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Research Article

AN EVALUATION FOR PREVENTING CROSS-HATCHED AREA VIOLATIONS ON HIGHWAYS

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ABSTRACT

Cross-hatched (chevron markings or simply hatched are also terms used in the literature) areas on highways emphasize that these areas are not permitted to be used by vehicles and also provide information for changing flow direction and/or for merging or diverging different flows. Thus, these areas are also indicators of possible bottleneck sections. Violations at these sections at peak hours cause reduction in road capacity. Violations at off peak hours, on the other hand, cause serious risks of accidents especially on high-speed highway merging and diverging ramps. Some parts of our road network, both urban and intercity, can be monitored by traffic camera systems, and traffic fines can even be sent to drivers who violate the traffic rules. However, there is no quantitative evaluation of these violations or their frequency. In our study we demonstrated that violations made by mostly commercial vehicles and meaningful differences on violations between observed sections seen as well.
In the study presented, comparative results with those of international literature are shared. This study was made with the help of Yildiz Technical University Traffic Control Centre Laboratory working in coordination with the Istanbul Metropolitan Municipality (YTU-IBB-TKM-Lab). We believe the results of the study are sociologically worthy of evaluation.
Keywords: Traffic safety, hatched area, traffic violation, enforcement.

1. INTRODUCTION

Transportation demand has been rising along with urbanization and population growth both in our country and the world. There has also been an almost daily increase in traffic accidents, environmental problems, overconsumption of natural resources, rising travel times, delays in trips and congested highways due to the overuse of private automobiles (1). To solve these problems and to meet demand there have been some developments in transportation modes.

Under the conditions of the present day, for many in society, it is an accepted fact that the enlargement of highway lanes or capacity, specifically, is not a proper or sustainable solution. So the focal point of solutions is the management of the transportation infrastructure in a more optimal way. Intelligent transportation systems, at this point in time, have the potential to make a major contribution for solution to traffic management problems.

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2. INTELL IGENT TRANSPORTATION SYSTEMS (ITS)

Initial work on Intelligent Transportation Systems (ITS) was performed in the USA during the 1970's. During these years, the main focus of ITS was mitigating the effects of traffic congestion much more than vehicular control (3). In Turkey, the development of ITS architecture which is aimed at an integrated and co-operative system, initiated and managed by the General Directorate of State Highways (KGM), is still ongoing. This work also determines the general framework of the National ITS architecture which is forecasted in the ITS strategy document published by the Ministry of Transportation, Maritime Affairs and Communications (UDH).

The fundamental functional areas, which are taken as the bases for the physical architectural framework of ITS, are determined within 8 areas.

1. Traffic Management
2. Passenger Information and Guidance
3. Public Transit Management
4. Vehicle Safety and Control
5. Freight and Fleet Management
6. Emergency and Disaster Management
7. Road Construction and Maintenance Management
8. Data and Archive Management

A typical example of traffic rule violation detection systems can be seen in Figure 1.

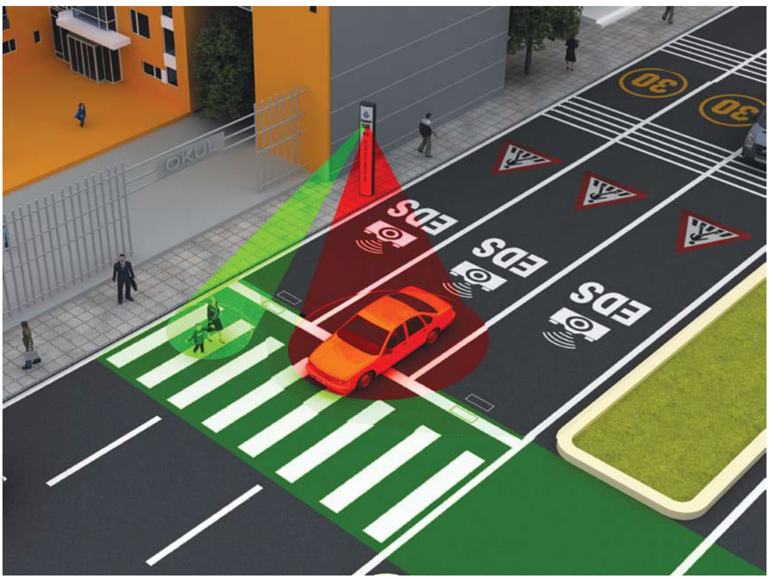

Figure 1. An example of traffic rule violation detection system (4)

Traffic rule violation detection systems are evaluated different categories; red light violations and safety lane violations are among these categories. It is important to keep in mind that in this work we focused only on cross-hatched area violations at merging and diverging flows.

Traffic safety culture has recently become a new concept. Thus, it does not have an agreed definition in the literature. There are some references about how traffic safety culture is grown and shaped in society. The structure of traffic safety culture is not understood completely and arguments about how this culture changes depending on society cannot be definitive. Different conceptualizations and institutional traffic safety culture definitions have been analysed to make a concrete definiti on of traffic safety culture. A foundation which does traffic safety research points out that the traffic safety concept is a fundamental subject of research in the USA (5).

2.1. Traffic Rule Violations

Traffic rule violations are basically defined as not obeying any kind of signs on the highways, which warn drivers, passengers and pedestrians in order to prevent several potential risks. Forcing drivers to drive safely is aided by legal enforcement. Determination of traffic rule violations and then producing outputs for ticketing or fining such violations are part of this process. Passing during a red light, disobeying warning signs, driving over the speed limits, dangerous passing, driving on emergency lanes, driving through cross-hatched areas and turning from prohibited road sections are the main traffic rule violations.

Many studies (5, 7, 8) have investigated the traffic rule violation of driving over the speed limit and how to mitigate this. Legal authorities have used developing technologies to solve the problem of exceeding the speed limitations which have demonstrated positive results in reducing vehicle speeds (6). Photo-radar and electronic speed warning signs are the most used applications among speed control systems. Photo-radar systems have been in use for almost 30 years in more than 40 countries (7) whilst electronic speed warning signs were developed at the end of the 1980's.

Traffic rule violations may be due to several causes. One of these causes may relate to traffic safety culture. Driver behaviours show differences depending on their countries. The KGM, reported that 8.6 deadly traffic accidents happened in Sweden, 11.3 in Finland, 23.3 in Greece and 38 in Turkey per 100,000 vehicles in the year 2006 (8). If traffic rule violations are grouped we may see a short list of factors

- Human,
- Vehicular,
- Road and
- Environmental.

An example of an electronic supervision system (EDS or (TEDES in Turkish)) can be seen in Figure 2.

Figure 2. An electronic supervision system (EDS) example (4)

3. METHOD

Observations were made from the traffic cameras from *YTU-IBB-TKM-Lab* that were established by YTU in coordination with the Istanbul Metropolitan Municipality. As a result of these observations, six locations (TEM Hasdal, D100 Cevizlibağ, D100 Otakçılar, D100 Zincirlikuyu, Basın Ekspress-Kuyumcukent, and D100 Bahçelievler Ömür Plaza) were identified where cross-hatched area violations were frequently made by vehicle drivers. During this process, some discontinuity of live camera streaming by IBB TKM (Istanbul Metropolitan Municipality Traffic Control Center) occurred in the network. Also, the view angles of cameras were shifted by IBB TKM on occasion (for example for accidents or unexpected events) or on a solely random basis. After communication with the authorized personnel in IBB TKM it was decided to keep the view angles of traffic cameras constant for the morning and evening peak periods at D100 Zincirlikuyu and D100 Cevizlibağ sections (see Fig. 3).

Figure 3. D100 Cevizlibağ and D100 Zincirlikuyu Sections

In March and April 2015, peak-hour observations were made for 3 days per month, one of which is given in Table 1 as an example. Due to the bad weather conditions and some camera breakdowns there are long time periods between the dates.

Traffic counts were made between the same reference points which were chosen on the road side to form a section. Examples of these can be seen in Figures 4 and 5. In Figure 4, it can be seen that traffic counts were made in the shaded area for the one-way four lane section of the D100 Cevizlibağ location. First, the total number of vehicles crossing from the section was counted and then on a one-minute basis, the number of all passing and cross-hatched area violating vehicles was noted as shown in Table 1. The same methodology was applied for the D100 Zincirlikuyu section. In Figure 5, the counting section can be seen. Counts were made from the direction of the European side to the Asian side. After this, the vehicles were divided by type, as can be seen in Table 1. All video recordings that were used for the observations and counts were approximately 45 minutes. Vehicle counts were made by stopping the video player system every minute. Every one minute of video records was viewed 8 times (for determining the total number of vehicles that crossed the section, the total number of cross-hatched area violating vehicles, the number of three different vehicle types that crossed the section and the number of cross-hatched area violating vehicles by the three vehicle types, which totals 8 counts). The total video viewing time is approximately 2160 minutes because we made counts at 2 different sites (D100 Cevizlibağ and D 100 Zincirlikuyu) and on 3 different days. This total duration (2160 minutes) is only the non-stop time of viewings. It excludes the time taken when the videos were stopped and notes were taken.

Figure 4. D100 Cevizlibağ observation section

Figure 5. D100 Zincirlikuyu observation section

Table 1. Vehicle count sheet example on a one-minute basis

D100 Cevizlibağ 19.03.2015								
Time	**Total Number of Vehicle**	**Total Passenger Car**	**Total Heavy Vehicle**	**Total Commercial Vehicle**	**Total Violating**	**Violating Passenger Car**	**Violating Heavy Vehicle**	**Violating Commercial Vehicle**
10:26:25	72	38	1	33	15	10	0	5
10:27:25	68	40	1	27	16	11	0	5
10:28:25	69	37	2	30	22	17	0	5
10:29:25	73	41	4	33	17	12	1	4
10:30:25	75	37	5	33	27	19	2	6
10:31:25	74	36	1	37	28	19	0	9
10:32:25	75	37	2	36	20	18	0	2
10:33:25	75	48	2	25	15	8	0	7
10:34:25	79	42	3	34	22	13	1	8
10:35:25	83	49	3	31	21	14	0	7
10:36:25	69	31	2	36	12	7	0	5
10:37:25	73	34	1	38	15	6	0	9
10:38:25	76	43	2	31	10	5	0	5
10:39:25	77	46	1	30	13	8	0	5
10:40:25	57	31	3	23	7	4	0	3
10:41:25	69	39	1	29	14	8	0	6
10:42:25	74	40	1	33	12	11	0	1
10:43:25	77	39	3	35	15	13	0	2

4. FINDINGS

Here, we present the graphical representations of the vehicle counts for cross-hatched area violations as well as the general findings. Some snapshot screen examples for the March 19, 2015 morning period cross-hatched area violations can be seen in Figures 6 and 7. As a result of the analysis of the video recordings, we calculated that 17% of the vehicles violated the cross-hatched area at that section. Detailed counts show that 11% of these are passenger cars, 0.5% are heavy vehicles and 5.5% are commercial vehicles. Another interesting observation is that toward noon, the cross-hatched area violations decreased.

Figure 6. Heavy vehicle shaded area violation at 19.03.2015; time: 10:28:40

Figure 7. Another shaded area violation snapshot at 19.03.2015; time: 10:31:17

From Figure 8 we may say the total number of vehicles crossing the observation section is almost steady though the number of cross-hatched area violating vehicles decreases towards the end of the peak period. It is possible that the reason for this is that more regular traffic flow occurs toward noon.

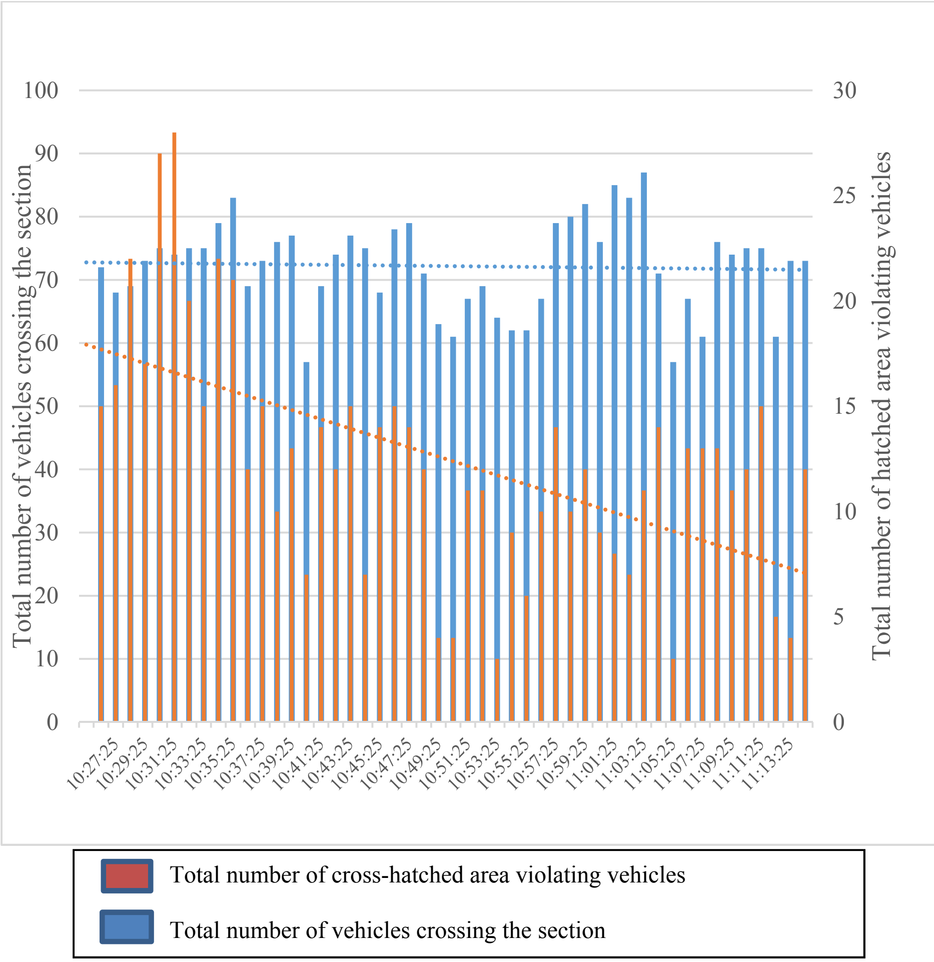

Figure 8. Total number of vehicles crossing the count section and total number of cross-hatched area violating vehicles per minute on 19.03.2015

Total and vehicle-type grouped violations of cross-hatched areas for all observation periods can be seen in Table 2.

While it was expected that commercial vehicles would violate the shaded areas more than the other types, surprisingly, more private vehicles were detected violating the shaded areas than the other two types of vehicles. The reason for this expectation was that the traffic penalty tickets were sent to companies instead of real persons. In Table 2, one can see that in five out of six observations, passenger cars made more violations for the cross-hatched areas than the other two. We believe this result is due to the total number of passenger cars being far higher than the other two types of vehicles. Another of our conjectures is that among the passenger cars there are many company cars, so these cars may cause this high percentage in the passenger car group. Table 3 also shows the percentage of vehicle types involved in violating the cross-hatched areas. If we compare passenger car and commercial vehicle violation percentages, then we see that commercial vehicles violate the cross-hatched areas more than passenger cars. One of the reasons of the heavy vehicles' low percentages may be that these types are not legally allowed to use the D100 Zincirlikuyu section, except for public buses.

Table 2. Cross-hatched area violation percentages by vehicle type at D100 Cevizlibağ and D100 Zincirlikuyu sections

	Date-Hour	**Percentage in Total**	**Passenger Cars**	**Heavy Vehicles**	**Commercial Vehicles**
D100 Cevizlibağ	19/03/2015 10:25-11:14	17%	11%	0.5%	5.5%
	26/03/2015 08:38-09:30	15.53%	8.70%	0.54%	6.30%
	14/04/2015 08:36-09:26	18.33%	11.20%	1.03%	6.10%
D100 Zincirlikuyu	19/03/2015 10:30-11:18	4.88%	2.27%	0.13%	2.47%
	26/03/2015 08:39-09:30	13.02%	7.87%	0.25%	4.90%
	14/04/2015 08:44-09:30	17.67%	10.99%	0.25%	6.43%

Another result obtained from Table 3 is that based on violation counts, passenger cars at the D100 Cevizlibağ section committed more violations than commercial vehicles. On the contrary, at the D100 Zincirlikuyu section we see that commercial vehicles committed many more violations than passenger cars. The possible reasons may be that the two sections have different geometries (one is a diverging place and the other is a merging place), there are different traffic composition/patterns and due to different driver behaviours (socio-economic and socio-cultural background). Nevertheless, we must accept that our hypotheses are not enough to generalize all behaviours based on only three days' counts, and so are insufficient to explain the differences in Table 3.

Table 3. Total numbers of vehicles passing count section by type and total number of shaded area violating vehicles

	Passenger Cars		Heavy Vehicles		Commercial Vehicles	
	Total Passing	Total Violating	Total Passing	Total Violating	Total Passing	Total Violating
19.03.2015 D100 Cevizlibağ	1871	392(20.95%)	106	17(16.03%)	1564	198(12.65%)
26.03.2015 D100 Cevizlibağ	2473	342(13.82%)	118	2218.64(%)	1368	250(18.27%)
14.04.2015 D100 Cevizlibağ	2098	428(20.40%)	627	40(6.37%)	1153	23420.29(%)
19.03.2015 D100 Zincirlikuyu	2532	83(3.27%)	112	5(4.46%)	827	89(10.76%)
26.03.2015 D100 Zincirlikuyu	3557	334(9.38%)	94	11(11.70%)	621	208(33.49%)
14.04.2015 D100 Zincirlikuyu	2938	421(14.32%)	27	9(33.3%)	901	242(26.85%)
Mean	2578	13.69%	181	15.08%	1072	20.38%

5. RESULTS AND RECOMMENDATIONS

This study indicates to us that prohibition of cross-hatched area violations are as important as the prohibition of other kinds of traffic rule violations. Our observations at the D100 Zincirlikuyu and D100 Cevizlibağ sections prove that vehicle violations of cross-hatched areas cause negative effects on regular traffic flows. Because fluctuations in traffic flows were not investigated in this work (and we know irregular driver behaviours cause shock waves in traffic flows which further causes a lowering of the road capacities), we do not have quantitative data for this argument. Based on our results, the average cross-hatched area violation values for passenger cars were found to be 13.70% and for commercial vehicles this figure is around 20.40%. These two sections can be considered as critical for Istanbul's overall traffic. A high rate of almost permanent violations in this kind of critical area makes us think there is both general disorder in the traffic and traffic safety problems in Istanbul city. Interestingly, drivers committed more cross-hatched area violations for both observation sections during free traffic flow conditions than during peak hours.

Based on previous works, driver behaviour is thought to be a reason for the cross-hatched area violations, though such an investigation is out of the scope of this work. However, high definition cameras can be used for determining and preventing these kinds of violations and this method may make drivers more aware of their own careless driving attitudes.

In the literature, it is seen that cross-hatched area violations can be mitigated by recommended applications. On the other hand, just determining the solutions is not enough to make drivers obey the rules. As with all traffic rule violations, cross-hatched area violations must also be paid by drivers who commit these violations. Also, in the literature we can see that if correction practices (traffic fines in this case) are removed over time, then for some time later violations tend to rise (9). For that reason, cross-hatched area violation observations and enforcements (fining drivers) must be continuous and permanent. Studies show that if violation prevention methods are removed or when these prevention measures are interrupted for some reason for a long period of time, then drivers tend to return to their initial behaviours.

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