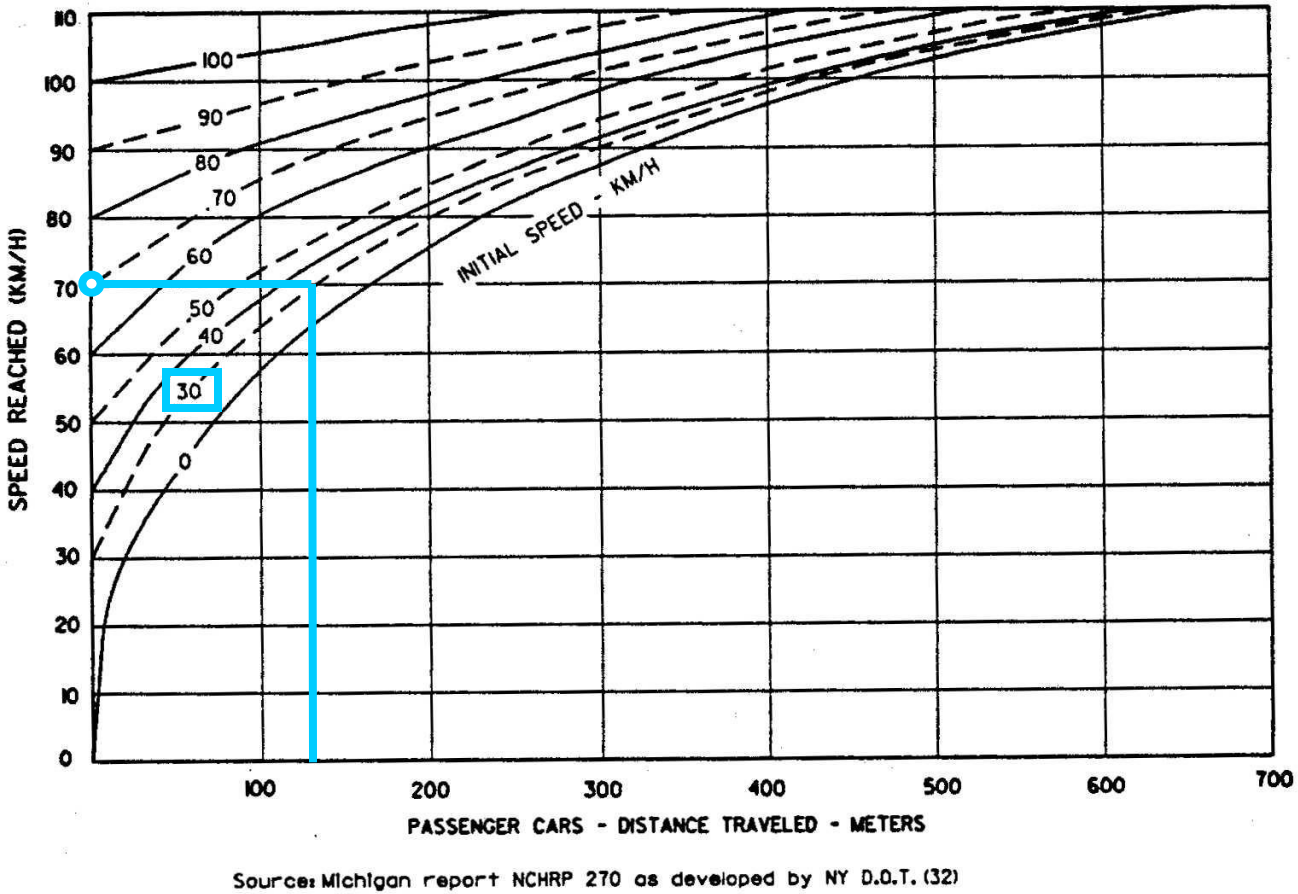
Characteristics

- acceleration
- deceleration
- difficulties in maintaining steady speed

Use

- intersections
- freeway ramps
- climbing or passing lanes

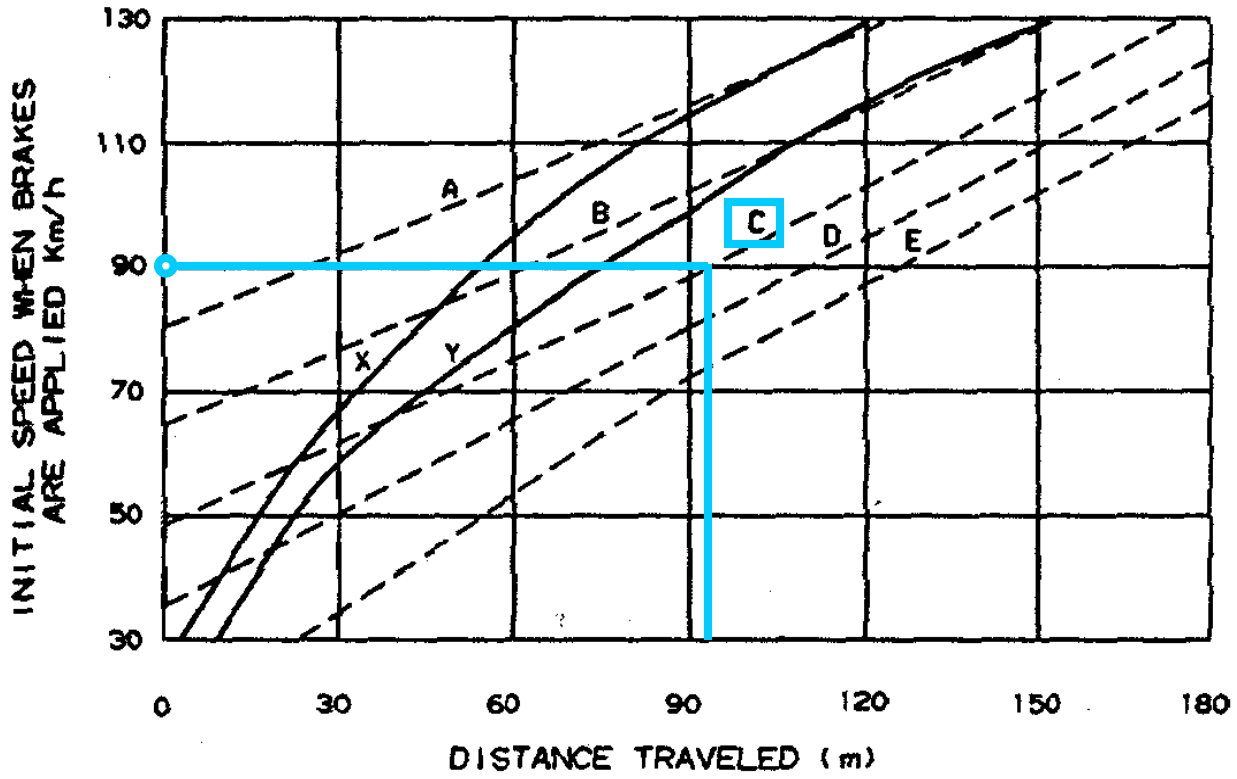
VEHICLE PERFORMANCE



Source: Michigan report NCHRP 270 as developed by NY D.O.T. (32)

Exhibit 2-24 Acceleration of passenger cars, level conditions.

VEHICLE PERFORMANCE



SPEED REACHED

(COMFORTABLE RATE)

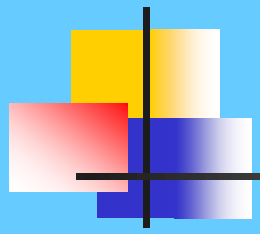
A = 80Km/h
B = 60Km/h
C = 50Km/h
D = 30Km/h
E = 0Km/h

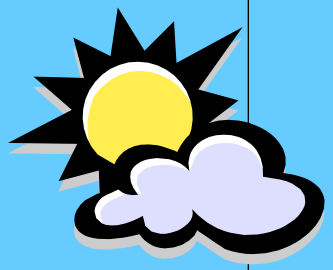
MINIMUM BRAKING DISTANCE

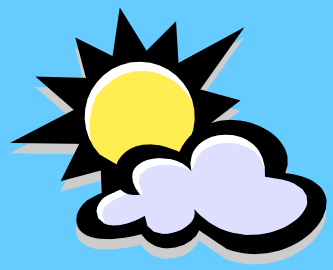
X = DRY PAVEMENT
Y = WET PAVEMENT

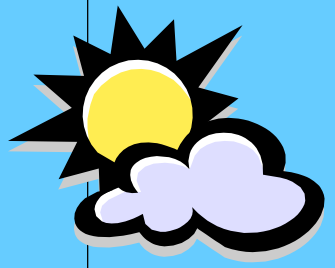
Exhibit 2-25

Deceleration distances for passenger vehicles approaching intersections.









ROAD CHARACTERISTICS

SIGHT DISTANCE

Distance a driver can see ahead at any specific time

Must allow sufficient distance for a driver to perceive/react and stop, swerve etc when necessary

Type

1) Stopping Sight Distance

2) Passing Sight Distance

STOPPING SIGHT DISTANCE

- Stopping sight distance is composed of two distances, what are they?
  - Distance traveled during perception/reaction time
  - Distance required to physically brake vehicle

Stopping Sight Distance = Reaction Distance + Braking Distance

STOPPING SIGHT DISTANCE

REACTION DISTANCE

$$D_r = 0.278\, t_r\, V$$

d_r = break reaction distance, m

t_r = reaction time, s

The Policy recommends 2.5-second

V = initial speed, km/h

STOPPING SIGHT DISTANCE

BRAKING DISTANCE

$$d_b = \frac{V^2}{254 f}$$

$$d_b = 0.039 \frac{V^2}{a}$$

d_b = braking distance, m

V = initial speed, km/h

f = coefficient of friction

a = 3.4 m/s², deceleration rate.

STOPPING SIGHT DISTANCE

Metric					US Customary				
Design speed (km/h)	Brake reaction distance (m)	Braking distance on level (m)	Stopping sight distance		Design speed (mph)	Brake reaction distance (ft)	Braking distance on level (ft)	Stopping sight distance	
			Calculated (m)	Design (m)				Calculated (ft)	Design (ft)
20	13.9	4.6	18.5	20	15	55.1	21.6	76.7	80
30	20.9	10.3	31.2	35	20	73.5	38.4	111.9	115
40	27.8	18.4	46.2	50	25	91.9	60.0	151.9	155
50	34.8	28.7	63.5	65	30	110.3	86.4	196.7	200
60	41.7	41.3	83.0	85	35	128.6	117.6	246.2	250
70	48.7	56.2	104.9	105	40	147.0	153.6	300.6	305
80	55.6	73.4	129.0	130	45	165.4	194.4	359.8	360
90	62.6	92.9	155.5	160	50	183.8	240.0	423.8	425
100	69.5	114.7	184.2	185	55	202.1	290.3	492.4	495
110	76.5	138.8	215.3	220	60	220.5	345.5	566.0	570
120	83.4	165.2	248.6	250	65	238.9	405.5	644.4	645
130	90.4	193.8	284.2	285	70	257.3	470.3	727.6	730
					75	275.6	539.9	815.5	820
					80	294.0	614.3	908.3	910

Note: Brake reaction distance predicated on a time of 2.5 s; deceleration rate of 3.4 m/s^2 [11.2 ft/s^2] used to determine calculated sight distance.

Exhibit 3-1. Stopping Sight Distance

$$d = 0.278 \cdot 2.5 \cdot V + 0.039 \frac{V^2}{3.4}$$

EXAMPLE (PRT DISTANCE)

- A driver with a PRT of 2.5 sec is driving at 105 km/h when she observed that an accident has blocked the road ahead. Determine the distance the vehicle would move before the driver could activate the brakes. The vehicle will continue to move at 105 km/h during the PRT of 2.5 sec.

SOLUTION

- Dr = 0.278 * V * t

  = 0.278 * 105 * 2.5 = 73 m.

SSD ON GRADES

A stopping distance on grades *G* is calculated as follows:

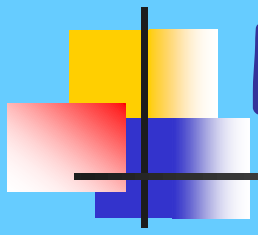
$$d = 0.278 \cdot t \cdot V + \frac{V^2}{254 \cdot (\frac{a}{9.81} \pm G)}$$

where *G* is the percent of graded divided by 100 with the minus sign for downgrades and the plus sign for upgrades.

BRAKING DISTANCE DUE TO SPEED REDUCED

$$d = \frac{V_1^2 - V_2^2}{254\left(\left(\frac{a}{9.81}\right) \pm G\right)}$$

EXAMPLE 1 (Determining Braking Distance)



- A student trying to test the braking ability of her car determined that she needed 5.64 m more to stop her car when driving downhill on a road segment of 5% grade than when driving downhill at the same speed along another segment of 3% grade. Determine the speed at which the student conducted her test and the braking distance on the 5% grade.

SOLUTION

- Let x = downhill braking distance on 5% grade
- (x + 5.64) m = Db on 5% grade
- V = 75.1 km/hr
- Db on 5% = 74 m

EXAMPLE 2 (Exit Ramp Stopping Distance)

- A motorist traveling at 105 km/h on an expressway intends to leave the expressway using an exit ramp with a maximum speed of 55 km/h. At what point on the expressway should the motorist step on her brakes in order to reduce her speed to the maximum allowable on the ramp just before entering the ramp, if this section of the expressway has a downgrade of 3%?

SOLUTION

- Use the speed reduced formula
- $Db = (V_1^2 - V_2^2)/254(a/g - 0.03)$

  $= (105^2 - 55^2)/254(0.35 - 0.03)$

  $= 98.5$ m

  The brakes should be applied at least 98.5 m from the ramp

EXAMPLE 3 (Distance Required to Stop for an obstacle in the roadway)

A motorist traveling at 90 km/h down a grade of -5% on a highway observes an accident ahead of him, involving an overturned truck that is completely blocking the road. If the motorist was able to stop his vehicle 10 m from the overturned truck what was his distance from the truck when he first observed the accident? Assume PRT = 2.5 sec

SOLUTION

- SSD = $0.278Vt + V^2/254(0.35 - 0.05)$

  $= 0.278*90*2.5 + 90^2/254(0.30)$

  $= 62.55 + 106.30$

  $= 168.85$ m

  Find the distance of the motorist when he first observed the accident: SSD + 10 m = 178.85 m

SSD ON GRADES

Metric							US Customary						
Design speed (km/h)	Stopping sight distance (m)						Design speed (mph)	Stopping sight distance (ft)					
	Downgrades			Upgrades				Downgrades			Upgrades		
	3%	6%	9%	3%	6%	9%		3%	6%	9%	3%	6%	9%
20	20	20	20	19	18	18	15	80	82	85	75	74	73
30	32	35	35	31	30	29	20	116	120	126	109	107	104
40	50	50	53	45	44	43	25	158	165	173	147	143	140
50	66	70	74	61	59	58	30	205	215	227	200	184	179
60	87	92	97	80	77	75	35	257	271	287	237	229	222
70	110	116	124	100	97	93	40	315	333	354	289	278	269
80	136	144	154	123	118	114	45	378	400	427	344	331	320
90	164	174	187	148	141	136	50	446	474	507	405	388	375
100	194	207	223	174	167	160	55	520	553	593	469	450	433
110	227	243	262	203	194	186	60	598	638	686	538	515	495
120	263	281	304	234	223	214	65	682	728	785	612	584	561
130	302	323	350	267	254	243	70	771	825	891	690	658	631
							75	866	927	1003	772	736	704
							80	965	1035	1121	859	817	782

Exhibit 3-2. Stopping Sight Distance on Grades

PASSING SIGHT DISTANCE

Minimum distance required to safely complete passing maneuver on 2-lane two-way highway

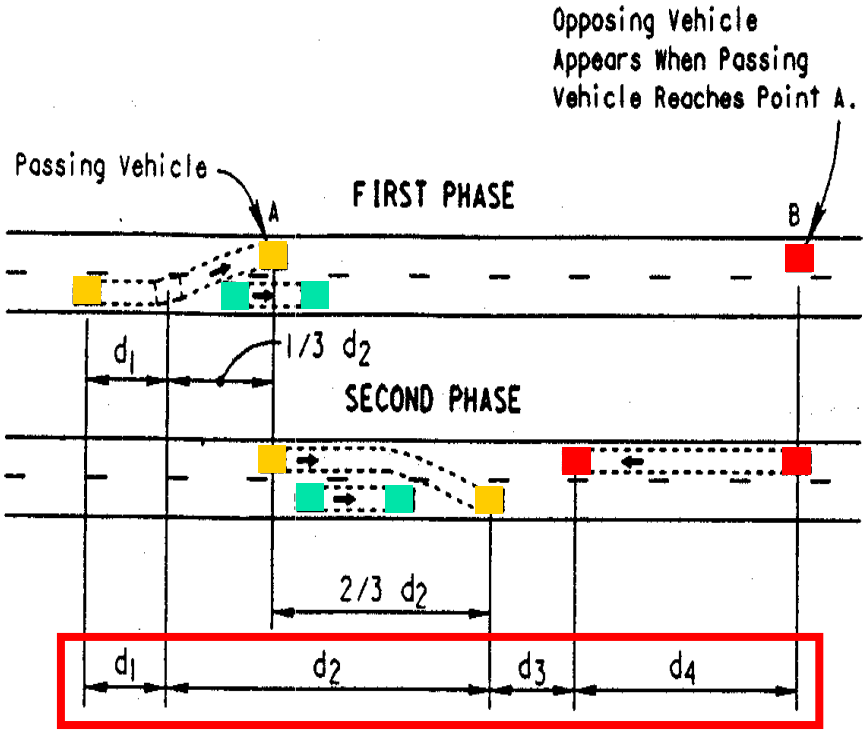
Allows time for driver to avoid collision with approaching vehicle and not cut off passed vehicle when upon return to lane

PASSING SIGHT DISTANCE

- **Assumes:**

1. Vehicle that is passed travels at **uniform speed**
2. **Speed of passing vehicle is reduced** behind passed vehicle **as it reaches passing section**
3. **Time elapses** as driver reaches decision to pass
4. Passing vehicle accelerates during the passing maneuver and velocity of the passing vehicle is **15 km/h greater** than that of the passed vehicle
5. **Enough distance** is allowed between passing and **oncoming vehicle** when the passing vehicle **returns to its lane**

PASSING SIGHT DISTANCE



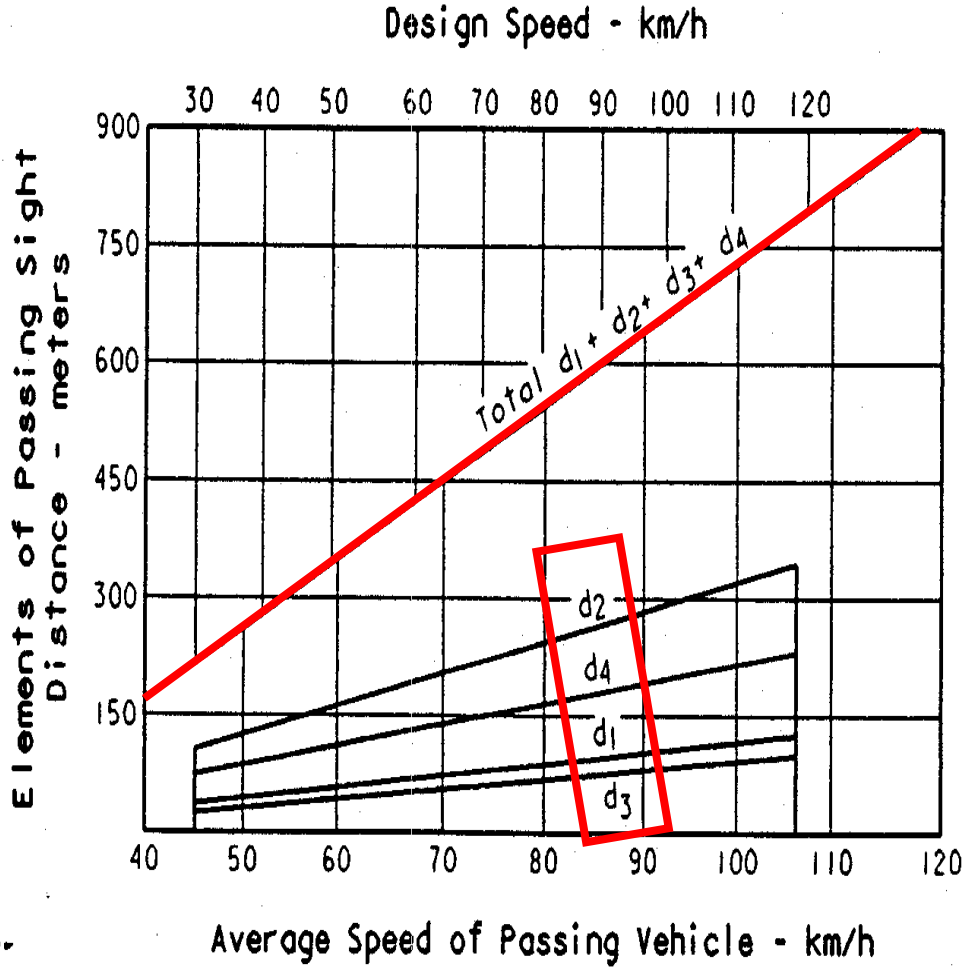


Figure III-2. Elements of and total passing sight distance.

PASSING SIGHT DISTANCE

$D_{passing} = d_1 + d_2 + d_3 + d_4$

d_1 = distance traveled during P/R time to point where vehicle just enters the right lane

$$d_1 = 0.278 t_1 (v - m + a t_1 / 2)$$

t_1 = time for initial maneuver (sec)
v = average speed of passing vehicle (km/h)
a = acceleration
m = difference between speeds of passing and passed vehicle

PASSING SIGHT DISTANCE

$D_{passing} = d_1 + d_2 + d_3 + d_4$

d_2 = distance traveled by vehicle while in right lane

$$d_2 = 0.278vt_2$$

where:

v = speed of passing vehicle (km/h)

t_2 = time spent passing in left lane (sec)

PASSING SIGHT DISTANCE

$D_{passing} = d_1 + d_2 + d_3 + d_4$

d_3 = clearance distance varies from 30 to 90m

d_4 = distance traveled by opposing vehicle during passing maneuver

d_4 usually taken as 2/3 d_2

PASSING SIGHT DISTANCE

Table 3.6 Components of Safe Passing Sight Distance on Two-Lane Highways

Component	Speed Range in mi/h (Average Passing Speed in mi/h)			
	30-40	40-50	50-60	60-70
	(34.9)	(43.8)	(52.6)	(62.0)
Initial manoeuvre:				
a = average acceleration (mi/h/sec)[a]	1.40	1.43	1.47	1.50
t1 = time (sec)[a]	3.6	4.0	4.3	4.5
d1 = distance travelled (ft)	145	216	289	366
Occupation of left lane:				
t2 = time (see)[a]	9.3	10.0	10.7	11.3
d2 = distance travelled (ft)	477	643	827	1030
Clearance length:				
d3 = distance travelled (ft)[1]	100	180	250	300
Opposing vehicle:				
d4 = distance travelled (ft)	318	429	552	687
Total distance, d1 + d2 + d3 + d4 (ft)	1040	1468	1918	2383

Example

- **Calculate the minimum passing sight distance required for a two-lane rural highway that has a posted speed limit of 70 km/h. The local traffic engineer conducted a speed study of the subject road and found the following:**

  - Average speed of the passing vehicle: 75 km/h with an average acceleration of 2.3 km/h/s

  - Average speed of impeder vehicles: 65 km/h

  Additional info can be seen from Table 3.6

SOLUTION

- $d_1 = 0.278*4[75 - 10 + (2.3*4/2)] = 77.4$ m
- $d_2 = 0.278*75*10 = 208.5$
- $d_3 = 55$ m (Table 3.6)
- $d_4 = 2/3 * 208.5 = 139$
- Total = 77.4 + 208.5 + 55 + 139 = 480 m (Minimum Passing Sight Distance)

Note: t_1 & t_2 can be seen in Table 3.6

Pedestrian Characteristics

- Influence design and location of pedestrian control device

Pedestrian Volume at peak hour	Traffic Volume (1 way) at peak hour	Type of Crossing
< 50	< 1000	Ordinary level crossing
50 - 100	100 - 2000	Signalised level crossing
> 100	> 2000	Overhead crossing/ underpass

Pedestrian Characteristics

- **Pedestrian movement between 0.9 – 2.4 m/s**

- **Pedestrian crossings warrant in area of heavy peak pedestrian movement such as**

  School

  Business area

  Abnormal hazard (road >2 lanes)