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Study on the opportunity of semaphore pedestrian crossing in terms of traffic flow

Andrei F. Clitan*[1]

[1] *Technical University of Cluj-Napoca, Faculty of Civil Engineering. 15 C Daicoviciu Str., 400020, Cluj-Napoca, Romania*

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Abstract

This paper is a study on the desirability of introducing traffic lights at pedestrian crossings on areas without semaphores. In these areas, under medium traffic of both vehicle and pedestrians, traffic lanes are often jamed, because of passing pedestrians.These stops lead to additional fuel consumption, exhaust emissions and higher traffic delays. Getting semaphores for pedestrian crossing can cause time delays, both in the case of vehicles and pedestrians, but can help the trafic flow. This happens when the time delay due to the semaphore crossing is less than the time delay caused by passing pedestrians at a pedestrian crossing without traffic lights. The study was conducted using the Vissim software for traffic-microsimulation, and two cases were considered. For the first case it was considered a non-semaphored pedestrian crossing. In the second case it is considered that the pedestrian crossing has trafic lights, determining the optimal time for the semaphores. In both cases it was determined the cross time of the sector, the delay times and the average speed, for several values of traffic, both for the pedestrians and for cars. Traffic was elected as heterogeneous, randomly generated. Finally attempted to find a correspondence between the values of traffic (both vehicles and pedestrians) and the opportunity of introducing traffic lights at pedestrian crossings.

Rezumat

Lucrarea de față face un studiu privind oportunitatea introducerii semafoarelor în zona trecerilor de pietoni nesemaforizate. În aceste zone, în condiții de trafic mediu, atât de autovehicule cât și de pietoni, pe benzile de circulație se formează cozi, datorită pietonilor care traversează. Aceste cozi duc la consum suplimentar de carburant, la emisii mai mari de noxe precum și la întârzieri de trafic. Semaforizarea trecerilor de pietoni, produce intârzieri de timp, atât în cazul autovehiculelor cât și în cazul pietonilor, dar pot ajuta la fluidizarea traficului. Acest lucru se intâmplă când întârzierea de timp datorată ciclului semaforului, este mai mică decât întarzierea de timp datorată traversării pietonilor pe trecerea de pietoni nesemaforizată. Studiul s-a făcut folosind softul Vissim pentru microsimularea traficului, tratându-se în principiu două cazuri. În primul caz s-a considerat o trecere de pietoni nesemaforizată. În al 2-lea caz s-a considerat că trecerea de pietoni este semaforizată, calculându-se timpul optim al semafoarelor. În ambele cazuri s-au calculat , timpii de traversare a sectorului, timpii de intarziere și viteza medie, pentru mai multe valori de trafic, atât auto, cât și pietonal. Traficul a fost ales unul eterogen, generat aleator. În final s-a incercat gasirea unei corespondențe între valorile de trafic, (atât de autovehicule cât și de pietoni) și oportunitatea introducerii semafoarelor la trecerile de pietoni.

* Corresponding author: Tel. / Fax.0040740377609
E-mail address: Andrei.CLITAN@dpcf.utcluj.ro

1. Introduction

Pedestrian crossings, are designed to facilitate the passage of pedestrians from one side of the road to the other. They are generally located at intersections corners, but in other cases they may be located in other areas, if a previous study has revealed that location necessity. In the case of pedestrian crossings without semaphores the pedestrians always have priority in crossing the street, and in the case of crossings with semaphores, they must wait a certain period of time until the semaphore for pedestrians turns green. The present paper carries out a study of traffic in the pedestrian crossings by means of simulation programs.

2. Traffic simulation

A simulation model is a computer program that uses mathematical models to perform experiments with traffic events on a transport installation or system, during certain periods of time [1]. Simulation models are designed to imitate the behaviour of traffic, within a system of transport in time and space, in order to predict system performance.

Depending on traffic flow and dynamics, traffic simulation models are divided into [2]:

- macroscopic models;
- mesoscopic models;
- microscopic models.

Micro-simulation represents the dynamic and stochastic modeling of individual vehicles within a transport system. Each vehicle is moved in the transport systems network, step by step, taking into consideration the physical characteristics of the vehicle (length, maximum speed, etc.), the fundamental principles of movement and the behavior of the driver (rules that he follows, rules on changing the lane, etc.). In these models, each vehicle is simulated and its status is updated into a final resolution. Thus, these models are widely supported in the management of traffic at an operational level [3].

The simulation was done using Vissim software for microsimulation.The software can analyze the public or private transport operations in relation to the configuration of the traffic lanes, traffic composition, traffic signals, public transport stations, thus making a useful tool for the evaluation of various traffic alternatives. VISSIM can be applied as a useful tool within a variety of transport issues. The accuracy of a traffic simulation model depends mainly on the quality of vehicle modeling, for example, the methodology of moving vehicles through the network. Unlike the less complex models, that use steady speed, VISSIM uses a model of psycho-physical behavior of the driver developed by Wiedemann [4]. The underlying concept of this model is that the driver of a faster vehicle will start deceleration when he perceives that the vehicle in front of him has a lower speed. Since the driver can’t determine the exact speed of the vehicle in front of him, his speed would slow down more than the speed of the vehicle in front until he begins to slightly accelerate again after reaching another threshold of perception. This results in an iterative process of acceleration and deceleration.

Distributions of stochastic speed and distance thresholds between vehicles mimic the characteristics of individual behavior of drivers. The model was calibrated by several mesurements on the field done by the Technical University of Karlsruhe (KIT 2009 Karlsruher Institut für Technologie), Germany. VISSIM allows drivers on roads with several lanes, to respond to vehicles in front of them, and to vehicles in adjacent lanes. Each driver, with its specific characteristics of behavior is assigned to a particular vehicle. As a consequence, the driver’s behavior will correspond to the technical capabilities of his vehicle. [4].

3. Case study

The case study was made on an area of 1 km road with 2 traffic lanes, in the middle of which a pedestrian crossing was placed. There were 2 cases considered. The first case considered is the one in which the pedestrians crossing is without traffic lights, and pedestrians pass freely. In the second case at the crossing point a traffic light was placed. In this case, both pedestrians and cars, are required to respect the semaphore, this leads to delays on both sides. It was considered that pedestrians cross the crosswalk in both directions, in approximately equal percentage. The two cases were divided as follows:

		Pedestrian traffic /hour
Case 1.1	Pedestrian crossing without semaphore	500
Case 1.2	Pedestrian crossing without semaphore	300
Case 2.1	Pedestrian crossing with semaphore	500
Case 2.2	Pedestrian crossing with semaphore	300

The elected traffic was urban composed mainly of cars. The average speed of traffic sector is considerate to be 50 km/h and the speed variation of the cars will be between 48 and 58km/h. The traffic is randomly generated. Variation of the acceleration depending on the speed of the vehicles is presented in Figure 1. The black curve represent a minimum and maximum of the acceleration that will be considered in the model.

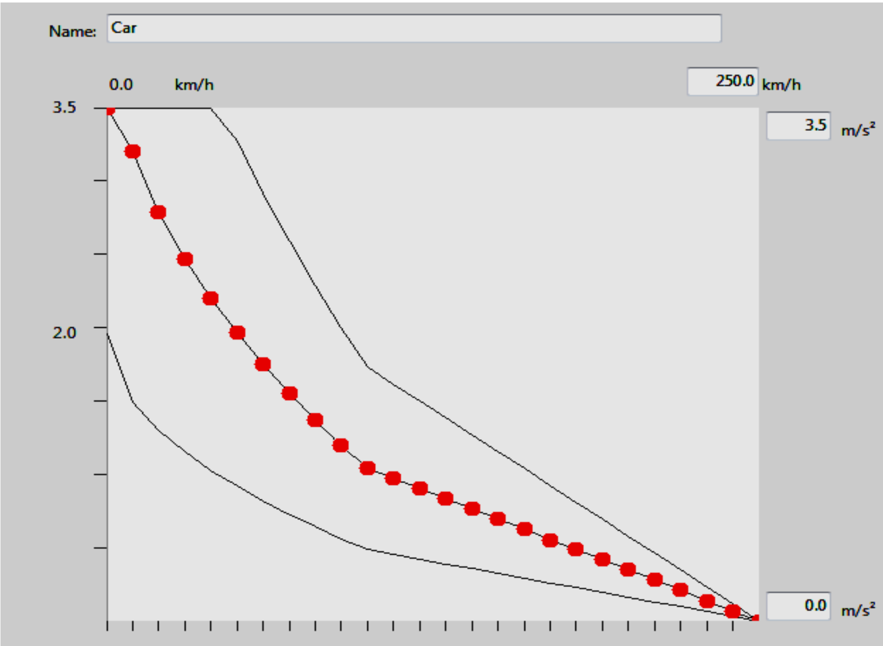

Figure 1. Car acceleration variation for the simulation model

The simulation period is 3600 seconds, being performed 10 runs in the simulation program, in each case, the average values were taken in consideration. As traffic values 10 variants were considered, such as in the following table.

In the 1.1 case for a pedestrian traffic of 500 persons/hour the following results were achieved. In this case, on the studied sector, the maximum capacity, that could be generated on the direction sense, was 960 vehicles/hour. Note that in this case the travel times increases greatly, along with the traffic. After simulating the 1.2 case the table 2 data were obtained, and the difference between the two tables is illustrated graphically in Figure 2.

Tabel 1- Results for the 1.1 simulation

Density on a band of circulation (vehicle/hour)	Sector of road	Distance (m)	Travel times			Average speed (km/h)	Average time delay (s)
			Average (s)	Min(s)	Max(s)		
200	1	1000	72.1	62.2	96.4	49.9	3.8
300	2	1000	73.3	62.1	97.1	49.1	5
400	4	1000	72.8	62	97.3	49.5	4.1
500	3	1000	76.2	62.2	101.4	47.2	7.6
600	5	1000	78.9	62.3	133.3	45.6	10.4
700	6	1000	76.3	62.2	106.1	47.2	7.8
750	8	1000	83.2	62.6	147.7	43.3	14.8
800	7	1000	86.6	62.9	131.4	41.6	17.8
900	9	1000	111.1	65.7	188.6	32.4	42.3
960	10	1000	157.9	67.6	254.4	22.8	89.3

Tabel 2- Results for the 1.2 simulation

Density on a band of circulation (vehicle/hour)	Sector of road	Distance (m)	Travel times			Average speed (km/h)	Average time delay (s)
			Average (s)	Min(s)	Max(s)		
200	1	1000	70.6	62.4	99.4	51	2.4
300	2	1000	70.5	62.1	84.9	51.1	2.3
400	4	1000	71.4	62	86.7	50.4	2.7
500	3	1000	72.3	62.2	93.4	49.8	3.7
600	5	1000	73.3	62.1	99	49.1	4.8
700	6	1000	71.3	62.4	82.9	50.5	2.8
750	8	1000	74.4	62.1	96.8	48.4	5.8
800	7	1000	74.9	62.3	95.4	48.1	6.1
900	9	1000	78.2	62.7	108.3	46	9.2
1000	10	1000	85.2	63	136.4	42.3	16.3

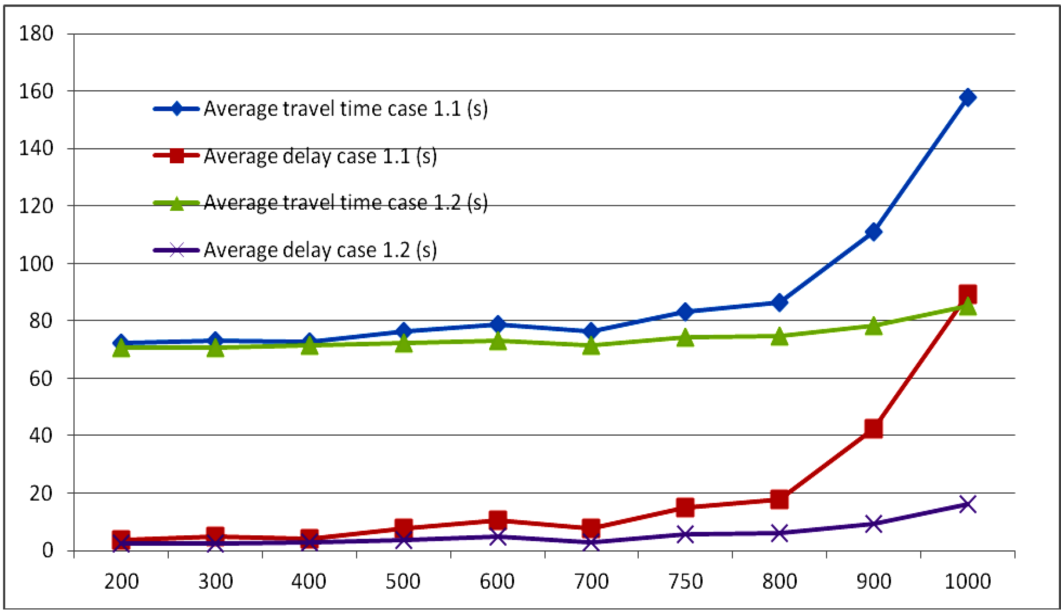

Figure 2 - Travel times and the average delay variation for case 1

In the second case the pedestrian crossing it is considered to have traffic lights. Semaphore times were chosen on several grounds:

- The traffic light cycle is not to exceed 60 seconds, for pedestrians to wait for a green light, and not try to cross the street illegally.
- Speed of moving vehicles it was considerated to be 50 km/hour and the pedestrian's, 5 km/h.
- depending on the number of pedestrians crossing, the time required to cross was calculated, resulting that a time of 15 seconds covers the both pedestrian traffic variants [5].
- The yellow traffic light was considered to go on for 4 seconds, so that any motor vehicle approaching the intersection to stop safely and avoid dilemma areas [6].

On the basis of the foregoing the traffic lights time schemes presented in Figure 3 resulted.

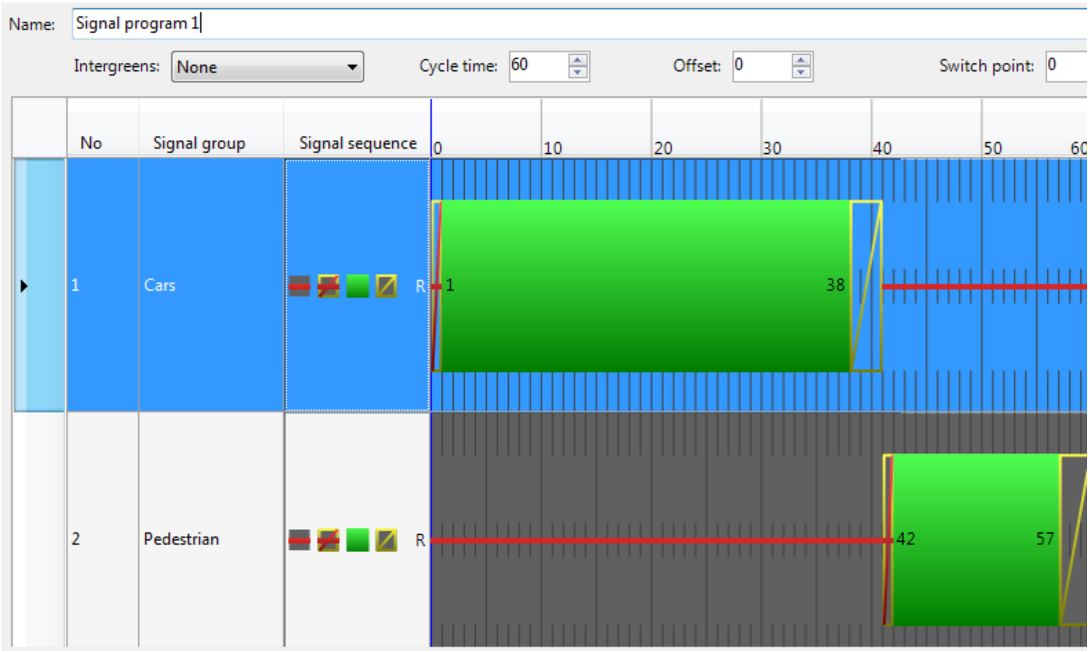

Figure 3 –Proposed time schemes for the traffic lights.

The results obtained in the 2nd case are presented in tables 3 and 4. The comparison results are presented in figures 4 and 5.

Table 3- Results for the 2.1 simulation

Density on a band of circulation (vehicle/hour)	Sector of road	Distance (m)	Travel times			Average speed (km/h)	Average time delay (s)
			Average (s)	Min(s)	Max(s)		
200	1	1000	72.9	62.1	93.8	49.4	4.3
300	2	1000	73.4	62.2	94.8	49	4.8
400	4	1000	74.9	62.1	96	48.1	6.3
500	3	1000	75.3	62.1	95.5	47.8	6.5
600	5	1000	75.9	62.1	97.4	47.4	7.2
700	6	1000	76.6	62.6	99.5	47	7.7
750	8	1000	76.8	62.4	97.4	46.9	8
800	7	1000	77.7	62.6	97.1	46.3	9
900	9	1000	78.6	62.2	100.6	45.8	9.7
1000	10	1000	79.9	62.5	101.1	45.1	10.9

Table 4. Results for the 2.2 simulation

Density on a band of circulation (vehicle/hour)	Sector of road	Distance (m)	Travel times			Average speed (km/h)	Average time delay (s)
			Average (s)	Min(s)	Max(s)		
200	1	1000	73.1	62.1	96.3	49.2	4.5
300	2	1000	73.4	62.2	94.8	49	4.9
400	4	1000	74.7	62.1	96	48.2	6.1
500	3	1000	75.2	62	96.3	47.9	6.4
600	5	1000	76.1	62.1	97.6	47.3	7.3
700	6	1000	76.5	62.5	98.3	47.1	7.7
750	8	1000	76.8	62.2	96.9	46.9	8.1
800	7	1000	77.6	62.3	98.1	46.4	8.8
900	9	1000	78.5	62.4	98.3	45.9	9.6
1000	10	1000	79.9	62.5	105.6	45.1	10.9

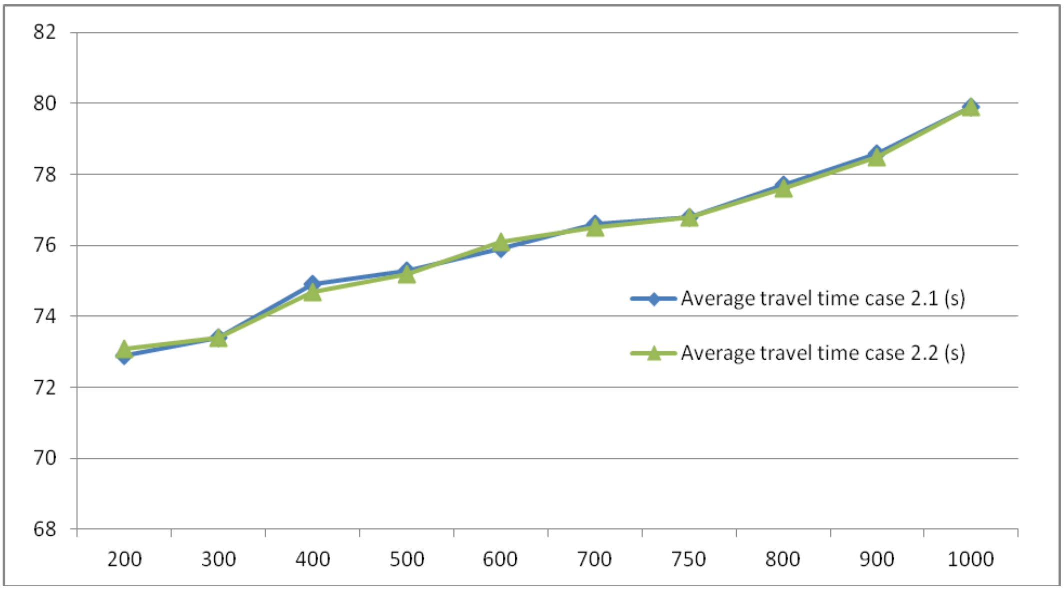

Figure 4 - Travel times variation for 2nd case

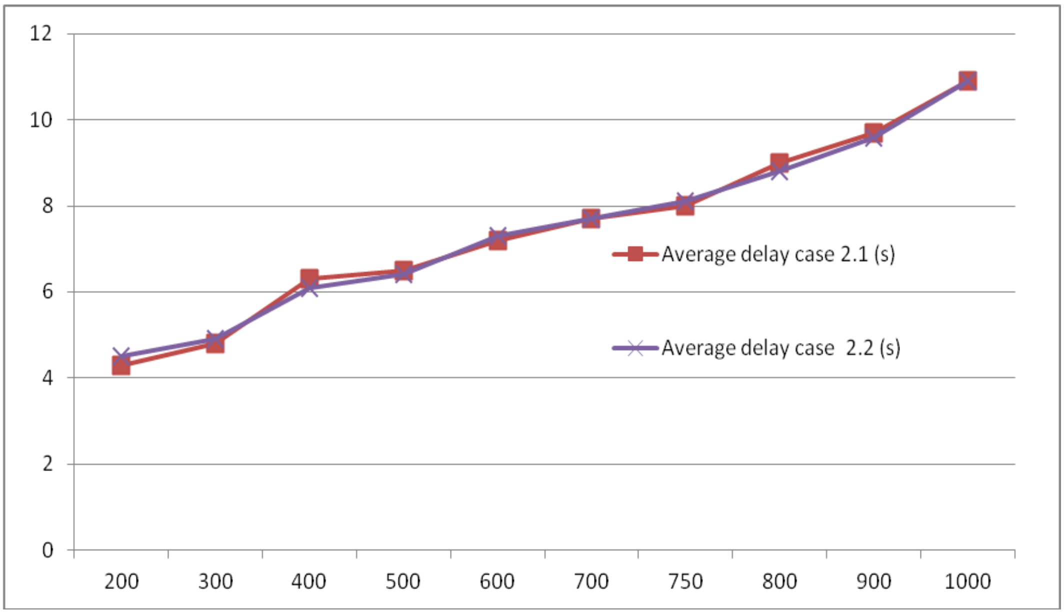

Figure 5 - Time delay variation for 2nd case

In the end a comparison of traveling times resulted from 1st and 2nd case was made, both for a pedestrian traffic of 500 per hour, as well as for 300 pedestrians per hour, resulting in the graphs below.

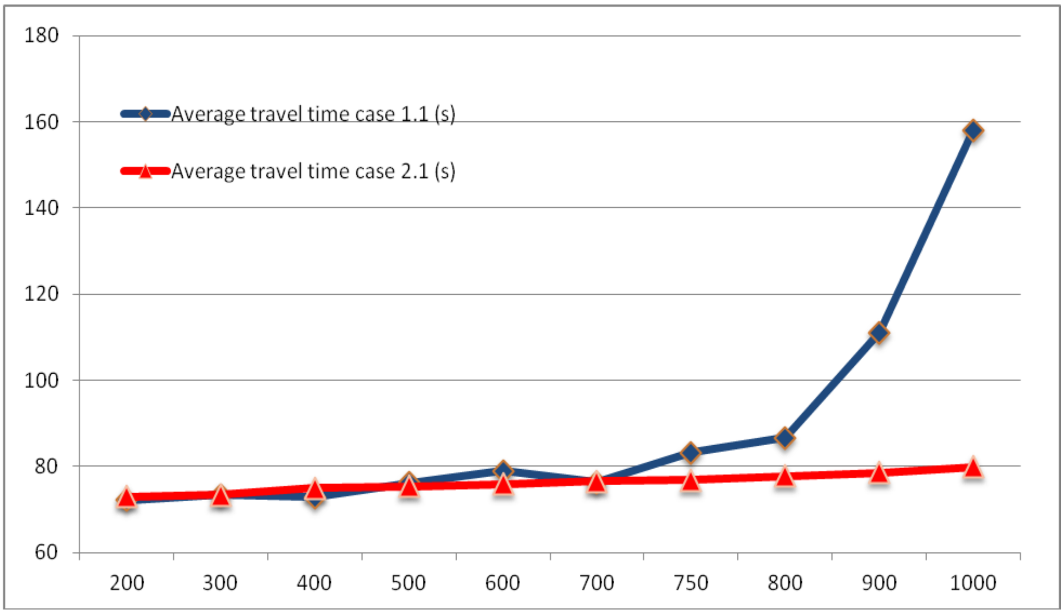

Figure 6 - Travel times variation for a traffic of 500 pedestrian

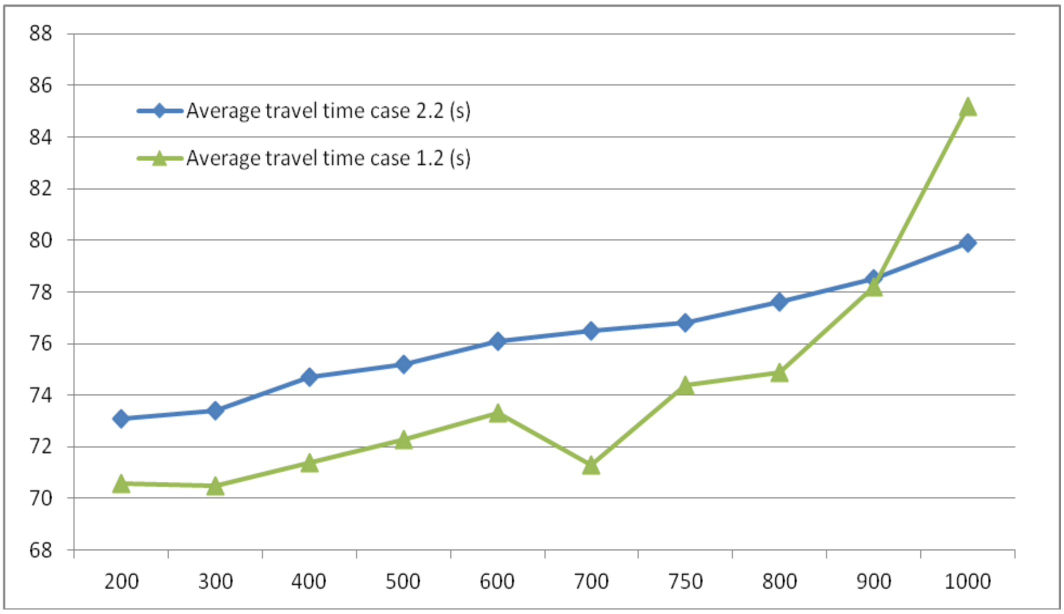

Figure 7 - Travel times variation for a traffic of 300 pedestrian

4. Conclusions

After analysis the results of this work the following can be concluded:

- Traffic lights for pedestrian crossings represent a viable solution for streamlining traffic in areas where pedestrian and car traffic is increased.
- In case of pedestrian crossings with semaphors, variations of the travelling times are smaller along with the increase of traffic, and does not depend on the number of pedestrians crossing the street.
- For a pedestrian traffic of 500 pedestrians, starting with traffic values of 700 vehicles /lane/hour placing traffic lights in that intersection becomes profitable. If the number of

pedestrians crossing the street is 300/hour, then placing traffic lights in that intersection becomes profitable for a traffic of over 900 vehicles/lane/hour.

- As the pedestrian traffic increases a semaphore in the interssection leads to improved travel times.
- The downside of traffic lights is that its results in traffic delays also in the case of pedestrians, but this may be justified if it helps streamlining traffic. The semaphore for a pedestrian crossing ensures greater degree of safety for them, the risk of accidents is decreased.
- Due to working models, that are very close to reality, the simulation programs are viable calculation methods to perform traffic analyses.
- The optimal solution is to use the traffic lights for pedestrian crossings during traffic peak hours, and in the remaining time when road traffic is low, ussing the the semaphors flashing yellow light. This light has an additional role in warning the drivers on the possible passage for pedestrians.

Acknowledgements

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