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Traffic Microsimulation Study to Evaluate Freeway Exit Ramps Capacity

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Abstract

Growing traffic in urban and suburban areas has resulted in a demand for freeway exit ramps with higher capacity in order to avoid congestion. The main objective of the paper was to elaborate recommendations about the best exit ramp layout according to different parameters by evaluating capacity. Seven different diverge layouts were analyzed using traffic microsimulation. The average delay of the vehicles among their exit path was calculated on each diverge layout; and the capacity was obtained as the diverging flow from which the average delay grew exponentially. The capacity of each diverge layout varied from 1600 to 2000 vehicles per hour in one-lane exit ramp. The values for two-lane exit ramp were included on the interval [2000, 4400] vehicles per hour.

Keywords: Motorway diverge; exit ramp; capacity traffic; microsimulation.

1. Introduction

Motorway merging and diverging usually results on bottlenecks in freeway operations. An efficiently designed diverge may allow traffic to leave main carriageway as quickly as possible, without disruptions on traffic remaining on mainline. The Spanish Standard (Ministerio de Fomento, 1999) established deceleration lane as a functional element designated to facilitate exiting mainlines. Two different diverge layout were proposed: taper; and parallel, which are shown in Figure 1. Both layouts are one-lane exit ramp.

In order to calculate deceleration lane length, a dynamic model was adopted. The model considered both operational speeds in upstream segment and exit ramp; and average grade. However, many other factors, which may result important on the design of this type of junction, were not considered, such as traffic flow and safety.

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Moreover, these diverge layout may be inefficient on motorways on urban and suburban areas, where traffic flow is higher and near approaching capacity.

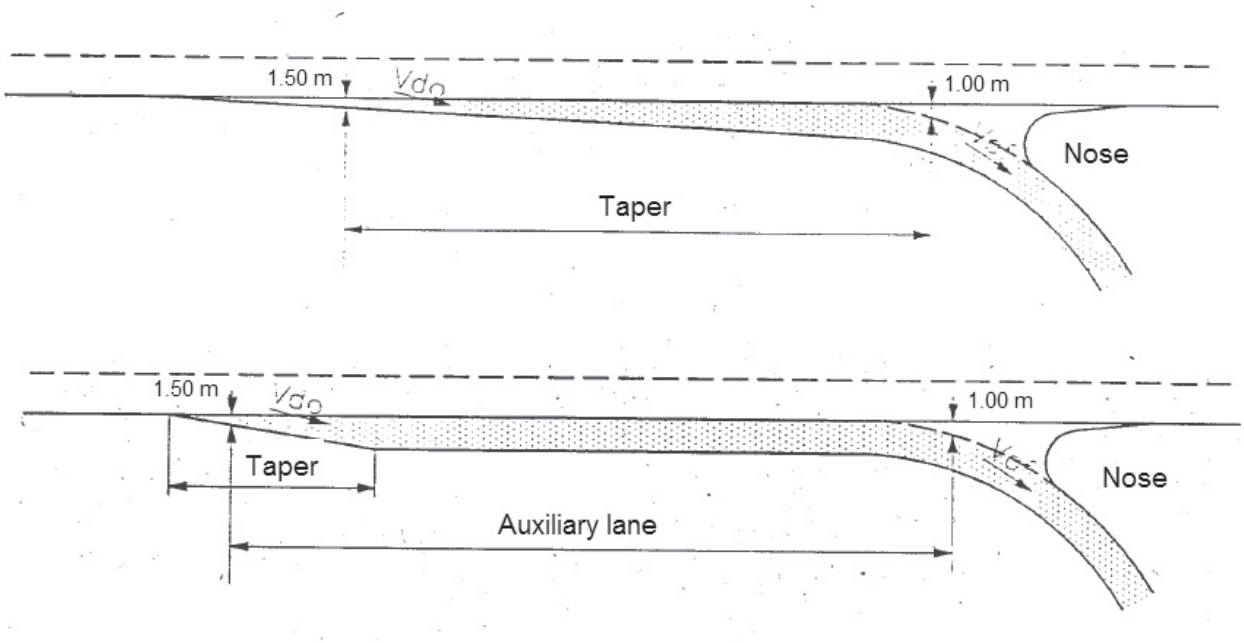

Figure 1. Motorway exit ramp layout: (a) Taper; (b) Parallel.

Other countries considered on their design guidelines not only exit ramp with one lane, but also two-lane exit ramps (AASHTO, 2004, Department of Transport, 2006). The need for understanding capacity is critical, as reflected in the U.S. *Highway Capacity Manual* (TRB 2000). Specifically, the HCM procedures provide estimates of levels of services but not of capacity. The latest UK Standard (Department of Transport, 2006) provided engineers a diverging flow-region diagram to help on the selection of the most appropriated layout depending on the mainline and diverging flows. Five layouts were considered: taper; parallel; taper lane drop; parallel lane drop; and parallel double lane drop. The regions were formed based on the maximum design working flows on both diverging and mainline. Both taper diverge and lane drop at taper diverge had a capacity of 1400 veh/h, while parallel diverge had 1800 veh/h capacity. Two-lane exit ramps presented capacity of 3600 veh/h at lane drop and lane drop at parallel diverge. Nevertheless, the research which these figures were based on is unclear and the design flow rate was lower than maximum working design flow (Wall and Hounsell, 2004). A microscopic model was used to verify the realistic representation of the diagram (Wall and Hounsell, 2005). It was concluded that taper and taper lane drop diverge layout had a limited range of diverging flows where operation was efficient. Parallel layout offered higher throughput results. However, no capacity values were given as result of the study.

A few research were conducted on freeway exit ramps areas focused on exit ramp performance analysis of safety and operations (Michalopoulos et al., 1990; Al-Kaisy et al., 1999; Bared et al., 1999; Batenhorst and Gerken, 2000; Bonnenson et al., 2005; Garber and Fontaine, 1999; Khorashadi, 1998; Lord and Bonnenson, 2005; Rakha and Zhang, 2006; Xinkai, 2007; Lu et al., 2010; Romero and Garcia, 2010; Anderson and Pedersen, 2010). It was concluded that only the off-ramp free-flow speed had a significant impact on capacity and operational performance