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Speed management in rural two-way roads: speed limit definition through expert-based system

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Abstract

Until recently, the design of road infrastructure involved mainly concerns related to the base speed value and to high levels of service. However, it is today consensually accepted that only an integrated approach is able to take into account the interests and needs of all the involved users. This vision led to different approaches on speed management along the road. During the last decade, new speed limits setting methodological approaches have emerged, based on new design models and tools, which take into account road geometric, safety and operational characteristics. This research work aimed to develop a decision-support methodology for the definition of the appropriate maximum speed in each road section, with a widespread use, applied to single carriageway roads in interurban areas, crossing different road environments with a mixed use. An analytical model able to accurately estimate that speed limit was developed based on a set of objective and easily measurable and obtainable explanatory variables characterizing the section under analysis and its surrounding areas. The resulting methodology is a Multinomial Logit model, and it was carried out using a case-study involving four different tracks of interurban roads crossing different environments. The model was estimated resorting to the use of values chosen by four traffic safety experts recorded for each road segment in both directions.

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1. Introduction

Speed is one of the most relevant factors that characterize road operation, directly and decisively influencing its evaluation by all its users, having several effects, either positive or negative. Usually, the most perceptible effect of

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speed is its impact over road accidents, whether over occurrence risk or over severity, whose relationship has been demonstrated by several studies (Baruya, 1998; Farmer et al., 1999; Kloeden et al., 2001; Taylor et al., 2002; Nilsson, 2004; Aarts and van Schagen, 2006; Elvik, 2013). Speed also affects environmental conditions, namely in what concerns exhaust emissions, fuel consumption, noise and the quality of life for people living and working near the road (ERSO, 2006; Kockelman, 2006; Austroads, 2010).

Despite the widespread use and acceptance of speed limits throughout the world, no consensus has so far been achieved among practitioners relating to the most adequate methods and techniques to be used to select the appropriate speed limit in a given road section. This is a major concern, since it leaves the technical personnel without definitive guidance in this field (Forbes et al., 2012).

Furthermore, the ever growing urban developments in most roads surrounding areas has, in many countries, led to the existence of not only purely rural environments, but also disperse and non-consolidated built-up areas in their surroundings, with the boundaries between these zones very often difficult to identify. This has resulted in ever more complex road environments, where the traditional road design and management principles tended not to be sufficient, with the subsequent problems arising to speed management strategies and, as a result, to speed limit setting methods, in terms of coherence and homogeneity (Aarts and van Schagen, 2006; Hauer, 2009; Stuster et al., 1998).

Hence, the major objective of the current work is to provide an integrated decision-support methodology for speed limit setting in interurban single-carriageway roads, crossing different types of road environments with a mixed use, capable of taking into consideration a range of significant and objective variables.

A number of approaches have over the years been developed and adopted to set speed limits in interurban roads. Most of these methodologies usually give prevalence to geometric features of the road layout, both in their vertical and horizontal alignments, and especially in critical sections, such as curves, intersections or in stretches with higher slopes. Examples of this approach can be found in numerous studies and are usually the basis of official guidelines and statutory documents. However, given the complexity inherent to the road environment, a wider set of factors related to the surrounding areas, safety, traffic and users may need to be included. A robust methodology should consider the wider number of factors possible, weighting their significance in this process.

The current work aimed to deliver an accessible and easy to use by the technical community methodology, based on data which can be collected remotely and is easily measurable. Therefore, a different approach is considered, which emphasizes factors related with the prevailing road environment, especially focusing on road integration into the surrounding areas. Previous work has already been done to develop a robust methodological approach (Seco et al., 2008; Correia and Bastos Silva, 2010; Correia and Bastos Silva, 2011; Bastos Silva et al., 2012). However, additional development is still necessary regarding the following subjects: 1) Use of an expedite method of expert assessment in laboratory; 2) Development of a new database, involving more itineraries crossing different environments, and thus broadening the model's applicability and representativeness; 3) Overall improvement of the methodological approach.

2. Literature review

Currently, four major approaches are adopted by the scientific and technical community to set speed limits: engineering philosophy, economic optimization philosophy, harm minimization philosophy and expert-based systems.

2.1. Engineering philosophy

According to this philosophy, speed limits are usually set based on an analysis of traffic and the road environment on the section under study and its surrounding roads. This approach includes as main basic methodology the Operating Speed Method, which has been widely used throughout the world, but especially in the United States, with notable examples in several states (such as Illinois, for instance) (Forbes et al., 2012).

The Operating Speed Method is based on the 85th percentile of speed (V85) and its usual procedure includes setting the speed limit in a value equal to or higher than the V85, eventually adjusting it in accordance to specific infrastructure and traffic conditions (Forbes et al., 2012). It takes into account that speed values equal to or near a standard deviation over the mean value (which is near that percentile) tend to correspond to a minimum accident risk for the driver (DfT, 2013). It also takes into consideration that this kind of speed limit is in accordance to the perception of a vast majority