CAPACITY OF WEAVING SECTION ON URBAN ROADS

MAYANK DUBEY,
Dr. SEWA RAM ,
D. SANYAL

CONTENTS

AREA OF RESEARCH

BACK TO CONTENTS

Weaving is the cause of disturbance in traffic stream, due to 'weaving vehicles' which change lanes within the length of weaving section. Hence, weaving section comes to have turbulence, great time headway and low capacity, and as a result, becomes a bottleneck of road system.

Research on issues of weaving sections is important to traffic administration and for facility design and plan, especially for enhancing the efficiency and safety of road system

OBJECTIVE, SCOPE & LIMITATIONS

BACK TO CONTENTS

Objective

•Studying the effect of weaving section upon Traffic flow characteristics is indispensible for this study.

•Further quantification of Flow level from delay and Flow (midblock only) is carried out.

•Relationship between capacities of weaving section was studied with Weaving length, speed, no. of lanes in weaving section and weaving ratio.

Scope

The research attempts to present the operational efficiency of weaving section on urban roads with respect to length of weaving section, speed of stream in weaving and the weaving behavior i.e. weaving ratio and volume ratio.

Limitations

•The study is limited to 6 lane divided urban arterial roads with weaving sections which follow or are being followed by ramps.

•Vehicle composition for simulation as part of validation is taken as observed through primary survey.

•Effect of angle of convergence and divergence upon flow in weaving section is not included as range of sample was less.

TERMS AND DEFINITIONS

BACK TO CONTENTS

Weaving Section

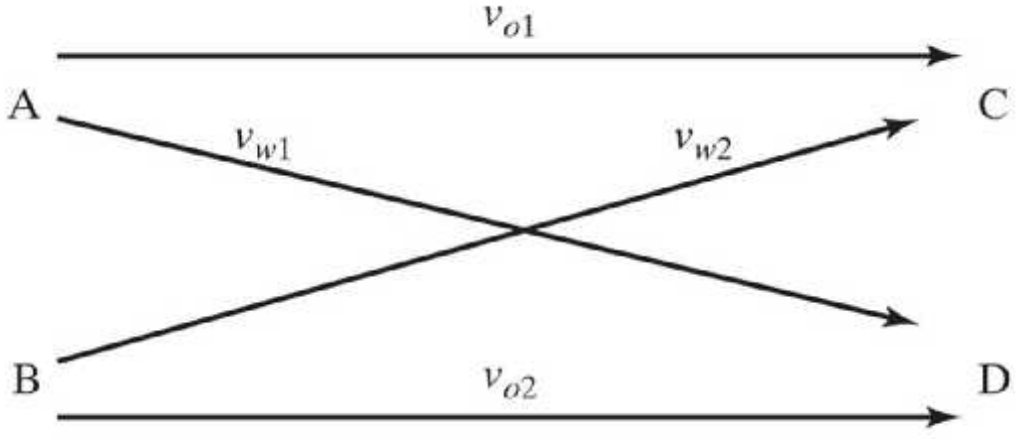
"Highway segments where the pattern of traffic entering and leaving at contiguous points of access results in vehicle paths crossing each other".

Or

"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".

Weaving and Non-weaving Volume

Vehicles in the area are classified as weaving vehicles and non-weaving vehicles. Vehicles with desire to change lane is considered as weaving volume while rest of the flow is called non weaving volume.



Weaving Diagram

$$v_w = v_{w1} + v_{w2}$$

$$v_{nw} = v_{o1} + v_{o2}$$

$$v = v_w + v_{nw}$$

$$\text{Volume Ratio} = v_w / v$$

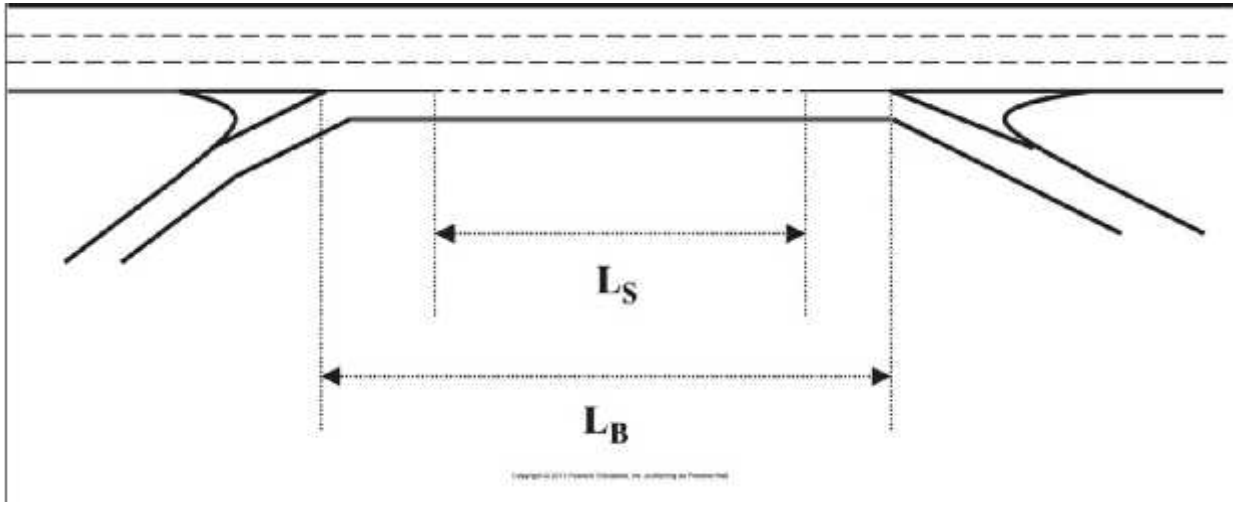
$$\text{Weaving Ratio} = v_{w2} / v_{w1}$$

TERMS AND DEFINITIONS

BACK TO CONTENTS

Length and Area of weaving section

Length between nose to nose of two weaving section where vehicles weave and change lanes. Width of weaving section is measured in the number of lanes which are available for lane change.



Weaving Capacity

There are two school of thoughts to represent the capacity in terms of flow per lane and no. of lane changes. The maximum number of vehicles (per hour) that can pass a weaving section during a period of time or the no. of lane change operations carried out within the given weaving section.

WHAT'S NEED OF LOS FOR WEAVING SECTION ?

BACK TO CONTENTS

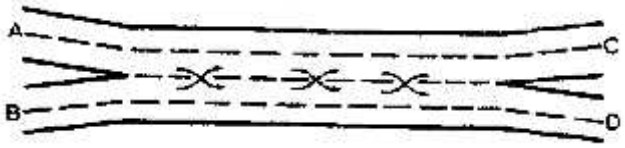
Mid - Block

Extent of flow underlines the Level of Service

Intersection

Extent of delay underlines the Level of Service

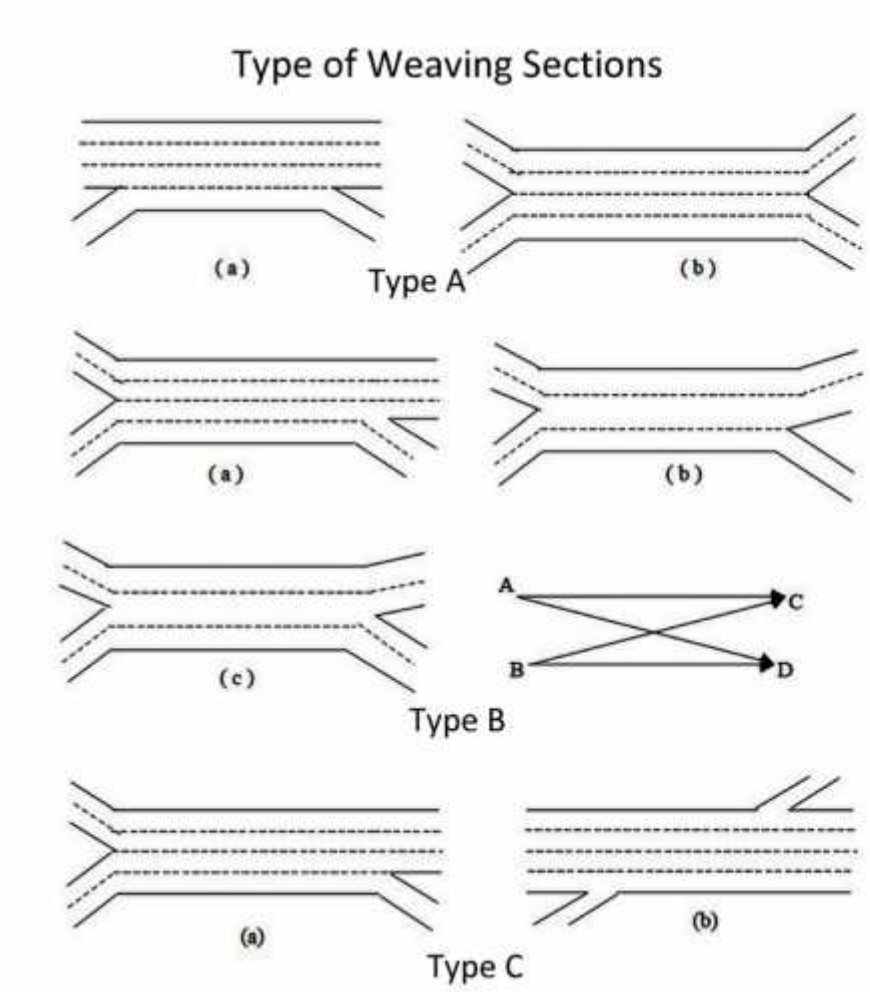
Weaving section



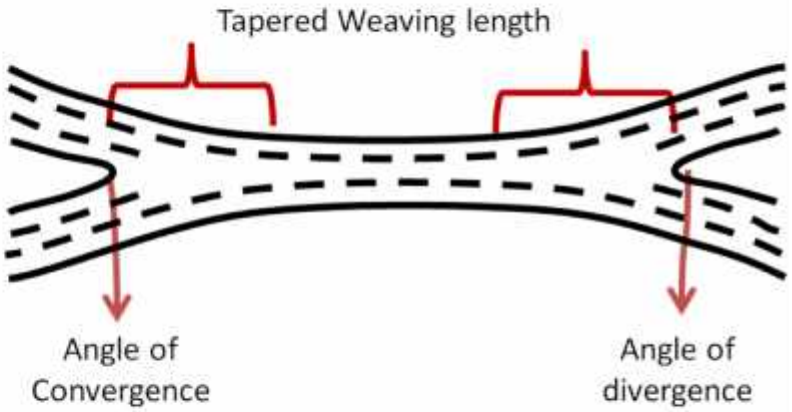
Since weaving section involves lane changing, which causes delay as well as reduced flow so …. **?**

TERMS AND DEFINITIONS

BACK TO CONTENTS



Components of Weaving Section



LITERATURE REVIEW

BACK TO CONTENTS

HCM 1950

Additional research (Normann, 1957; Hess, 1963; Leisch, 1958; Leisch, 1964)

- **Doubling the traffic volume triples the length of the section required and doubles the number of lanes required for the weaving vehicles**
- At no instant could the number of vehicles in the act of crossing the crown line exceed the number that can crowd into a single lane
- The manual found that maximum volumes for weaving sections occur at speeds **between 20 and 30 miles per hour**. Higher speeds are possible only when volumes and traffic density were lower.

HCM 1965

Additional research : Roess, McShane, and Pignataro (1974) ,

- Weaving performance is dependent on the length and width of the weaving section, as well as the composition of traffic.
- Regardless of length or number of lanes, a weaving section will become **congested when the number of weaving vehicles approach the possible capacity of two traffic lanes**
- Weaving section will operate satisfactorily only if traffic on the approach road is well below the practical capacities of these approaches and the weaving section has one more lane than would normally be required for the combined traffic from both approaches.

LITERATURE REVIEW

BACK TO CONTENTS

NCHRP Report 159 : 1975

Additional research Pignataro, McShane, Roess, Crowley, and Lee (1975)

- The procedure takes into account additional variables, including geometrics, traffic composition, volumes of main line vehicles, and volumes of weaving vehicles for weaving section analysis.
- Space mean speeds (average speeds for weaving and non-weaving traffic) rather than operating speeds should be used to develop LOS.
- **Separate equations for major weaving sections and ramp weaving sections should be used.**

HCM 1985

Additional research : Fazio and Rouphail, (1986)

- Complete descriptions and definitions of configuration types for weaving sections were now given and defined by the number of lane changes that must be made to successfully complete each weaving maneuver.
- maximum weaving length criteria at 2,000 feet for Type A configuration and 2,500 feet for Type B and C configurations**. These limits were based on the fact that operations beyond these length were basically isolated merging and diverging actions rather than weaving.**
- Weaving capacity was established at 1,800 passenger cars per hour (pcph) for Type A weaves and 3,000 pcph for Type B & C configurations

LITERATURE REVIEW

BACK TO CONTENTS

HCM 2000

Additional research HCM 2010

Improvements were suggested for the speeds of weaving and non-weaving vehicles, adjustments to the constants that generate the weaving intensity factors, and an attempt to develop a **model for capacity of a weaving section depending upon gap acceptance behavior**.

The new models continue to suggest that capacity is affected by the length of the weaving sections. For Type A configurations there appears to be a great sensitivity to length. Type B and C sections show a small difference in capacity.

when higher free flow speeds are achieved, higher capacity values will occur.

SAFETY

Safety, together with capacity, speed, operational flexibility, cost, and level of service, constitute fundamental design criteria. **Cirillo (1970)** analyzed the effective length of weaving sections, acceleration lanes, and deceleration lanes and the effect on accident experiences of these facilities.

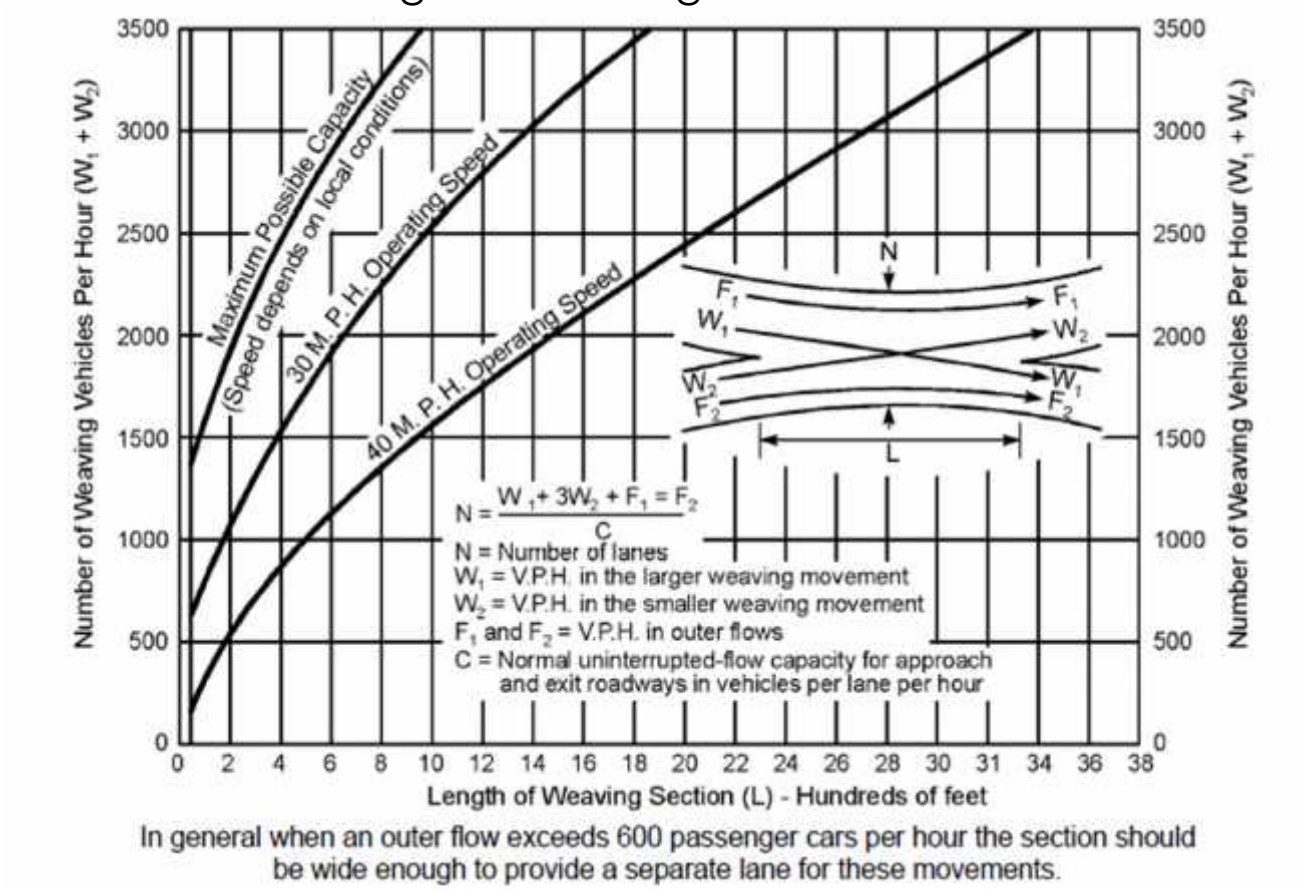
Fazio, Holden, and Rouphail (1993) concluded that weaving sections with shorter lengths (500 ft. or less) have higher conflicts but lower crash rates.

HCM 2000, The accident rates were substantially higher for acceleration lanes than for deceleration lanes.

CAPACITY MODELS

BACK TO CONTENTS

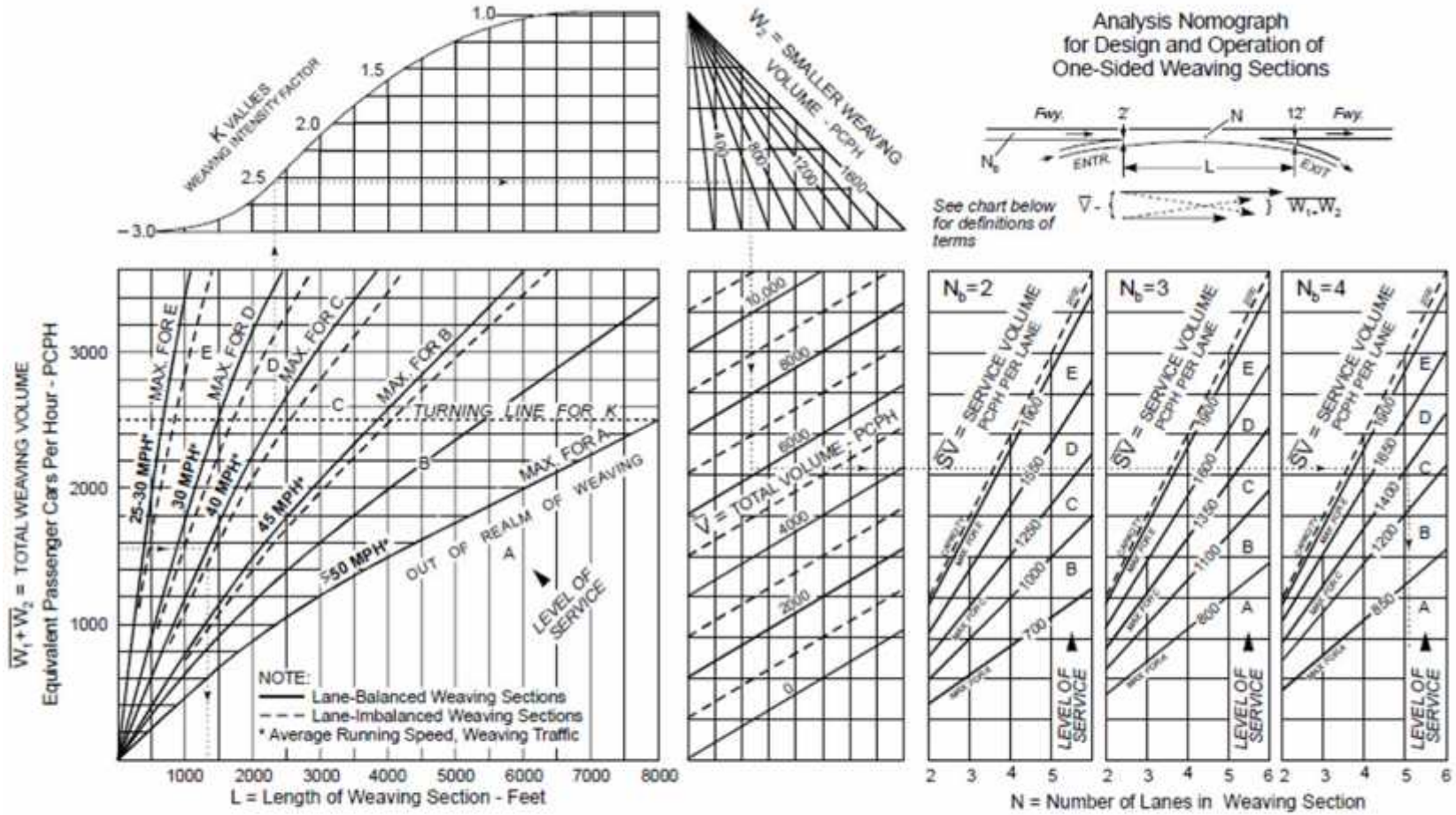
For a given weaving length, speeds of weaving and non-weaving vehicles decrease as the weaving volume increases. Similarly, speeds increase as weaving length increases for a given weaving volume.



Source : Highway Capacity Manual, 2000,

CAPACITY MODELS

BACK TO CONTENTS

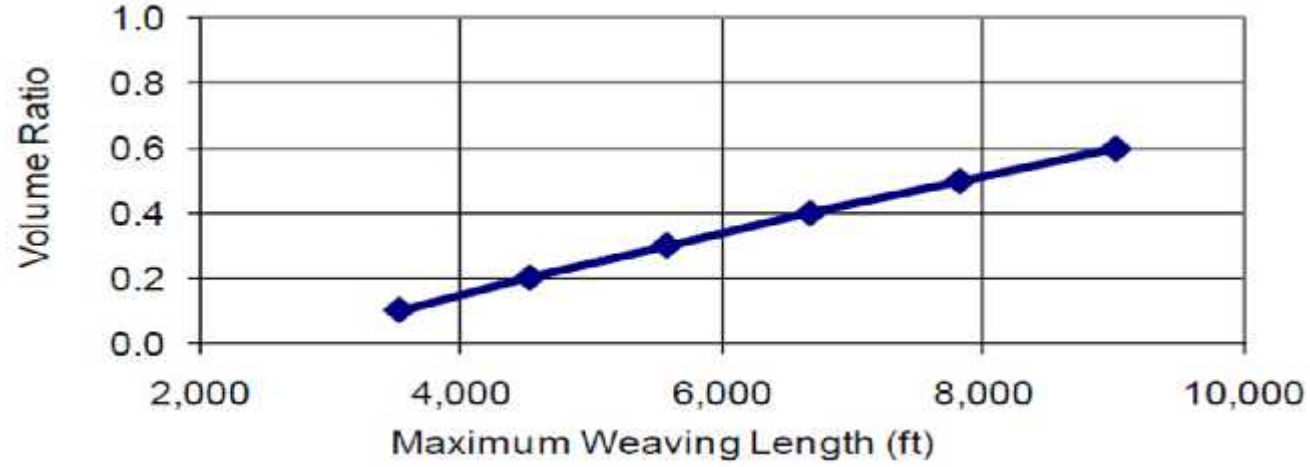


Nomograph for Design and Analysis of Weaving Sections – One-Sided Configurations

Source : Highway Capacity Manual, 2000,

CAPACITY MODELS

BACK TO CONTENTS



$$L_{max} = [5728(1+VR)1.6]-[1566*N_{WL}] \quad (3)$$

where:

L_{max} = the maximum weaving section length (using the short-length definition);
VR = volume ratio: $VR = v_W/v$;
v = total demand flow rate in the weaving section (pc/h);
v_W = weaving demand flow rate in the weaving section (pc/h): $v_W = v_{RF} + v_{FR}$;
v_{RF} = ramp-to-freeway demand flow rate in the weaving section (pc/h);
v_{FR} = freeway-to-ramp demand flow in the weaving section (pc/h); and
N_{WL} = number of lanes from which a weaving maneuver may be made with one or no lane changes (for a section with an auxiliary lane, $N_{WL} = 2$).

Source : Roess, RP and Ulerio JM (1999), “Weaving Area Analysis in the Year 2000 Highway Capacity Analysis”.

CASE STUDY DETAILS

BACK TO CONTENTS

[redacted]

serial	Name	Angle of convergence in degree	Angle of divergence in degree	Length of weaving in km	Length of taper in km	No of lanes before & after weaving	No. of lanes in weaving	Lane Nomenclature
1	ITO Flyover on ring road	15	15	0.17	0	6 & 6	3	3-3---3---3-3
2	Between Millennium Depot and sarai Kale khan	5	5	0.36	0.3	6 & 6	4	3-3---4---3-3
3	Between DND Flyway and Eastern Avenue Road	10	90	0.5	0.3	6 & 6	3	3-3---3---3-3
4	Between Eastern Avenue Road and Ashram	90	5	0.25	0.05	6 & 6	3	3-3---3---3-3

CASE STUDIES

BACK TO CONTENTS

1. Weaving Section on ITO Flyover , ring road.

Lane configuration –

3-3-----3------3-3

2. Weaving Section from millennium park to sarai kale khan on ring road.

Lane configuration –

3-3-----4------3-3

3. Weaving Section from eastern avenue road to Ashram on ring road.

Lane configuration –

3-3-----3------3-3

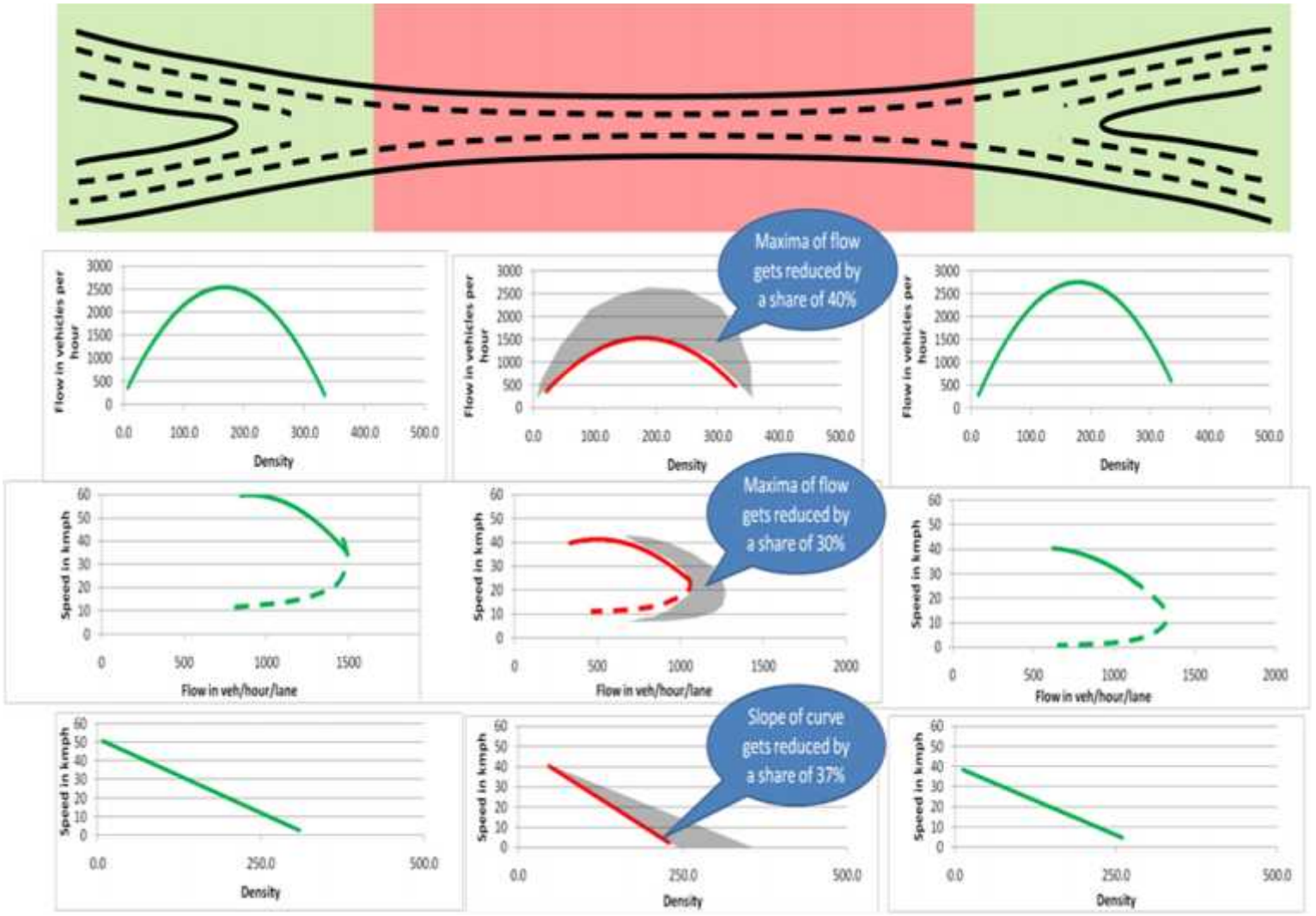
4. Weaving Section from DND to eastern avenue road on ring road.

Lane configuration –

3-3-----3------3-3

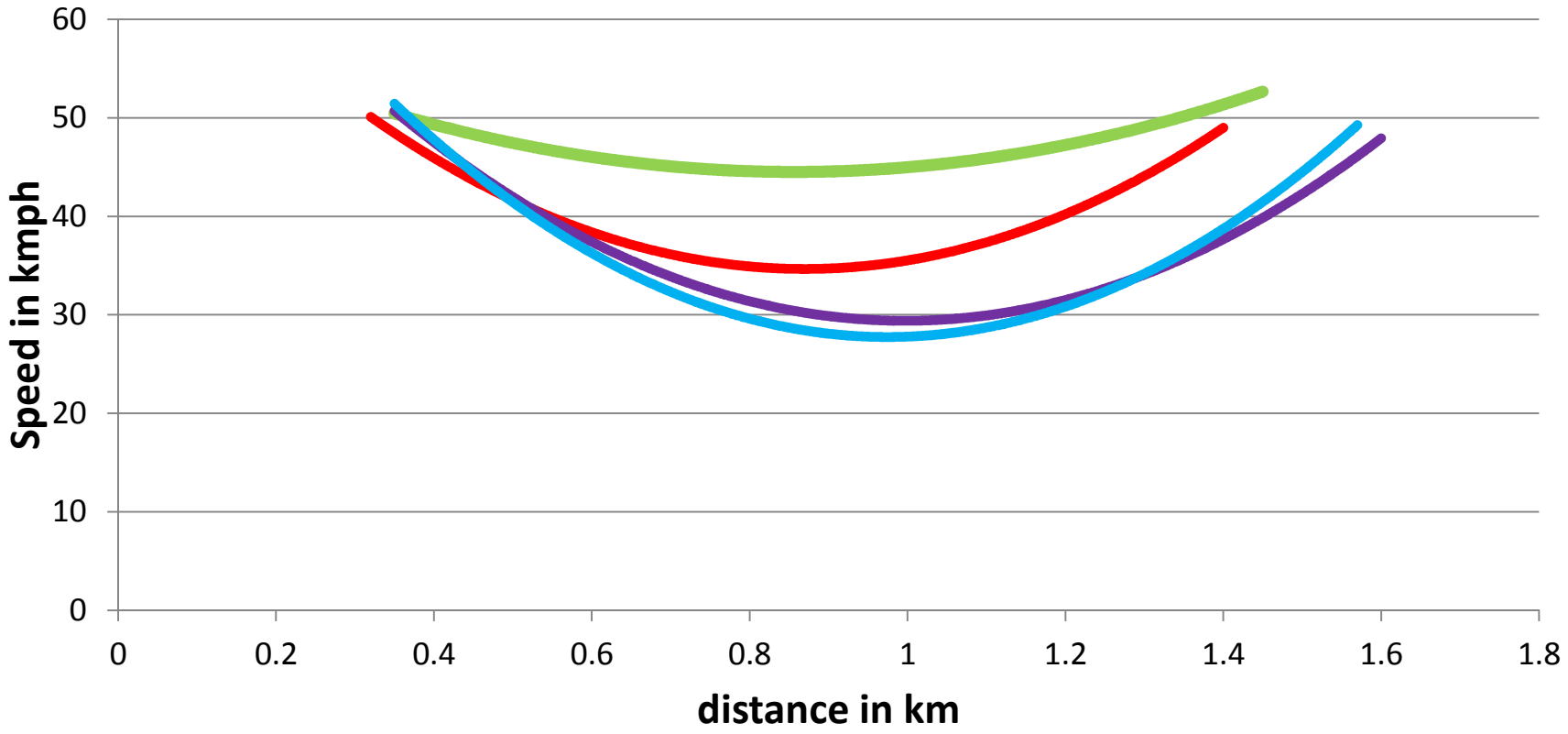
TRAFFIC FLOW CHARACTERISTICS IN WEAVING SECTION

BACK TO CONTENTS



DATA ANALYSIS ... 1

BACK TO CONTENTS



Saturation Level B

$y = 23.144x^2 - 39.641x + 61.481$

$R^2 = 0.2088$

Saturation Level C

$y = 51.028x^2 - 88.793x + 73.281$

$R^2 = 0.3003$

Saturation Level E

$y = 50.927x^2 - 101.53x + 79.993$

$R^2 = 0.5803$

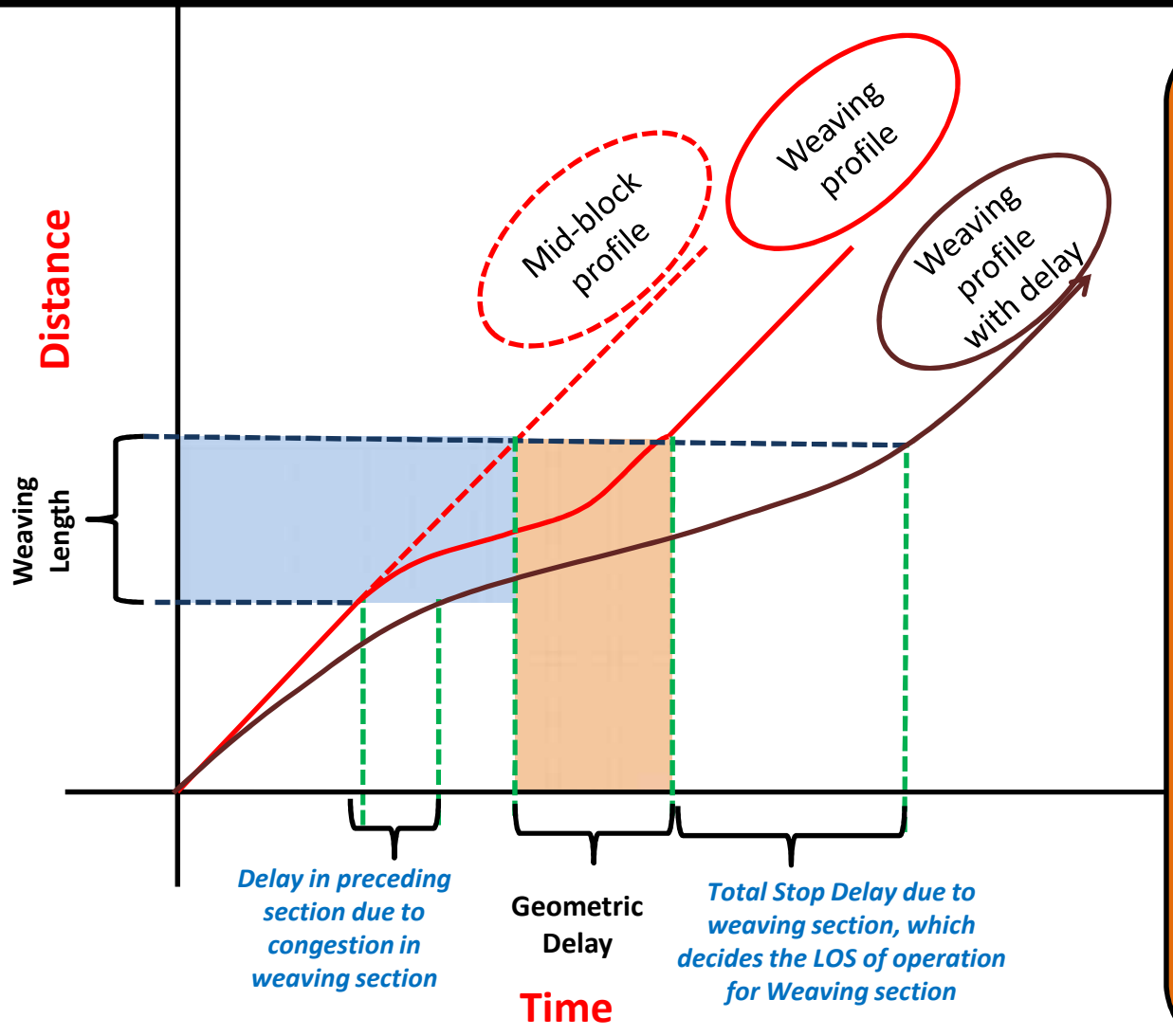
Saturation Level F

$y = 60.73x^2 - 118.38x + 85.433$

$R^2 = 0.468$

DATA ANALYSIS... 2

BACK TO CONTENTS

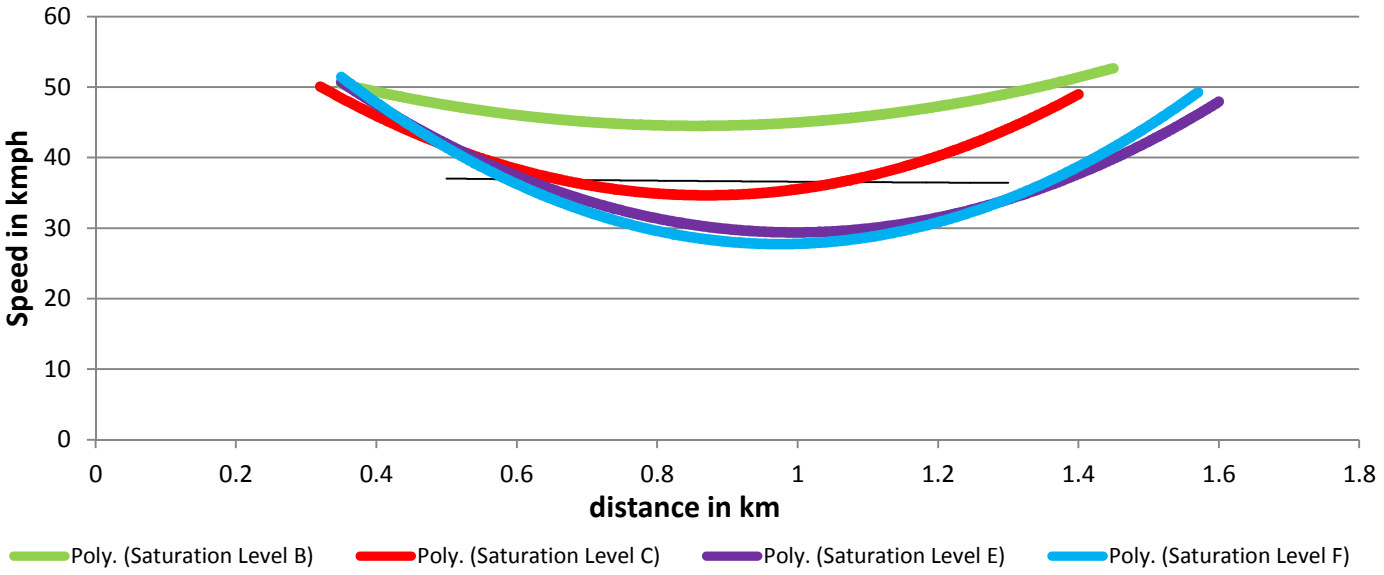


Reasons for varying "Total Stop Delay" :

- **Insufficient length of weaving Section**
- **Reduced no. of lanes as compared to preceding mid-blocks.** *(Although reduced no. of lanes is good for reducing speed of stream and hence helps in accepting gap)*
- ***Different Weaving ratio and volume ratio***
- ***Different vehicle composition***
- ***Side Friction***

DATA ANALYSIS... 3

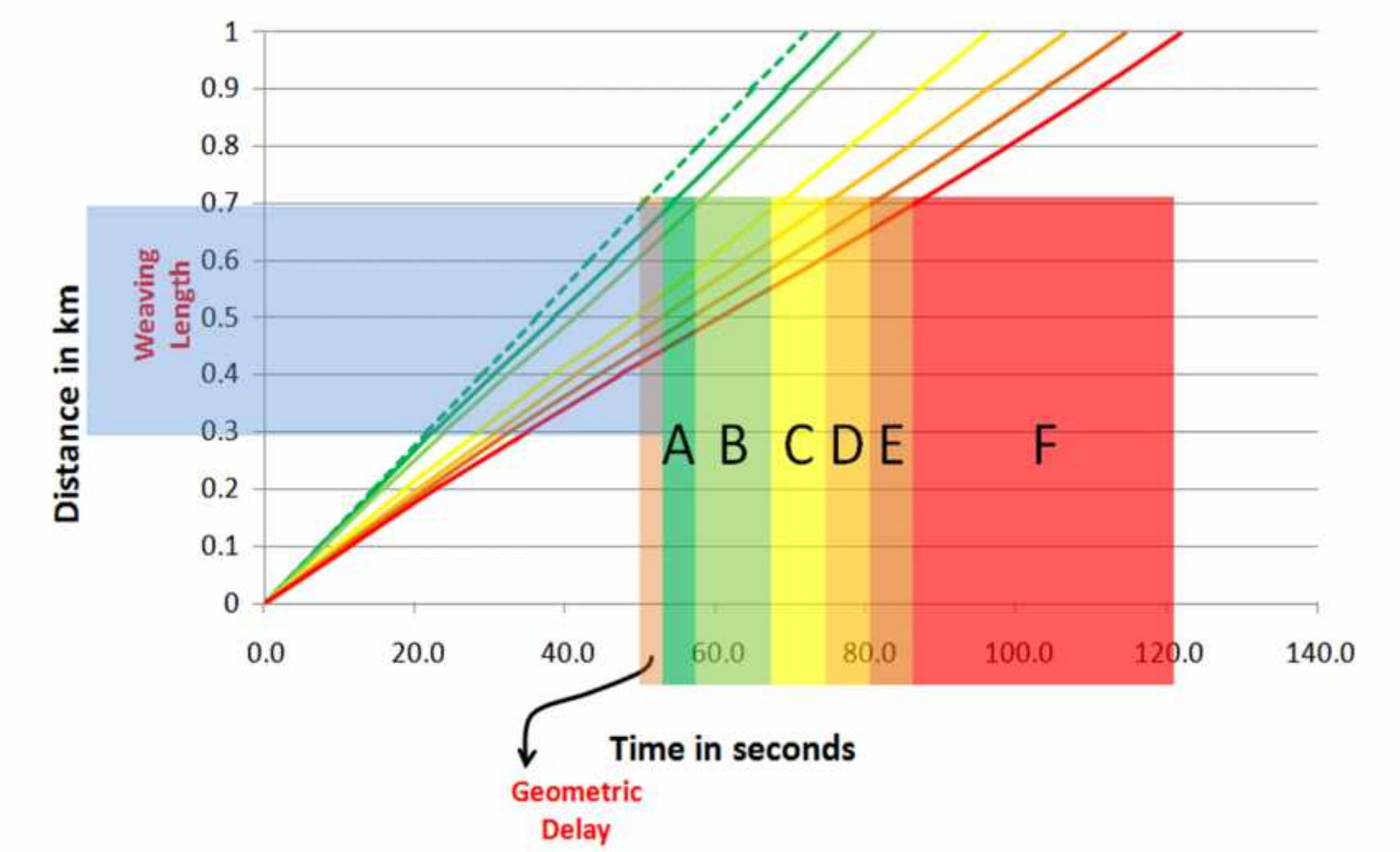
BACK TO CONTENTS



Saturation Level	Flow	eqn	Weaving distance in km at given speeds in kmph						
			70	60	50	40	30	20	10
A	514		2.44	1.67	0.90	0.13			
B	857	23.14X^2 -16.49X +47.44	2.44	1.67	0.97	0.45			
C	1200	51.02X^2 -37.76X +41.64	2.44	1.67	1.05	0.76	0.45		
D	1543		2.44	1.67	1.12	0.90	0.51	0.14	
E	1714	50.92X^2 -50.6X +41.96	2.44	1.67	1.27	1.02	0.77	0.51	0.25
F	2091	60.73X^2 -57.65X +41.42	2.44	1.67	1.37	1.14	1.03	0.91	0.80

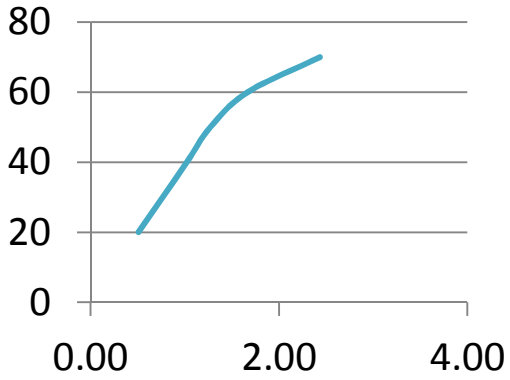
DATA ANALYSIS… 4

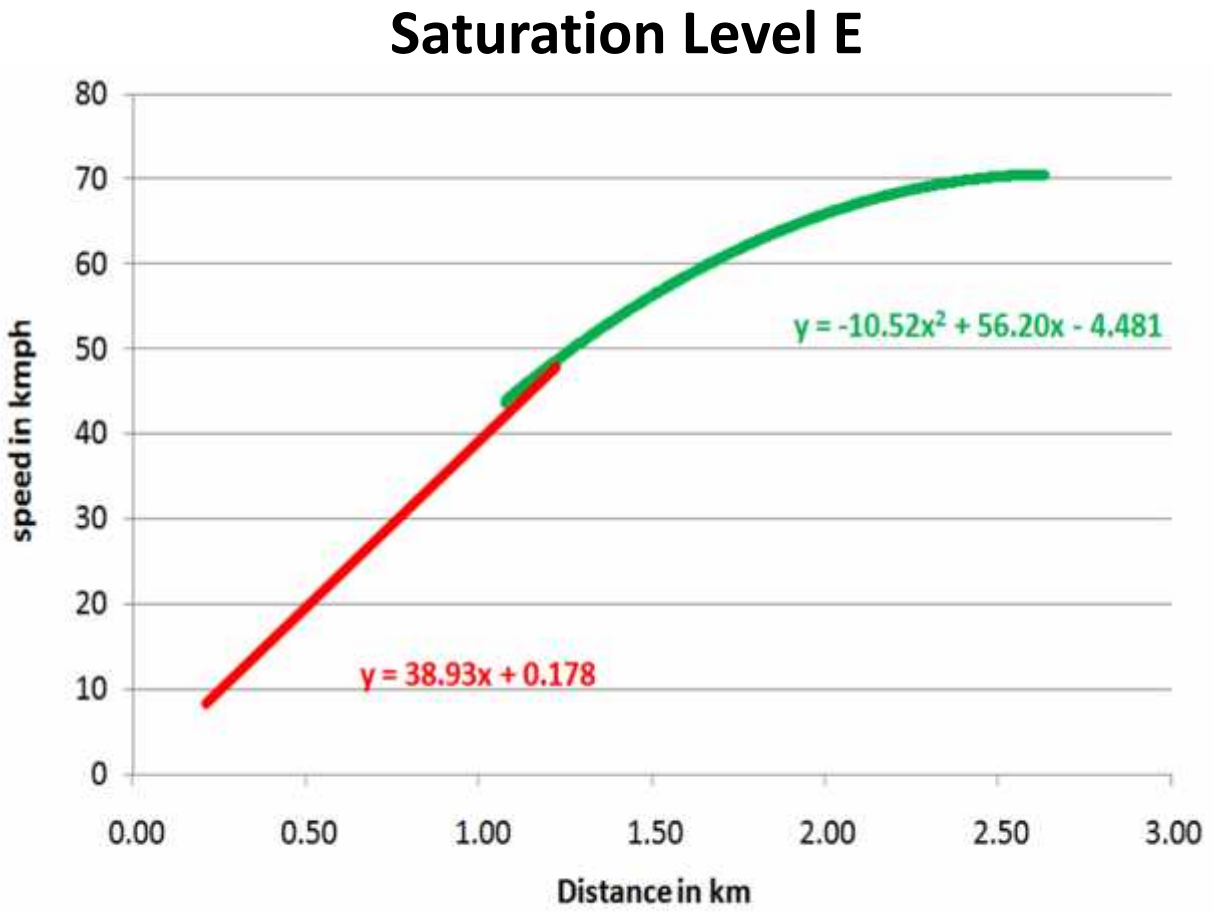
BACK TO CONTENTS



MODEL FORMULATION … 1

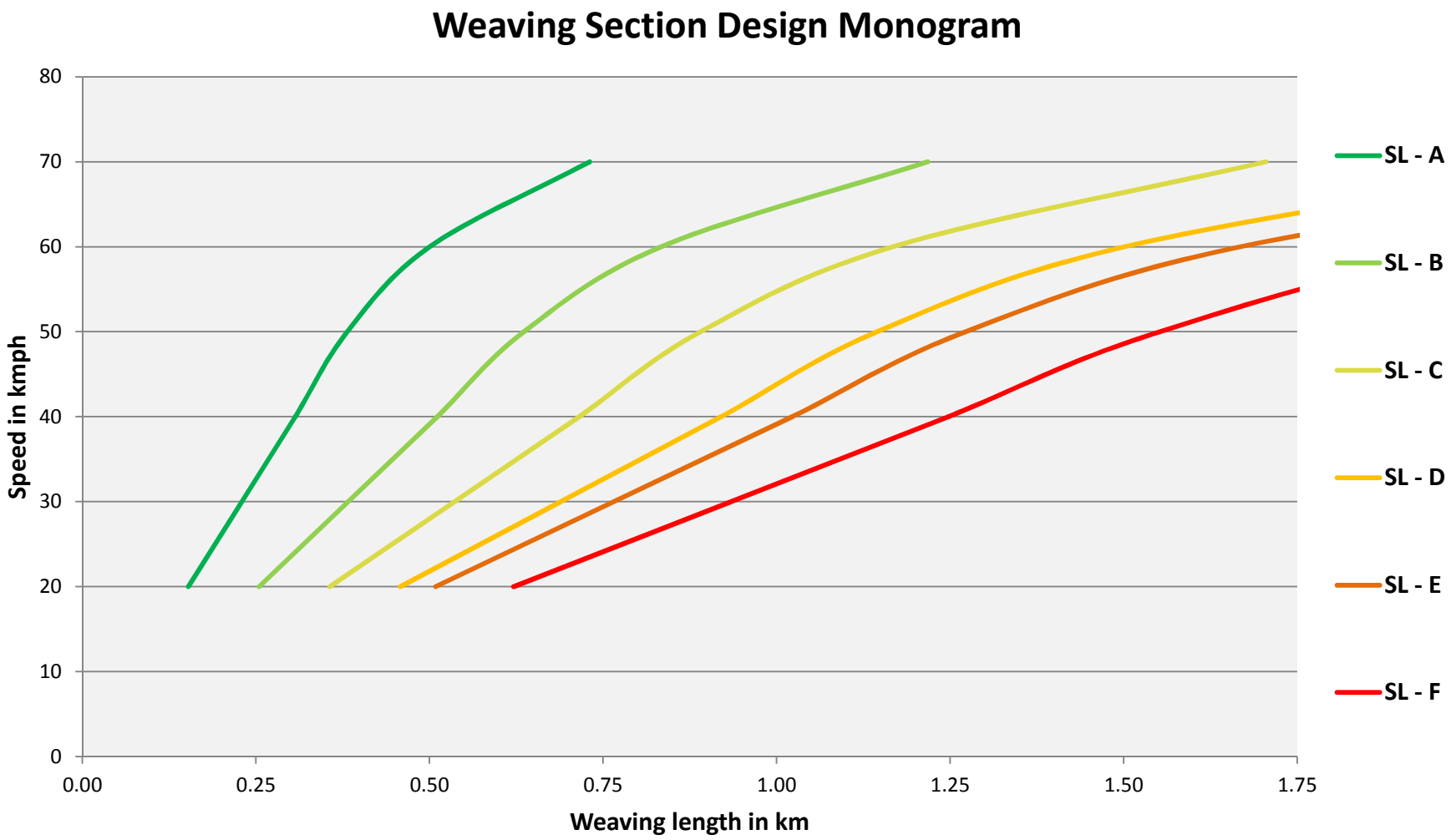
BACK TO CONTENTS





MODEL FORMULATION ... 2

BACK TO CONTENTS

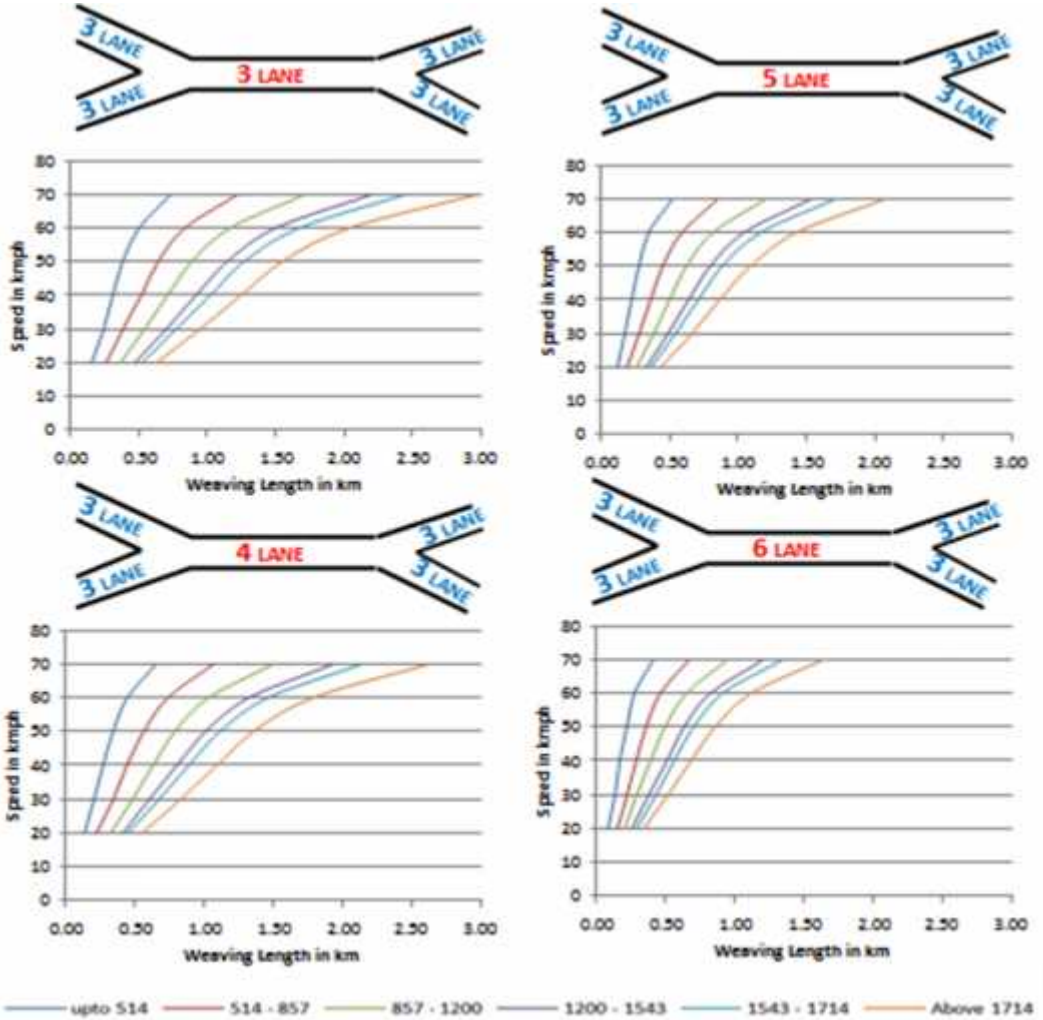


MODEL FORMULATION … 3

BACK TO CONTENTS

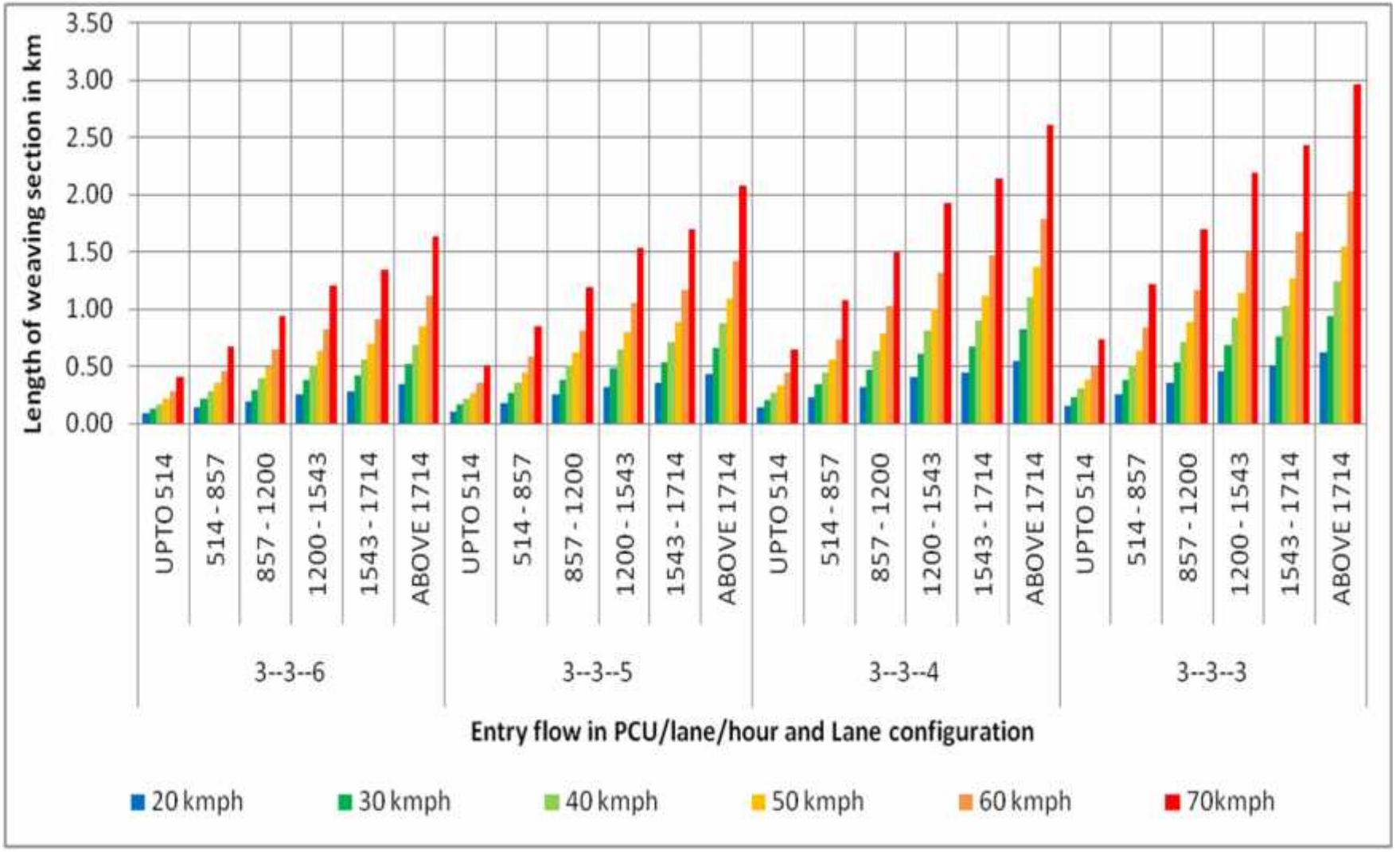
[redacted]

Lane Configuration	Speed / Flow	20	30	40	50	60	70
3--3--6	UPTO 514	0.08	0.13	0.17	0.21	0.28	0.40
	514 - 857	0.14	0.21	0.28	0.35	0.46	0.67
	857 - 1200	0.20	0.29	0.39	0.49	0.64	0.94
	1200 - 1543	0.25	0.38	0.51	0.63	0.83	1.21
	1543 - 1714	0.28	0.42	0.56	0.70	0.92	1.34
	ABOVE 1714	0.34	0.51	0.69	0.85	1.12	1.63
3--3--5	UPTO 514	0.11	0.16	0.21	0.27	0.35	0.51
	514 - 857	0.18	0.27	0.36	0.45	0.58	0.85
	857 - 1200	0.25	0.38	0.50	0.62	0.82	1.19
	1200 - 1543	0.32	0.48	0.64	0.80	1.05	1.53
	1543 - 1714	0.36	0.54	0.72	0.89	1.17	1.71
	ABOVE 1714	0.43	0.65	0.87	1.09	1.42	2.08
3--3--4	UPTO 514	0.13	0.20	0.27	0.34	0.44	0.64
	514 - 857	0.22	0.34	0.45	0.56	0.73	1.07
	857 - 1200	0.31	0.47	0.63	0.78	1.03	1.50
	1200 - 1543	0.40	0.61	0.81	1.01	1.32	1.93
	1543 - 1714	0.45	0.67	0.90	1.12	1.47	2.14
	ABOVE 1714	0.55	0.82	1.10	1.37	1.79	2.62
3--3--3	UPTO 514	0.15	0.23	0.31	0.38	0.50	0.73
	514 - 857	0.25	0.38	0.51	0.64	0.83	1.22
	857 - 1200	0.36	0.54	0.72	0.89	1.17	1.71
	1200 - 1543	0.46	0.69	0.92	1.15	1.50	2.19
	1543 - 1714	0.51	0.77	1.02	1.27	1.67	2.44
	ABOVE 1714	0.62	0.93	1.25	1.55	2.04	2.97



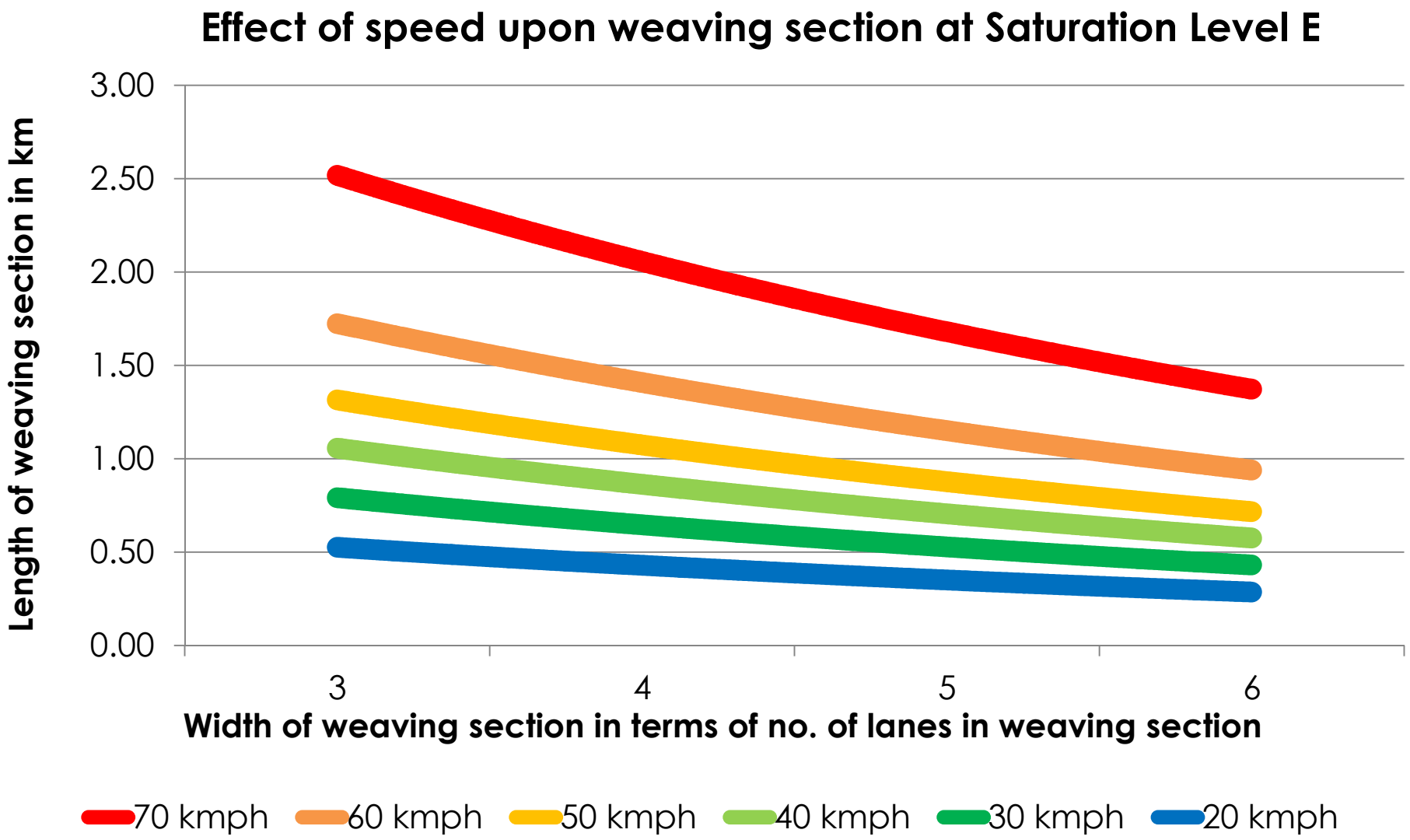
MODEL FORMULATION … 4

BACK TO CONTENTS



MODEL FORMULATION … 6

BACK TO CONTENTS



RECOMMENDATIONS

BACK TO CONTENTS

Traffic Management Technique

- If flow exceeds the permitted maximum flow on a weaving section then traffic diversion may be adopted.
- Depending upon the directional flow, no of lanes needed can be increased/decreased

Design of Urban weaving sections

- Design of weaving section depending upon entry flow, speed, available length, available width, and weaving ratio

Spacing of Flyovers and Ramp Spacing

- Depending upon the available length and width, lane configuration can be defined for design
- By varying weaving length and width, speed of stream can also be regulated

SCOPE FOR FURTHER RESEARCH

BACK TO CONTENTS

- Capacity of Weaving Section based upon GAP ACCEPTANCE behavior
- Effect of conflict angle and convergence/divergence upon capacity of Weaving Section
- Identifying the maximum and minimum spacing between merging and diverging
- Effect of different types of weaving upon capacity of weaving section
- LOS standards for Weaving Section operations
- and further more…

REFERENCES

BACK TO CONTENTS

- Cassidy, M.J., and May, A.D. *Proposed analytical technique for estimating capacity and level of service of major freeway weaving sections*. Transportation Research Record, No. 1329 pp. 99-109, 1991.
- D.C., T. n. (1985). *Highway Capacity Manual, Special Report 209,*.
- Fitzpatrick, K., and Nowlin, L. *One-sided weaving operations on one-way frontage roads*. Transportation Research Board Annual Conference, Washington D.C., 1996.
- Hess, J.W., "Traffic Operation in Urban Weaving Areas." Bureau of Public Roads (1963 data, in preparation for publication).
- Highway Capacity Manual (HCM) 2000 – Weaving Segments, Chapter 24, Transportation
- HRB Special Report 87: Highway Capacity Manual, HRB, National Research Council, Washington, DC 1965, pp. 160-186
- McShane, W.R., and Roess, R.P. Traffic Engineering. Prentice Hall, Englewood cliffs, New Jersey. ISBN 0-13-926148-6., 1990.
- Ostrom,B., Lannon, L., and May A.D. *Suggested procedures for analyzing freeway weaving sections*. Transportation Research Record, No. 1398 pp. 42-48, 1993.
- Special Report 209: Highway Capacity Manual. TRB, National Research Council, Washington, D.C., 1985
- TRB. (1965). *Highway Capacity Manual, Special Report 87*. TRB national research council.
- TRB national research council Washington D.C. (1985). *Highway Capacity Manual, Special Report 209,*.
- TRB national research council Washington D.C. (1965). *Highway Capacity Manual, Special Report 87*.
- Transportation Research Board, Highway Capacity Manual, Special Report 209, 1997.

BACK TO CONTENTS

LET'S *DISCUSS*

BACK

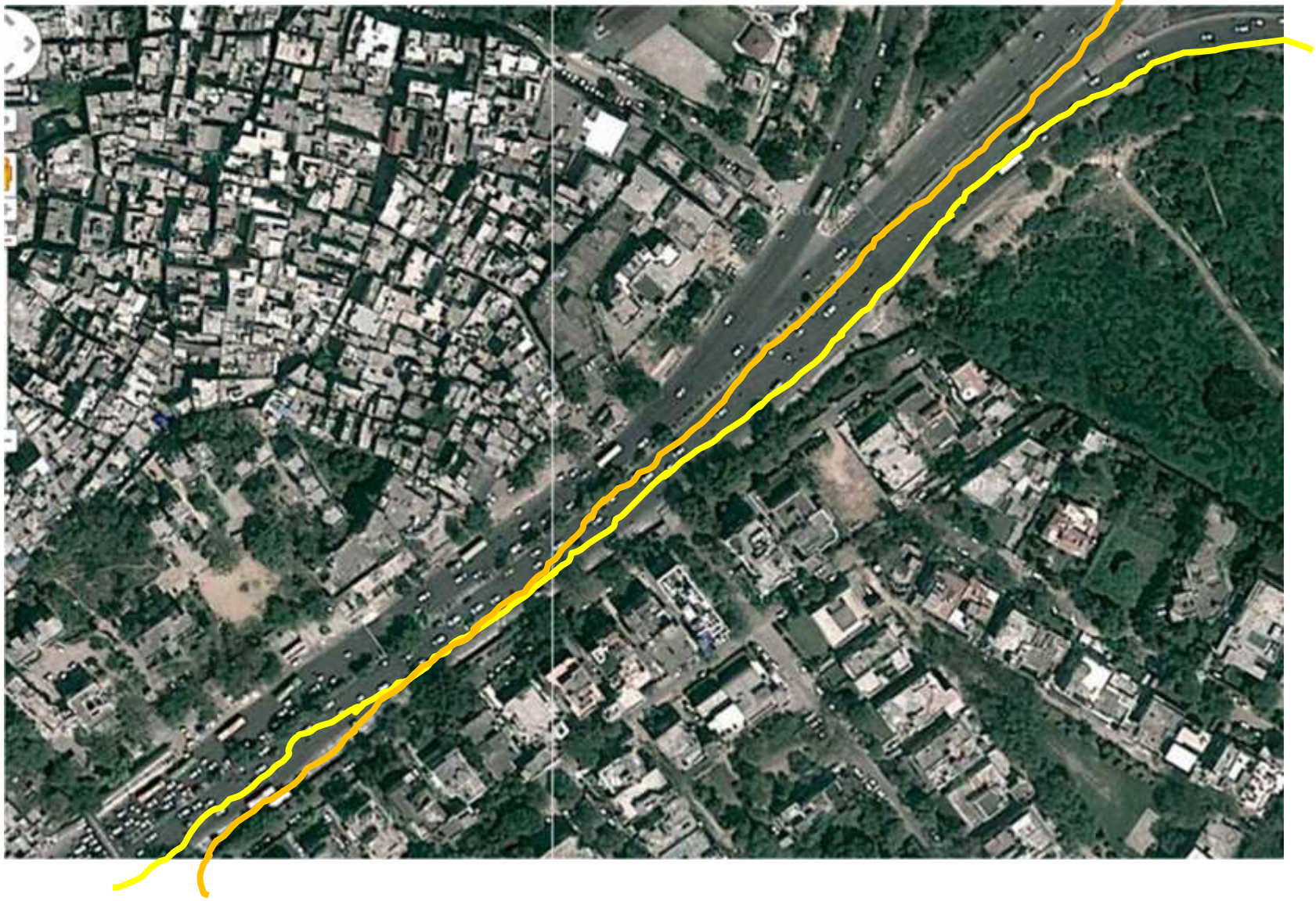
ITO Flyover on ring road

Between Millennium Depot and sarai Kale khan

BACK

Between DND Flyway and Eastern Avenue Road

BACK



BACK

Between Eastern Avenue Road and Ashram