Providing a Model in Order to Transportation Safety in Accident Black Spots in Suburban Roads from Economical Optimizing Point of View

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***Abstract*—High Statistic of accidents in Iran on one hand, and limited budget allocated on provinces by government to execute road construction projects on the other hand show that mentioned budget is not sufficient to transportation safety all regions in our country. Then firstly, it is necessary to survey accident studies and accident black spots, and try to safety these regions from economical point of view. Research on Ahvaz-Shoushtar axe show that most of these accidents happened in cross-roads, main ways and entrance of villages. Therefore, special pattern was provided to safety mentioned regions by safety signals, that showed according to executive costs of plan and comparing them to annual accidental costs in Iran, statistic of accidents decreased so much and was evident of economical save in budget in our country.**

***Index Terms*—Transportation safety, accidents, accident black spots, safety signals.**

I. Introduction

The main causes of traffic accidents are as followed: human characteristics, plan deficiencies, vehicle wearing out, environmental, Traffic and geometrical status [1]. Often, accidents in suburban roads are more damages than accidents inside the cities, because of high speed of vehicles [2]. Researches show that more than 24000 kill persons in traffic accidents in Iran every year [3]. According to evaluations of World Bank, cost of traffic accidents in developing country is 1.4-2 $ milliard, that equal to 1-3% national gross production in these countries.[4]. While according to executed researches in Iran (2009) mentioned cost in more than 7% national-gross production. [5]. Surveying different statistics of Iran show that inefficient availability causes to happen different road accidents [6]. Lack of suitable regulations to marginal availability, managing and controlling these availabilities causes to increase accident statistic. [7]

II. Back Ground History

EU (1993) defined Transportation safety as a major part of discussions in European Transportation policies [8].

Accidents are complicated events that risen from interactive effects of different factors such as road, vehicle, humanity factors and environment [9]. Accident black spots are regions that 10 accidents happen in them during 3 years [10]. Transportation safety in one region is defined as followed: Selecting and optimizing cross-road that happen so many accidents in them [11]. Road safety in these regions is performed by reforming road geometrical plan, road tissue, and installing safety equipment and signals [12]. Safety engineering evaluates safety in different sub-divisions and in accordance it with standard framework [13].Determining priority in dangerous Cross-roads based on uni-criteria methods such as rate of accident, density of accident, and accident frequency [14]. In accordance with research executed on India, road environmental and geometrical parameters such as number of lines, vehicles and width of the roads, allocated special number on them is called weight number, and collected these numbers on each criteria and finally achieved on number which is called accidental number.

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III. Subject and Method

Safety Management System (SMS) is controlled all road Transportation process in respect of improving Safety level [16]. This system is used to decrease cost of accidents in dangerous regions by providing preventive proceeding, suitable optimized plans and methods [17]. This article is surveyed accident statistic during 5 years (2009-2005) in connective axes in Khouzestan province by SMS. Also, accident statistic analyzed Ahvaz-Shoushtar axe and found accident black spots, then provided safety pattern or model to transportation safety of cross-road in suburban roads.

A. Suburban Accident statistics in Khouzestan Province According to Axes Separation

Table (1) show accident statistics in Khouzestan province during 2005-2009 based on accident index according to (1) [18].

$$AR = \frac{M}{L} \quad (1)$$

M= annual accidents.

L= length of region (km)

AR= accident rate

In accordance with table (I) Ahvaz - Mollasani Axe have highest accidental rate in this province, that its main reason is high traffic rate and transportation, density villages and availability on axe in accident black spots.

TABLE I: ACCIDENTS IN KHOZESTAN PROVICE (2005-2009) IN ACCORDANCE WITH ACCIDENT RATE

Name of axe	Length (km)	Number of accidents in a year	
		Sum of 5 years	*Accident rate*
Ahvaz-Mollasani	32	1184	37
Ahvaz-Andimeshk	145	4437	30.6
Ahvaz-Bandar Emam	170	4340	25.5
Andimeshk-Zal Bridge	60	1320	22
Ahvaz-Abadan	113	2034	18
Shoushtar- Dezful	53	700	13.2
Behbahan-Kheir Bridge	19	202	10.6
Ramhormoz-Koupal	38	401	10.6
Ramhormoz-Behbahan	102	1090	10.7
Mollasani-Shoushtar	55	514	9.3
Abadan-Banadr Emam	76	681	9
Ramhormoz-Dehdez	192	1216	6.3
Ahvaz-Khoramshahr	125	778	6.2
Others	3592	15314	4.3
Total	4772	34211	7.2

B. Suburban Accident Statistics in Khouzestan Province According to Space of Origin

Table (II) shows road accidents frequency in Khouzestan province according to space of origin of axe. According to these information most of accidents happen near the cities, so that 53% of accidents happen in 30 km the cities. We use of safety coefficient 99% in all statistics society (2), (3):

$$\frac{18169}{34211} = \frac{x}{n} = \bar{p} = 0.53 \qquad (2)$$

$$\bar{p} - z\sqrt{\frac{\bar{p}(1-\bar{p})}{n}} \le p \le \bar{p} + z\sqrt{\frac{\bar{p}(1-\bar{p})}{n}} \qquad (3)$$

$$0.53 - 2.58\sqrt{\frac{0.53\times 0.47}{34211}} \le p \le 0.53 + 2.58\sqrt{\frac{0.53\times 0.47}{34211}} \Rightarrow 0.52 \le p \le 0.54$$

X= number of accidents in 5 years in 30 km near the cities.
N= total number of accidents in 5 years.
P= possibility of accident
C=ac=99%
Z=2.85
1-*c*=*a*→ Error=1%

Therefore, safety coefficient 99% shows that 52%-54% accidents happen in 30 km the cities. In other word, reforming roads of province in 30 km near the cities, and removing other effective elements in the field of 99% coefficient, causes to decrease 52%-54% total accident in Khouzestan province. There are 13 axes in this province, that 11 province have 2 cities in each part of axe. Two axes Andimeshk- Zal Bridge and Behbahan- Kheirabad Bridge have one city in both sides of their axes, too. Therefore, length of all roads that achieved by safety coefficient must be reform and are as followed:

$$(11*2-30) + (2*30) = 720\text{km}.$$

whereas, total length of roads in Khouzestan province is 13091 km [19]. Then we will have:

$$\frac{720}{13091} \times 100 = 5.5\% .$$

Therefore, if we control elements that result in accident in 5.5% of the roads around the cities in this province, we can decrease road accidents at least 52% and max 54%.

TABLE II: ACCIDENTS IN KHOZESTAN PROVICE DURING THE 5 YEARS ACCORDING TO DISTANCE OF ORIGIN

Distance of origin (km)	Number of accidents from 2005 to 2009	Frequency	Total frequency
0-5	3420	10	10
6-10	3161	9.3	19.3
11-15	3128	9.2	28.3
16-20	2977	8.7	37.2
21-25	2809	8.2	15.4
26-30	2644	7.7	53.1
34-35	2398	7	60.1
36-40	2116	6.2	66.3
41-45	1828	5.3	71.6
46-50	1902	5.6	77.2
50	7798	22.8	100
Total	34211	100	

C. Suburban Accident Statistic in Khouzestan Province According to Accident time

Table (III) shows frequency of road accidents in this province according to accident time. In accordance to information in this table the highest frequency of accidents is related to times between14-18 that is sun-set time. The least frequency is seen in midnights between 22 in night to 6 in morning. Obviously, safety coefficient will increase in the nights, because rate of traffic decrease in these times Noting to 5% of daily transportations is between 22-6 in morning, it predicted that 5% accidents happened in these times. That is from total 34213 accidents 1711 accidents happen in these times, while in accordance with information in table 3, totally 6439 accidents happened in mentioned times that was more than 317 times of predicted accidents. Therefore, it is necessary to use enough light in accident black cross-roads to decrease accidents.

Decrease road accidents at least 52% and max 54%.

TABLE III: SUM OF ACCIDENTS DURING THE 5 YEARS IN KHOUZESTAN PROVINCE ACCORDING TO TIME OF HAPPENING

Time (hour)	Number of accident 2005-2009	Frequency	Total Frequency
6-2	2964	8.6	8.6
6-10	6542	19.2	27.8
10-14	7560	22.1	49.9
14-18	7713	22.5	72.4
18-22	5959	17.5	89.9
22-2	3475	10.1	100
total	34213	100	

D. Surveying Cross-Roads and Available Roads in Ahvaz-Shoushtar Axe

Ahvaz-Shoushtar Axe is one of the most busy axes in Iran, especially in Khouzestan Province. As table (IV) shows, the most important cross-roads in this axes. This axe includes communication axe are as followed:

1) Ahvaz - Mollasani axe, it is a kind of highway with 6 lines in each direction and connects Ahvaz to Mollasani city. It starts Zarkan powerhouse in the north of Ahvaz and ends to Ahvaz-Shoushtar police Station. The length of this axe is 32 km.

2) Shoushtar – Mollasani axe, that is the main road and starts from Ahvaz-Shoushtar police Station and ends to Shoushtar. The length of this axe is 55km. Table shows cross-roads, villages and available ways to Ahvaz-Shoushtar according to distance of offset.

TABLE IV: CROSS-ROADS, VILLAGES AND AVAILABLE WAYS TO AHVAZ-SHOUSHTAR ACCORDING TO DISTANCE OF OFFSET

Name of axe	Distance of start of the axe (km)	Considered Place	Explanation
Ahvaz-Mollasa	1	Mahshar- cross-road	Interchange cross-road
	18	Vais cross-road	Antena cross-road
	18.5	Ramin power house	Antena cross-road
	29	Mollasani city	Along the road
Mollasani-Shoushtar	1.5	Nadafieh Village	Along the road
	3.1	Daravizeh Village	Along the road
	6.8	Bandghir Village	Antena cross-road
	13.6	Sarimeh Village	Antena cross-road
	14.3	Valiabab Village	Antena cross-road
	17.8	Naghshiyat Village	Antena cross-road
	20	Deilam Village	Antena cross-road
	27.5	Arab Hassan Village	Along the road
	36	Haj Ali Village	Antena cross-road
	41	3 Boneh Village	Antena cross-road
	43.5	Mehdiabad Village	Antena cross-road
	47.5	Shili Village	Antena cross-road

It is necessary to note 25% of all accidents in Iran happen in special places, but these regions are so much less than ordinary ways, therefore, should be noticed them[20]. Cross-road is a kind of connection point that connects vehicles in transportation system and their connective place and should be surveyed in researches. [21]

E. Statistics of Accidents in Ahvaz-Shoushtar According to Kind of Vehicle Incidence

As table (V) shows 28 % accidents happened by incidence from front to side of the car. The main reason is diversify road, unsuitable availability, villages and insecure return ways in roads.

TABLE V: STATISTICS OF ACCIDENTS IN AHVAZ-SHOUSHTAR ACCORDING TO KIND OF VEHICLE INCIDENCE

Kind of accident	Name of axe	
	Ahvaz-Mollasani	***Mollasani-Shoushtar***
Front to front	3	24
Front to side	30	37
Side to side	22	23
Side to back	20	6
Overturn	27	21
Other	10	18
Total	112	129

F. Statistics of Accidents in Ahvaz-Shoushtar According to Road situation

As table (VI) shows, the most important accidents happened in direct one and 25% in cross-roads.

TABLE VI: STATISTICS OF ACCIDENTS IN AHVAZ-SHOUSHTAR ACCORDING TO ROAD SITUATION

Location of the road	Name of axe	
	Ahvaz-Mollasani	***Mollasani-Shoushtar***
Return	10	9
Direct road	68	82
Cross-road	31	28
Oil station	3	0
Bridge	0	10
Total	112	129

G. Statistics of Accidents in Ahvaz-Shoushtar According to Disregarding Signals in Roads and Place of Accident

As table (VII) shows, when the main cause of accident are rods, then can refer to disregarding vertical signals with frequency 28%.

TABLE VII: STATISTICS OF ACCIDENTS IN AHVAZ-SHOUSHTAR ACCORDING TO SEPARATING EFFECTIVE DISREGARDING IN ROADS

Road disregarding	Name of axe	
	Ahvaz-Mollasani	**Mollasani-Shoushtar**
Difference of level between asphalt and shoulder of the road	4	7
Disregarding horizontal signals	31	7
Lack of light	3	2
Lack of guardrail	4	7
Vertical signal	35	33
Lack of suitable Asphalt level	6	7
Others	29	66
Total	112	129

H. Statistics of Accidents in Ahvaz-Shoushtar According to Time

Table (VIII) shows the highest rate of accidents will observe in Ahvaz-Mollasani axe between 14-18 afternoons, that its main reason is high temperature and its negative effect on driver's operation. Most of the accidents happened in 10-14 o'clock in Shoushtar-Mollasani axe and its main reason is high traffic density in this time, the effect of high temperature on driver's operation and increasing friction of asphalt level car wheels.

TABLE VIII: STATISTICS OF ACCIDENTS IN AHVAZ-SHOUSHTAR ACCORDING TO TIME

Time of accident	Name of axe	
	Ahvaz-Mollasani	***Mollasani-Shoushtar***
2-6	3	4
6-10	22	31
10-14	19	33
14-18	34	25
18-22	24	27
22-2	10	9
Total	112	129

I. Statistics of Accident in Ahvaz-Shoushtar axe According to Direction of Way

One-side and two-side roads are so effective in accidents. Most of the road accidents arise from counter incidence and dangerous pass that happen in two-side roads [22]. According to table (IX) most of the accidents in Ahvaz-Mollasani axe happen in two-side roads. High speed and different ways are the main cause of these accidents. Also, most of the accidents in Mollasani-Shoushtar happen in common two-side roads and the main cause of them is high speed and different available ways in the length of road and lack of enough light.

TABLE IX: STATISTICS OF ACCIDENT IN AHVAZ-SHOUSHTAR AXE ACCORDING TO DIRECTION OF WAY

Direction of movement	Name of axe	
	Ahvaz-Mollasani	***Mollasani-shoushtar***
Separated two-side	56	22
One-side	42	29
Un separated two-side	13	73
unlimited	1	5
Total	112	129

IV. Comparison Between Safety and Accident Costs

Accident costs are included in direct costs such as treatment costs, remedy of car damaged and indirect costs such as life, injuries or dysfunction and mental damages. [23]. Obviously, the most expensive methods aren't always the best and efficient ways [24]. Researches in US, California show that constructing new ways with the cost equal 33300$, save only one person's life while by increasing signals and lines in the roads save life by spending only 350$. The results show that some cheaper ways such as drawing a line, reforming and constructing cross-roads by safety signals are so much efficient [25].

V. Providing a Suitable Design to Transportation Safety in Cross-Roads

Fig. 1 shows plan to transportation safety in suburban cross-roads from economical optimized point of view that is used vertical signals such as information, alarm and horizontal signals like longhand width lines, blinker and increasing and decreasing speed band and hump in sideways. Estimating costs of executive plan is about 57,000$ that firstly, comparing on other transportation safety methods in cross-roads including increase road width, and use middle guardrail or newgercy with cost more than 100000 $, and also constructing cross-road , over path and under path that their cost will be more than 800,000 $ and is more economic. Other advantage of executing this plan is its short-time period to operate in respect of other methods. Secondly, comparing to cost of accidents this is so less amount.

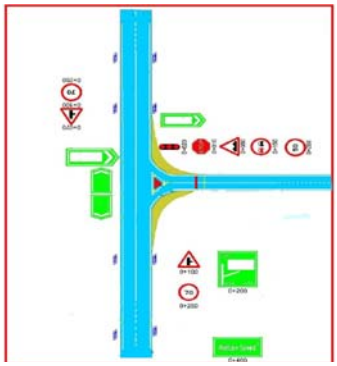

Fig. Plan of transportation safety in suburban cross-roads from economical optimized point.

VI. Conclusions

According to executed researches, it is concluded that least 5% and extreme 54% of accidents will be decreased by reforming roads 30 km near the cities, removing other effective factors on accidents in Khozestan Province with safety coefficient 99%. Surveying accident statistics in Ahvaz-Shoushtar axe showed that disregarding vertical signals caused to increase accidents 28% and front to side incidences was their main reason. Also, 25% of accidents happen in sideways to main ways, entrance of villages, interchange cross-roads and … Therefore, a suitable plan provided to transportation safety in cross-roads and available roads from economical safety or optimizing point of view that tried to decrease rate of accidents by least cost. At first, we must recognize accident black cross-roads and then execute this design. The results of researches shows that total cost of executing plan is about 57000$ that comparing to other ways of transportation safety in cross-roads including widening roads in cross-roads and annual costs of accidents and use middle guardrail or newgercy with cost more than 100000 $, and also constructing cross-road, over path and under path that their cost will be more than 800,000 $ it is more economic because it executes in short-time to and also is lowest amount in comparing to annual accidents in Iran that is 7% gross domestic production and is about 21$ milliard. If this plan execute rate of accidents will decrease so much and we will observe economical save considerably in budget of Iran.

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