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USE OF MICROSIMULATION IN THE ADAPTATION TO PORTUGAL OF THE HCM 2000 METHODOLOGY FOR BASIC FREEWAY SEGMENTS

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Abstract. *Portugal is one of the European countries with higher spatial and population freeway network coverage. The sharp growth of this network in the last years instigates the use of methods of analysis and the evaluation of their quality of service in terms of the traffic performance, typically performed through internationally accepted methodologies, namely that presented in the Highway Capacity Manual (HCM). Lately, the use of microscopic traffic simulation models has been increasingly widespread. These models simulate the individual movement of the vehicles, allowing to perform traffic analysis. The main target of this study was to verify the possibility of using microsimulation as an auxiliary tool in the adaptation of the methodology by HCM 2000 to Portugal. For this purpose, were used the microscopic simulators AIMSUN and VISSIM for the simulation of the traffic circulation in the A5 Portuguese freeway. The results allowed the analysis of the influence of the main geometric and traffic factors involved in the methodology by HCM 2000. In conclusion, the study presents the main advantages and limitations of the microsimulators AIMSUN and VISSIM in modelling the traffic circulation in Portuguese freeways. The main limitation is that these microsimulators are not able to simulate explicitly some of the factors considered in the HCM 2000 methodology, which invalidates their direct use as a tool in the quantification of those effects and, consequently, makes the direct adaptation of this methodology to Portugal impracticable.*

1 INTRODUCTION

In the last years, Portugal increased very significantly their road network namely in terms of freeways. Between 2000 and 2013 the total length of the Portuguese freeway network increased more than 106%, from 1486 km (2000) to 3065 km (2013) [1,2]. Thus, Portugal is one of the European countries with higher spatial and population freeway network coverage (6th among the 28 countries of the European Union). This sharp growth of the infrastructure, combined with the increase of traffic demand, means that it is necessary to use methods to analyse and evaluate the quality of the service that is provided in this type of road infrastructure. Traditionally, the evaluation of the quality of service is performed through internationally accepted methodologies, namely those that are recommended in the Highway Capacity Manual (HCM) [3]. With these methodologies is possible the determination of the level of service in the various components of a freeway (basic freeway segments, ramp segments, weaving segments).

However, from a theoretical point of view the simple and direct transposition to the Portuguese reality of a methodology developed to another country raises some reservations, since all the elements that compose the road environment (infrastructure, vehicle and driver) are somewhat different from the United States reality for which it was developed HCM [3].

Lately, the use of microscopic traffic simulation models has been increasingly widespread. These models seek to recreate in a virtual environment the individual vehicle movements within a traffic system, and from that representation to enable a set of traffic analysis.

The main target of this study was to verify the possibility of using microsimulation as an auxiliary tool in the adaptation of the methodology by HCM 2000 to Portugal. For this purpose, the microscopic simulators AIMSUN and VISSIM were used for the simulation of the traffic circulation in the A5 Portuguese freeway. This allowed to identify the main advantages and limitations of the microsimulators AIMSUN and VISSIM in modelling the traffic circulation in Portuguese freeways.

Furthermore, this work tried to verify if the microscopic simulators used (AIMSUN and VISSIM) are able to represent the influence of all the factors involved, in order to, in a second phase, quantify their influence to the Portuguese reality.

2 MICROSCOPIC TRAFFIC SIMULATION MODELS

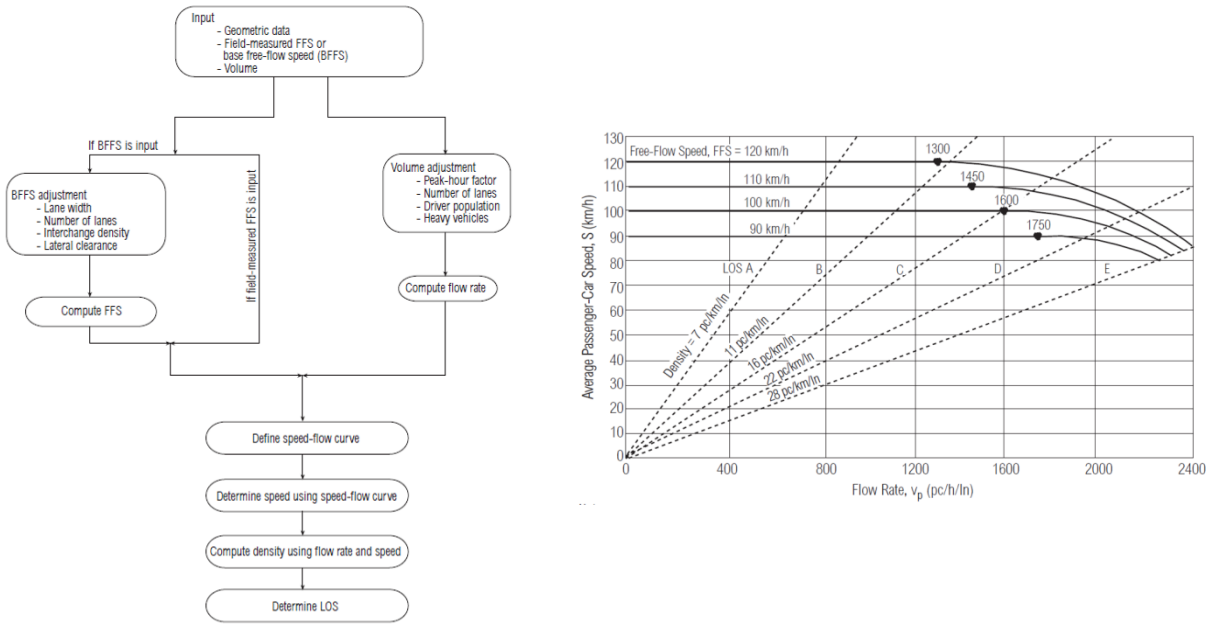
In recent years there has been a huge growth in the use of microscopic traffic simulation models. These models consist of software tools that try to recreate, in a virtual environment as realistically as possible, the individual movement of vehicles in a traffic system. Their potentialities rendered traffic simulation an important role as decision support tool in the field of traffic engineering, since they enable a wide range of traffic analysis. According to Caltrans [4], microsimulation is the dynamic and stochastic modelling of individual vehicle movements within a system of transportation facilities. Each vehicle is moved through the network of transportation facilities on a split second by split second basis according to the physical characteristics of the vehicle (length, maximum acceleration rate, etc.), the fundamental rules of motion (e.g. acceleration times time equals velocity, velocity times time equals distance) and rules of driver behaviour (car following rules, lane changing rules, etc.). Thus, in the microscopic traffic simulation the dynamics of each vehicle is represented based on several behaviour theories: car-following; lane-changing; and gap acceptance models [5, 6]. The more

recent microsimulators also represent and simulate cyclists and pedestrians in addition to motor vehicles.

This work used two of the most popular microsimulation software available worldwide: AIMSUN and VISSIM. Further information about these microsimulation software can be found in [7, 8, 9].

3 HCM 2000 METHODOLOGY FOR BASIC FREEWAY SEGMENTS

The HCM 2000 methodology for basic freeway segments can be used to analyse the capacity, level of service (LOS), lane requirements and effects of traffic and design features in this component of the freeways facilities [3]. According to HCM 2000 [3] a basic freeway segment is a segment of freeway outside of the influence area of ramps or weaving areas of the freeway and can be characterized by three performance measures: density in terms of passenger cars per kilometre per lane; speed in terms of mean passenger car speed; and volume-to-capacity (v/c) ratio. Each of these measures is an indication of how well traffic flow is being accommodated by the freeway. To estimate the level of service of a freeway the measure used is the density calculated using the methodology and speed-flow curves presented in the Figure 1 [3].



a) b)

Figure 1. a) HCM 2000 basic freeway segments methodology; b) Speed-flow curves and LOS [3]

The determination of the density (D) is performed in an indirect way by computing the passenger-car equivalent flow rate (v_p), based on traffic volume for peak-hour, and the average passenger-car speed (S) of the traffic stream. The equation used is as follows:

$$D = \frac{v_p}{S} \tag{1}$$

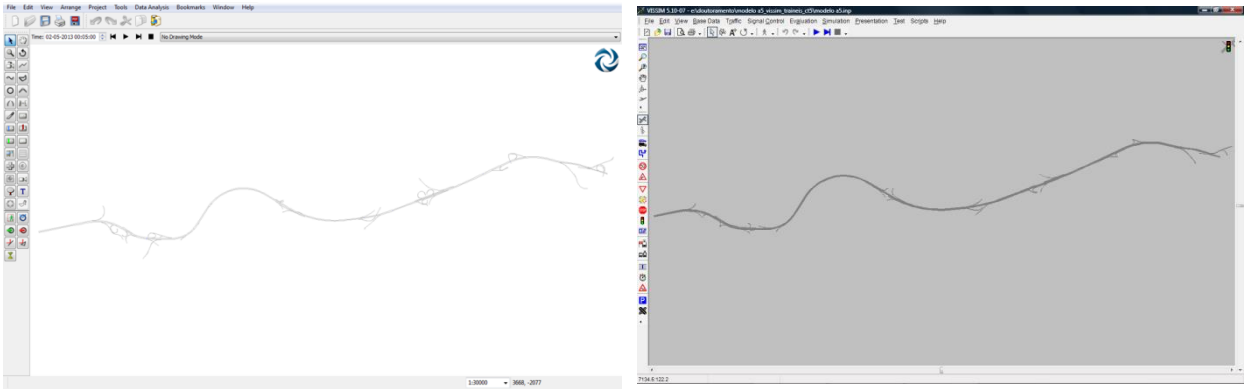
As can be observed in the Figure 1a) the parameters that can influence the LOS are: lane width; number of lanes; interchange density; lateral clearance; peak-hour factor; driver population; heavy vehicles (traffic composition). Further information can be found in [3]

4 APPROACH USED

The first step consisted in the comparison of the speed-curves observed in the A5 Portuguese freeway that links Lisbon to Cascais (Figure 2) with those that are presented in the HCM 2000.

Figure 2. A5 freeway

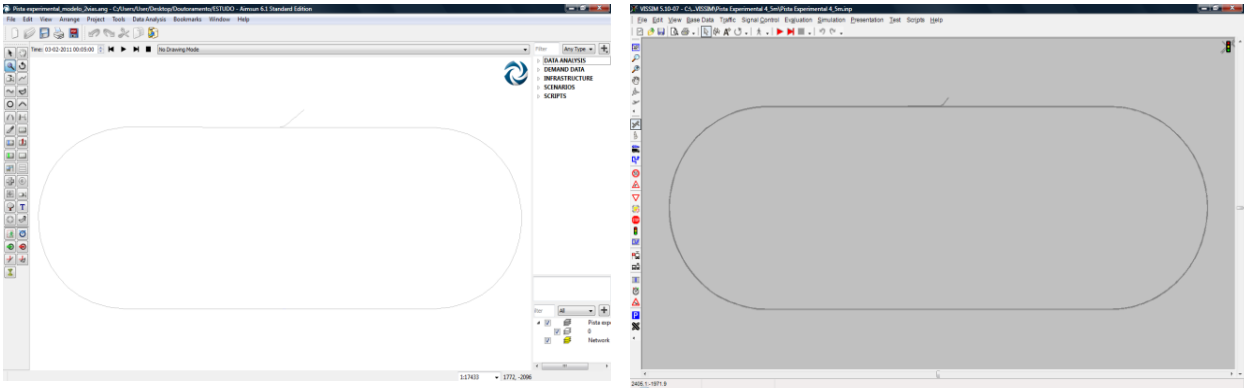
In order to perform the analysis of the ability of each of the two microscopic traffic simulators used, AIMSUN and VISSIM, to represent the macroscopic behaviour of traffic streams in basic freeway segments, a typical day was simulated in the coded A5 freeway and the results obtained were analysed (Figure 3).



a) b)

Figure 3. Microsimulation Models of the A5 Freeway: a) AIMSUN; b) VISSIM

To carry out a sensibility analysis to some of the parameters (lane width; lateral clearance; traffic composition) used in the HCM 2000 methodology, it was coded in each of the microsimulators an experimental track, inspired in the approach used by Manstetten et al. [10] (Figure 4).



a) b)

Figure 4. Experimental track used in the sensibility analysis: a) AIMSUN; b) VISSIM

The models were calibrated trying to represent the speed-flow represented in the HCM 2000 using base conditions [3].

5 RESULTS AND DISCUSSION

This section presents the obtained results during the study. First of all, was applied the HCM 2000 methodology to some segments of the A5 freeway. The results obtained are presented in the Figure 5.

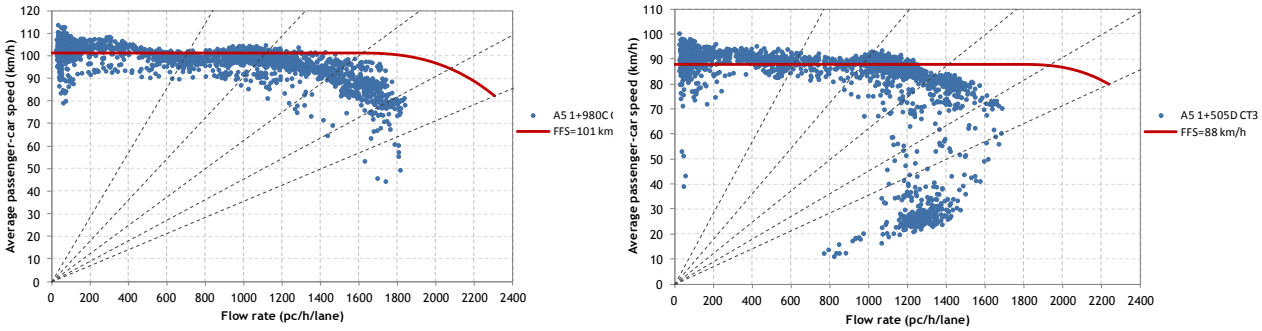


Figure 5. Speed-flow curves observed versus HCM 2000 curves: a) Lisbon-Cascais; b) Cascais-Lisbon

It can be concluded that the HCM 2000 methodology is not able to represent satisfactorily the speed-flow curve observed in the A5 freeway. This suggests that an adaptation of the HCM 2000 methodology is necessary to the Portuguese reality.

Using the models constructed in the simulators a comparison between the observed and the simulated data was performed. The Figure 6 presents that results obtained during the calibration (Figure 6a) and validation (Figure 6b) in the AIMSUN-VISSIM results were very similar.

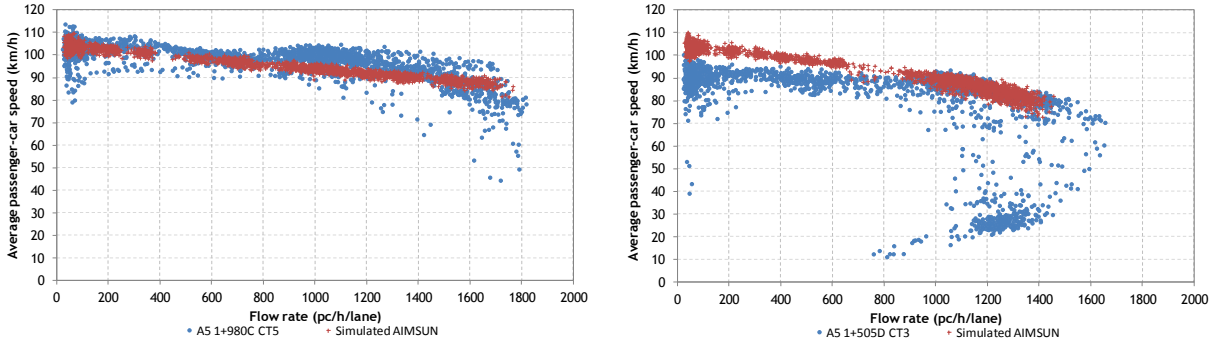
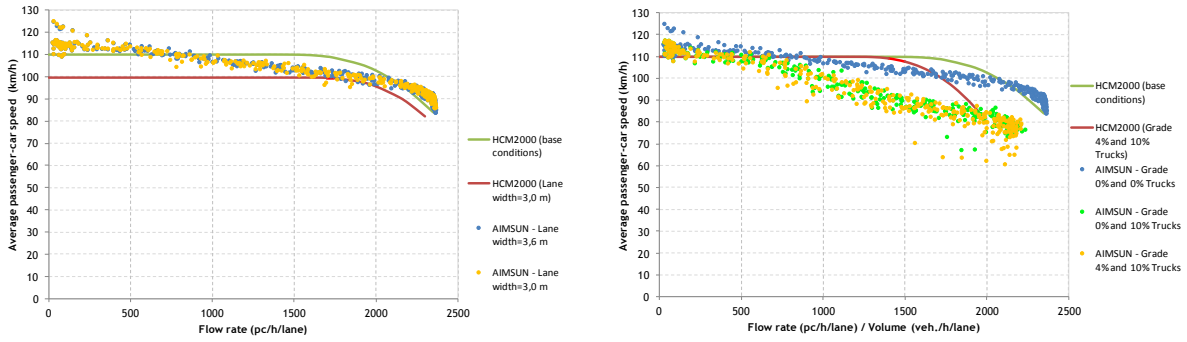


Figure 6. Speed-flow curves observed versus simulated in AIMSUN: a) calibration; b) validation

Observing Figure 6 is possible to perceive that the microsimulators can represent the traffic flow at the A5 freeway. However, the results showed in the Figure 6b allow to conclude that this representation is still not perfect.

Finally, Figure 7 presents some of the results obtained from the sensibility analysis using the AIMSUN. The results presented correspond to the analysis of the influence of lane width and heavy vehicles (traffic composition and grades). Also here the results obtained with the VISSIM were similar to those that were obtained with the AIMSUN [11].



a) b)

Figure 7. Sensibility analysis using the AIMSUN: a) influence of lane width; b) influence of heavy vehicles

The results show that the influence of these factors on the traffic streams are not well represented in the simulators. This invalidates their direct use as a tool in the quantification of those effects and, consequently, makes the direct adaptation of this methodology to Portugal impracticable.

6 CONCLUSIONS

A study on the assessment of the possibility of use of microsimulation in the adaptation to Portugal of the HCM 2000 methodology of basic freeway segments was presented. The study presents the main advantages and limitations of the microsimulators AIMSUN and VISSIM in modelling the traffic circulation in Portuguese freeways. The main limitation is that these microsimulators are not able to simulate explicitly some of the factors considered in the HCM 2000 methodology, which invalidates their direct use as a tool in the quantification of those effects and, consequently, makes the direct adaptation of this methodology to Portugal impracticable. This study ends providing solutions on how these limitations can be overcome, so that the adaptation of the HCM 2000 methodology to Portugal (or other country) can be achieved in the future.

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