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PRIORITIZING SUGGESTED STRATEGIES TO REDUCE ROAD ACCIDENTS AT THE CITIES ENTRANCE USING ANALYTIC HIERARCHY PROCESS

Seyed Rasoul Davoodi[1†] ---- Pooya Ahmadi[2]

[1]*Department of Civil Engineering, Faculty of Engineering, Golestan University, Gorgan, Iran*

[2]*Department of Civil Engineering, Faculty of Engineering, Shomal University, Amol, Iran*

ABSTRACT

Accidents in developing countries are the greatest death cause more than 60% of the accidents occur at the entrance of the cities; in fact the quality and quantity of the road accidents show the safety of the roads. Although the entrance of the cities have the same structure as the suburban roads, in terms of function due to its applications are the same as city roads. Inappropriate behavioral pattern of the road users to the entrance of the cities causes chaos in traffics and leads to accident. The purpose of this study is to check the affecting factors on accidents at the entrance of the cities for this study Karaj- Qazvin highway was taken inconsideration in order to prioritize the suggested options through Analytic Hierarchy Process (AHP). Improving the road users' culture and improving the brake systems and navigation of vehicles and also creating signs and physical speed breaker on the roads are some of the best options in the result of prioritizing process. In the study some suggested options as strategies according to the existing situation are presented to reduce accidents at the entrance of the city.

Keywords: Cities entrance roads, Reduce road accidents, Driver behaviour, Safety, AHP.

Contribution/ Originality

The paper's primary contribution is prioritize the strategies of reducing accidents in city entrance. According to field observation and studied cases in the study, most important and appropriate strategies for the road is prepared as questioner and ranked through Analytic Hierarchy Process. Improving the road users' culture and improving the brake systems and navigation of vehicles and also creating signs and physical speed breaker on the roads are the best options in the result of prioritizing process.

† Corresponding author
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1. INTRODUCTION

Everyone knows the economic, politic and social role of the transportation in todays' world. Transportation is one of the major bases of stable and balance development in societies, in fact transportation networks deal with important factors like economy, safety and social justice. In the process of the economic and social development of the countries, there is a direct relation between improving the transportation and gaining more economic development rate, and transportation is one of the main and basic tasks to develop and evolution of economy. One of the major parameters in desirability of road networks is its safety and on the other side is the accident. Accidents in terms of accident rate and its severity will have a negative effect on the safety of the roads and will cause reduction in transportation on the road and so on economic rate. Also accidents in another point of view lead to psychological issues in the society and family section. Injuries and damages due to road accidents are a matter of importance which unfortunately in most of the cases is not took into account.

Public health is a challenge which requires coordinated attempts and measurement to prevent effectively and continuously. Accidents' costs are so high. As valuing the human lives and suffers due to a family member death is impossible, evaluating the exact cost of an accident is completely impossible. Economic costs and damages caused by an accident, in low income countries is 1 percent of their Gross National Production (GNP), in average income countries is 1.5 percent of their GNP and in rich and high income countries is 2 percent of their GNP. The total annual cost in terms of money value is estimated more than 518 billion US dollars around the world. This cost for low income countries and average income ones is about 65 billion dollars which is more than the funds they get for developing aids. Damages and harms due to road traffics, will impose a lot of costs not only to the national and international economy, but also to the family economy. A lot of the families that their breadwinner died or disabled in an accident, severely got poor (World Road Association, 2003).

2. LITERATURE REVIEW

Researches that have been conducted on this subject are limited and are mostly in the title of "road accidents" which was first conducted by Ayati and under the title of "road accidents in Iran", in 1371 was published as book in Ferdosi University of Mashhad. Ayati checked the accidents' factors in two-lane roads which is the basis of lots of the researches for roads between the cities in Iran (Ayati, 1992). McGinnis and McGrath (2001) presented a suitable strategy to improve side of road safety, side of the road at the entrance of the city is so important, because people who use the roads for different destinations enter here (Mohammadi, 2012).

In 2001 another researcher named Miaou, in his research analyzed the omission of road shoulders at the entrance of the cities which is not usually built and psychologically makes the drivers to drive away from the edge of the road and causes to reduce the width of the road so lessens the safety. Also he studied the parking of vehicles at the sides of the road, lighte ning of the place and the geometric design of crossroads at the entrance of the cities which were problematic (Miaou, 2001). Baguley (2001), studied the accident data system and road safety and affecting factors on road accidents according to the data achieved from the data analysis of the accidents in

Asia and Oceania. The data from the statistics show the relativity of the accidents with the safety parameters (Baguley, 2001). Royer (2000), suggested a fix and logical object with suitable lightening as an effective factor in reducing the accidents on the entrance roads of the cities. Other researchers in 2003 by studying the safety of the roads and analyzing the amount of the accidents on the highways between the cities found that most of the accidents occur 10 to 30 KM away from the pay tolls (Guo *et al.*, 2003).

Mehri (2009), checked the effect of the environment, social and natural situations on the safety of the roads and the amounts of the accidents. In this study, he studied on how the environment affects on the amounts of the accidents and by checking the statistics and different charts, he suggested some strategies to reduce the accidents outside of the cities caused by the environmental effects on the road (Mehri, 2009). Meysam *et al.* (2007), in a study looked for a method to determine the accident-prone points using the GPS and AHP. In this study, affecting parameters in determining the accident-prone places of the roads were checked and a method to determine the accident-prone zones of the roads in the form of a risk map were presented by using the GPS and AHP and finally the method was compared with the existing statistic methods.

In general, safety of the roads is affected by three factors; human, vehicles, road and its environment. Every accident will be the result of the imbalance of these 3 factors. WRA (2003). Studies show that 90% of the road accidents are due to human errors. Nevertheless, role of the roads and its environment in occurring accidents and even preventing them is significantly important. Generally to reduce the human factors in accidents, improving the culture of driving, suitable training, and improving the quality of the cars need long term investment. If it happens, it won't cover all of the society because always it was hard to change human behaviors and it took time (WRA, 2003).

In investigating human factors, first we should consider type of the road in terms of function and main role of the road, crossing traffic of the road, number of the heavy vehicles on the road especially on rush hours, existence of separate lanes and other structural parameters of the road, and then the role of the human errors will be measured. Perhaps in lots of roads of country, inappropriate structure of the road will lead to human errors.

For example, a road that is for transporting and linking to cities, but instead of highway or freeway function has a two lane two way road, the accidents in it is mostly due to illegal overtaking especially by heavy vehicles, in this case the cause of the accident was not just the human but the incorrect and inappropriate design of the road. How many of these accidents were the result of same factor of road and human. In fact correcting most of the road defects will considerably reduce the accident percentage resulted from drivers' misunderstanding of road. As above said, human errors is completely inevitable and some of them happen in road transportation which is because of the human nature. Regarding this we should carefully design the roads to some extends prevent human errors and in case of occurring of an error reduce its damages. In general we can divide human factors causing road accidents into two groups:

1. physical and mental inabilities and limitations
2. negligence and violation of traffic rules

Each group is consisted of different factors that are categorized in the Table 1. Also Table 2 shows the categorization of road factor in road accidents.

Table-1. Human factors affecting on road crashes (Shafabakhsh and Mousavi, 2007).

Physical and mental inabilities and limitations	Negligence and violation of traffic rules
Tiredness , unrest and misunderstandings	Unfasten seat belt
Disability	Violating the safe distance from the front car
Sight error	High speed
Senility	Talking on the phone
	Illegal overtaking

Tiredness is an important parameter at the entrance of cities that happens as physical and mental tiredness, followings are the main reasons of this kind of tiredness:

A. The traffic selects city zones as a place to rest and drive with their highest mental and physical energy to this zone.

B. Traffic with the destination of the city that drivers use their highest physical and mental ability.

C. Just a small portion of traffic will cross the city without stop.

Table-2. Categorization of road factor in road accidents(WRA, 2003)

Geometry of the road	Specifications of road surface	Side of the road	Road equipment
Upright direction, junction	Altitude, friction, way	Inside the city, outside of the city	Signs, linings, lightening, obstacles
Horizontal direction	Slippery, rubbish	Playground, shopping center	
		Amount of traffic	
		Main users	

2.1. Purpose of Study

The purpose of this study is to prioritize the strategies of reducing accidents in city entrance. To achieve the aim the entrance of Karaj and Qazvin in Karaj- Qazvin highway is studied as a case study. First we will study the current condition of the road. Then according to field observation and studied cases in the study, most important and appropriate strategies for the road is prepared as questioner and ranked by reporters. Finally, according to the AHP method these facilities are categorized and the result is estimated and studied.

3. METHOD

3.1. The Condition of Entrance of Karaj and Qazvin Highway

All over the road, the superstructure of the road was in a good condition and even at the beginning of the road there was new asphalt layer but the objection to it is the loss of lining signs and superstructure surface signs in the beginning parts of the road and the faded signs in farther parts. Different direct accesses to the highway even in some cases unpaved roads have been seen that clearly will reduce the role of highway function of the way; also there are no signs for

navigating and warning other drivers of these secondary roads. Existence of direct access and loss of reduce and increase speed lanes and also loss of warning traffic signs and navigation signs in appropriate places before different applications and existing direct access will lead to reduce the speed in low-speed lanes and sudden change of lane by vehicles and even sudden stops in case of crossing of the access and even moving by differential gear which increase the likelihood of accident. Table 3 shows affecting factors on road accidents in Karaj-Qazvin.

Table-3. Affecting factors on road accidents in Karaj-Qazvin according to accident statistics in 2011

Human factors	Vehicle defect	Road defect
Inappropriate speed and hurry	Flattened Tire	Freezing and tarring of road
Inattention to front and driving	Loss of wiper	Loss of guard at the sides
Speed violation	Defects of brake system	Arch with oblique angle
Tiredness and sleepiness	Defects of lightening system	Defects of lining
Loss of enough skill in navigation and loss of vehicle control		Defects of asphalt layer
Unfamiliarity to the road		Defects of horizontal and vertical signs

3.2. Analysis Process; AHP

In general the analysis process of AHP is consisting of four stages:

Modeling or making AHP tree, conducting couple comparisons and making couple comparison matrix, relative weight calculation, final weight calculation. Decision tree of AHP is a graphic show of a real problem. In this graph decision making is at the top, at the second level criteria and the next level options.

3.2.1. Determining the Criteria and Options of Study

In determining the providing criteria of safety according to the studies, creating factors of road accidents is described and after studying the current condition the portion of each one of the affecting factors in road accidents are defined, also according to above said cases and field observation which is done from the road our criteria and tree options of AHP are created. Table 4 presents criteria and related options which are the result of experts ranking.

Table-4. Criteria and decision options

Speed violation	Tiredness and sleepiness	Not paying attention to front	Exposing to pedestrians	Defects in road surface	Defects of road design and equipment
Correction of installation place and improving traffic signs	Establishing horizontal changes and altitude changes on road and not constructing the road as long direct parts	Improving culture and training to drivers	Creating under ways	Improving the quality of superstructure of road	Correction of inappropriate turns in horizontal arches
Existence and increasing the warning signs for the high speed having cultural massages	Installing rumble strips	Improving the vehicle to navigation system	Creating footbridge	Preventing from road frozen	Enough lightening of road
Installing speed announcement signs	Creating parks at the sides of roads or between the roads	Improving vehicles to appropriate braking system	Enough lightening of road	Removing surface waters	Installing and improving navigation signs
Improving lining and signing of road	Enough lightening of road	Installing rumble strips	Increasing the sight removing the obstacles like trees	Cleaning of the road	Correcting the installation place and improving traffic signs
De-coloring of the road in special places	Creating appropriate retire rooms		Correcting the installation place and improving traffic signs	Improving lining and signing of road	Increasing and correcting safety guards to the sides of the roads
Installing bumps in special locations and in different distance	Improving vehicles to lane keeping systems		De-coloring of the road in special places		Improving vehicles to appropriate braking system
Installing rumble strips	Improving culture and training to drivers		Improving lining and signing of road		Installing bumps in special locations and in different distance
Improving culture and training to drivers					

3.2.2. Providing Questioner

The questioner is arranged according to the AHP basis and binary comparisons from decision options in related criteria. The questioner is ranked by experts and an average from the total ranks was presented and is used as expert ranks in the process of AHP.

3.2.3. Binary Comparison Matrix

In creating binary comparison matrix, each element weight is compared with another element in binary. In general we can find the preference of one element to another one through the following method: providing questioner and statistics, experts view, existence documents, using Expert Choice software, etc. In the study, in general, the preference of options and criteria for prioritizing the safety strategies on accidents at the entrance of cities was obtained from expert survey.

3.2.4. Calculating Relative Weight

After creating binary comparison matrix, first the matrixes should be normal to calculate relative weight of options and criteria. After normalizing, in one method, averaging of each line of the normalized matrix, the relative weight will be calculated.

Normalizing method will be as the following:

- First we will accumulate each line.
- Then each element in the binary matrix will be divided into its sum of its column to normalize the binary matrix.
- Now, the average of each line in the normalized matrix will be calculated to calculate the relative weight of each element.

4. RESULTS

After calculating the relative weight for all of the options and criteria according to the Tables 5 and 6, final weight of each of the options and criteria are shown.

Table-5. Prioritizing suggested options according to the final weight of each option

Rank	Decision options	Final weight
1	Improving culture and training to drivers	0.23
2	Installing rumble strips	0.14
3	Improving the vehicle to navigation system	0.081
4	Improving vehicles to appropriate braking system	0.076
5	Installing bumps in special locations and in different distance	0.075
6	Enough lightening of road	0.06
7	Improving vehicles to lane keeping system	0.047
8	Creating footbridge	0.037
9	Improving lining and signing of road	0.0315
10	Correcting the installation place and improving traffic signs	0.028
11	De-coloring of the road in special places	0.024
12	Preventing from road frozen	0.0234
13	Installing speed announcement signs	0.022
		Continue

14	Correction of inappropriate turns in horizontal archs	0.022
15	Increasing and correcting safety guards to the sides of the roads	0.018
16	Establishing horizontal changes and altitude changes on road and not constructing the road as long direct parts	0.018
17	Creating appropriate retire rooms	0.015
18	Removing surface waters	0.0138
19	Creating under ways	0.0126
20	Creating parks at the sides of roads or between the roads	0.009
21	Installing and improving navigation signs	0.0077
22	Existence and increasing the warning signs for the high speed having cultural massages	0.0072
23	Improving the quality of superstructure of road	0.006
24	Increasing the sight removing the obstacles like trees	0.0045
25	Cleaning of the road	0.0036

Table-6. Prioritizing the study criteria according to the relative weight of each criteria

Rank	Criteria	Weight
1	Not paying attention to front	0.31
2	Speed violation	0.24
3	Tiredness and sleepiness	0.18
4	Defects of road design and equipment	0.11
5	Exposing to the pedestrians	0.09
6	Defects of road surface	0.06

5. CONCLUDION

The above mentioned was the estimation and prioritizing of strategies for reducing accidents at the entrance of cities in Karaj-Qazvin highway road which is according to the data of current condition and statistics of accidents in 2011. These strategies and also suggestions that are cited in the discussion on safety of this zone can be applied to the same road and conditions. Whatever should be considered to make the entrance zone of cities safe and determine research criteria is to choose the strategies and criteria according to the type of road and structure of the city and for different ways will have different results.

The best options of the results in the process of hierarchy as guideline presentation are as followings:

- improving the culture of driving and training to the drivers: training is to prevent dangerous behaviors to occur while driving like talking on the phone, training the drivers to know the entrance of the cities and deciding to control the speed according to the changes of the environment are one of the most important strategies of this problem that its fulfillment method can be done through primary training to the teenagers at schools, through driving training centers, brochures and training magazine that can be available in different places or subway or buses to the public, through banners and signs and also radio advertisements.
- Improving vehicles to have alarming system to alarm when it goes out of the road: exiting from the road normally happens in tiredness and sleepiness and when not paying attention to the front. Exiting alarm system according to the amount and intensity of direction change of the vehicle and obstacles around the driver will alarm and get his attention.

- Improving the vehicles to navigation system: this system will alarm in case of closing to an obstacle and in the advanced types it will reduce the vehicle's speed automatically.
- Improving the vehicles to an appropriate brake system: appropriate braking system that provides the vehicle with less braking time can prevent the accident.
- Installing Rumble Strips: rumble strips are appropriate equipment not only reduce the speed of the vehicle but also takes the driver's attention that he is driving in a different zone of the highway and there would be the chance of an accident or a pedestrian.
- Installing standard bumps in special locations and in different distances: as previously said, entrance of the cities, have a condition between outside and inside roads, so to let the driver know about this change the environment should be indicating this change. In dangerous locations and also in the places that high speed will cause risk for pedestrians it is recommended to use these bumps. But the writer suggests using more rumble strips and improving driver trainings.
- Installing speed announcing signs for vehicles: in many cases that the driver enters to the entrance of the cities, doesn't pays attention to his speed or thinks that his speed is lower than his real speed. So installing these intelligent signs to remind the driver's speed can be effective in reducing his speed.

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