

## About Pedestrian Crossing Safety in Ulaanbaatar

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**Abstract:** Inspection of pedestrian crossings has been conducted at the busiest sections of the road network in the city of Ulaanbaatar. Gathered information along with the analysis of official statistic of accidents at pedestrian crossings has elicited general reasons of high level accident rate at the studying spots. By this research work, we try to study the possibility of improving the pedestrian traffic safety, revealing the dangerous cases and improving the condition of crossings.

*Key words:* safety of pedestrian crossings, traffic sign, road accident

### 1. INTRODUCTION

The issue of road traffic accidents and injuries is one of the emerging global problems. Road traffic injury is the 11th leading cause of mortality worldwide and comprises 23% of overall mortality due to trauma. 90% of road traffic accidents occur in low and middle income countries. However, only 20% of all cars worldwide are operating in these countries, where 81% of the world population lives. Every year, 1.2 million people or 3.242 persons a day die due to road traffic injury (Dinesh Mohan 2006).

Children and young people under the age of 25 years account for over 30% of those killed and injured in road traffic crashes. The highest rates of road traffic fatalities in the 0-25 year age range occur among road users in the Eastern Mediterranean regions. Among 15-19 year-olds road traffic injuries are the leading cause of death, while among the 10-14 years and 20-24 years age groups they are the second leading cause of death. (Toroyan T., Peden M. 2007).

According to the latest World Health Organization data published in April 2011 Road Traffic Accidents Deaths in Mongolia reached 824 or 6.79% of total deaths. The age adjusted Death Rate is 31.64 per 100,000 of population ranks Mongolia #26 in the world.

Ulaanbaatar is the capital city of Mongolia with 1.2 million residents, which represents 42.0% of the country's total population (3 million in 2015). The traffic safety situation is the biggest subject of worry among citizens of Ulaanbaatar (Demberelsuren J. 2010). The road quality, road construction activities, missing or low level of illumination are seen to be also inadequate. There is a clear need for improvements to traffic behavior and attitudes of traffic participants. The majority of pedestrians (63%) consider the traffic safety situation in Ulaanbaatar as dangerous. Only 5% of respondents consider it as safe. Participation in traffic is a cause of fear and stress for both pedestrians and drivers (70% of drivers are involved in aggressive acts and 20% of pedestrians running when crossing road).

According to different studies, pedestrian accidents occur most frequently at street crossing, especially for older pedestrians, at traffic facilities like a zebra crossing. A research

by Federal Highway Administration shows that pedestrian crossings are not sufficient to cross safely, if not integrated with adequate equipment.

The organizers of the road traffic mainly focus their attention only on the safe and uninterrupted movement of vehicles, pedestrians also remain unprotected and vulnerable, even at pedestrian crossings. Analysis of traffic accidents involving pedestrians shows that most of them due to the lack of safe conditions for walking, and above all it refers to the relevant equipment of pedestrian crossings: their lighting equipment, traffic lights, traffic signs, road markings, use of humps, the division of traffic and pedestrian flows, fencing roadway.

By this research work, studying the possibility to improve pedestrian traffic safety, releasing the dangerous cases and improving the condition of crossings.

## 2. STATISTIC RESULT OF PEDESTRIAN TRAFFIC ACCIDENTS

By 2009 Traffic Police statistics, 67.2% of all traffic crash mortalities (total 317 death cases including pedestrians, drivers and passengers) were among men, and 11.8% were under 18. Out of total traffic crash mortality, 71.4% in Ulaanbaatar were pedestrians. 68.1% of injuries due to traffic crashes in Ulaanbaatar were registered among pedestrians. 20.5%, among them 76% are young people under 35 and male group dominant of pedestrians had traffic injuries in their life time (Traffic Police Statistics 2013).

Focusing on the survey of traffic accidents the accidents that depend on faulty action of pedestrian are 23.1 percent of total accidents, 25.74 percent of accidents in capital. Table 1.

Table 1. The manner of the registered traffic accidents through the country that the pedestrian was hit by vehicle, the total percentage of the accidents

Year		The pedestrian was hit by vehicle	
		In country	In Ulaanbaatar
2011	Number	3330	3044
	Percent	17.1	18.1
2012	Number	3217	2942
	Percent	<b>19.7</b>	<b>21.7</b>
2013	Number	4238	3889
	Percent	<b>23.1</b>	<b>25.74</b>

In Table 2 we show the result of the comparison of the traffic accidents caused by the faulty action of pedestrian with the previous year. It looks the number of accidents is increased throughout the nation. But the percentage of the total accident was increased by 0.3% form previous year.

Table 2. The percentage of the faulty action of pedestrian in the traffic accidents

2011	Throughout the nation	942	
	<i>The percentage in the total accidents</i>	4.8	
	Throughout the capital city	855	
	<i>The percentage in the total accidents</i>	5.1	
2012	Throughout the nation	466	↓

	<i>The percentage in the total accidents</i>	2.9%	↓
	Throughout the capital city	398	↓
	<i>The percentage in the total accidents</i>	2.9%	↓
2013	Throughout the nation	475	↑
	<i>The percentage in the total accidents</i>	2.6%	↓
	Throughout the capital city	359	↓
	<i>The percentage in the total accidents</i>	2.4%	↓

In Figure 1 we showed the number of the injured or dead people by traffic accidents. The number of injured and dead people was increased from previous years.

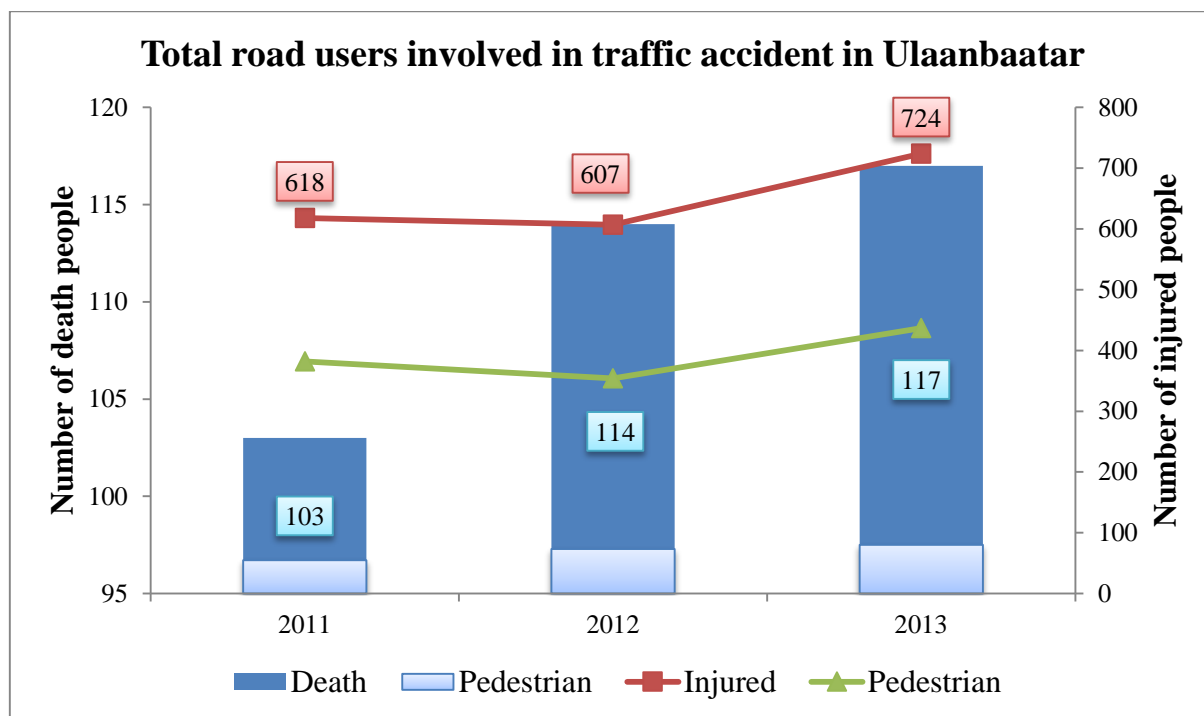


Figure 1. Road user type who death in road traffic accident in Ulaanbaatar

In the Traffic Police report 2012 shows that last 6 years 1409 pedestrian were attended road action drunk with ability of not controlling themselves and died (Erdenechimeg Ts. 2012).

Common faulty actions of pedestrian are:

- crossing a road without attention while using a cellular phone,
- try to cross a congested road,
- running suddenly in front of vehicles
- crossing a road inadequate visibility sections in front of big truck.



Figure 2. Mapping pedestrian accidents

In the rules of the road of Mongolia, drivers approaching to a not regulated pedestrian crossing should decelerate the speed and give way to pedestrians using the crossing (Traffic regulation of Mongolia, 2004). But driver's faulty actions that don't follow rules are:

- not decelerating the speed when approaching to a pedestrian crossing,
- not giving a way to pedestrian,
- not choosing an appropriate speed while traffic congested
- using an audible warning device's when approaches to crossing.

### 3. VEHICLE TRAFFIC SURVEY

#### 3.1. Traffic volume survey

We have done the traffic study which take place from the beginning of the Chinggis Avenue or the intersection of the Central Post to the Peace Bridge in Ulaanbaatar. The survey made by request of Oyu-Tolgoi LLC and focused on 0,7 km long road. The road located in the center of city and it's the most crowded road, the big organizations such as central library, hotels, restaurants, theater, department stores, company and hall of children are placed at both sides of the road.

The research was done with the help of surveillance cameras.

Vehicle motivation intensity is the number of vehicle passing the road cross section at unit time.

To survey the road intensity going at rush hours of morning (09.00-10.00), afternoon (12.00-13.00) and evening (18.00-19.00), on the days of Monday, Wednesday, Friday, Saturday and Sunday. Count of the vehicles, divides the vehicle in two types

- First types involve the small passenger cars, van
- Second types involve bus, trolley bus, truck and tractors with trailer

Total vehicles that used on the road consisted as a small passenger cars, 95 percent and others, 5 percent.

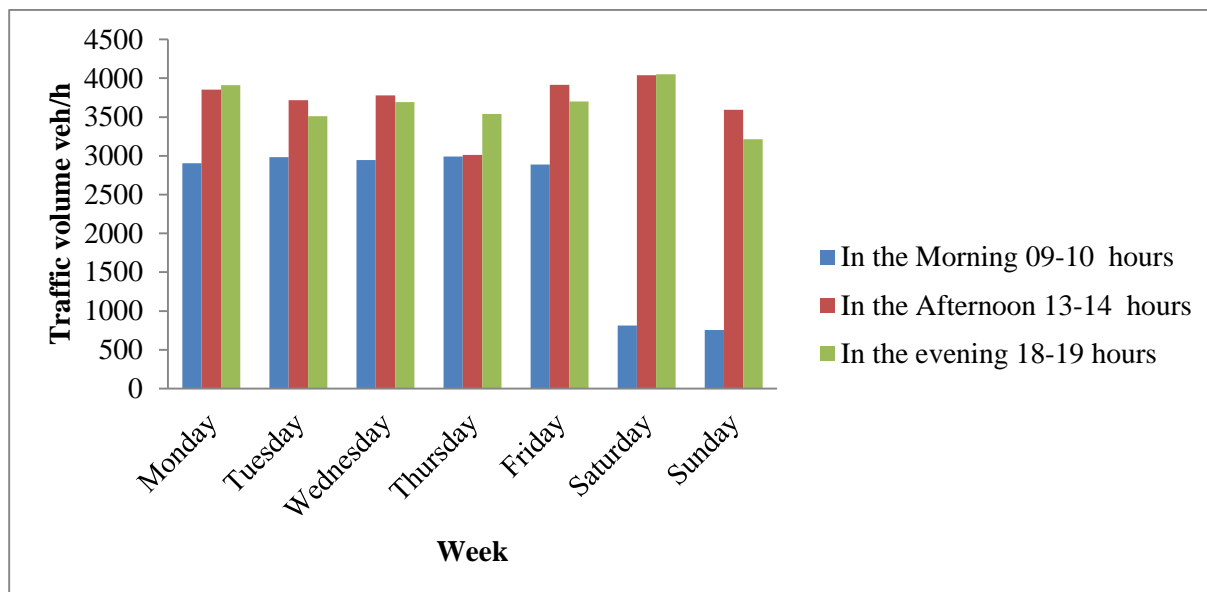


Figure 3. Traffic volume in the Chinggis avenue stretches

### 3.2. Average speed of vehicle traffic survey

To determine the average speed of vehicle, the 100 cars speed was determined by timer that measures the time to pass 20 m long road.

The following Table 3 shows the speeds that are determined by 20 m distance divided by time.

Table 3. Speed of vehicle

N <sub>o</sub>	t, sec	V, m/s	V km/h
1	2.84	7.0	25.4
2	3.12	6.4	23.1
3	4.43	4.5	16.3
4	2.94	6.8	24.5
5	2.74	7.3	26.3
6	1.86	10.8	38.7
7	1.76	11.4	40.9
8	1.98	10.1	36.4
9	3.04	6.6	23.7
10	3.86	5.2	18.7
...	...	...	...
100	3.22	6.2	22.4

After arraying the random variables with grouping we find the maximum and minimum values. The maximum and minimum values are:

$$X_{\max} = 45.9, X_{\min} = 11.9 \quad [\text{km/h}]$$

If observation numbers  $n=100$ , group numbers  $\kappa = 4$  the clearance width of group is:

$$\Delta x = \frac{x_{\max} - x_{\min}}{k} \tag{1}$$

Hence, the random variables can group (11.9-45.9) in 4 groups with width  $\Delta X = 8.5$ . The results are shown in Table 4.

Table 4. The random variables with grouping

Numbers of group	Limit of group	Average of group, km/h	Repetition in group	Test repetition in group
	a – b	$X_i = (a+b)/2$	$m^*$	$P_i = m^*/100$
1	11.9-20.4	16.15	10	0.1
2	20.4-28.9	24.65	39	0.39
3	28.9-37.4	33.15	45	0.45
4	37.4-45.9	41.65	6	0.06
			100	1

The mathematical expectation is:

$$\bar{x} = M^*(x) = \sum_{i=1}^n \bar{x}_i P_i^* \qquad \bar{X} = 28.6 \text{ km/hr} \tag{2}$$

Average speed of movement is 28.6 km/h.

In the traffic police research report of 2009 in the Ulaanbaatar road network, the vehicle technical speed is divided into three groups by road safety.

Table 5. Classification of vehicle speed

Class	Speed	Note
Low	10 – 30 km/h.	Road traffic accident occur commonly
Average	30 – 50 km/h.	Normal
High	50 - 60 km/h.	Road traffic accident occur frequently

#### 4. PEDESTRIAN CROSSING

Pedestrian cross one or more roads at some point in their journey, whether at an intersection or not. In many situations, crossing the road increases their risk of traffic injury. Intersections are associated with high rates of pedestrian collisions and injures because they include a large number of pedestrian and vehicle conflict points (Lane PL 1994, Lord D 2007).

Uncontrolled intersections exacerbate such conflicts, as pedestrians may encounter oncoming vehicles travelling at elevated speeds that are not required to stop or yield. In some

situations, the only way pedestrians can signal their intent to cross is to stand in the pedestrian crossing (Guth D 2005, Crowley Koch BJ 2011).

Although signalized intersections appear to be safer for pedestrians than uncontrolled intersections, they are still dangerous environments for pedestrians. A major issue at signalized intersections is the conflict between left-or right-turning vehicles, which require a larger turning radius, as well as the fact that crossing pedestrians may be obscured from the driver's view. The length of time allowed for pedestrians to complete crossing is also a factor. Though motorists are required to give priority to pedestrians at signalized intersections, vehicles sometimes start turning while pedestrians are still crossing (Lord DA 2013).



A. Condition in 2011

B. Nowadays condition

Figure 4. Pedestrian cross location

Application at pedestrian crossings technical means of traffic, such as road signs and markings, is not always effective (Gaifullin V.M.2008). Road marking tends to wear off, and very often it is virtually absent in the roadway. Road signs are not always visible because of overgrown foliage of trees or parked in violation of the rules of the road vehicles. It should also be noted that the visibility of road signs "Pedestrian crossing" to the right, almost not available if the driver moves in the second or third lane, under the conditions of constrained motion, as well as at night.

The height of the sign installation is 5-6 m, similar to the signs of "Traffic direction by lane".

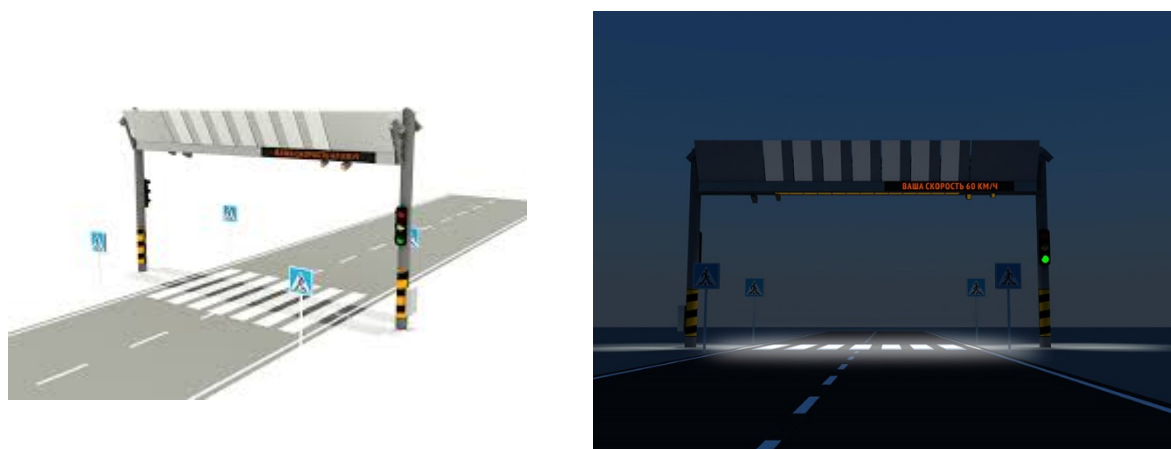


Figure 5. New scheme of the organization unregulated pedestrian crossing

Road signs 5.16 a.b "Pedestrian Crossing" located above the roadway, this method of installation will allow drivers to see road signs on all lanes.

Unregulated pedestrian crossing should be supplemented by artificial lighting, which will be implemented through two spotlights directed in opposite directions and thus completely covering the crosswalk. Despite the less heavy traffic at night, accidents with pedestrians during this period occur more frequently and are more severe than during the day. In this regard, artificial lighting plays a huge role in unregulated pedestrian crossings. To preserve the safety in the dark passage must be equipped with special lighting. In order to attract the attention of drivers, the lighting will be switched automatically by the two motion sensors located at the beginning and at the end of the pedestrian crossing. When a person in the coverage area of the sensor, that is, as soon as suitable for pedestrian crosswalk, instantly turns lighting. Thus, the driver will not only be aware of the presence of pedestrians on the crossing, but it will be clearly visible in the dark and gloomy time of day, as well as in conditions of poor visibility.

#### 4.1. Pedestrian volume survey

Not regulated crossing at Chinggis Avenue locates near bus stop. Distance between crossings is 200m. All crossings have marking and formed by sign.

The survey of pedestrian intensity engages on the crossing that utilized with marks and signs at the rush hours of morning (08.00-09.00), afternoon (13.00-14.00), evening (18.00-19.00). Schematic conflict of the pedestrian and vehicles flow on the pedestrian crossing is shown in Figure 6.

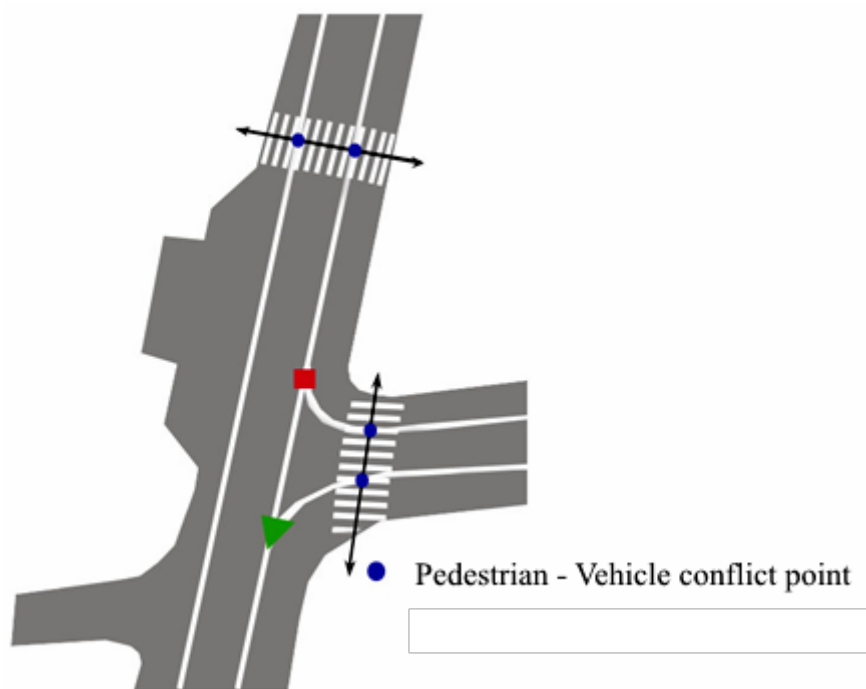


Figure 6. Schematic of conflict the pedestrian and vehicles flow on the pedestrian crossing

Rush hour of pedestrian flow on the crossing section is an evening time, 18.00-19.00, and 1402 people cross a road in rush hour. At the time of work start and finish about 600-1000 people cross the road at road crossing mark.



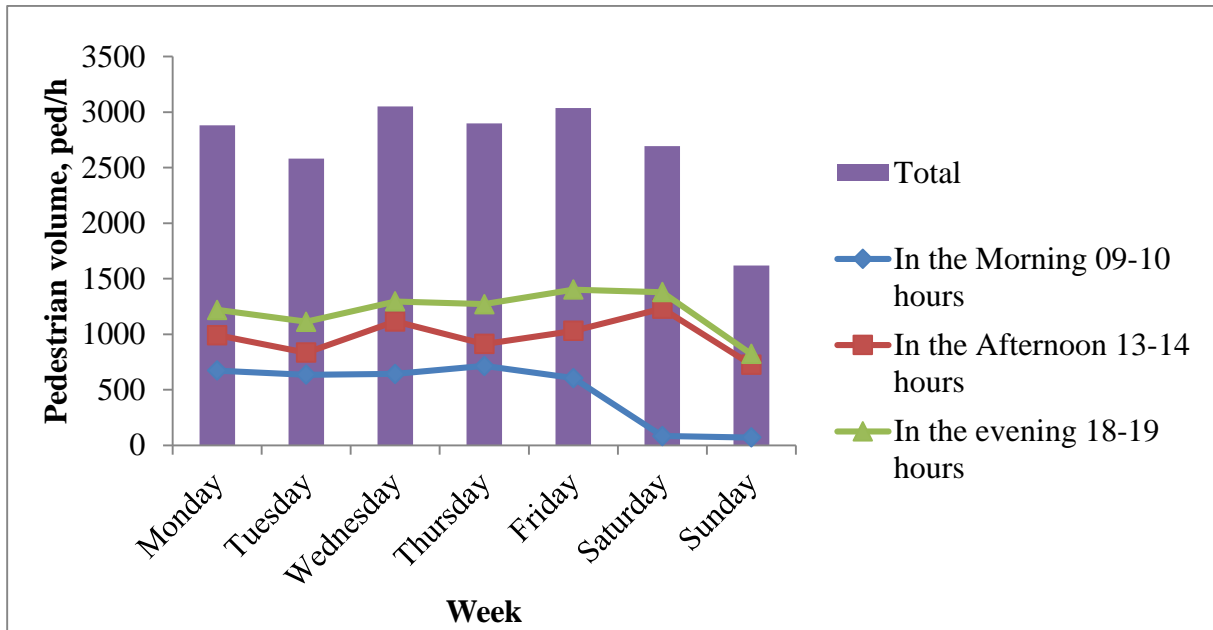
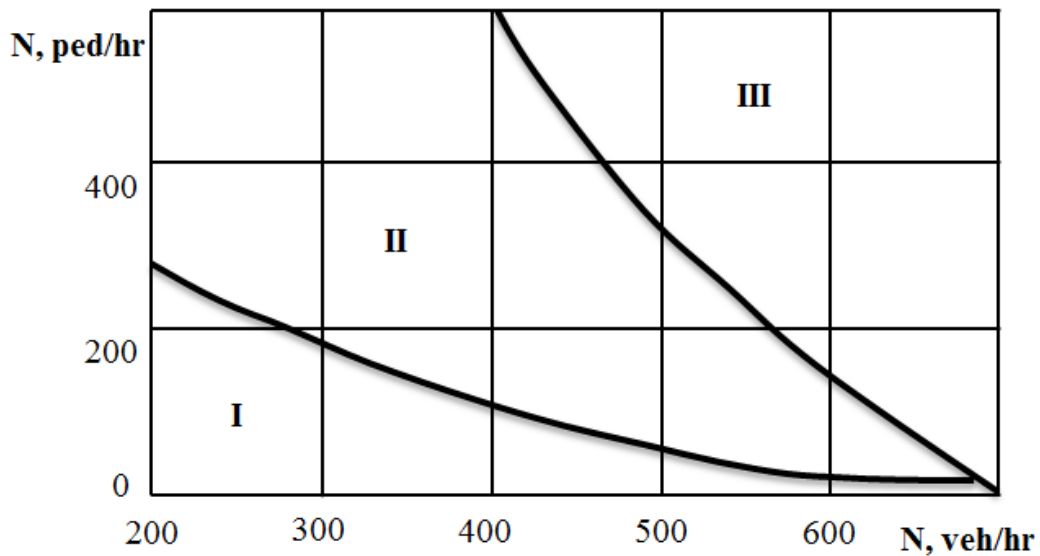


Figure 7. Pedestrian traffic volume at rush hour on the crossing

Pedestrian crossing term is increasing on weekdays and it is decreasing at the weekends. The locations of the large offices, central libraries and cultural centers of the left and right side of the road are affected on the crossing term.



Source: Russian standart of SP34.13330.2012. Automobile road.

Figure 8. Limits to the use of different types of pedestrian crossings

Limits to the use of different types of pedestrian crossings, depending on the intensity of pedestrian traffic (ped/h - vertical) and vehicular traffic (veh/h - horizontal).  
 Area I - is unregulated pedestrian crossing, II - controlled crosswalk, III - pedestrian crossing at different levels (underground or above ground).

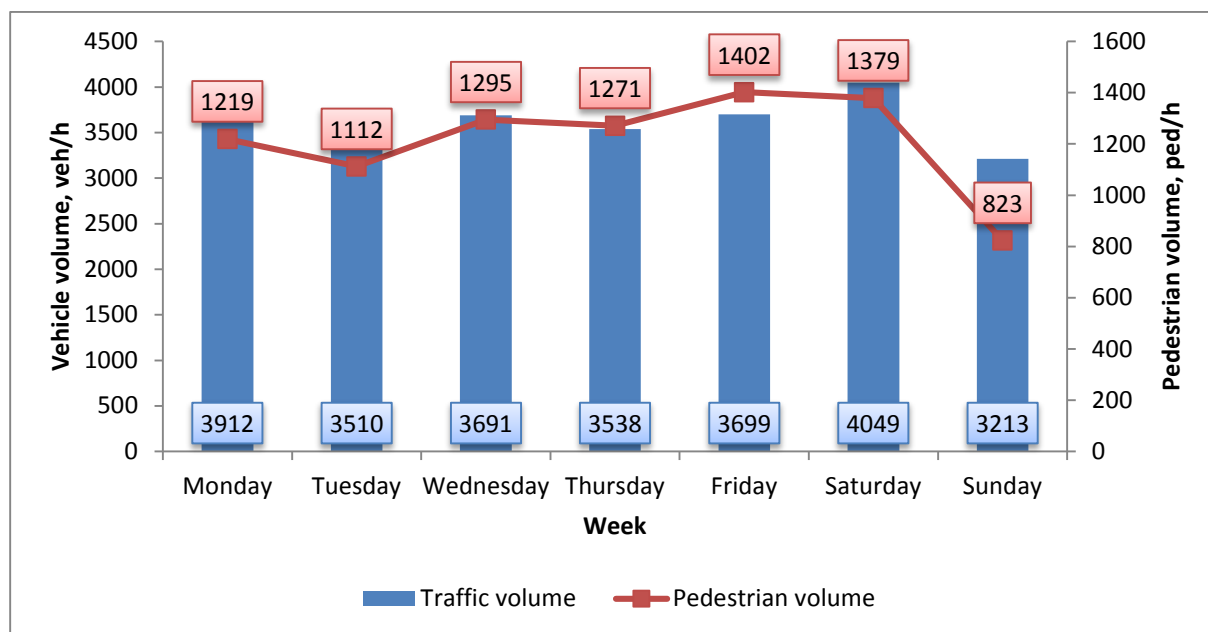


Figure 9. Pedestrian and Vehicle volume in the evening pick hour

As shown in Figure 9 and according to Figure 8 pedestrian and vehicle traffic term indicators related to the third zones. Therefore more efficient method to build the underpass or overpasses for the pedestrian.

Ulaanbaatar city road map increasing year by year. Many roads became from two lanes to 4 – 6 lane roads. For example in Nisekh – Yarmag road before was 2 lane roads and now renewed for 6 lane road. Road widening increases pedestrian injury risk (Hummer JE 2000). Wider lanes and roads, and higher design speed tend to increase motor vehicle traffic speed, which increases pedestrian risk. Wider roads with more traffic lanes and higher traffic speeds are also more dangerous for pedestrians to cross. In fact that last six month in this road died 21 people. Over the last 2 years, in crowded sections of Ulaanbaatar 3 overpass has been commissioned to build effectively.

## CONCLUSION

Across the globe there is an epidemic of traffic injuries and fatalities that is particularly marked in low and middle-income countries and almost 90 percent of traffic fatalities occur in such countries. The most vulnerable are pedestrians, cyclists and public transport users. The poor, young and the old people are especially at high risk.

The section of roads with pedestrian crossing marks that we have researched and studied are with high flow of traffic and pedestrians. Even the traffic flow speed is not high (28.6 km/h) there still high number of traffic accidents that mostly involved by pedestrians. The poor visibility of road crossing lines, lack of illumination of the road area, low responsibility and attention of drivers and pedestrians are still main cause of providing safety of this case.

By survey, confirmed that the pedestrian safety isn't kept, the following arrangement have required to improve.

- To improve the visibility necessary to mark unregulated pedestrian crossings colored stripes with light-reflective glass beads.

- Apply to the unregulated pedestrian crossing "noise markings." It is a special line of embossed cold two-component plastic that creates not only the noise but also the effect of vibration and makes the driver observe speed limits.
- At night time it is necessary to consolidate the use of clothing, as well as personal items with the retroreflective elements effect.
- To preserve the safety in the dark passage must be equipped with special lighting. In order to attract the attention of drivers, the lighting will be switched automatically by the two motion sensors located at the beginning and at the end of the pedestrian crossing. When a person in the coverage area of the sensor, that is, as soon as suitable for pedestrian crosswalk, instantly turns lighting. Thus, the driver will not only be aware of the presence of pedestrians on the crossing, but it will be clearly visible in the dark and gloomy time of day, as well as in conditions of poor visibility.
- Some pedestrian crossings need to regulate by traffic light with push button for pedestrian.
- In central area need to build different level of pedestrian crossing.

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