六、公路幾何設計控制與視距

◎ 緒論：

[公路幾何設計、設計控制、與視距]

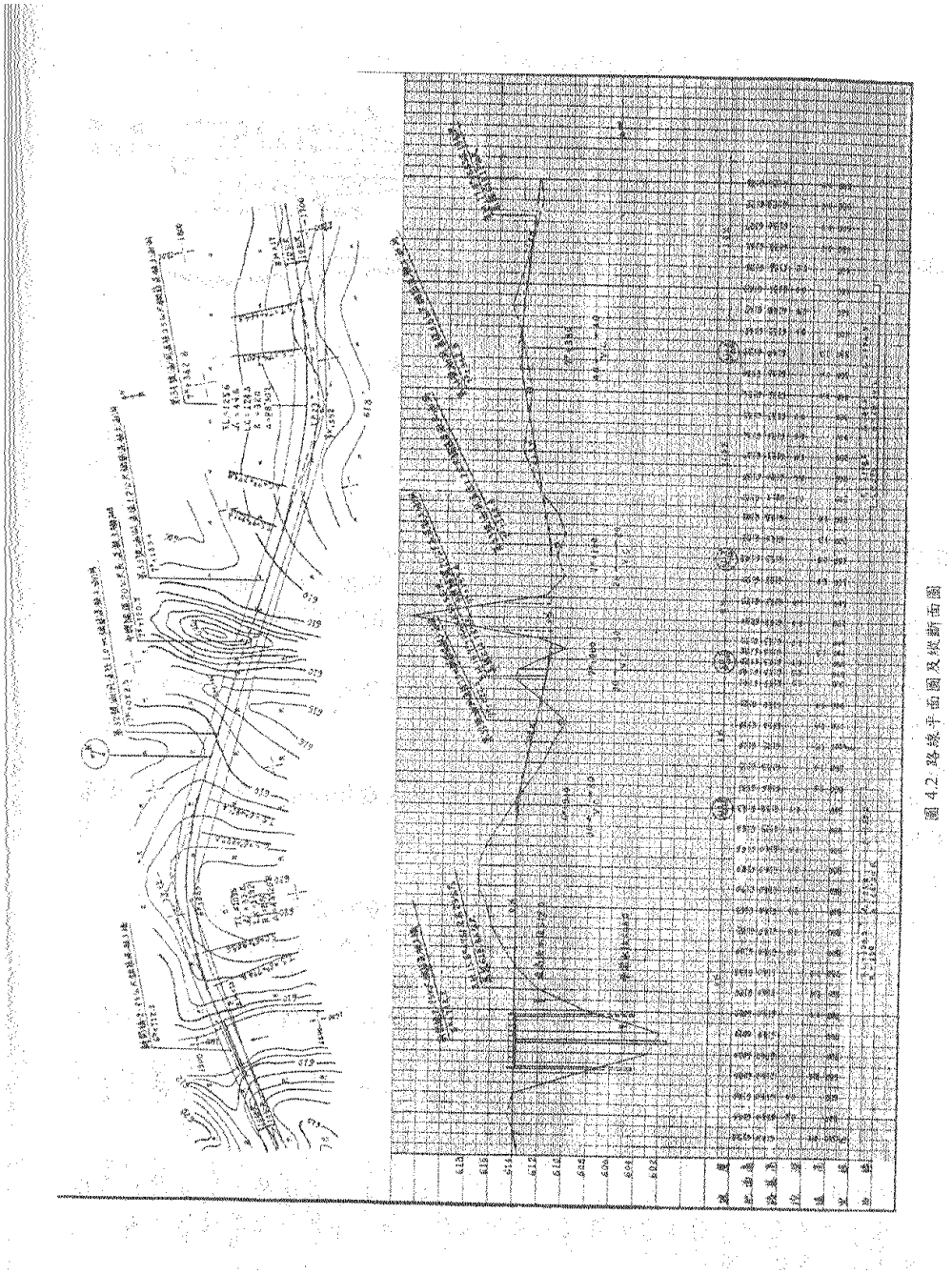


圖 4.2 路線平面圖及縱斷面圖

◎ 設計控制與標準

地形與人爲條件、交通特性、速率、用路人特性、公路容量與服務水準、設計車型、建設成本與可用資金、安全考量、環境考量

◎ 交通特性

1. 平均每日交通量(ADT)：不可作爲公路幾何設計之依據
2. 尖峰小時交通量
3. 設計小時交通量(DHV)：全年中第三十個最高小時交通量(HV_{30})

   採用原因：經濟合理、易於估算

   (圖 8-1)

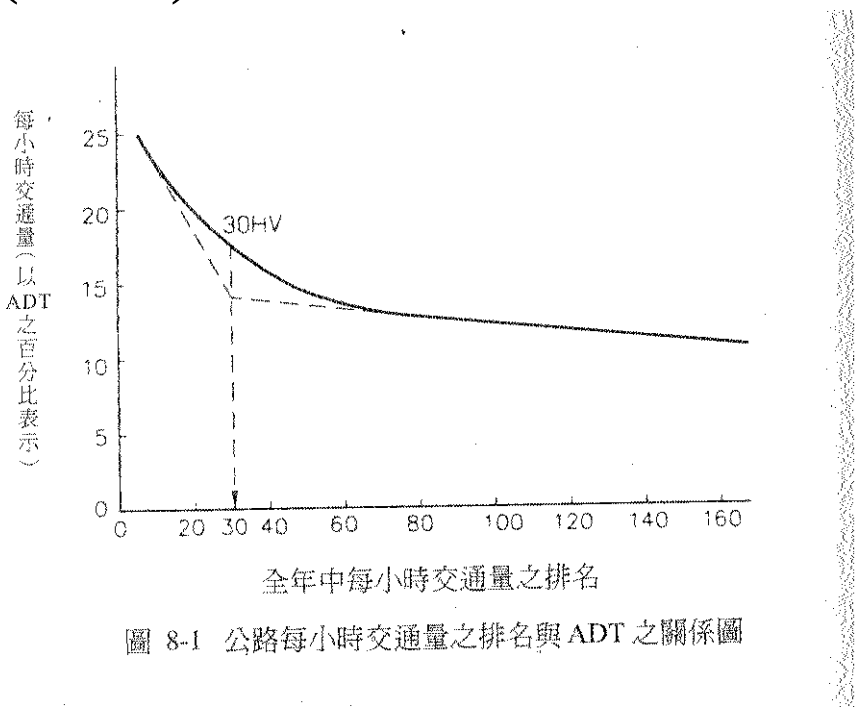


圖 8-1 公路每小時交通量之排名與 ADT 之關係圖

4. K 值：K = DHV/ADT ≈ 常數
   (美國鄉間道路 K=12~18%，郊區 K=10~15%，市區 K=8~12%)
5. 方向分佈(D) ：交通量大之一方向
6. 交通組成(T)：大型車佔全交通量之比 ADTT
7. 小客車單位(PCU)、小客車當量(PCE)
(大型車對公路交通之影響爲小型車之數倍)
一輛重型車相當於幾輛小客車之值

$$f_{hv} = \frac{100}{100 - P_T - P_B + P_T E_T + P_B E_B}$$

表 5.3 方向分佈之調整係數

方向分佈	100/0	90/10	80/20	70/30	60/40	50/50
調整係數 f_d	0.71	0.75	0.83	0.89	0.94	1.00

表 5.4 車道寬與路肩寬調整係數

車道寬(m) / 服務水準 / 可用路肩寬 (m)	3.6		3.3		3.0		2.7	
	A–D	E	A–D	E	A–D	E	A–D	E
≥1.8	1.00	1.00	0.93	0.94	0.84	0.87	0.70	0.76
1.2	0.92	0.97	0.85	0.92	0.77	0.85	0.65	0.74
0.6	0.81	0.93	0.75	0.88	0.68	0.81	0.57	0.70
0	0.70	0.88	0.65	0.82	0.58	0.75	0.49	0.66

表 5.5 各型車之小客車當量換算係數

車型	服務水準	地形		
		平原區	丘陵區	山嶺區
大貨車, E_T	A	2.0	4.0	7.0
	B–C	2.2	5.0	10.0
	D–E	2.0	5.0	12.0
休閒車, E_R	A	2.2	3.2	5.0
	B–C	2.5	3.9	5.2
	D–E	1.6	3.3	5.2
大客車, E_B	A	1.8	3.0	5.7
	B–C	2.0	3.4	6.0
	D–E	1.6	2.9	6.5

◎ 速率

依路況、氣候、交通狀況、速率限制而定

1. 可運行速率：當氣候良好，在一般的交通狀況下，可行駛之最高速率
2. 設計速率：當公路情況良好時，車輛所能維持之最大安全速率
   (設計速率必需緩和變更)
3. 行車速率：車輛在某一特定路段之實際速率=行車距離/行車時間
   (可評估公路服務水準、新建或改善公路之效益)
   (行車速率 ≈ 平均定點速率)
   圖 8-2 平均行車速率、設計速率、與交通量之關係

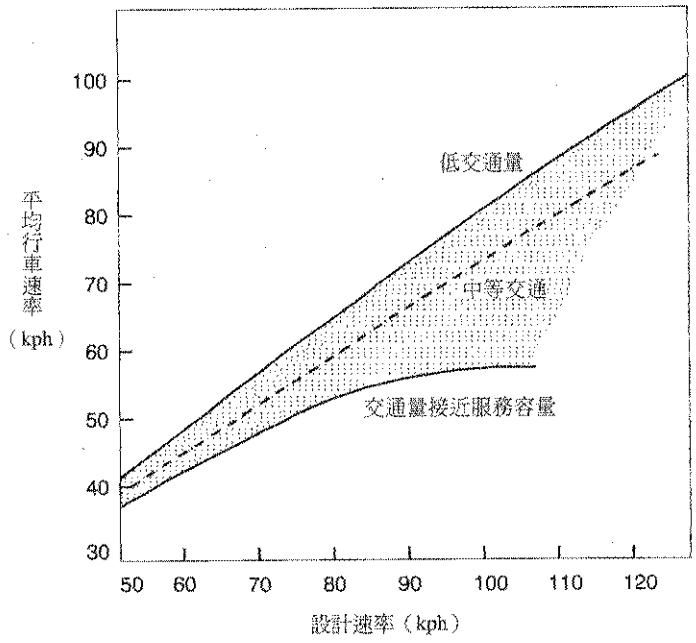


圖 8-2 平均行車速率與設計速率、交通量之關係曲線圖
（資料來源：[14]）

◎ 用路人特性

[用路人=車輛駕駛人+行人]

1. 車輛駕駛人：

＊認識時間(Perception Time)=駕駛人自看見前方狀況，認知其有害行車並決定採取因應行動之時間過程(1~2 sec)

＊煞車反應時間(Break Reaction Time)=駕駛人決定煞車，採取實際行動到煞車器生效之時間(0.5 sec)

(避免駕駛人易犯之過失)

2. 行人：安全、便利

◎ 公路容量與服務水準

＊公路容量=表示公路之基本運輸能力，在天候及路面狀況良好時，每單位時間內公路某一斷面所能合理通過之最大車輛數

＊服務水準(LOS)：A~F 級

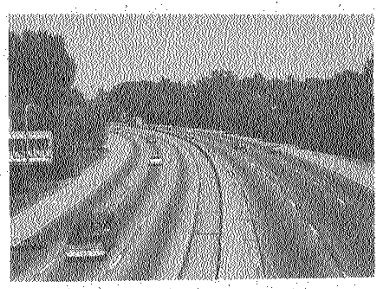
A:自由車流　　B~C:穩定車流

D:高密度的穩定車流

E:接近容量之車流 (Unstable)

F:強迫性車流

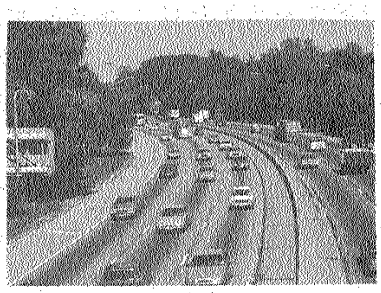
＊服務流率=在某一特定服務水準下，每小時公路某一斷面所能合理通過之最大車輛數



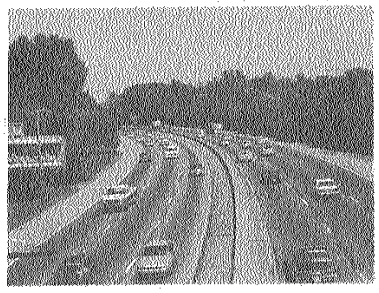
A 級服務水準

D 級服務水準

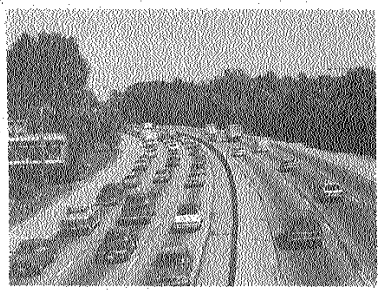
B 級服務水準



E 級服務水準



C 級服務水準



F 級服務水準

圖 5.2 各級服務水準之行車情況

四、D 級服務水準

Level of Service	Controlled Access Highways	Multilane Rural without Access Control	Two Lanes	Urban and Suburban Arterials
A	Free flow. Operating speeds at or greater than 60 mph. Service volume of 1,400 passenger cars per hour on two lanes, one direction. Each additional lane serves volume of 1,000-vph lane.	Operating speed 60 mph or greater. Under ideal conditions, volume is limited to 600 passenger cars per lane per hour or 30 percent of capacity. Average speeds are likely to be influenced by speed limits.	Operating speeds of 60 mph or higher. 75 percent of passing maneuvers can be made with little or no delay. Under ideal conditions, a service volume of 400 passenger vph, total two-way, can be achieved.	Average overall travel speed of 30 mph or more. Free flowing with volume/capacity ratio of 0.60. Load factor at intersections near the limit of the 0.6 range. Peak-hour factor at about 0.70.
B	Higher speed range of stable flow. Operating speed at greater than 55 mph. Service volume on two lanes in one direction not greater than 2,000 passenger vph. Each additional lane above two in one direction can serve 1,500 vph.	Beginning of stable flow area. Volume at which actions of preceding vehicle will have some influence on following vehicles. Volume will not exceed 50 percent of capacity of 1,000 passenger vehicles per lane per hour, at a 55 mph operating speed under ideal conditions.	Operating speeds of 50 mph or higher. Volumes may reach 45 percent of capacity with continuous passing sight distance. Volumes of 900 passenger cars per hour, total two-way, can be carried under ideal conditions.	Average overall speeds drop due to intersection delay and inter vehicular conflicts, but remain at 25 mph or above. Delay is not unreasonable. Volumes at 70 percent of capacity and peak-hour factor approximately 0.80. Load factor at intersections approximately 0.1.
C	Operation still stable, but becoming more critical. Operating speed of 50 mph. Service flow on two lanes in one direction at 75 percent of capacity or not more than 5-min flow rate of 3,000 passenger cars per hour. Under ideal conditions each additional lane above two in one direction would serve 1,900 vph.	Stable flow to a volume not exceeding 75 percent of capacity or 1,350 passenger cars per lane per hour, under ideal conditions, maintaining at least a 45-mph operating speed.	Flow still stable. Operating speeds of 40 mph or above with total volume under ideal conditions equal to 70 percent of capacity with continuous passing sight distance, or 1,400 passenger vph total two-way.	Service volumes about 0.80 of capacity. Average overall travel speeds of 20 mph. Operating conditions at most intersections approximate load factor of 0.3. Peak-hour factor approximately 0.85. Traffic flow still stable with acceptable delays.

Table II-5. Level-of-service characteristics by highway type.

HG Table II-5 in 7/8:

Level of Service	Controlled Access Highways	Multilane Rural without Access Control	Two Lanes	Urban and Suburban Arterials
D	Lower speed range of stable flow. Operation approaches instability and is susceptible to changing conditions. Operating speeds approximately 50 mph. Service flow rates at 90 percent of capacity. Peak 5-min flow under ideal conditions cannot exceed 3,600 vph for two-lanes, one direction; 1,800 vph for each added lane.	Approaching unstable flow at volume up to 90 percent of capacity or 1,800 passenger cars per hour at an operating speed of about 50 mph under ideal conditions.	Approaching unstable flow. Operating speeds approximately 35 mph. Volumes, two-direction, at 75 percent of capacity with continuous passing opportunity, or 1,700 passenger cars per hour total two-way under ideal conditions.	Beginning of low capabilities of street operation. Approaching unstable flow. Service volumes approach 80 percent of capacity. Average overall speeds drop to 15 mph. Delays at intersections may become extensive with some cars waiting two or more cycles. Peak hour factor approximately 0.90, load factor of 0.7.
E	Unstable flow. Overall operating speeds of 30-35 mph. Volumes at capacity or 2,000 vph lane under ideal conditions. Traffic flow metered by design constructions and bottlenecks, but long backups do not normally develop upstream.	Flow at 100 percent of capacity or 2,000 passenger cars per lane per hour under ideal conditions. Operating speeds of about 30 mph or less.	Operating speeds in neighborhood of 30 mph but may vary considerably. Volumes under ideal conditions, total two-way, equal to 2,000 passenger vph. Level E may never be attained. Operation may go directly from Level D to Level F.	Service volumes at capacity. Average overall traffic variable, but in area of 15 mph. Unstable flow. Continuous backup on approaches to intersections. Load factor at intersections in range between 0.7 and 1.0. Peak-hour factor likely to be 0.95.
F	Forced flow. Freeway acts as a storage for vehicles backed up from downstream bottleneck. Operating speeds range from near 30 mph to stop-and-go operation.	Forced flow, congested condition with widely varying volume characteristics. Operating speeds of less than 30 mph.	Forced, congested flow with unpredictable characteristics. Operating speeds less than 30 mph. Volumes under 2,000 passenger cars per hour, total two-way.	Forced flow. Average overall traffic speed below 15 mph. All intersections handling traffic in excess of capacity with storage distributed throughout the section. Vehicular backups extend back from signalized intersections, through unsignalized intersections.

Table II-5. Continued.

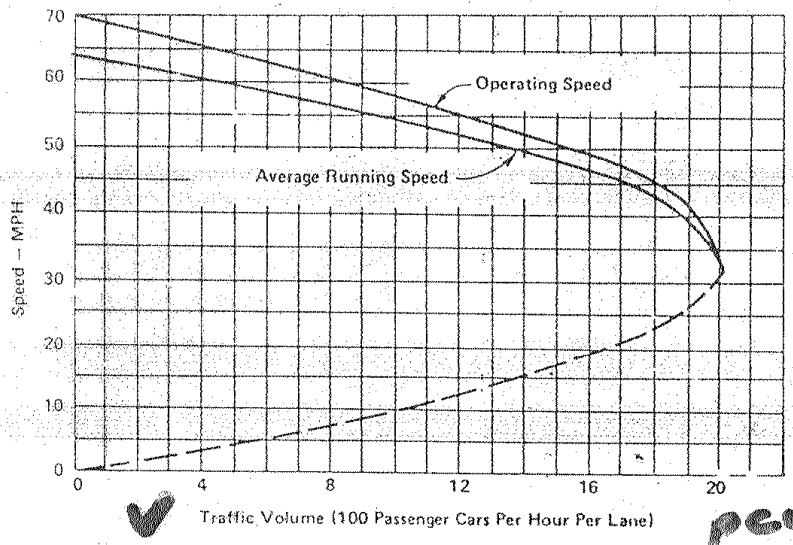


Figure II-23. Speed-volume relationship on six-lane freeways.

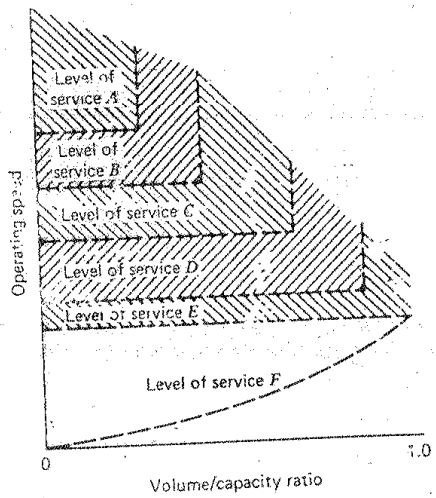


Fig 4-10. General concept of relationship of level of service to operating speed and volume/capacity ratio (not to scale). (Courtesy Transportation Research Board.)

◎ 設計車型

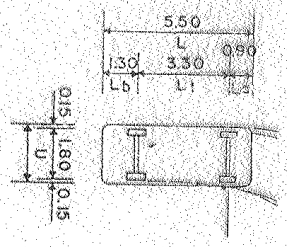
B.1.3 設計車輛

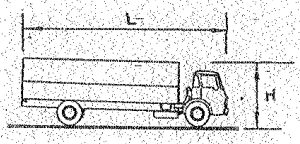
1.7 設計車輛與最小轉向軌跡

公路路線設計用車如下表，其最小轉向軌跡示如附圖：

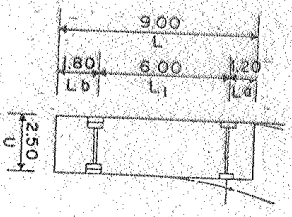
設計車種	車輛尺寸（公尺）									
	全長 L	全寬 U	全高 H	前懸 L_a	前軸 L_1	中軸 L_2	軸距 L_x	結軸 L_y	後軸 L_3	後懸 L_b
小客車 P	5.5	2.1	1.3	0.9	3.3	—	—	—	—	1.3
貨車 SU	9.0	2.5	4.1	1.2	6.0	—	—	—	—	1.8
大客車 BUS	12.0	2.5	4.1	2.1	7.5	—	—	—	—	2.4
中型半聯結車 WB40	15.0	2.5	4.1	1.2	3.9	7.5	—	—	—	1.8
大型半聯結車 WB50	16.5	2.5	4.1	0.9	5.4	9.0	—	—	—	0.6
全聯結車 WB60	20.0	2.5	4.1	0.6	3.0	6.1	1.2	1.7	6.4	1.0

P





SU



◎ 建設成本與可用資金

◎ 安全考量、環境考量

◎ 設計要件 (Design Designation)
表示公路設計之主要控制:交通量(ADT, DHV, D, T)、設計速率、設計車型之特性、各型車輛之比例

[Example]

表 8-1（a）服務水準主要評估項目表

交通設施名稱	衡量項目
高速公路	
基本路段	密度
匝道	流率
交織區段	平均行駛速率
一般郊區公路	
多車道郊區公路	密度
雙車道郊區公路	延滯時間百分比、平均行駛速率
市區街道	
號誌化交叉路口	平均每車延滯
非號誌化交叉路口	容量
市區幹道	平均行駛速率
公車設施	承載因子
行人交通設施	空間

表 8-1（b）高速公路基本路段服務水準評估表（設計速率 120 kph）

服務水準等級	平均行駛速率（kph）	密度（pcu/km/ln）	V／C	最大服務流率（pcu/hr/ln）
A	$\mu > 85$	$k < 10$	～0.35	850
B	$85 \geq \mu > 72$	$10 \leq k < 18$	0.35～0.54	1,300
C	$72 \geq \mu > 60$	$18 \leq k < 31$	0.54～0.77	1,850
D	$60 \geq \mu > 51$	$31 \leq k < 43$	0.77～0.93	2,200
E	$51 \geq \mu > 46$	$43 \leq k < 52$	0.93～1.00	2,400
F	$\mu \leq 46$	$k \geq 52$	—	—

（資料來源：[3]）

表 8-2 各類公路在各種地區、地形之設計服務水準表

公路類型	地區及地形			
	鄉間平原地	鄉間丘陵地	鄉間山嶺地	市區及郊區
高速公路	B	B	B	C
主要道路	B	B	C	C
次要道路	C	C	D	D
地區性道路	D	D	D	D

（資料來源：[14]）

◎ 視距

車輛駕駛人沿公路前方所能看見的距離

[停車視距、超車視距]

◎ 停車視距(SSD)

=自望見障礙物、判斷應煞車、採取行動、至煞車器生效所行駛之距離+自煞車器生效至車輛完全停止之距離

$$SSD = dp + db = vt + \frac{v^2}{2gf} = 0.278Vt + \frac{V^2}{254f}$$

(單位爲何？) (表 8-5 停車視距表)

坡道時，$d_b = \frac{V^2}{254(f \pm G)}$

SSD 之量測：

h1 = 107 cm (3.5 ft), h2 = 15 cm (6 in.)

表 8-5 各設計速率下之停車視距表（平坡、潮溼路面）

設計速率（kph）	假設行車速率（kph）	認識與煞車反應		摩擦係數 f	煞車距離（m）	停車距離	
		時間（sec）	距離（m）			計算值（m）	設計值（m）
30	30	2.5	20.8	0.40	8.9	29.7	40
40	38~ 40	2.5	26.4~27.8	0.38	15.0~ 16.6	41.4~ 44.4	45
50	45~ 50	2.5	31.3~34.7	0.36	22.2~ 27.3	53.5~ 62.0	55~ 65
60	52~ 60	2.5	36.1~41.7	0.34	31.3~ 41.9	67.4~ 83.6	70~ 85
70	56~ 70	2.5	38.9~48.6	0.31	39.8~ 62.2	78.7~110.8	80~115
80	70~ 80	2.5	48.6~55.9	0.30	62.2~ 84.7	110.8~140.6	115~145
100	84~100	2.5	58.6~69.5	0.29	95.8~135.8	154.4~205.3	160~210
120	94~120	2.5	65.3~83.4	0.28	124.2~202.5	189.5~285.9	190~290

◎ 超車視距(PSD)

[雙向雙車道超車]

※基本假設：

1. 被超車輛等速行駛
2. 進入超車路段，超車與被超車等速
3. 有一短時間以認清前方並決定超車

4. 延滯開始、加速、由左車道超越、急速返回右車道，佔左車道之平均速率比被超車輛大 16.1 kph (10 mph)

5. 回右車道時與對向來車有適當淨距

$$PSD = d_1 + d_2 + d_3 + d_4$$

$$d_1 = 0.278\, t_1 \left(V - m + \frac{a\, t_1}{2} \right)$$

$$d_2 = 0.278\, V\, t_2$$

[各變數之定義；m = 16.1 kph，a = 2.24 ~ 2.4 kph/sec，t_1 = 3.6 ~ 4.5 sec，t_2 = 9.3 ~ 11.3 sec，d_3 = 33 ~ 90 m，$d_4 \approx 2/3\ d_2$]

PSD 之量測：(視點與目標物之高度)

h_1 = 107 cm (3.5 ft), h_2 = 130 cm (4.25 ft)

表 8-6 雙車道公路所需之最短超車視距

設計速率（kph）	假設被超車輛速率（kph）	假設超車車輛速率（kph）	最短超車視距（m）
30	30	46	230
40	35	51	280
50	43	59	350
60	50	66	420
70	57	73	480
80	66	82	540
100	77	93	670
120	92	108	810

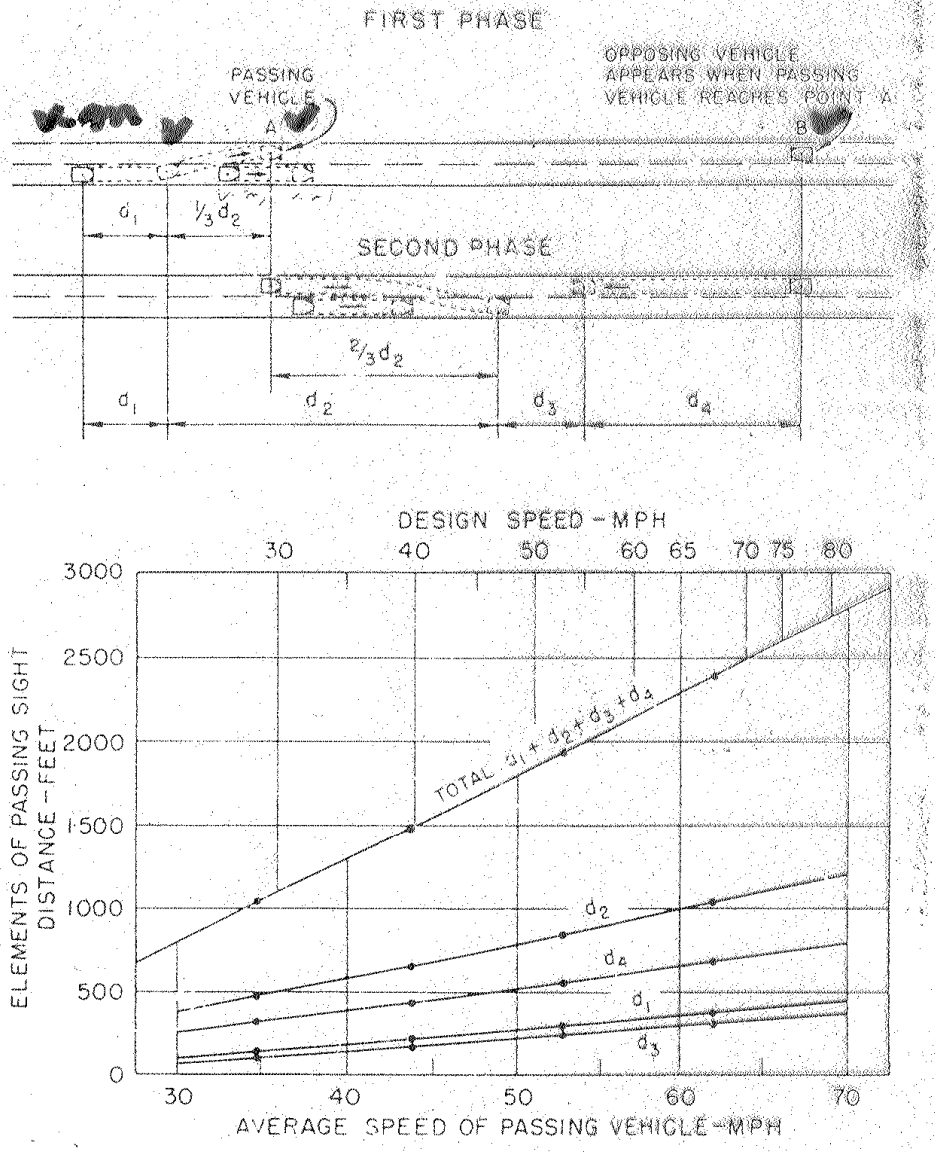


Figure III-2. Elements of and total passing sight distance—two-lane highways.

Speed Group (mph)	30-40	40-50	50-60	60-70
Average Passing Speed (mph)	34.9	43.8	52.6	62.0
Initial maneuver:				
a = average acceleration (mph/sec)[a]	1.40	1.43	1.47	1.50
t_1 = time (sec)[a]	3.6	4.0	4.3	4.5
d_1 = distance traveled (ft)	145	215	290	370
Occupation of left lane:				
t_2 = time (sec)[a]	9.3	10.0	10.7	11.3
d_2 = distance traveled (ft)	475	640	825	1,030
Clearance length:				
d_3 = distance traveled (ft)[a]	100	180	250	300
Opposing vehicle:				
d_4 = distance traveled (ft)	315	425	550	680
Total distance, $d_1 + d_2 + d_3 + d_4$ (ft)	1,035	1,460	1,915	2,380

[a]For consistent speed relation, observed values adjusted slightly.

Table III-4. Elements of safe passing sight distance—two-lane highways.

Design Speed (mph)	Assumed Speeds: Passed Vehicle (mph)	Assumed Speeds: Passing Vehicle (mph)	Minimum Passing Sight Distance (ft): Figure III-2	Minimum Passing Sight Distance (ft): Rounded
20	20	30	810	800
30	26	36	1,090	1,100
40	34	44	1,480	1,500
50	41	51	1,840	1,800
60	47	57	2,140	2,100
65	50	60	2,310	2,300
70	54	64	2,490	2,500

Table III-5. Minimum passing sight distance for design of two-lane highways.

【例題】

一、公路測量與選線：

解釋名詞：(a)主要控制與次要控制

二、依美國 AASHTO 之建議，公路之設計小時交通量(Design Hourly Volume, DHV)應如何選定最為恰當？試說明理由。

三、當計算最短停車視距時，試詳述所應考慮之各段長度．

四、在雙向雙車道超車時，請說明超車視距之基本假設、各段長度之計算公式、與各變數之定義。

五、假設在甲、乙兩地間擬建造一條高速公路，其相關之設計要件如下：ADT(1997)=13,500，ADT(2017)=28,000，K=15%，D=60%，T=15%，V=100kph。若PCE=6，設計服務水準為C級，最大服務流率=1,850 pcu/hr/ln，試計算該高速公路雙向總共需要多少車道數？

六、解釋名詞與簡答：

(a)公路容量與服務流率　　(b)可運行速率、設計速率、行車速率

(c)小客車當量與小客車單位　(d)公路之設計小時交通量

七、解釋名詞與簡答：

(a)公路容量與服務流率

(b)小客車當量與小客車單位

(c)公路之服務水準

(d)可運行速率、設計速率、行車速率

(e)停車視距之各段長度

(f)超車視距之各段長度

(g)停車視距與超車視距

(h)設計小時交通量