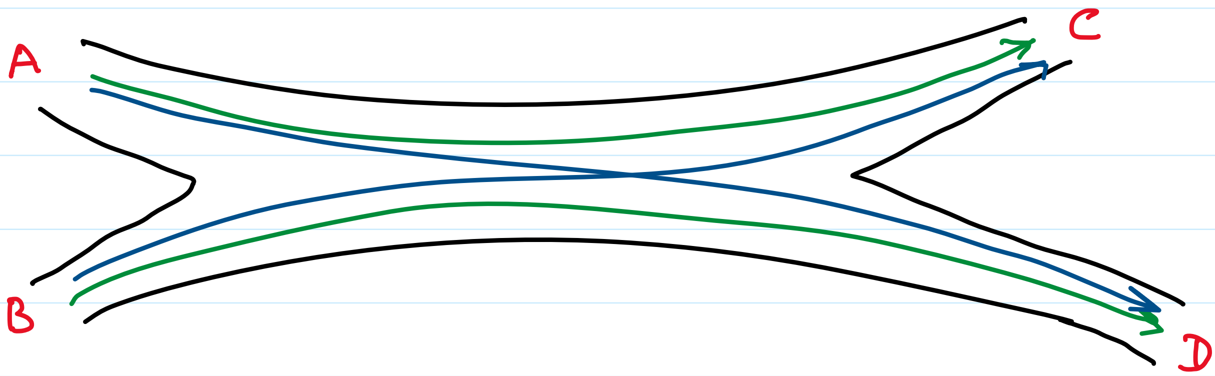
Basics of a Freeway Weaving

→ Weaving - Definition
→ Weaving Configuration — Type A, B, C
→ Weaving Length
→ Weaving Width. → effective
↳ min. no. of lane changes required for weaving operation.

Weaving Segment Definition:

Defined as the crossing of two or more traffic streams traveling in the same general direction along a significant length of highway without the aid of traffic control devices (except tr. signs and road markings)



AD & BC → Weaving movements ✓
AC & BD → Non weaving movements. ✓

Weaving Configuration

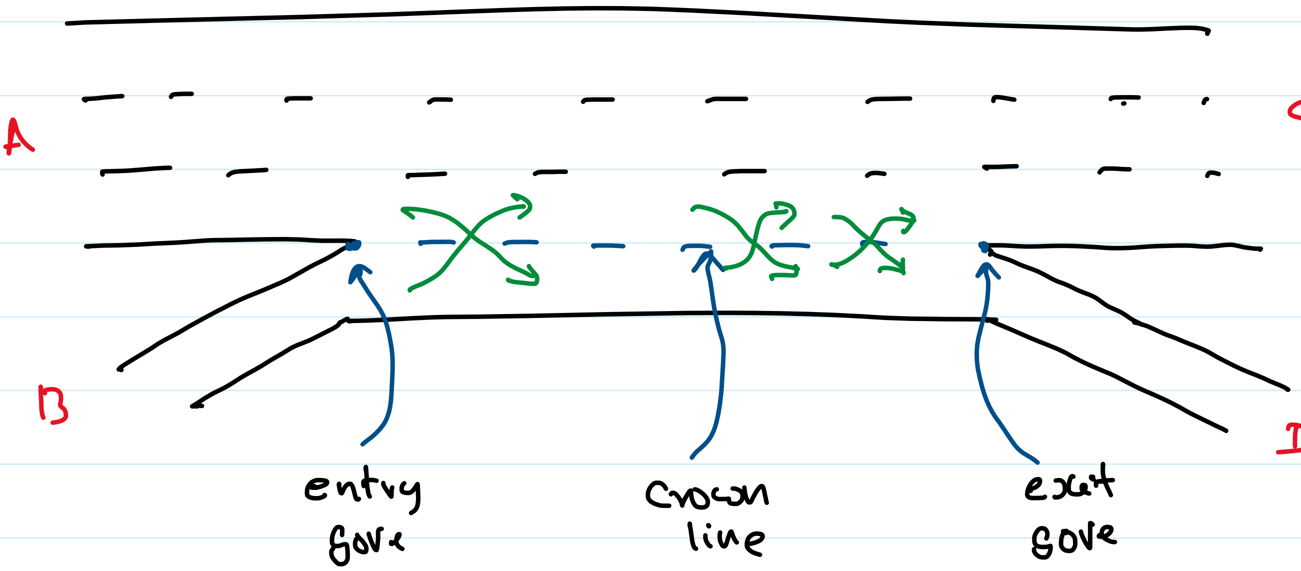
→ 7 types < A 2, B 3, C 2

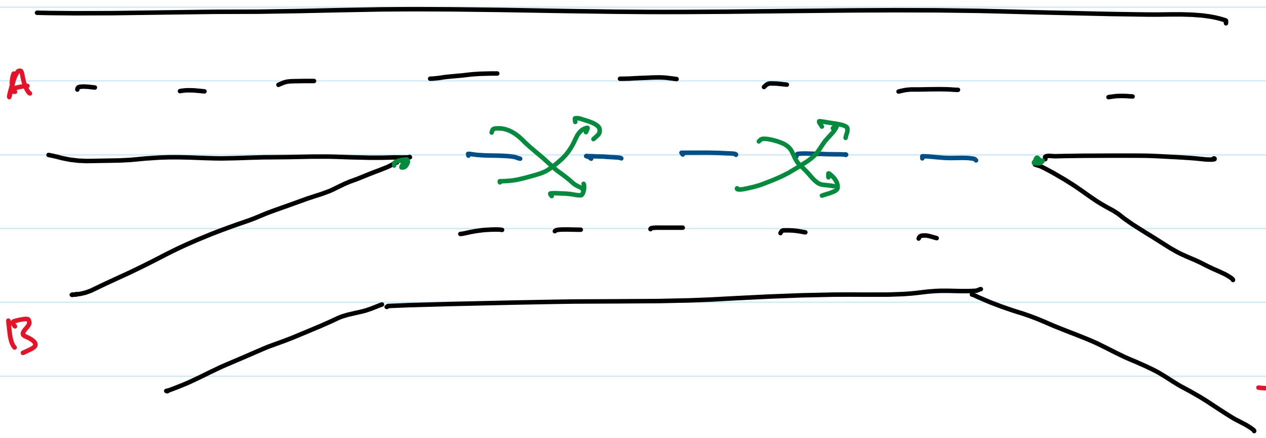
→ 7 types < B 3, C 2

Type. A → All weaving vehicles must make ONE lane change to complete their maneuver successfully.

1 – 1

→ All these happens across the crown line which connects the entry gore and exit gore



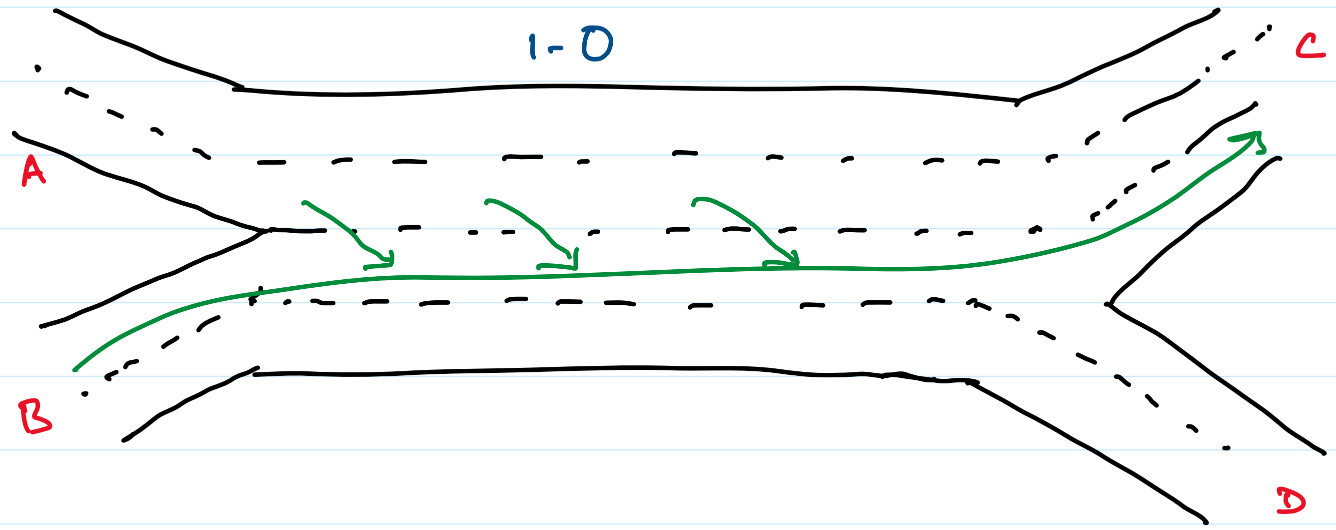


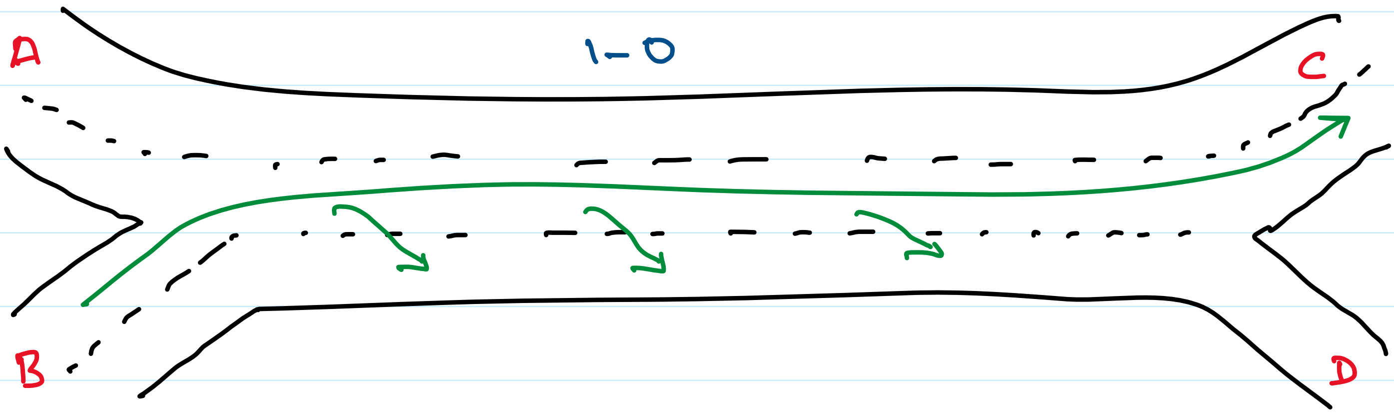
Type- B → One weaving movement with NO Lane change

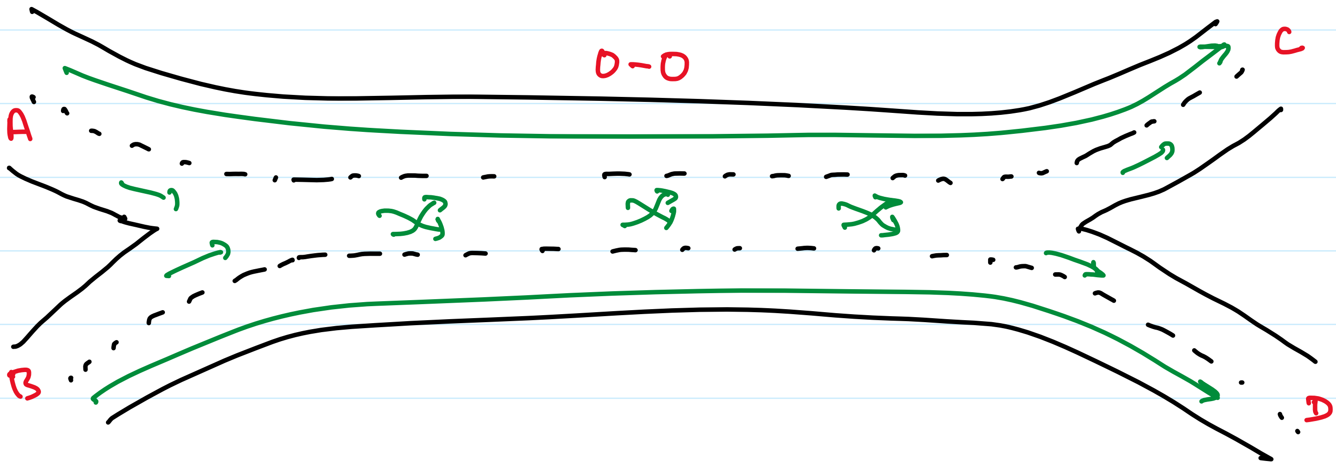
1 – 0

→ Other weaving movement

→ Other weaving movement require atmost ONE lane change.





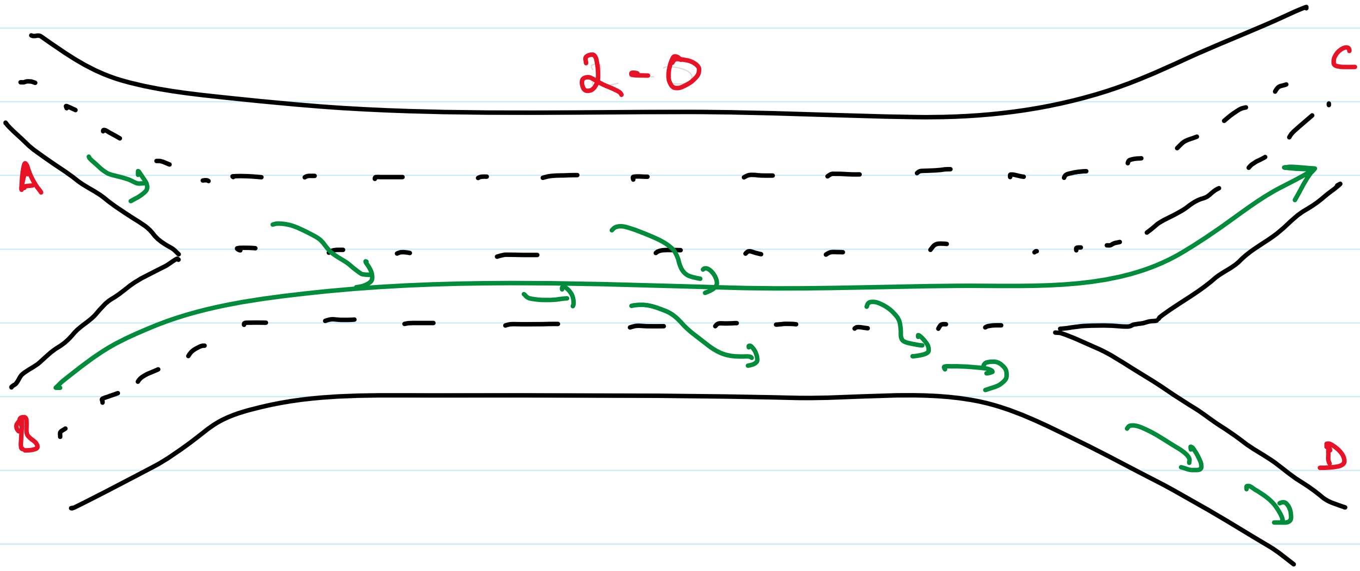


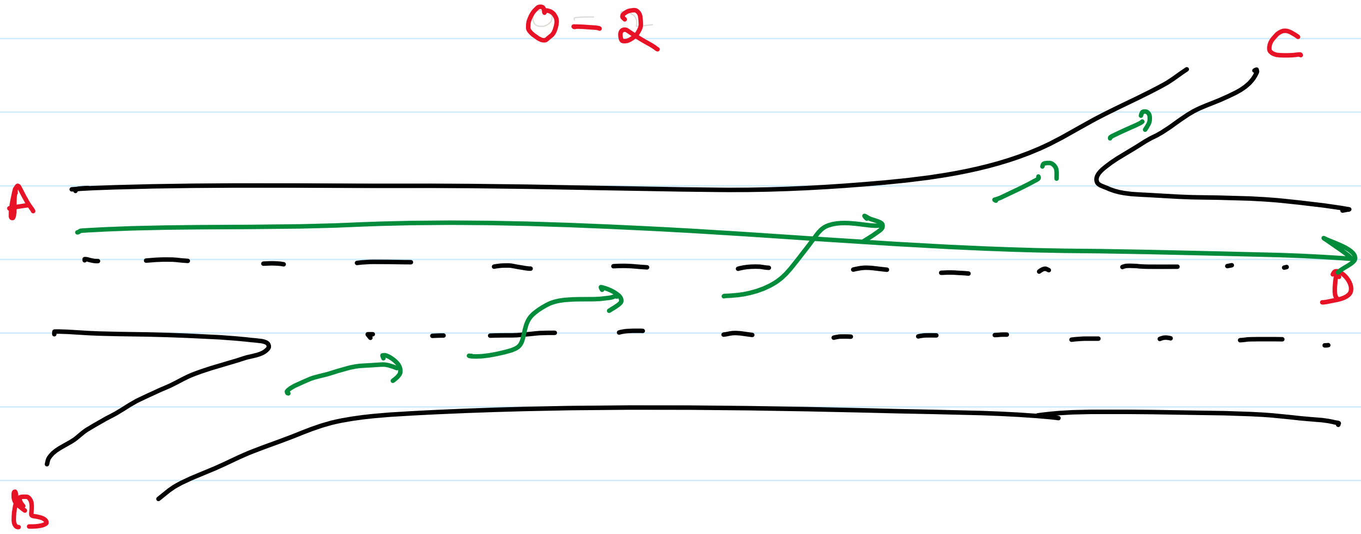
Type-C → One weaving movement may be made with NO lane change

0-2

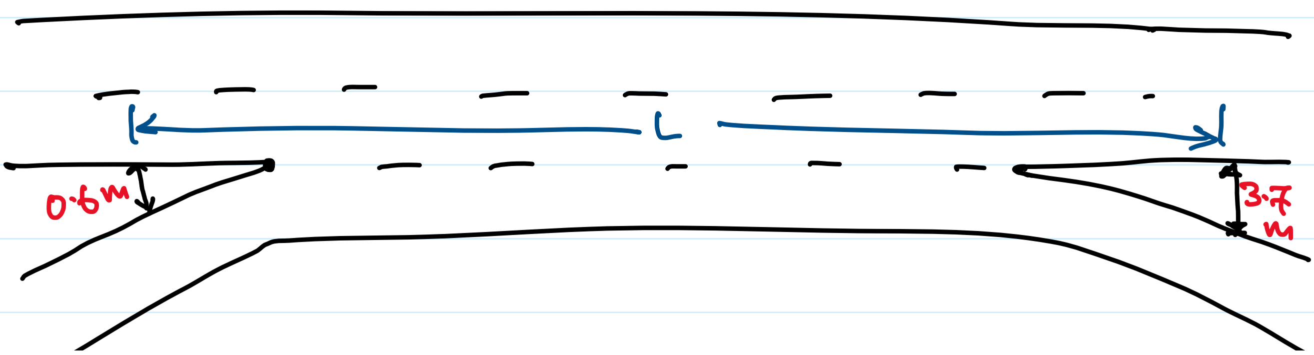
→ Other weaving movement require

→ Other weaving movement require
Two or more lane changes

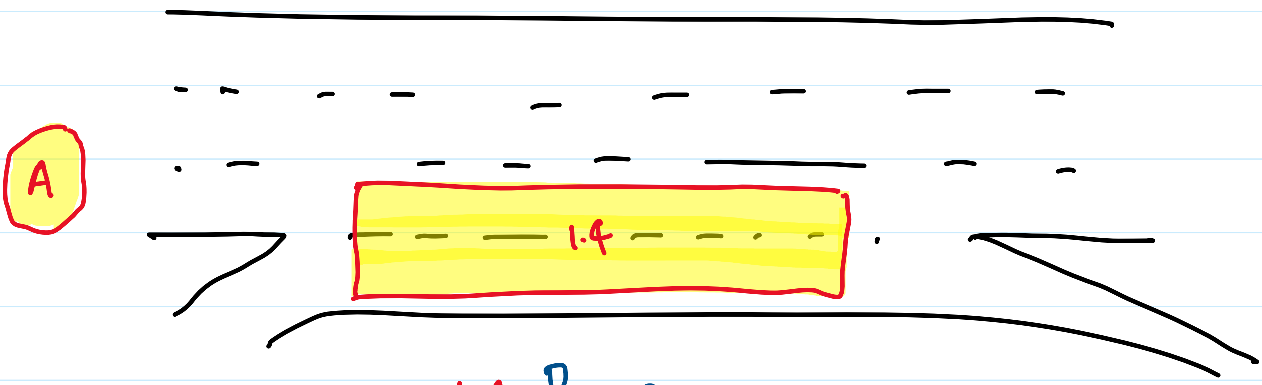




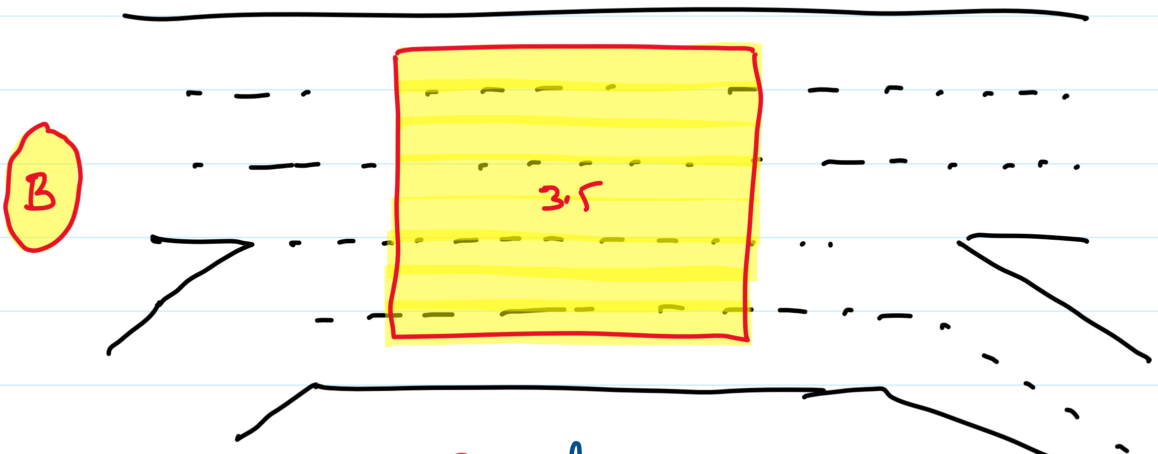
Length of Weaving Area.



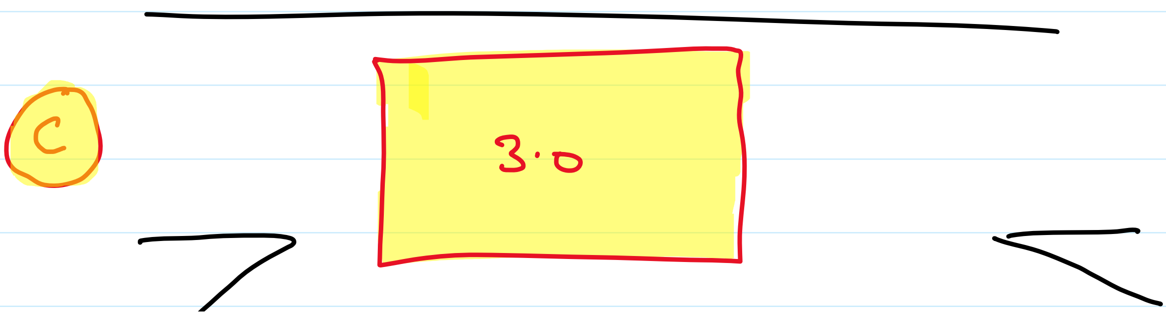
Weaving Width → measured in terms of the no. of lanes provided or effectively used by each type (A, B, C)

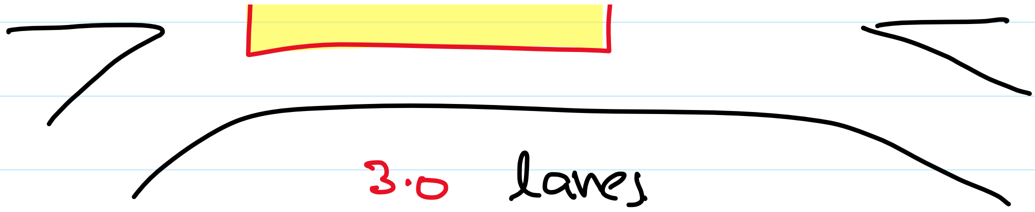


1.4 lane



3.5 lanes





Operational Mode → Constrained
→ unconstrained

N_w → No. of lanes required by weaving veh. to achieve service quality approximatly equal to that of non-weaving movement

N_w^{max} → Max. no. of lanes that is available for use in a particular lane configuration.

If $N_w > N_w^{max}$ ⇒ Constrained. i.e weaving vehicles are restricted by the no. of lanes available.
⇒ performs NOT better than non-weaving vehicles.

else unconstrained. ⇒ weaving vehicles will have a quality same or better in compared to non-weaving.

is compared to non-weaving.

Part - B

Freeway Analysis Methodology

HCM 2000 ch: 24

① Models predicting mean speed of weaving vehicles

② Models describing proportional use of lanes by W and Nw
↳ whether weaving is Constrained / Unconstrained

③ Models to convert predicted speed to average Density within the weaving section

④ Definition of LoS Criteria

⑤ Model for determining the Capacity of the weaving section

Speed
proportion
W
Nw
C & UC
LoS

LoS criteria

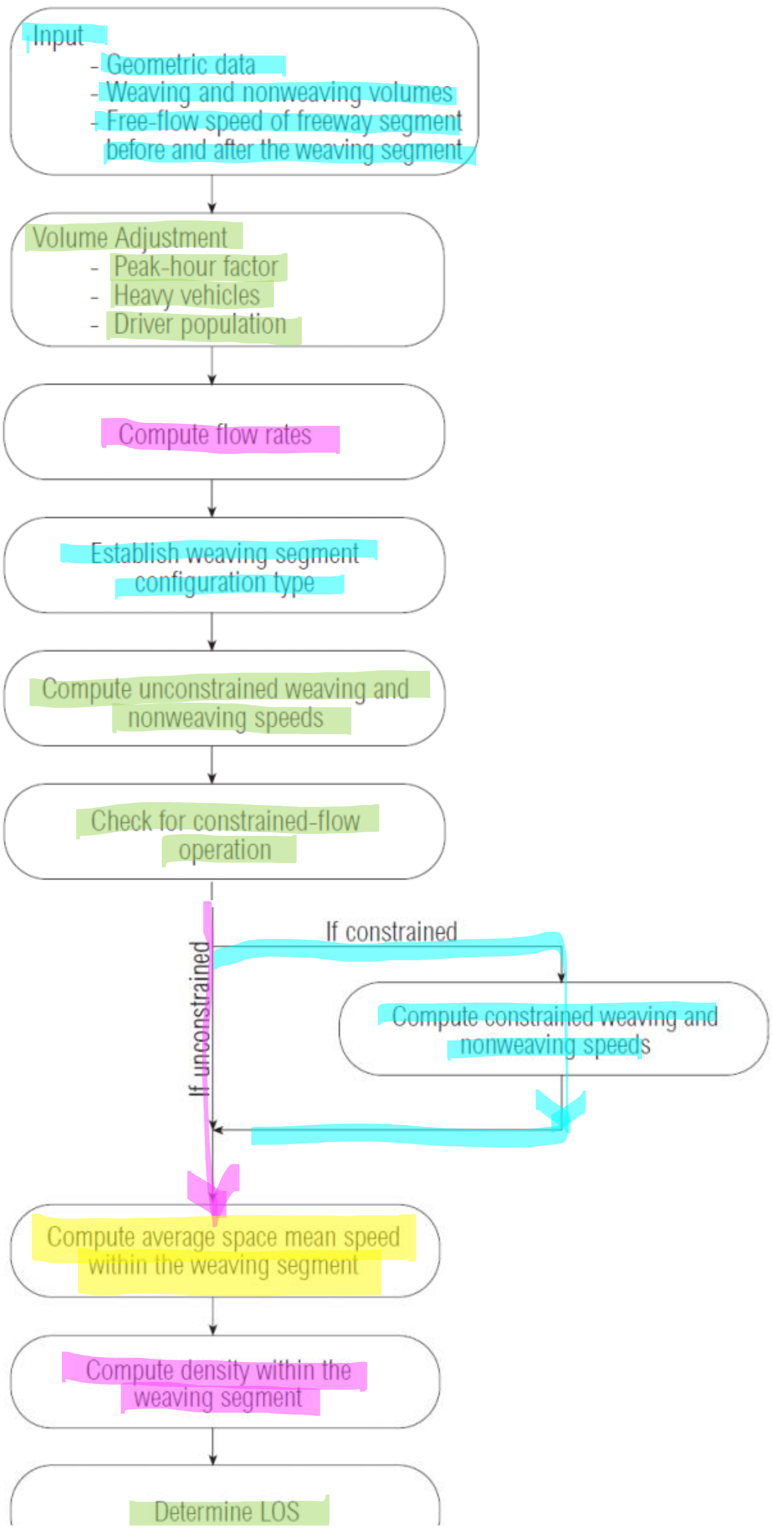
EXHIBIT 24-2. LOS CRITERIA FOR WEAVING SEGMENTS

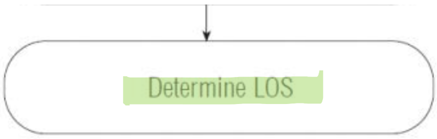
LOS	Density (pc/km/ln) Freeway Weaving Segment	Density (pc/km/ln) Multilane and Collector-Distributor Weaving Segments
A	≤ 6.0	≤ 8.0

LOS	Freeway Weaving Segment	Multilane and Collector-Distributor Weaving Segments
A	≤ 6.0	≤ 8.0
B	> 6.0–12.0	> 8.0–15.0
C	> 12.0–17.0	> 15.0–20.0
D	> 17.0–22.0	> 20.0–23.0
E	> 22.0–27.0	> 23.0–25.0
F	> 27.0	> 25.0

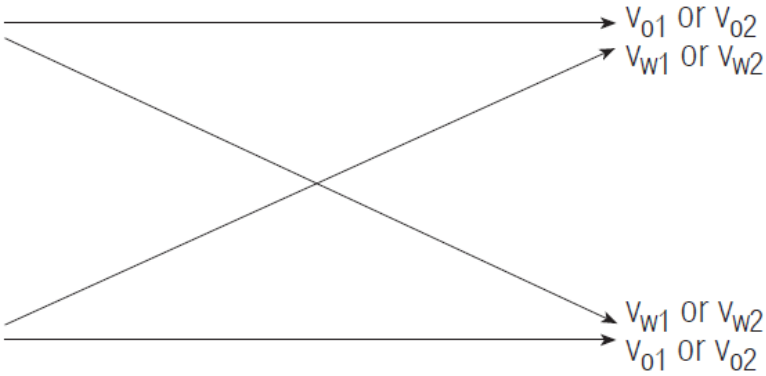
Methodology-

EXHIBIT 24-1. FREEWAY WEAVING METHODOLOGY





Notation



Symbol	Definition
L	Length of weaving segment (m)
N	Total number of lanes in the weaving segment
N_w	Number of lanes to be used by weaving vehicles if unconstrained operation is to be achieved
$N_w(max)$	Maximum number of lanes that can be used by weaving vehicles for a given configuration
N_{nw}	Number of lanes used by nonweaving vehicles
v	Total flow rate in the weaving segment (pc/h)
v_{o1}	Larger of the two outer, or nonweaving, flow rates in the weaving segment (pc/h)
v_{o2}	Smaller of the two outer, or nonweaving, flow rates in the weaving segment (pc/h)
v_{w1}	Larger of the two weaving flow rates in the weaving segment (pc/h)
v_{w2}	Smaller of the two weaving flow rates in the weaving segment (pc/h)
v_w	Total weaving flow rate in the weaving segment (pc/h) ($v_w = v_{w1} + v_{w2}$)
v_{nw}	Total nonweaving flow rate in the weaving segment (pc/h) ($v_{nw} = v_{o1} + v_{o2}$)
VR	Volume ratio; the ratio of weaving flow rate to total flow rate in the weaving segment ($VR = v_w/v$)
R	Weaving ratio; the ratio of the smaller weaving flow rate to total weaving flow rate ($R = v_{w2}/v_w$)
S_w	Speed of weaving vehicles in the weaving segment (km/h)
S_{nw}	Speed of nonweaving vehicles in the weaving segment (km/h)
S	Speed of all vehicles in the weaving segment (km/h)
D	Density of all vehicles in the weaving segment (pc/km/ln)
W_w	Weaving intensity factor for prediction of weaving speed
W_{nw}	Weaving intensity factor for prediction of nonweaving speed

Determining the Flow Rate

$$v = \frac{V}{PHF \times f_{HV} * f_p}$$

peak hour flow

peak 15 min

peak 15 min flow rate — $PHF \times f_{HV} * f_p$

- PHF → Peak hour factor
- f_{HV} → adj. for H.V.
- f_p → adj. factor for driver pop.

Weaving Seg. Config.

		No. of lane change req. for V_{w2}: 0	1	≥2
No. of lane change required for V_{w1}	0	B	B	C
	1	B	A	×
	≥2	C	×	×

Determine Weaving and Non Weaving Speed

($i = w$ for weaving, $i = nw$ for non weaving)

$$S_i = S_{min} + \frac{S_{max} - S_{min}}{1 + W_i}$$

- S_{min} → min. speed ≒ 24 kmph
- S_{max} → max. speed = average of the entering and exiting FFS
- W_i → weaving intensity factor

$$S_i = 24 + \frac{S_{FFS} - 16}{1 + W_i}$$

$$S_i = 24 + \frac{FFS - 16}{1 + W_i}$$

Note: initial speed estimates are based on unconstrained operation.

→ speeds are re computed if it is found to be constrained.

Determining the W_i

$$W_i = \frac{a\,(1+VR)^b \left(\frac{V}{N}\right)^c}{(3.28\,L)^d}$$

- VR: Volume Ratio
- V: weaving flow rate
- N: No. of lanes in the segment
- L: weaving length

Ex 24.b

	i = w				i = nw			
	Constants for Weaving Speed, S_W				Constants for Nonweaving Speed, S_{nw}			
	a	b	c	d	a	b	c	d
Type A Configuration								
Unconstrained	0.15	2.2	0.97	0.80	0.0035	4.0	1.3	0.75
Constrained	0.35	2.2	0.97	0.80	0.0020	4.0	1.3	0.75
Type B Configuration								
Unconstrained	0.08	2.2	0.70	0.50	0.0020	6.0	1.0	0.50
Constrained	0.15	2.2	0.70	0.50	0.0010	6.0	1.0	0.50
Type C Configuration								
Unconstrained	0.08	2.3	0.80	0.60	0.0020	6.0	1.1	0.60
Constrained	0.14	2.3	0.80	0.60	0.0010	6.0	1.1	0.60

Determination of type operation

If $N_w \geq N_w^{max}$ ⇒ Constrained

else Unconstrained.

Compute N_w & N_w^{max}

Ex 24:7

Configuration	Number of Lanes Required for Unconstrained Operation, N_W	$N_W(max)$
Type A	$1.21(N)\,VR^{0.571}L^{0.234}/S_W^{0.438}$	1.4
Type B	$N[0.085 + 0.703VR + (71.57/L) - 0.0112(S_{nw} - S_W)]$	3.5
Type C	$N[0.761 + 0.047VR - 0.00036L - 0.0031(S_{nw} - S_W)]$	3.0[a]

↳ Recompute the speed if it is constrained.

Determination of Weaving Seg. Speed

$$S = \frac{v}{\left(\frac{v_w}{S_w}\right) + \left(\frac{v_{nw}}{S_{nw}}\right)}$$

- v → total flow rate
- v_w → flow rate of weaving
- S_w → SMS of the weaving
- S → SMS of all vehicles.

Determination of Density.

$$D = \frac{v/N}{S}$$

- v → total flow rate
- N → no. of lane
- S → SMS of all vehicles.

From D find LoS.

Finding the Capacity.   Ex 24:8

Type	FFS	L	N	VR
A	120	150	3	0.1
B	110	300	4	0.2
C	100	450	5	

B	110	300	4	0.2
C	100	450	5	:
	90	600		:
		750		0.8

↳ Base Capacity C_b.

$$c = c_b * PHF * f_{HV} * f_p$$

Part. C

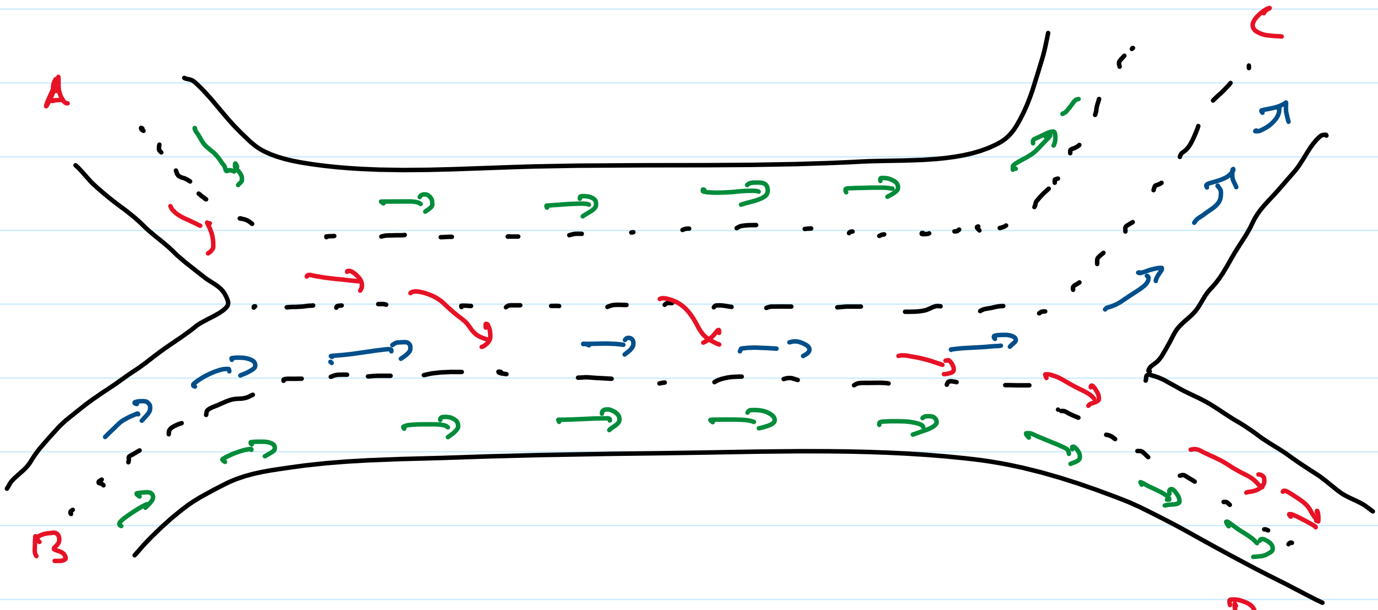
Numerical Example.

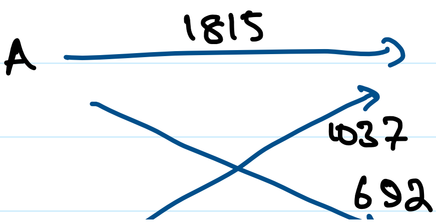
To find Cap. and LoS for weaving segment.

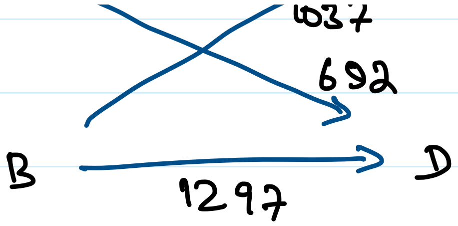
Given: ① 10% trucks, ② 0.91 = PHF ③ level terrain

④ drivers are familiar with the facility

⑤ FFS = 110 kmph ⑥ Weaving length L = 450 m.







Solution

Step ① (a) $f_{HV} = \frac{1}{1+0.1(1.5-1.0)} = 0.952$

(b) $f_p = 1.0$

(c) $V = \frac{V}{PHF \times f_{HV} \times f_p}$

$\therefore V_{AC} = 1815/(0.9 \times 0.952 \times 1.0) = 2095$ pc/hr

$V_{AD} = 692/$ " $= 799$ V_{w2}

$V_{BC} = 1037/$ " $= 1197$ V_{w1}

$V_{BD} = 1297/$ " $= 1497$

Step ② Weaving segment configuration = Type B

AD → 1 lane change
BC → 0 lane change } ⇒ Type B.

Step ③ Critical Volumes.

$V_w = 1197 + 799 = 1996$ pc/hr

$V_{nw} = 2095 + 1497 = 3592$ pc/hr.

$V = 1996 + 3592 = 5588$ pc/hr.

Volume Ratio $\quad V_R = \frac{V_w}{V} = \frac{1996}{5588} = 0.357$

Weaving Ratio $\quad R = \frac{V_{w_2}}{V_w} = \frac{799}{1996} = 0.4$

Step ④ Assume: Unconstrained operation.

ⓐ $$W_i = \frac{a(1+V_R)^b (V/N)^c}{(3.28\ L)^d}$$

Type B unconstrained ∴ Ex 24.6

$$W_w = \frac{0.08(1+0.357)^{2.2} \times \left(\frac{5588}{4}\right)^{0.70}}{(3.28 \times 450)^{0.50}}$$

$= 0.648$

$$W_{NW} = \frac{0.0020(1+0.357)^{6.0} \times \left(\frac{5588}{4}\right)^{1.0}}{(3.28 \times 450)^{0.5}}$$

$= 0.464.$

ⓑ $$S_i = 24 + \frac{S_{FF} - 16}{1 + W_i}$$

$$S_w = 24 + \frac{110 - 16}{1 + 0.648} = 81.00 \text{ kmph}$$

$$S_{NW} = 24 + \frac{110 - 16}{1 + 0.454} = 88.6 \text{ kmph.}$$

$1 + 0.454$

Step ⑤

Ex 24.7 take B

$$N_w = 4\left[0.085 + 0.703\,(0.357) + (71.57/450)\right]$$
$$(-)\left[0.012\,(88.6 - 81.0)\right]$$
$$= 1.64.$$
$$N_w^{max} = 3.5.$$

$\therefore\ N_w < N_w^{max}$ $\therefore$ Unconstrained.

$\therefore$ Speed re-computation not required.

Step ⑥ Compute weaving seg: speed

$$S = \frac{V}{\frac{V_w}{S_w} + \frac{V_{Nw}}{S_{nw}}} = \frac{5588}{\left(\frac{1996}{81}\right) + \left(\frac{3592}{88.6}\right)}$$

$\therefore$ $S = 85.7$ kmph.

⑦ Density.

$$D = \frac{(V/N)}{S} = \frac{(5588/4)}{85.7}$$

$D = 16.3$ pc/km/lane.

⑧ LoS ⇒ D 16.3 → LoS = C Answer.

$$D = 16.3 \text{ pc/km/lane.}$$

(8) LoS ⇒ D 16.3 → **LoS = C** Answer.

(9) Capacity.

Base Capacity C_b from table.

Ex 24:8 (F)

Type	B
FFS	110
L	450
N	4

VR 0.3 → 8820

0.4 → 8120

From Ex 24:8 F.

VR → 0.357

Using interpolation

$$C_b = 8820 - \left[\frac{8820 - 8120}{0.4 - 0.3} \times (0.357 - 0.3)\right]$$

$= 8421$

$$\text{Capacity} = C_b \times PHF \times f_{HV} \times f_p$$

$\therefore \quad = 8421 \times 0.91 \times 0.952 \times 1.0$

$\therefore$ **$C = 7295$ veh/h** Answer.

Capacity = $C_b \times f_{HV} \times f_{HU} \times f_p$

$\therefore \quad = 8421 \times 0.91 \times 0.952 \times 1.0$

$\therefore$ **C = 7295 veh/h** Answer.