



Traffic Calming Measures in Highway Work Zones (A Before and After Study)

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Work Zone fatalities - Globally

- **Netherlands** : 16% of total fatalities are on Dutch motorways of which 39% are in a Work Zone (SWOV 2005)
- **USA** :3 times higher accident risk on workzones (www.workzonesafety.org/crash_data/workzone_fatalities)
- **INDIA** - Work zones accident statistics are not well documented. With increasing road construction activity in India, high risk of work zone fatalities

Work Zone Fatalities - Globally

- **USA** - Annual work zone fatalities rose from **872** in 1999 to **1,028** in 2003 (FHWA, 2004)
- **Finland** - Work-related road crashes caused **28.5%** of traffic deaths in Finland from 2001-2005
- **India** – Results of the Safety Audit done by IIT Delhi (2010) in work zones on NH-28

Site No.	Length (km)	Duration (month)	Fatal	Non-fatal	Fatal accident/month/km
1	36.75	15	24	112	0.044
5	44	17	38	100	0.051
7	39.2	19	32	202	0.043
8	41.115	18	28	20	0.038
10	38	19	22	38	0.030
11	36	18	12	26	0.019
12	40	18	11	59	0.015

- With increasing road construction activity (NHDP project) in India, high risk of work zone fatalities

The logo for TRIPP (Traffic Research and Information Processing Program) is located on the left side of the slide. It consists of a vertical blue bar with the word "TRIPP" written in white, bold, capital letters. Above the bar is a stylized graphic of a road or bridge structure with a white circle above it.

Speed Management at Work Zones

- Benekohal and Wang (1994) compared the speeds of vehicles in advance warning zone and the construction zone;
- the vehicles moving at higher initial speeds reduced their speeds more than did vehicles with lower initial speeds in the construction work zone,
- however kept higher speeds in the work zone

Work Zone Crashes: Research Review

➤ Deaths and injuries at work zones are caused by a variety of factors (Lindly et al. 2002)

- **speeding traffic**
- inadequate visibility of signs
- poor road surface condition
- inadequate traffic control
- improper management of material
- equipment, and personnel in work zones
- not paying attention to work zone signs or flaggers indicating slow down
- distraction by cellular phone calls, conversations and activities at roadside

➤ **“Appropriate speed” at work zones** has been identified by many researchers as one of the most important factors

What impacts Work Zone speeds?

- **Static signs were ineffective at reducing speeds** unless construction activity was in place (Bham et al., 2011).
- Speed limit signs are not only ineffective, they can make drivers skeptical of the validity of signs posted at other WZs in case of no construction activity in long WZs (Outcalt, 2009).

The logo for TRIPP (Traffic Research and Information for Planning and Policy) is located on the left side of the slide. It features a vertical blue bar with the word "TRIPP" written in white, bold, capital letters. Above the bar, there is a stylized graphic of a road or highway with a white line and a blue background, and a small white circle above that.

Objectives of the study

- To determine the speed characteristics of vehicles in Advance Warning Zone (AWZ), Working Zone (WZ) and Terminal Transition Zone (TTZ) before and after the installation of Active traffic calming measures like Rumble strips on NHs
- To estimate speed limit compliance in WZs using Active traffic calming measures in work zones
- To determine the effectiveness of different Warning sign configuration (shape and colour) in Work Zones

Experiment – 1

Pilot Study on NH-8 (Delhi-Jaipur section)

- The study was done at 8 sites on National Highway 8 (NH-8) between Delhi and Jaipur in January 2012, the characteristics of which are

Site	Chainage	Date	Time	Length of WZ (m)
1.	84+640 km to 85+900 km	23/1/2012	10:50 am – 12:10 pm	1240
2.	86+140 km to 84+420 km	23/1/2012	1:00 pm – 2:10 pm	1720
3.	99+020 km to 100+210 km	23/1/2012	4:20 pm – 5:25 pm	1200
4.	100+120 km to 99+01 km	23/1/2012	5:45 pm – 7:35 pm	1120
5.	139+550 km to 138+410 km	24/1/2012	10:00 am – 11:05 am	1140
6.	139+070 km to 139+720 km	24/1/2012	11:20 am – 12:35 pm	1650
7.	181+400 km to 180+740 km	24/1/2012	2:35 pm – 3:35 pm	1660
8.	181+010 km to 181+680 km	24/1/2012	3:45 pm – 4:50 pm	670

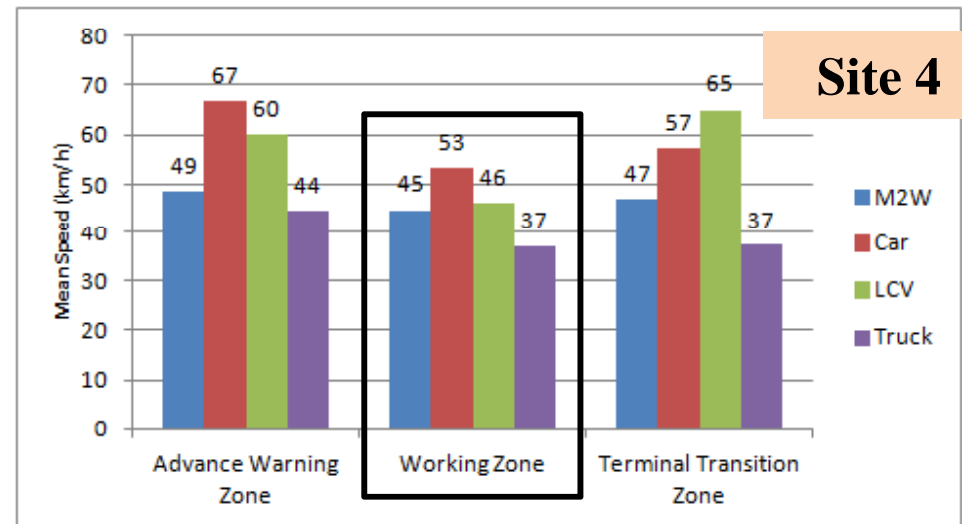
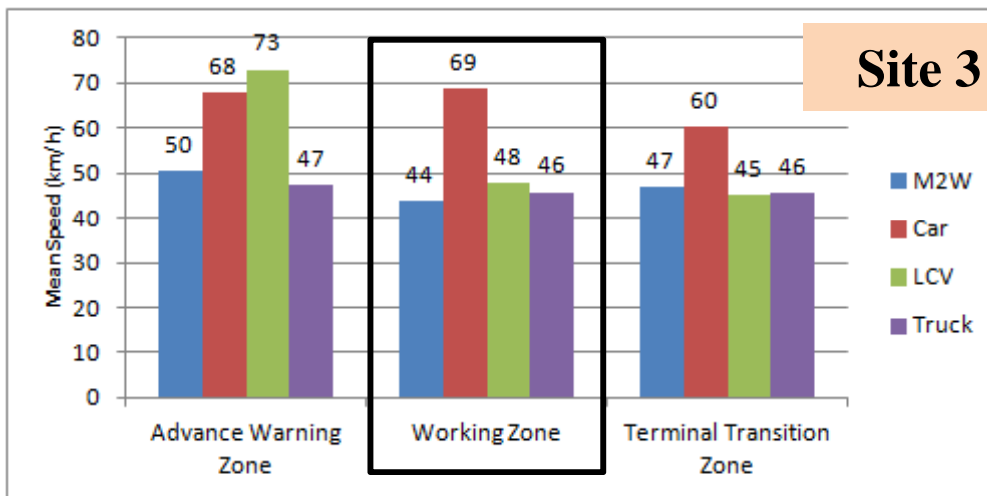
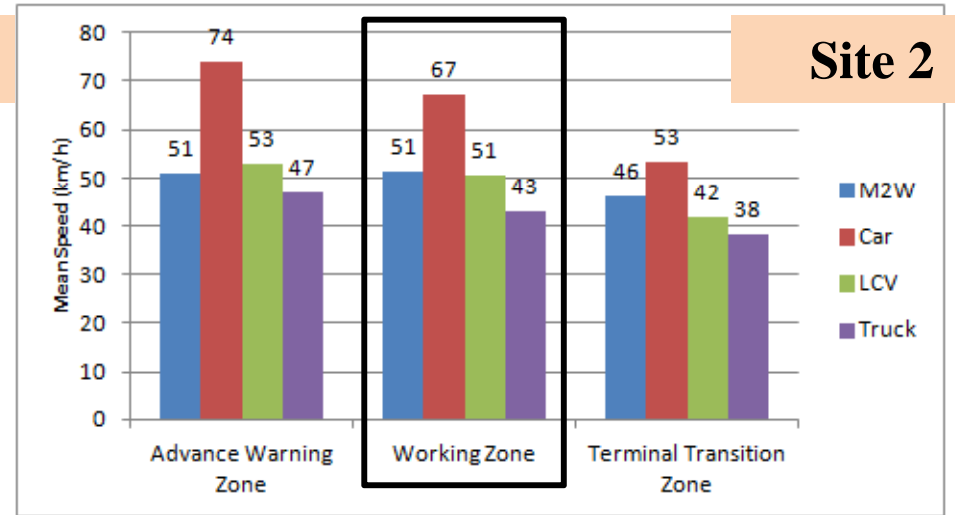
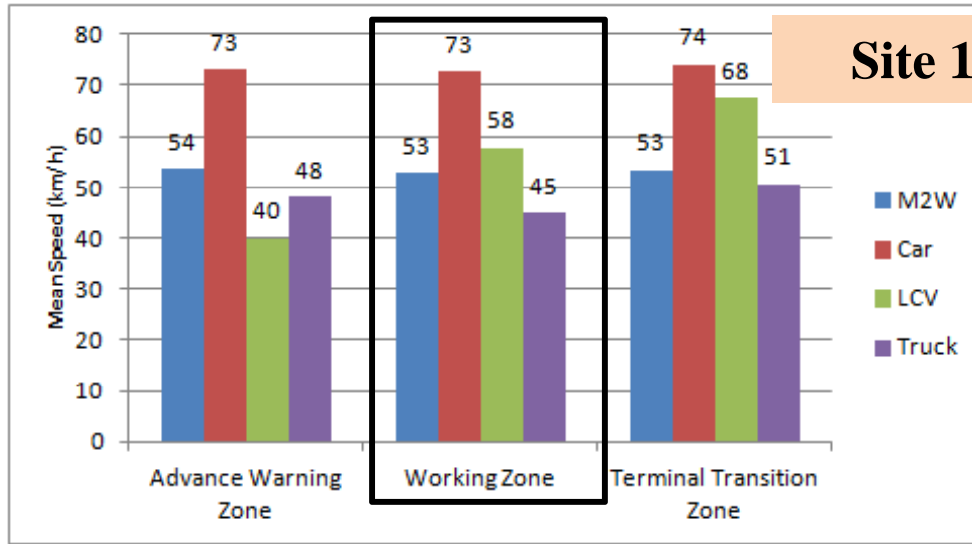
- Common characteristics for all sites –
 - Widening of the existing four lanes into six lanes was being done.
 - Due to construction activity, only **two** lanes were opened to the traffic in WZ whereas in AWZ and TTZ, all the **three** lanes were opened to the traffic.
 - The normal regulatory speed limit of AWZ and WZ was **40 km/h** at all the sites.
 - Only **Passive traffic calming measures** like signages, New Jersey Crash Barriers, Metal Barricades, solar flashers, etc. were present
 - Mostly non-standard signs and barricades (not following IRC:SP:55:2001)**

Non-standard signs and barricades



Mean speeds in Traffic Control Zones

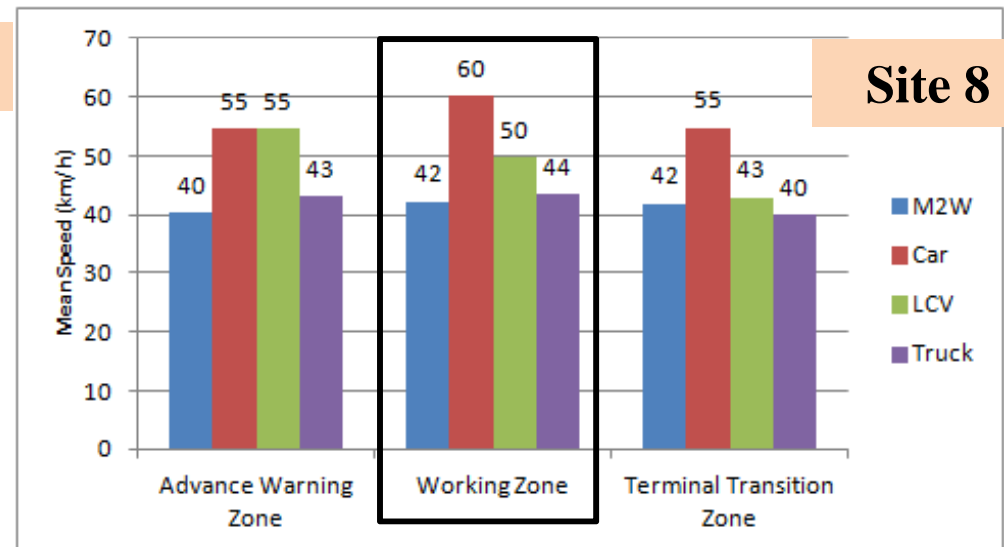
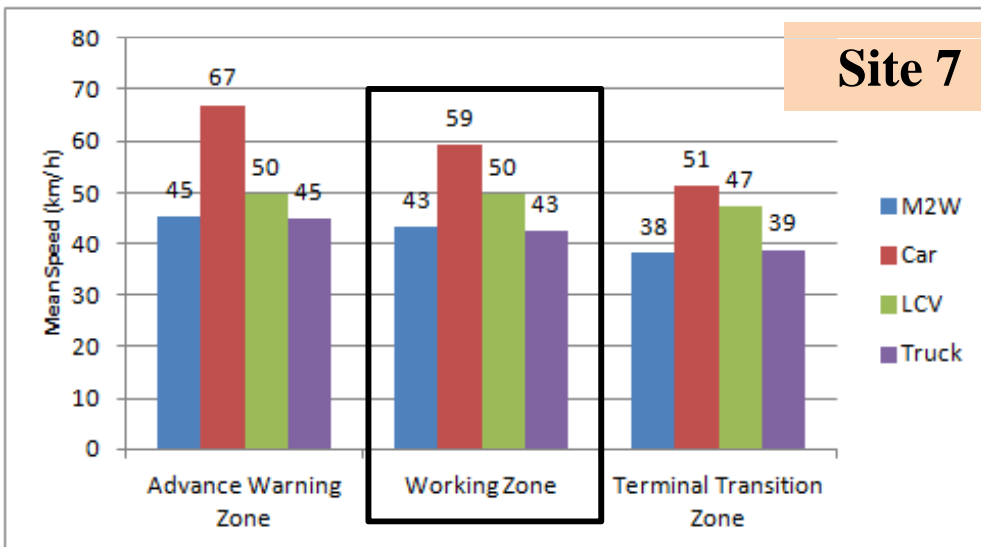
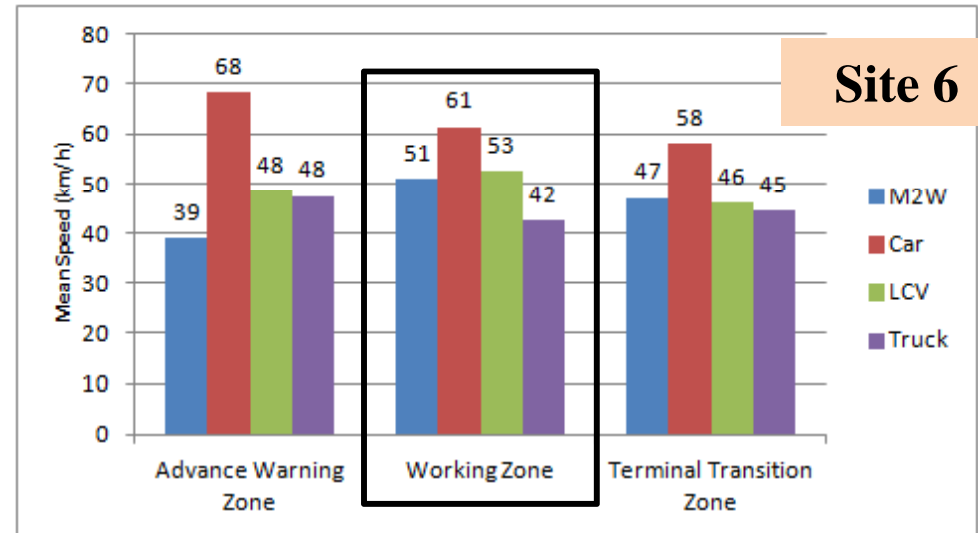
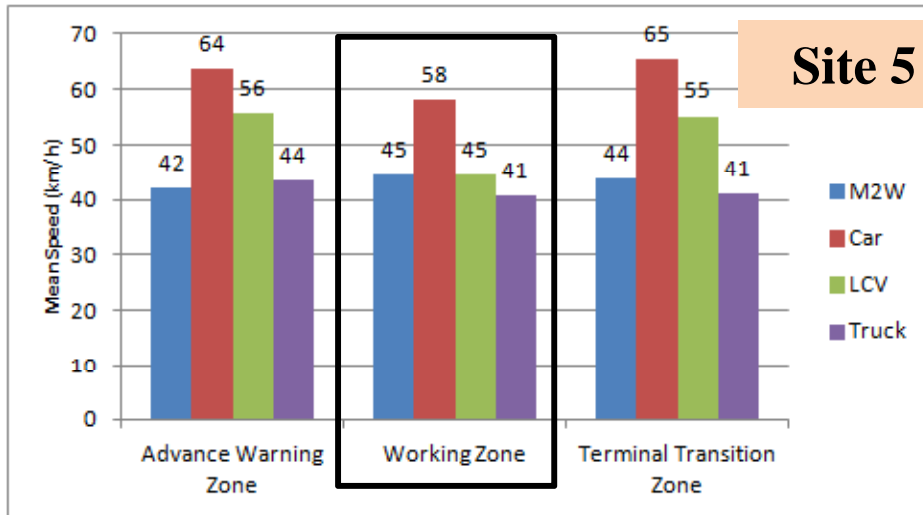
Posted speed limit = 40 km/h



- Highest speeds by Cars followed by LCVs and Motorized 2-Wheelers
- No difference in speeds in Advance Warning, Working and Terminal Transition zones

Mean speeds in Traffic Control Zones

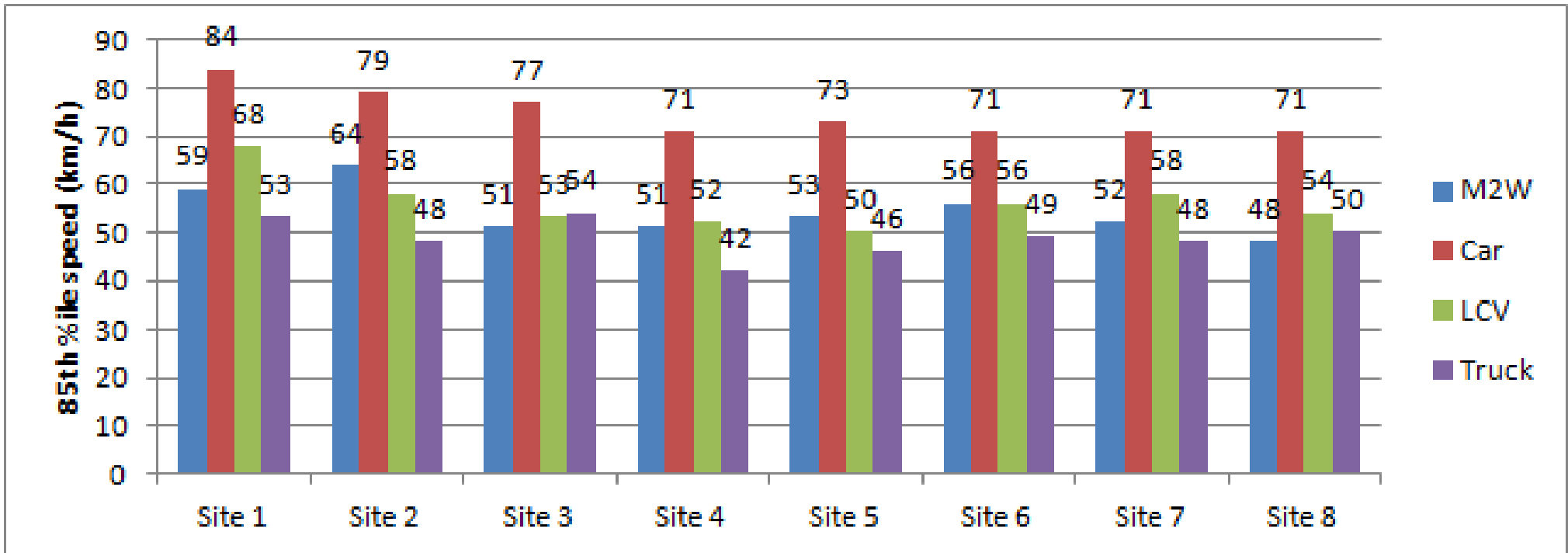
Posted speed limit = 40 km/h



- Highest speeds by Cars followed by LCVs and Motorized 2-Wheelers
- No difference in speeds in Advance Warning, Working and Terminal Transition zones

85th %ile speeds in Working Zone

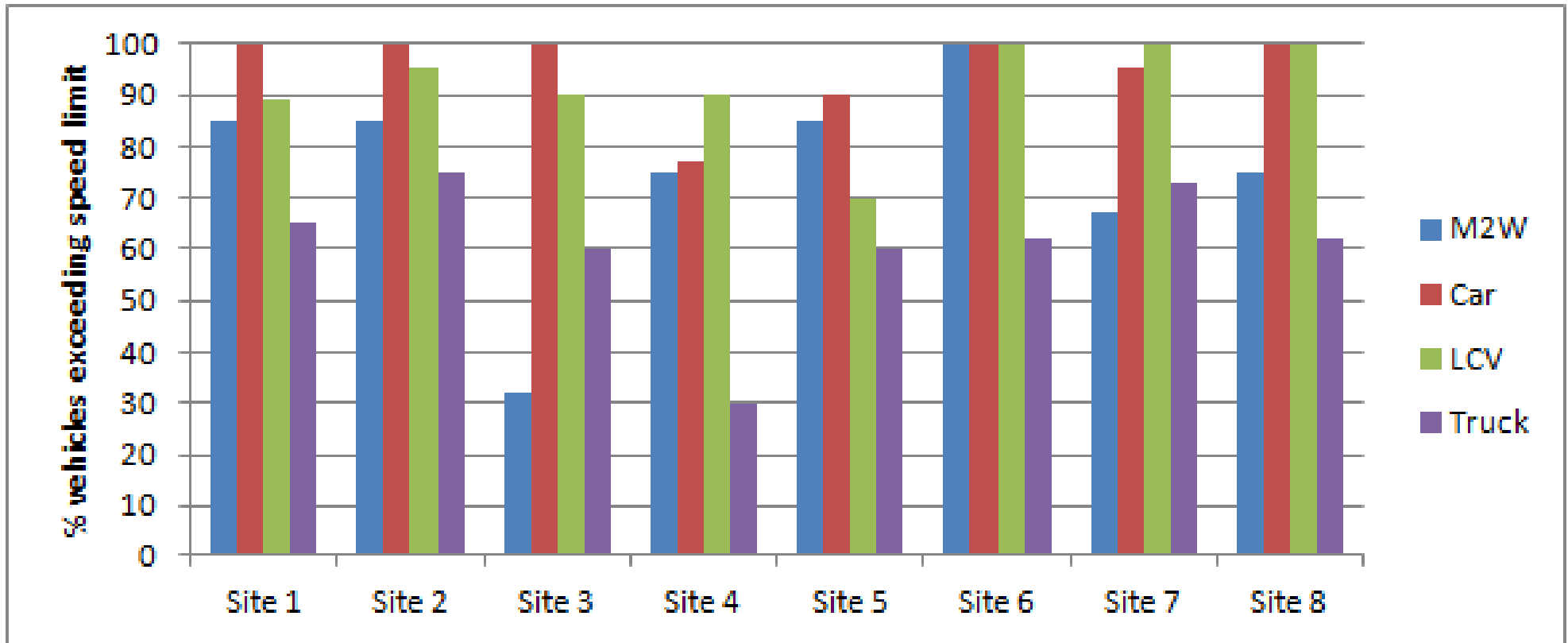
Posted speed limit = 40 km/h



➤ 85th percentile speeds of all vehicle types are much higher than the posted speed limit of 40 km/h in WZ at all the selected sections (varies from 42-84 km/h)

% vehicles exceeding posted speed limit in WZ

Posted speed limit = 40 km/h



☐ **>90% of Cars and >50% of Motorized 2-wheelers, LCVs & Trucks exceeded the posted speed limit of 40 km/h in WZ at all the selected sections**

Experiment - 2

- For this study, three sites were selected on NH-8 (Delhi-Jaipur section), the characteristics of which are given below-
 - WZ Type-1 (Ch.144) - Baseline condition where the triangular warning signs with white background, red border and black symbols were installed by the concessionaire
 - WZ Type-2 (Ch.162) - Triangular warning signs with **yellow background**, red border and black symbols
 - WZ Type-3 (Ch.168) - Diamond warning signs with **orange background, black border**, black symbols, black font (representing the meaning of the sign) and Rumble Strips
- Except warning signs and diversion signs, all other type of signs for WZ Type-2 and WZ Type-3 were as per specifications of IRC:67-2012 “Code of Practice for Road Signs (Third Revision)”.
- Speed studies were carried out at WZ Type-2 (Ch.162) and WZ Type-3 (Ch.168) to compare Passive and Active measures respectively.

WZ Type-1 (Traffic signs installed by concessionaire)

Daytime



Nighttime



WZ Type-2 (Triangular warning signs with YELLOW background)

Daytime



Nighttime



WZ Type-3 (Diamond warning signs with ORANGE background)

Daytime



Nighttime



Site Characteristics

<u>Chainage</u>	Date	Time	Length of WZ (m)
162	19/4/2013	11:50 am – 12:50 pm	1000
		05:50 pm – 06:50 pm	
	20/4/2013	08:30 am – 09:45 am	
168	8/6/2013	11:25 am – 01:25 pm	1020
		04:00 pm – 05:40 pm	
	9/6/2013	08:45 am – 10:45 am	
		01:40 pm – 03:40 pm	
		04:15 pm – 05:45 pm	
	10/6/2013	08:00 am – 10:00 am	
		12:00 pm – 01:00 pm	
		02:15 pm – 04:15 pm	

- Common characteristics for all sites –

- Widening of the existing four lanes into six lanes was being done.
- Due to construction activity, only **two** lanes were opened to the traffic in WZ whereas in AWZ and TTZ, all the **three** lanes were opened to the traffic.
- The normal regulatory speed limit of AWZ and WZ was **30 km/h** at all the sites.

Rumble Strip specifications

- **Height** – 0.025 m
- **Width** – 0.5 m
- **C/C gap between two rumble strips** – 0.9 m
- **Material** - Bitumen
- Each set has 3 Rumble strips



- 3 sets of Rumble Strips were installed at WZ Type-3 (Ch.168) as shown in Traffic Management Plan (TMP)

[168.jpg](#)



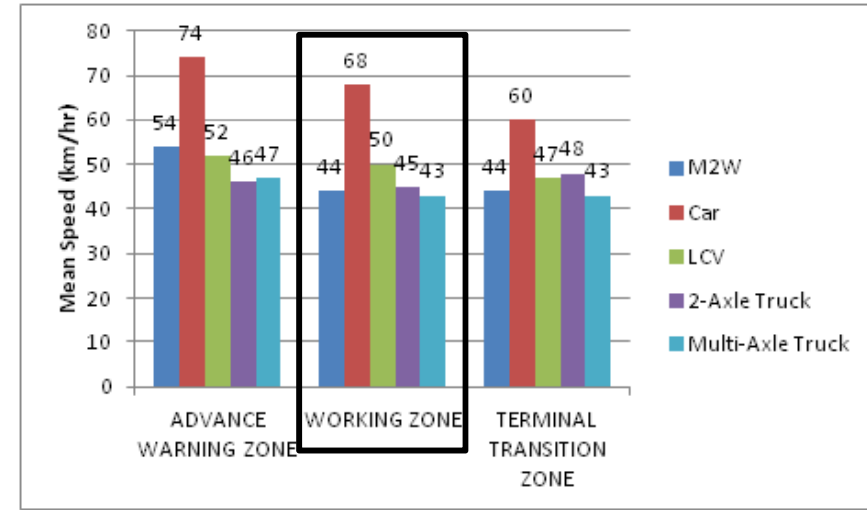
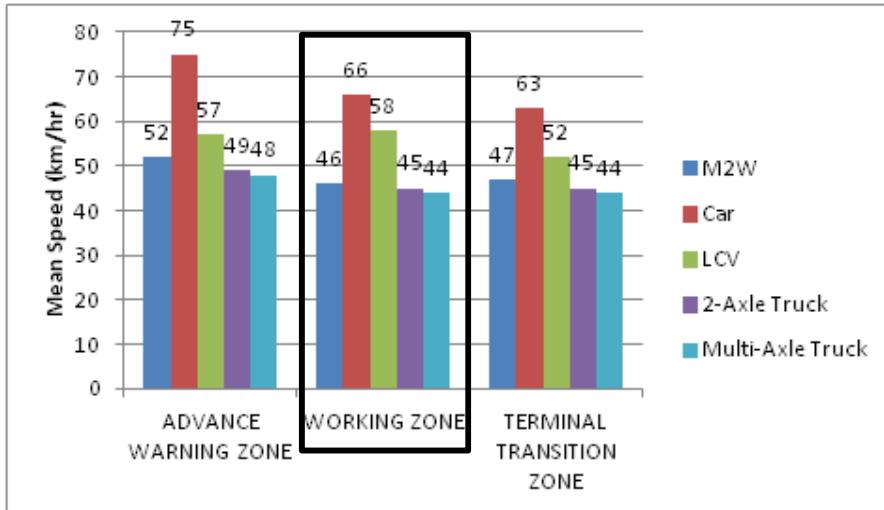
Mean speeds in Traffic Control Zones at Ch.162 (Only Passive measures)

Day-1 (19 April 2013)

Posted speed limit = 30 km/h

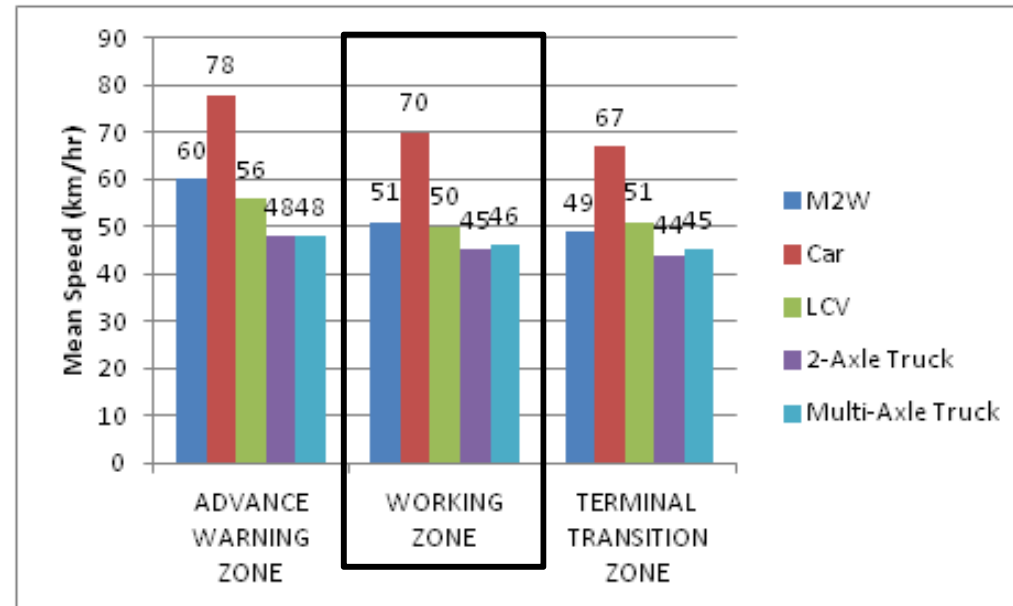
1150-1250

1750-1850



Day-2 (20 April 2013)

0830-0945



- Highest speeds by Cars followed by LCVs and Motorized 2-Wheelers
- No difference in speeds in Advance Warning, Working and Terminal Transition zones

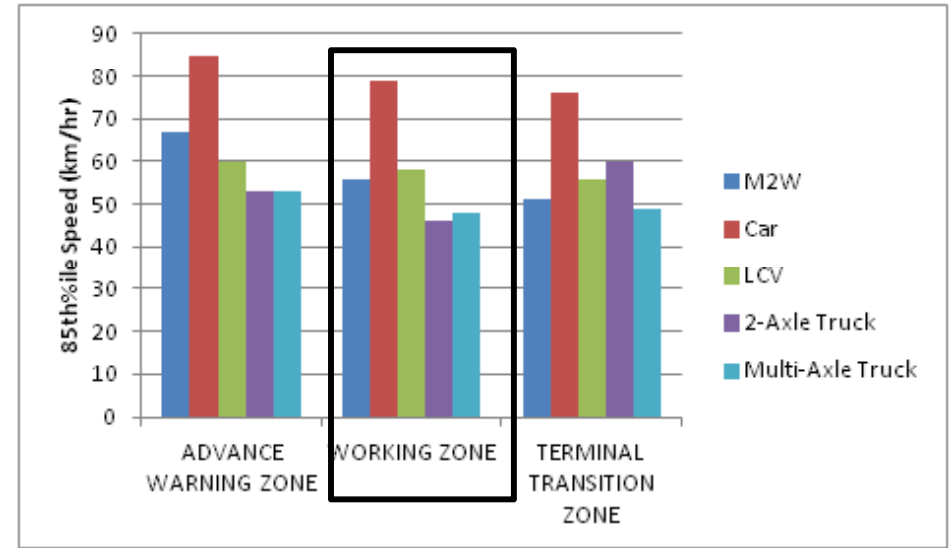
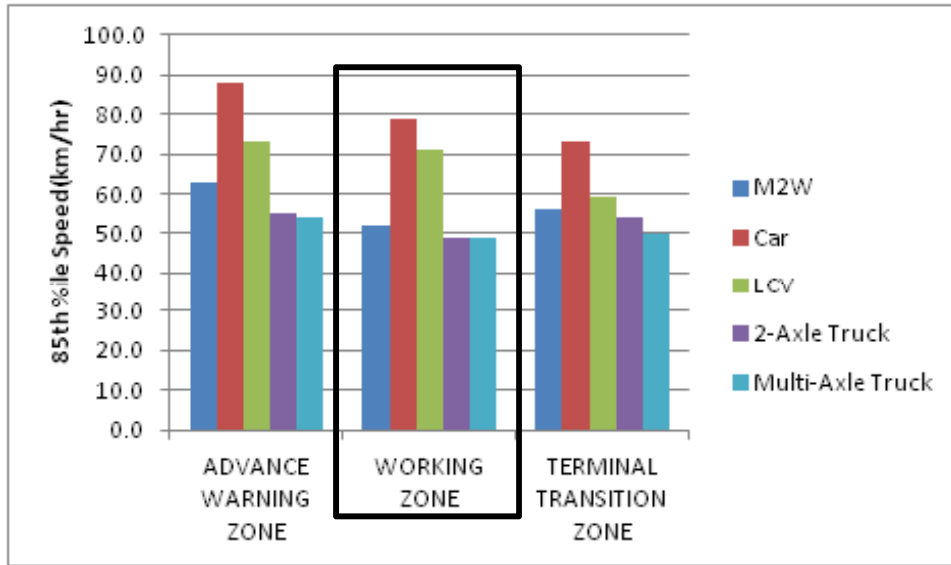
85th %ile speeds in Traffic Control Zones at Ch.162 (Only Passive measures)

Day-1 (19 April 2013)

Posted speed limit = 30 km/h

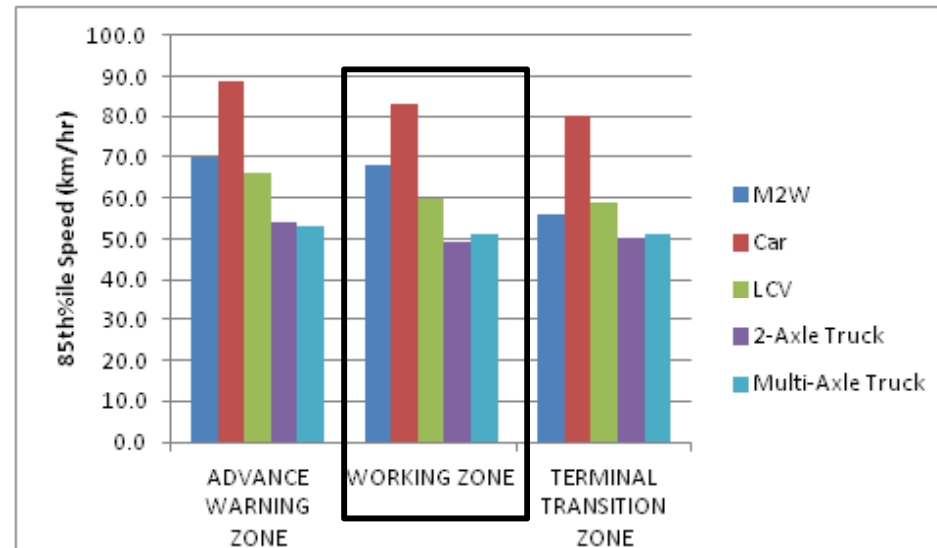
1150-1250

1750-1850



Day-2 (20 April 2013)

0830-0945



➤ 85th percentile speeds of all vehicle types are much higher than the posted speed limit of 30 km/h in WZ at all the selected sections

ANOVA Results for Ch.162 (Only Passive measures)

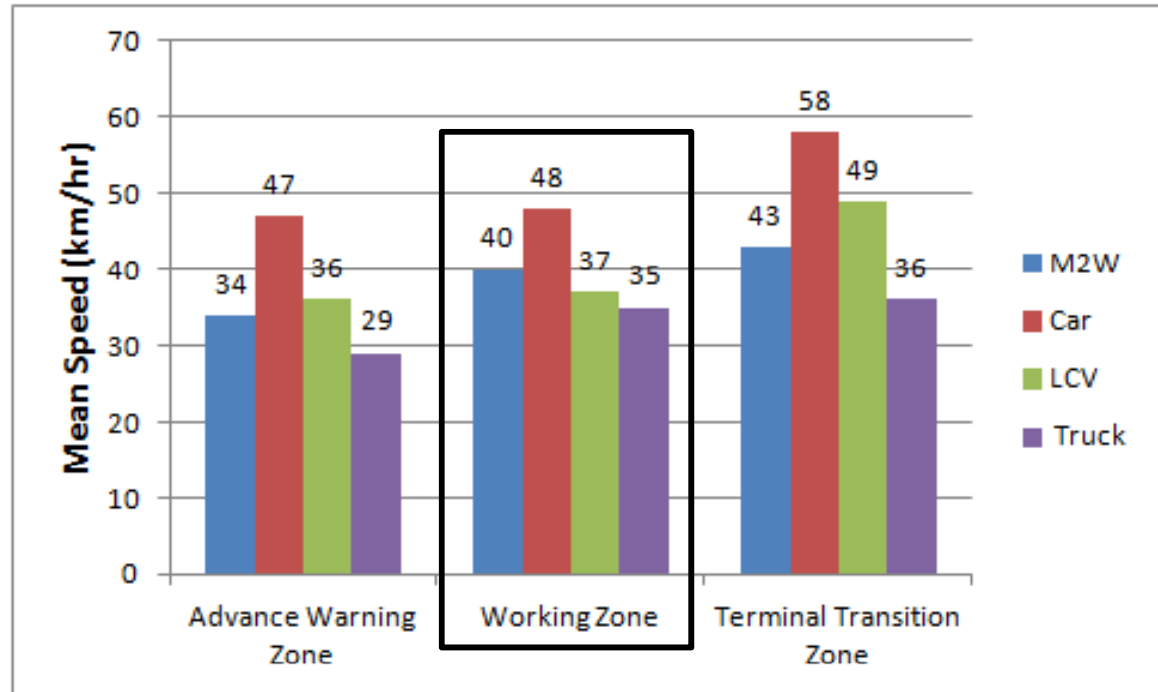
S.No.	Mode	F- value	P-value
1	M2W	22.127	0.279
2	Car	61.180	0.345
3	LCV	32.235	0.230
4	2-Axle Truck	18.000	0.140
5	Multi-Axle Truck	15.443	0.132

*NO significant difference in speeds of vehicles in AWZ, WZ and TTZ for all type of vehicles.

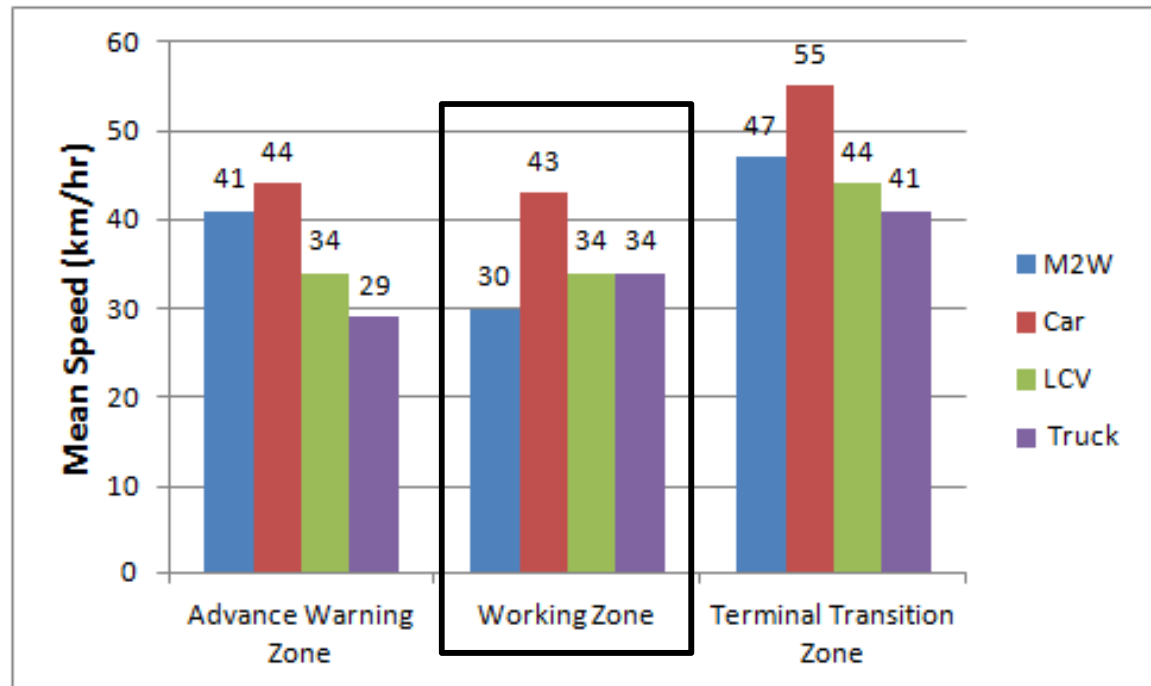
Mean speeds in Traffic Control Zones at Ch.168 (Both Active & Passive measures)

1125-1325

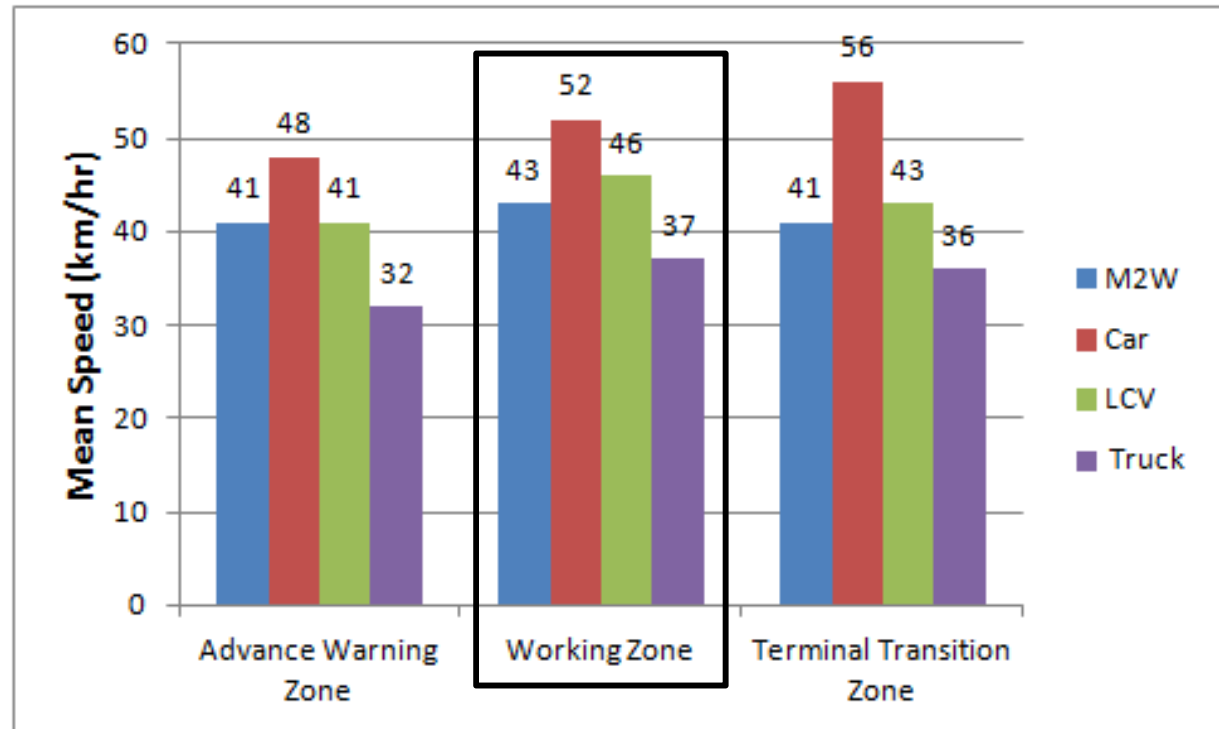
Posted speed limit = 30 km/h



0845-1045

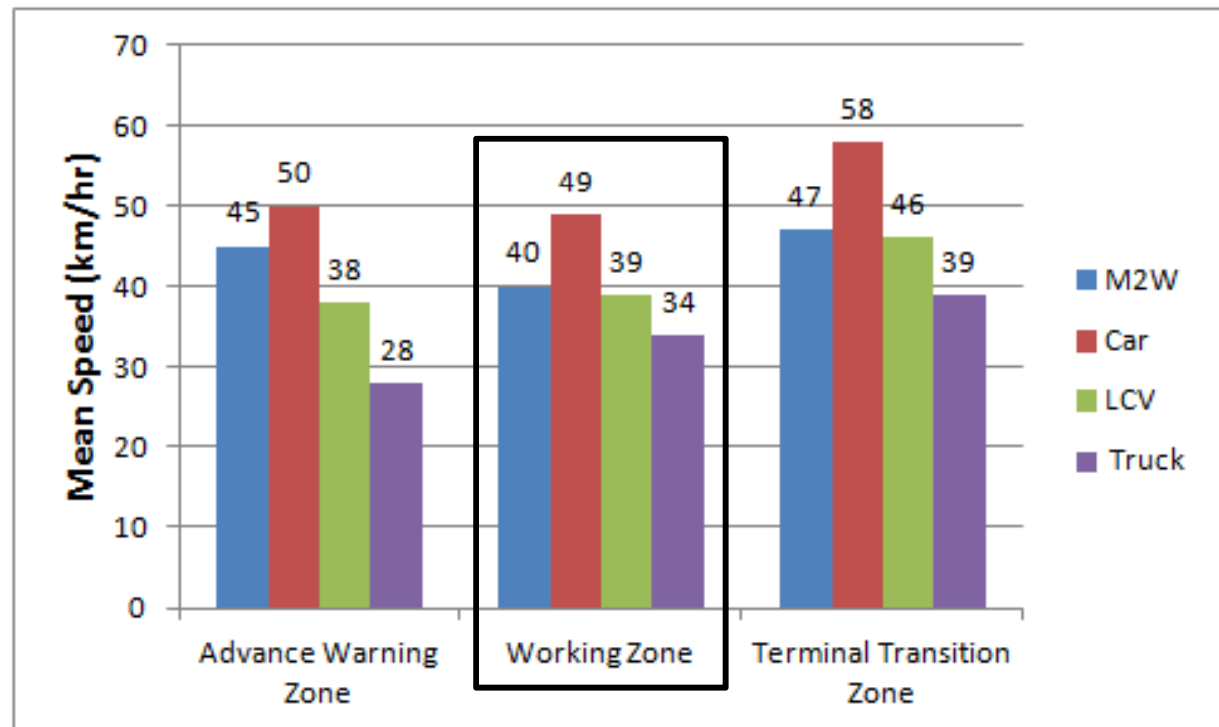


1200-1300



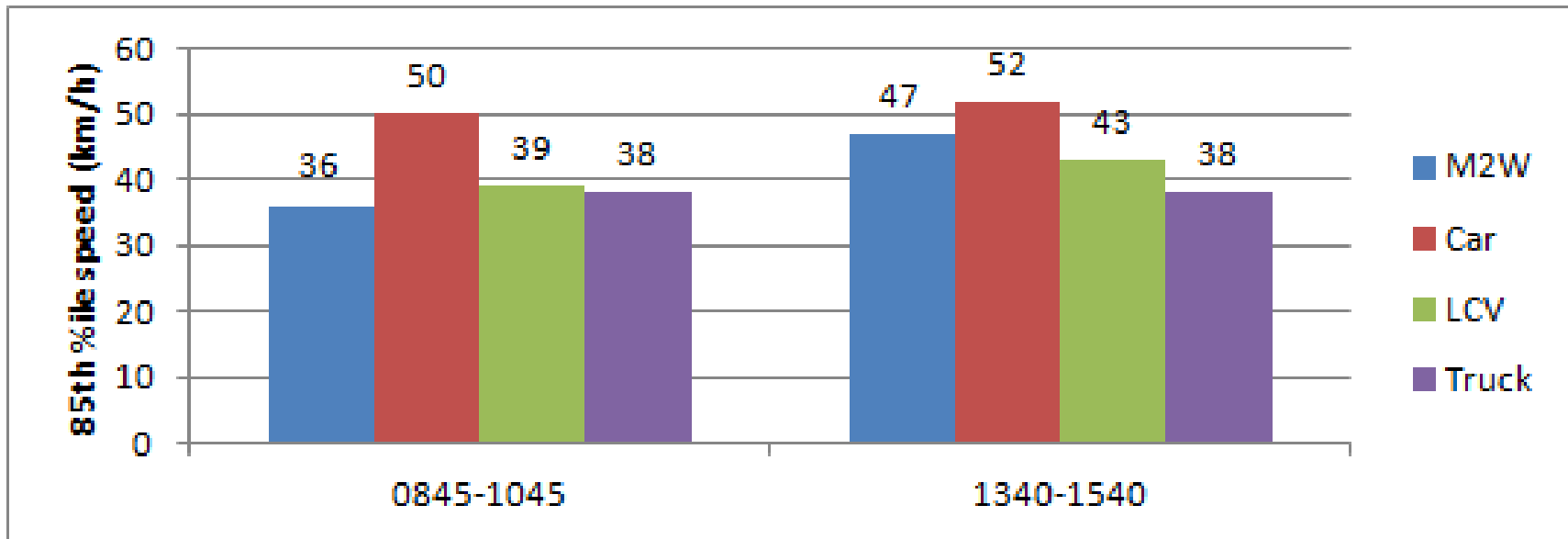
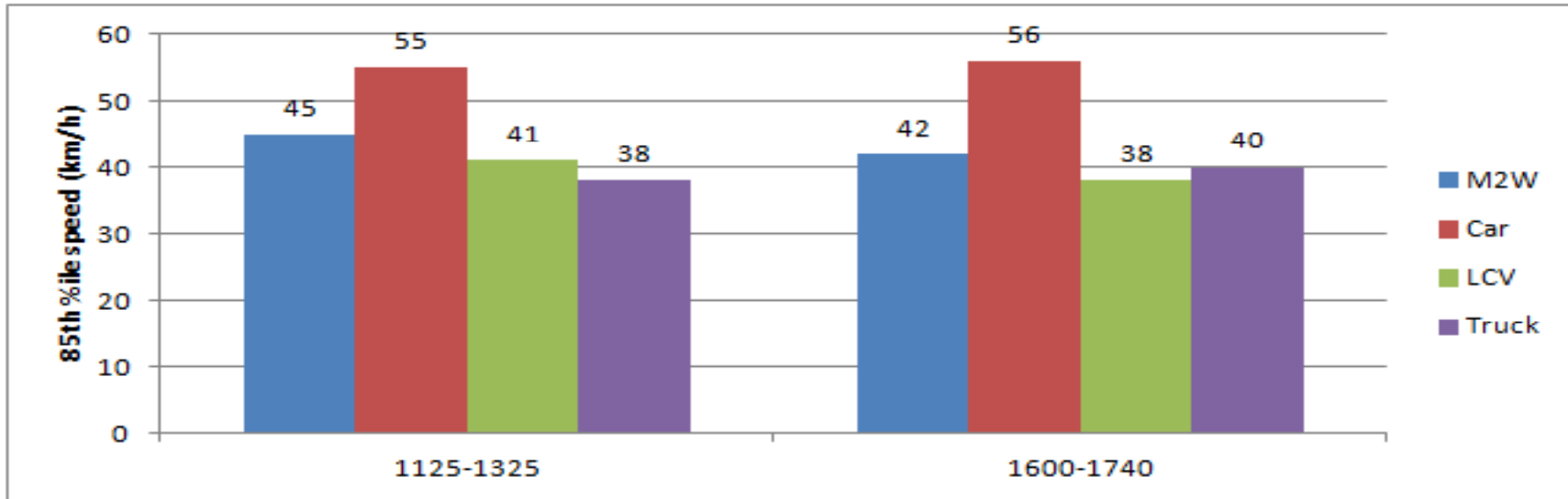
Posted speed limit = 30 km/h

1340-1540



85th %ile speeds in Working Zone at Ch.168 (Both Active & Passive measures)

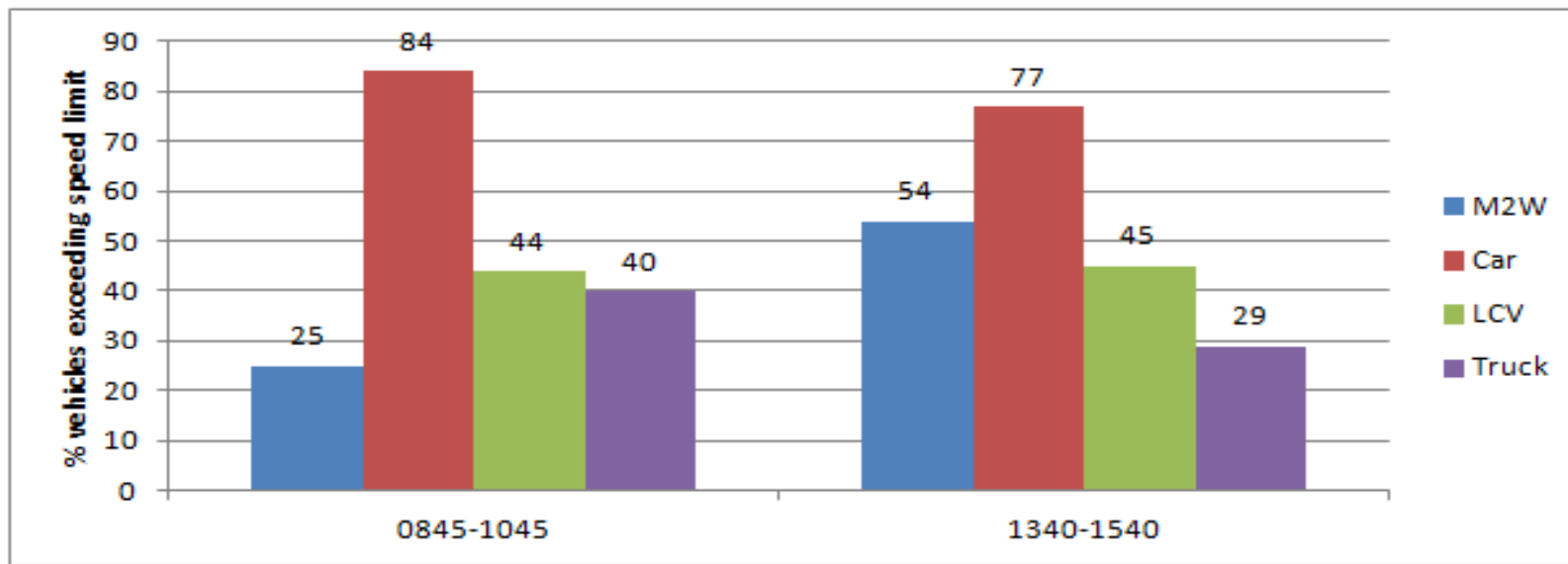
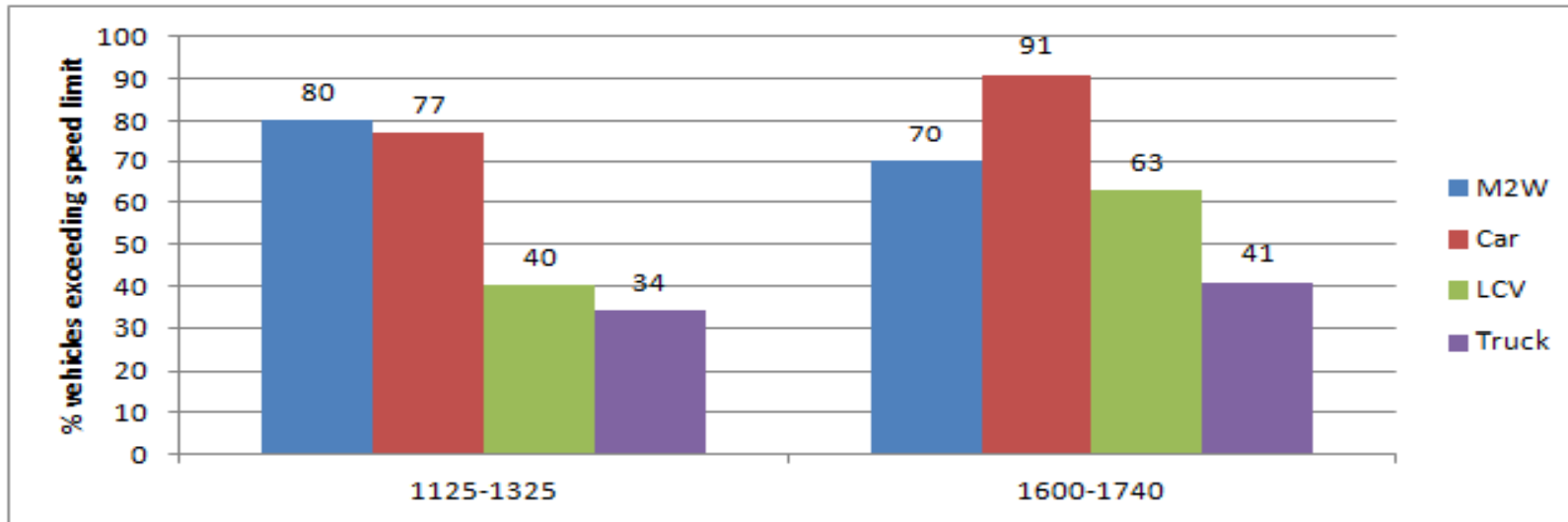
Posted speed limit = 30 km/h



➤ Drop in 85th percentile speeds of all vehicle types (varies from 36-56 km/h)

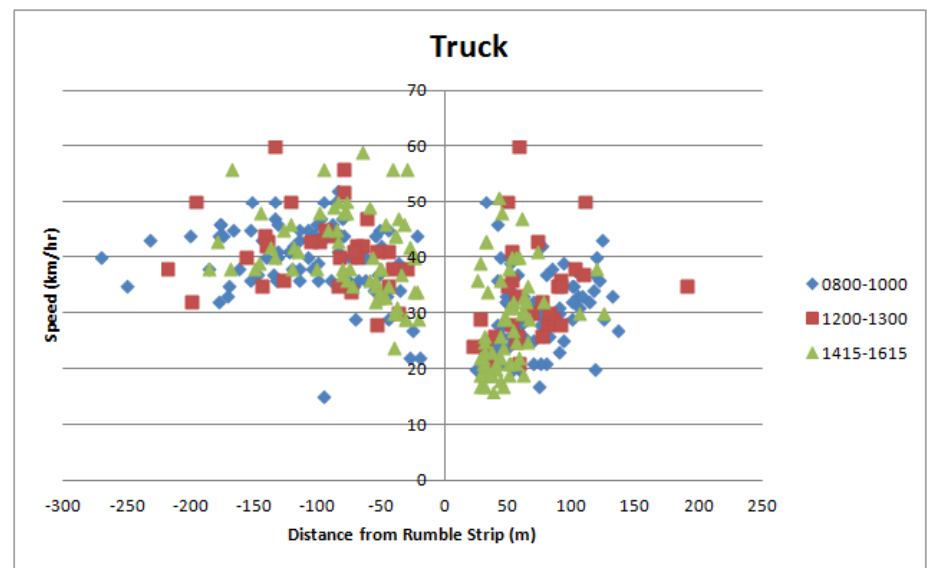
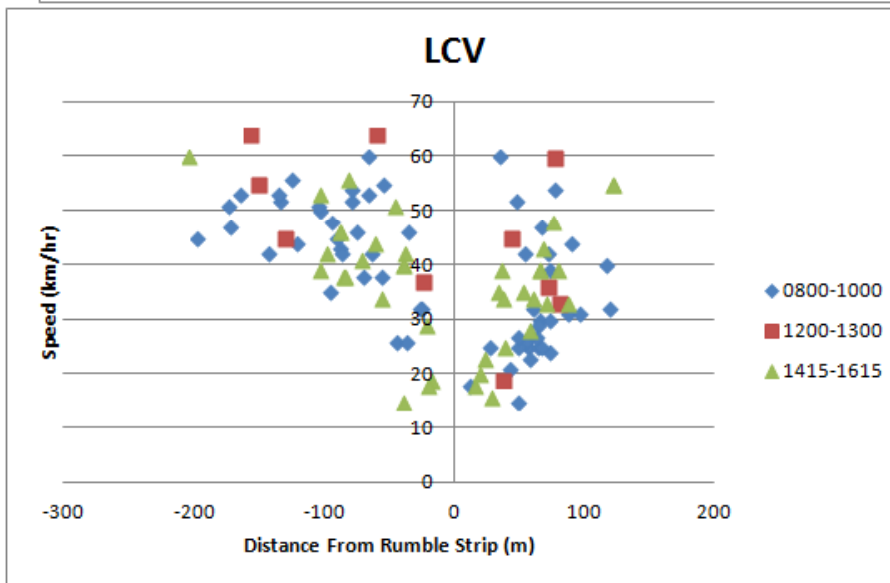
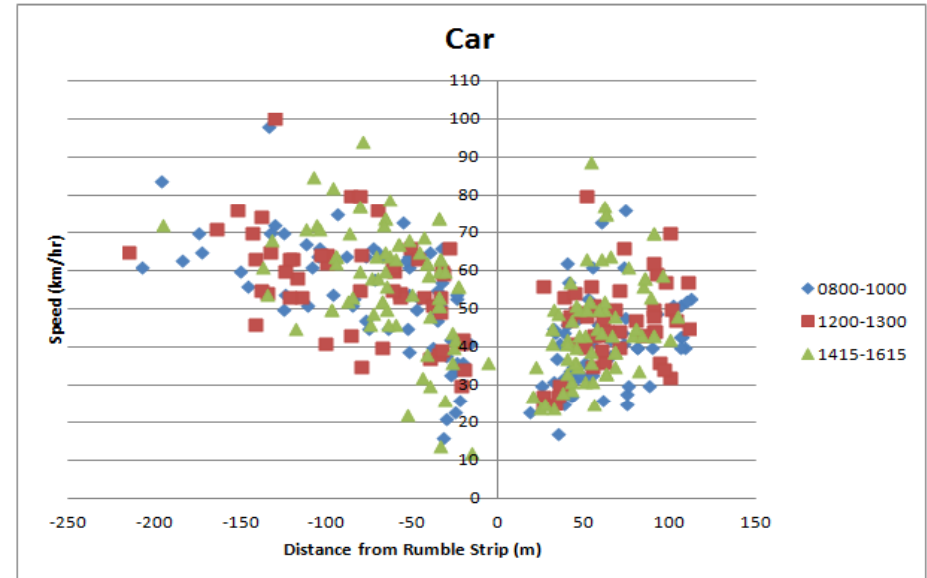
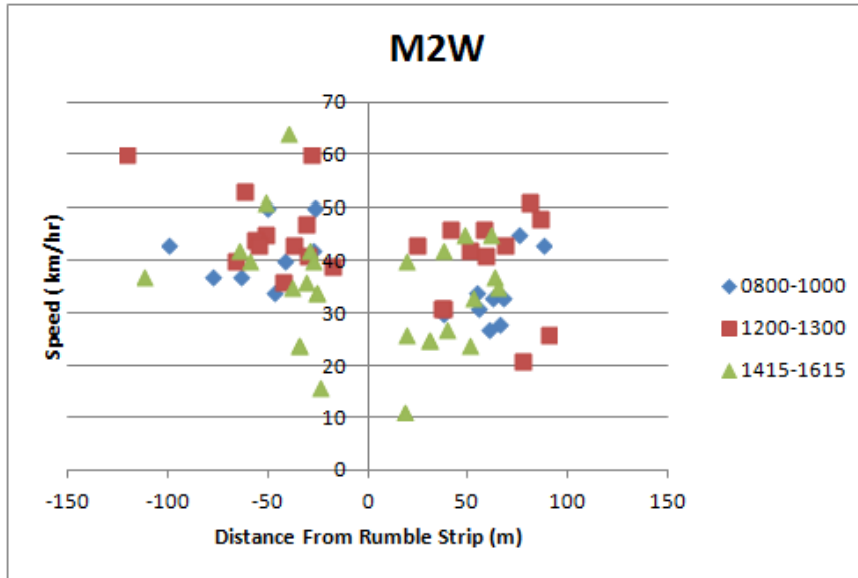
% vehicles exceeding posted speed limit in WZ at Ch.168 (Both Active & Passive measures)

Posted speed limit = 30 km/h



☐ Drop in the percentage of vehicles exceeding speed limit

Variation of Speeds before and after Rumble Strips at Ch.168 (Working Zone)



Reduction in speeds 50m before and after Rumble strips for all vehicle groups

ANOVA Results for Ch.168 (Both Active & Passive measures)

Date: 8 June 2013

Time: 11:25-13:25

<u>S.No.</u>	Mode	F- value	P-value
1	M2W	8.576	0.000
2	Car	30.394	0.000
3	LCV	33.888	0.000
4	Truck	33.465	0.000

Time: 16:00-17:40

<u>S.No.</u>	Mode	F- value	P-value
1	M2W	8.293	0.000
2	Car	31.325	0.000
3	LCV	32.602	0.000
4	Truck	33.289	0.000

*significant difference in speeds of vehicles in AWZ, WZ and TTZ for all type of vehicles.

ANOVA Results for Ch.168 (Both Active & Passive measures)

Date: 9 June 2013

Time: 08:45-10:45

<u>S.No.</u>	Mode	F- value	P-value
1	M2W	9.365	0.000
2	Car	30.412	0.000
3	LCV	31.256	0.000
4	Truck	33.752	0.000

Time: 13:40-15:40

<u>S.No.</u>	Mode	F- value	P-value
1	M2W	7.521	0.000
2	Car	31.931	0.000
3	LCV	34.856	0.000
4	Truck	31.486	0.000

*significant difference in speeds of vehicles in AWZ, WZ and TTZ for all type of vehicles.

ANOVA Results for Ch.168 (Both Active & Passive measures)

Date: 10 June 2013

Time: 08:00-10:00

<u>S.No.</u>	Mode	F- value	P-value
1	M2W	9.215	0.000
2	Car	33.256	0.000
3	LCV	33.027	0.000
4	Truck	34.523	0.000

Time: 12:00-13:00

<u>S.No.</u>	Mode	F- value	P-value
1	M2W	8.685	0.000
2	Car	30.437	0.000
3	LCV	32.369	0.000
4	Truck	34.812	0.000

*significant difference in speeds of vehicles in AWZ, WZ and TTZ for all type of vehicles.

COMPARISON (Daytime)

WZ Type-1



WZ Type-2



WZ Type-3



COMPARISON (Nighttime)

WZ Type-1



WZ Type-2



WZ Type-3



Conclusions & Recommendations

- Passive traffic calming measures like signages, road markings, cones, barricades, etc. implemented in work zones on NH-8 had no significant effect in reducing the speed of vehicles in WZs.
- Active Traffic calming devices show considerable potential for reducing speeds and improving work zone speed limit compliance.
- Impact of colour and shape may influence legibility of workzones