Design of Traffic Control Systems for Commercial Vehicles in Freeways

Mahmoud Saffarzadeh , Associate Professor and Member of Piarc Committee
Tarbiat Modares University, Tehran, P.O. Box 155-4838
Hamid Reza Bahramian , Research Associate of Transportation Institute
Transportation Research Institute, Ministry of Roads & Transportation

Synopsis

Freeways are the most important routes in ground transportation network in terms of traffic volume, speed and level of service. The concept of controlling traffic in freeways includes many topics. In this study two items including speed control and weigh in motion were chosen and Tehran- karaj corridor was selected as a case study due to its important role in transportation in the country. At first the necessity of speed and weigh controlling was investigated. Regarding to similar studies in developed countries, speed cameras and weigh in motion systems were chosen as suitable technologies for speed and weigh control in the corridor. Finally methods for finding appropriate locations for equipment installation were studied. After collecting traffic data and analyzing them, positions for placement of speed cameras and WIM technologies were determined.

Keywords: Traffic control, Commercial Vehicle, Freeways, Weigh in Motion, Speed Control

Design of Traffic Control Systems for Commercial Vehicles in Freeways

INTRODUCTION

The importance of vehicle speed as a major contributing factor in the high number of people killed or injured on roads in developing countries warrants a special focus on speed reduction as a priority strategy to control the rising fatalities associated with road transport. In general the higher the speed of a vehicle, the higher the probability of being involved in a crash and greater the likelihood of more severe injuries sustained [Afukaar, 2003].

Swedish researcher suggests a fourth power relationship between mean traffic speed and the proportion of fatal crashes [Nilsson, 1993]. On the other hand the volume of heavy vehicles, i.e., over weigh vehicles is the most important factor for deterioration of road pavement. WIM is described as the process of measuring the dynamic tire forces of a moving vehicle and estimating the corresponding tire loads of the static vehicle.

LITERATURE REVIEW

Speed control cameras are increasingly being used in recent years. In Victoria State of Australia speed cameras were first installed in September 1989 and 57 speed control cameras were installed at the high accident prone points, where some complains were received concerning high speed vehicles.

In New South Wales of U.S.A these cameras were used after vast notifications concerning speed control of vehicles. The comparison of accident statistics prior to and after using these cameras resulted in 22 to 30% reduction in rate of accidents. Installation of the cameras in European highways had positive results in decreasing unauthorized speed. For example, in Hium highway of Tempest, speeding vehicles rate reduced from 55% to 20% after using speed control cameras.[Hyden,1993]

The first laws regulating truck weighs in U.S. were passed in 1913, and by 1933, all U.S states had a truck weigh limit of some kind. The surface transportation Assistance Act of 1978 allowed penalties to be imposed on states which did not comply with weigh enforcement programs. Five years later, the office of the inspector general reported that state weigh law enforcement programs were inadequate deterrents to overweight trucking and recommended that WIM systems be implanted nationwide to measure the effectiveness of state weigh law enforcement programs. Between 1984 and 1987 the number of trucks weight with WIM scales increased from 5.8 to 13.4 million [Iowa State University, 1997]

RESEARCH METHODOLOGY

Most roads in developing countries have been built to allow different types of road users going at widely ranging speeds and weighs in the same space. Such all purpose roads tend to have high accident rates and deterioration. Better road designs which seek to segregate the slow moving from the fast moving transport, will largely improve road safety.

One major opportunity to control speed and weigh in developing countries is using devices that would warn drivers of their violation of speed and weigh applicable to the roads on which they are driving. This paper is focused on using speed cameras and WIM Technology as the most important devices for speed and weight control. In order to locate appropriate places for installation of speed cameras, the corridor was divided to sections where traffic characteristics were changed.

To analyze speed in the corridor, vehicles speed was measured at different sections and finally to assess appropriate locations for installation of speed cameras accidents situation in each section was determined.

To use WIM technology, capacity analysis was done after assessment of effective factors to use the system. Then the volume of heavy vehicles was analyzed and finally the best places for installation of the system were determined regarding to level of service and volume of heavy vehicles in each corridor section. Figure 1 illustrates framework of research methodology.

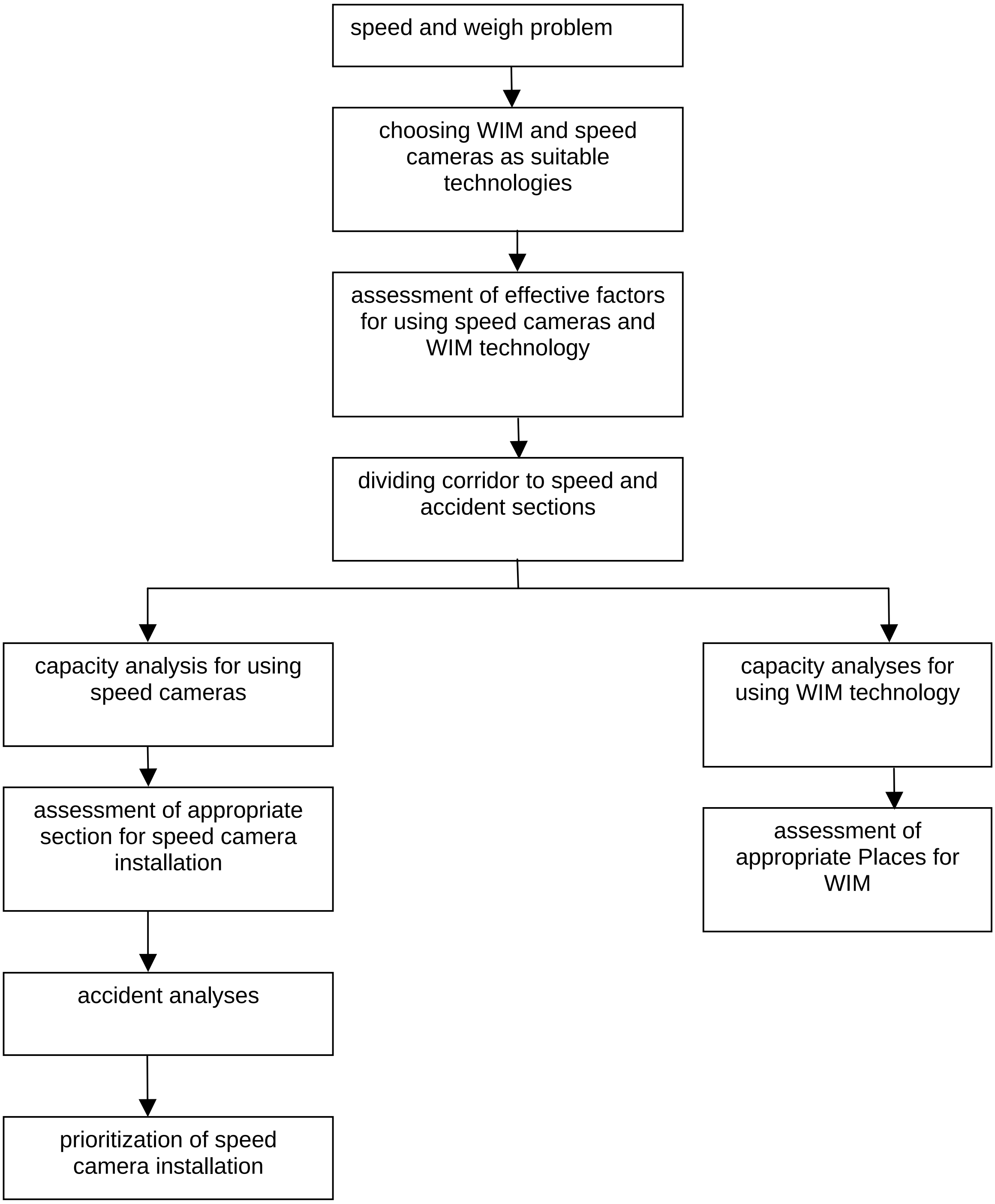


Figure 1: Framework of research methodology

EFFECTIVE PARAMETERS FOR USING SPEED CAMERAS

To determine appropriate places for installation of speed metering cameras it is required to assess the effective factors for selection of camera's locations. These factors include:
Maximum length of 500m for each road section
Occurrence of at least 3 injury accidents during the last 3 years
Occurrence of at least 5 fatal accidents during the last 3 years
Difference of 85th percentile speed with the allowable speed more than 16km/h

EFFECTIVE PARAMETERS FOR USING WIM TECHNOLOGY

To install and use WIM technology some necessary conditions should be provided. The parameters affecting efficiency, accuracy and operation of WIM system are as follows:

Geometric Design

Geometric design of a roadway is an important factor for using dynamic load measurement to estimate static load accuracy. This is due to the influence of longitudinal and transverse offsets have on the behavior of the drive.
Each standard should set guidelines for horizontal curvature, the longitudinal gradient, the lateral slope and the width of the paved roadway to use WIM systems.
Table 1 shows the ASTM standard geometric design requirements for each type of system.

Table 1: ASTM standard (E-1318-94) geometric design requirements

Characteristic	Type I	Type II	Type III	Type IV
Horizontal Curvature	Radius $\geq$1740m 46m before/after	Radius $\geq$1740m 46m before/after	Radius $\geq$1740m 46m before/after	Radius$\geq$ 1740m 46m before/after
Roadway Grade	$\leq$2% 46 before/after	$\leq$2% 46 before/after	$\leq$2% 46 before/after	$\leq$1% 46 before/after
Cross Slope (Lateral)	$\leq$2% 46 before/after	$\leq$2% 46 before/after	$\leq$2% 46 before/after	$\leq$1% 46 before/after
Lane Width	3 to 4.5m 46m before/after	3 to 4.5m 46m before/after	3 to 4.5m 46m before/after	3 to 4.5m 46m before/after

Pavement Condition

The roadway pavement has a direct impact on vehicle bounce. By increasing road roughness, the range of vehicle vibration and therefore under tire pressure will increase.

Site Location

The specification and required conditions of an appropriate place for installation of WIM system include:
Accessibility to electrical power and phone
Adequate location for controller cabinet
Adequate drainage
Traffic conditions

TEHRAN-KARAJ FREEWAY

Tehran is connected to Karaj via 3 main paths which are Freeway (H1), Makhsos highway (H2) and Ghadim highway (H3). This route is the most important corridor connecting the capital to west and vice versa. Figure 2 illustrates the aforementioned paths and sections of each road.

The role of Tehran-Karaj corridor in transportation network of the country is very important due to following reasons:

- It has been located on the route of the most trips to the north, northwest and west.
- The corridor is the connective link of capital to the very important corridor of Tehran-Bazargan.
- Transportation of 40 million tons of goods is done via this corridor.

Reported accident data shows that 1280 and 780 crashes have occurred in Tehran-Karaj Freeway and H2 highway respectively in 1998 due to the following reasons:

- High Rate of Traffic Volume
- High Speed of Vehicles
- Insufficient Information Services to Drivers.
- Neglecting Traffic Regulations.

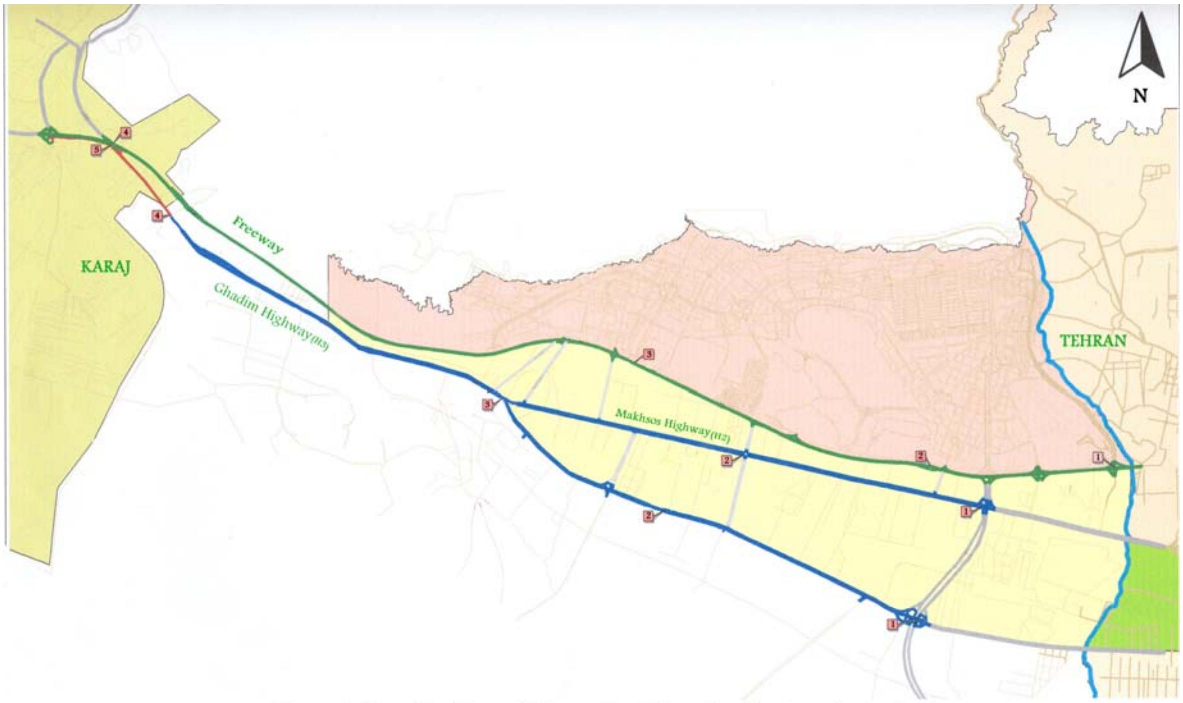


Figure 2 :Speed Sections of Tehran-Karaj Corridor for Capacity Analysis

SPEED ANALISIS

To analyze speed in Tehran karaj road, vehicles speed was measured at different sections of H2, and H3 and highways and H1 freeway where traffic characteristics were changed. Table 2 shows speed analyses for necessity determination of speed camera installation in each speed section of the freeway regarding the parameters mentioned in section 4.

ACCIDENT ANALYSIS FOR PRIORITIZATION OF SPEED CAMERAS' INSTALLATION

The priority of installation of speed cameras was determined by accident analysis for each section. As Mentioned before, accident analysis was performed by determination of rate of accidents due to speeding and loosing car control. Table 3 shows a sample of accident analysis in two sections of the freeway.

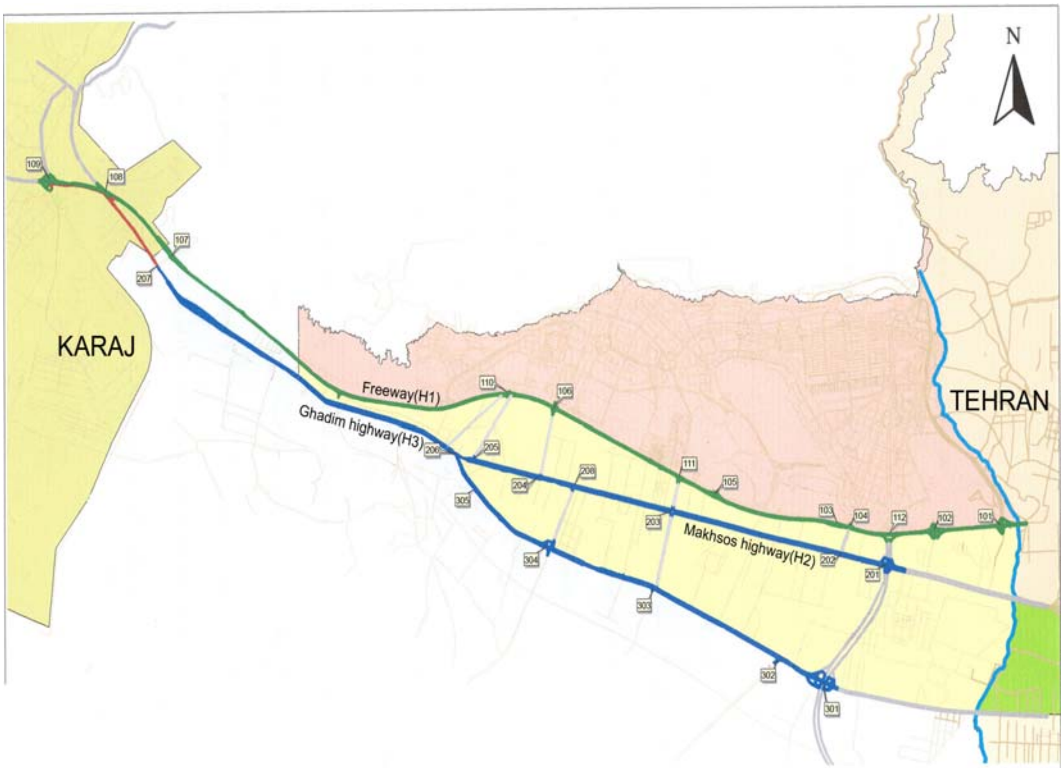
APPROPRIATE SECTIONS FOR INSTALLATION OF WIM SYSTEMS

To determine suitable places for installation of WIM systems at first level of service was measured for different sections of only H1 and H2 highways because heavy vehicles are not allowed to enter freeway.

Capacity Analysis

As mentioned before the first step for determination of appropriate places of WIM technology is capacity analysis. To determine level of service average density of each lane has been used. The intervals between sections have been numbered from east to west. Tables 4 and 5 show the results of capacity analyses for H2 and H3 highways.

Figure 3 illustrates traffic counting stations numbering in the corridor.



Figure(3):Traffic counting stations in tehran-karaj corridor

Table 2: Analysis for necessity determination of speed camera installation

Speed Section	Movement	Lane	Average Speed	Allowable Speed (km/h)	85th percentile Speed	Difference of 85th Percentile Speed with allowable Speed	Camera Installation Necessity
1	East	1	78	60	88	28	Yes
		2	91	70	104.5	34.5	
		3	99	80	111	31	
	West	1	77	60	88	28	
		2	91	70	101	31	
		3	102	80	110	30	
2	East	1	79	70	87.5	17.5	Yes
		2	91	90	103	13	
		3	120	110	135	25	
	West	1	84	70	94.5	24.5	
		2	99	90	113	23	
		3	115	110	125	15	
3	East	1	85	70	91	21	Yes
		2	100	90	113	23	
		3	120	110	140	30	
	West	1	85	70	117	47	
		2	100	90	113	23	
		3	120	110	135	25	
4	East	1	80	70	89	19	Yes
		2	90	90	102	12	
		3	115	110	132	22	
	West	1	80	70	80	10	No
		2	90	90	101	11	
		3	115	110	113	3	

Heavy Vehicles' Volume Analysis

To analyses volume of heavy vehicles the statistics of a 15-hour traffic volume was considered. Figure 4 and 5 show the volume of heavy vehicles in H2 & H3 highways. Although traffic volume in H3 highway is more than H2 but level of service in H2 highway is better than H3. H3 highway has only 2 lanes and is not qualified for installation of WIM systems. Regarding traffic volume in H2 highway stations, it was found that the best locations for installation of WIM systems were about 202 and between 202 and 207 stations. Since the section between 202 and 207 stations in addition to traffic volume priority, has a better LOS (A from east to west and B from west to west) and the number of lanes is more than 2 the mentioned section is appropriate for installation on WIM systems.

It should be noted that some of the heavy vehicles in H3 highway exit toward other destinations and since the cost of using WIM technology is more than other weight control systems, it seems that the movable bascules which can be transported by police can also be used for weigh control. Therefore, some special locations should be allocated to movable bascules. It seems that the parking areas beside the highway are the best places to use bascules because of prevention of traffic slowness.

Table 3: Accident analysis in tehran karaj freeway [Saffarzadeh, 2004]

Speed Section	Accident Section	Length	Injury Accidents	Injuries 500m	Fatal Accidents	Fatalities 500m	Accident due to Losing car	Rate of Accident	Speed Violation	Accidents/ 500m	Total Accidents	Installation Priority
1	1	3	24	4	6	1	6	1	2	0.35	159	1
	2	4	17	2.1	4	0.5	8	1	2	25	158	2
	3	2	26	6.5	3	0.75	4	1	0	0	168	4
	4	3	9	1.5	2	0.35	7	1.15	0	0	86	3
2	1	2	17	4.25	3	0.75	5	1.25	4	1	120	2
	2	4	33	4.15	3	0.4	7	0.9	7	0.9	172	1
	3	3	16	2.65	2	0.35	6	1	1	0.35	149	3
	4	1	8	4	1	0.5	19	9.5	0	0	91	4
	5	3	15	2.5	3	0.5	5	-0.85	1	0.15	74	6
	6	2	12	3	1	0.25	4	1	1	0.25	55	5

Table 4: Capacity analysis of H2 highway [Saffarzadeh,2004]

Section Number	Movement	Peak Period	Traffic Volume	Traffic Volume Lane	Free Flow Speed	Density	LOS
1	West	Morning	2098	777	54.7	14.2	B
1	East	Morning	1249	462	56.6	8.2	A
1	West	Evening	3467	1284	54.7	23.5	C
1	East	Evening	2628	972	56.6	17.2	B
2	West	Morning	1397	517	56.6	9.1	A
2	East	Morning	1343	497	56.6	8.8	A
2	West	Evening	1603	593	56.6	10.5	A
2	East	Evening	2603	963	56.6	17.0	B
3	West	Morning	2228	825	56.6	14.6	B
3	East	Morning	1220	451	56.6	8.0	A
3	West	Evening	2196	813	56.6	14.4	B
3	East	Evening	1832	678	56.6	12.0	A
4	West	Morning	573	212	56.6	3.7	A
4	East	Morning	614	227	56.6	4.0	A
4	West	Evening	655	231	56.6	4.1	A
4	East	Evening	797	295	56.6	5.2	A
5	West	Morning	543	200	56.6	3.5	A
5	East	Morning	614	227	56.6	4.0	A
5	West	Evening	660	243	56.6	4.3	A
5	East	Evening	797	294	56.6	5.2	A
6	West	Morning	2002		-	-	E
6	East	Morning					
6	West	Evening	2002		-	-	E
6	East	Evening					

Table 5: Capacity analysis of H3 highway [Saffarzadeh, 2004]

Section Number	Movement	Peak Period	Traffic Volume (PCPH)	Traffic Volume /Lane	Free Flow Speed	Density	LOS
1	West	morning	4040	1469	56.6	26.7	C
1	East	morning	3251	1203	56.6	21.3	C
1	West	evening	4373	1620	56.6	29.3	D
1	East	evening	5229	1936	56.6	36.3	E
2	West	morning	3665	1358	56.7	24.8	C
2	East	morning	3632	1346	56.6	23.8	C
2	West	evening	4373	1618	56.7	30.3	D
2	East	evening	3991	1476	56.6	26.3	C
3	West	morning	3665	1358	56.6	24.0	C
3	East	morning	3631	1346	56.7	24.6	C
3	West	evening	4373	1618	56.6	29.3	D
3	East	evening	3962	1465	56.7	27.0	C
4	West	morning	3076	1142	56.7	20.9	C
4	East	morning	3280	1213	56.6	21.4	C
4	West	evening	3980	1474	56.7	27.3	C
4	East	evening	3638	1346	56.6	23.8	C
5	West	morning	2872	1061	56.7	19.4	B
5	East	morning	4098	1516	56.6	27.1	C
5	West	evening	3863	1434	56.7	26.3	C
5	East	evening	3542	1310	56.6	23.1	C
7	West	morning	1915	709	56.6	12.5	B
7	East	morning	999	369	56.6	6.5	A
7	West	evening	1923	704	56.6	12.4	B
7	East	morning	1915	709	56.6	12.5	A
8	West	morning	2659		-	-	F
8	East	morning					
8	West	evening	3660		-	-	F
8	East	evening					
9	West	morning	2312		-	-	E
9	East	morning					
9	West	evening	2899		-	-	F
9	East	evening					

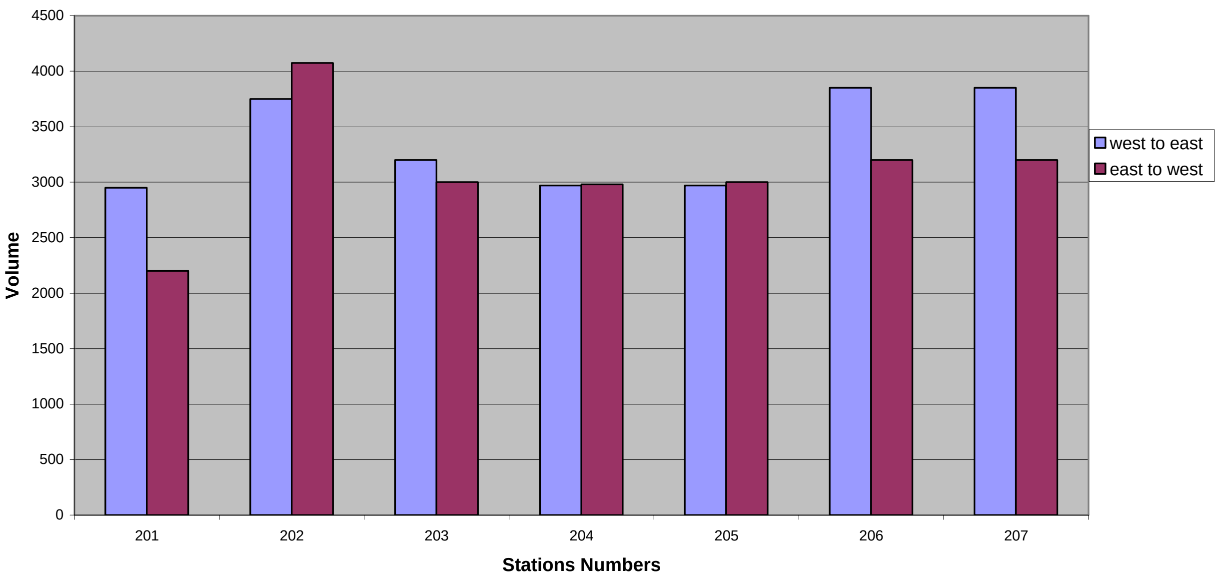


Figure 4 : 15 Hours heavy vehicles' volume in H2 highway

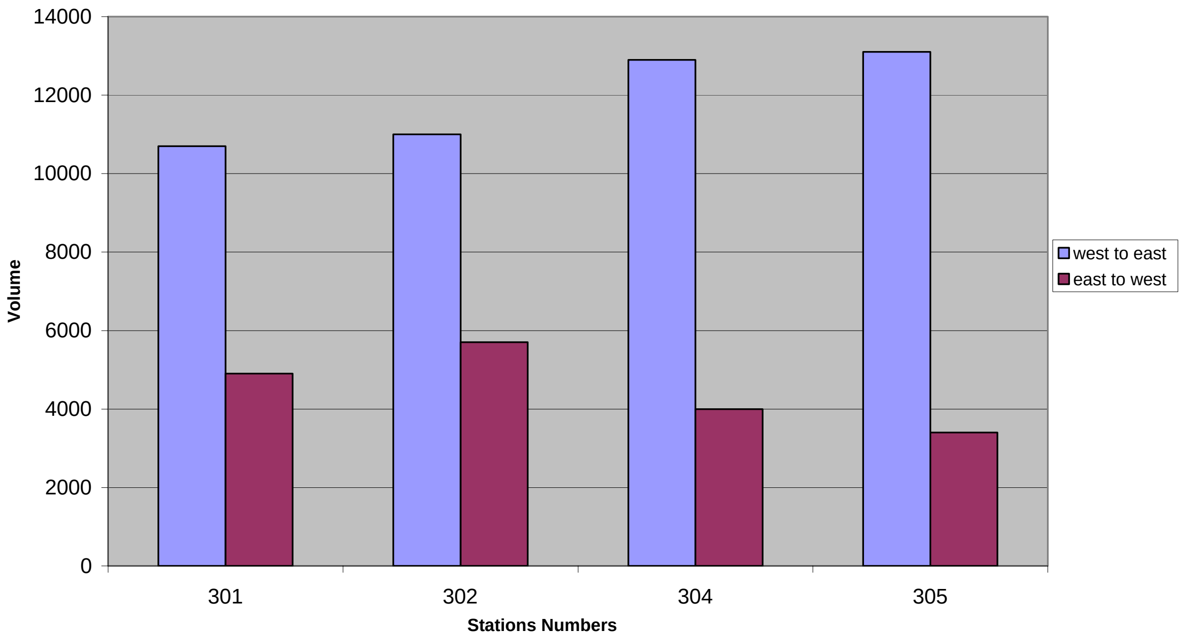


Figure 5 : 15 Hours heavy vehicles' volume in H3 highway

CONCLUSIONS

Using speed cameras and WIM technology can be very useful for reducing the number of accidents and rate of pavement deterioration in developing countries but it should be considered that speed and weigh control have been achieved through combined application of many other factors like enforcement of traffic laws and continuous drivers training.

However assessment of effective parameters in using speed control cameras and WIM technology needs field studies and consumes a lot of time and money but will help traffic officials to use the systems efficiently.

REFERENCES

1- Francis K. Afukaar, (2003) speed control in developing countries: issues, challenges and opportunities in reducing road traffic injuries, journal of injury control and safety promotion, vol. 10, no.1, pp-77-81.

2- Hyden C, (1993) , the speed limiter a simple potentially efficient device, proceeding of 26th International symposium on automotive technology and automation, Aachen, Germany.

3- Nilsson G, (1993) Relationship between speed and safety: calculation method, the speed review: appendix of speed workshop papers, federal office of road safety, report CR127A, department of transport and communications, Canberra.

4- Saffarzadeh. M. and Negahban. M.,(2004), Designing the controlling system of commercial vehicle transportation, thesis submitted for the degrees of master of science, Tarbiat Modares University.

5- States successful practices Weigh in Motion handbook, (1997), Iowa state university,