Operational Analyses of Freeway Off-Ramp Bottlenecks

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Abstract

The paper presents the findings to date of operational analyses at freeway off-ramps with emphasis on analysis procedures on recurrent off-ramp bottleneck locations at the Attiki odos motorway (Attica Tollway) in Athens, Greece. We compared the observed traffic performance metrics at two sites with the predicted measures using the methodology of freeway diverge areas and weaving sections in the 2010 edition of Highway Capacity Manual (HCM) for a wide range of traffic conditions. The findings indicate that the HCM volume predictions at the diverge area are in close agreement with field data and the density is underestimated by 7% on the average. The HCM weaving analysis methodology underestimated the weaving section capacity especially for high weaving volumes, and overestimated the section density by 17% on the average.

Keywords: freeway weaving, off-ramps, freeway capacity, mathematical models

1 Introduction

Freeway diverging areas and weaving sections are common design elements on freeway facilities such as near ramps and freeway-to-freeway connectors. When the traffic demands exceed the capacity at these locations congestion may occur, which affects the operation of the entire freeway section. In particular when off-ramps traffic demand exceeds the capacity at the downstream ramp terminal, the resulting spillback reduces the entire freeway discharge rate, increases delays and causes potential safety problems.

The objectives of the work reported in this paper is to develop and apply analysis tools to assess the traffic operations at the Attica Tollway in Athens, Greece, identify recurrent bottlenecks and

propose operational improvements. The paper presents the findings to-date from the first phase of the research involving the application of the HCM on two off-ramp bottleneck locations.

The next section of the paper describes the study sites along the Attica Tollway. Next the findings of the HCM methodology for diverging areas are presented. The following section presents the findings from the application of the HCM weaving analysis methodology. Section 4 discusses the study findings, and outlines ongoing and future work.

2 Study Site

Attica Tollway consists of five interconnected tolled freeways in the Athens Greece metropolitan area, with a total centerline length of 44 miles (70 km). There are 29 interchanges, and the number of lanes varies between 2 and 5 lanes per direction. There are 38 toll stations (three stations at the main entrances with 15 lanes each, and 35 stations on the access ramps, each with three to six lanes). The Tollway is actively managed to ensure safe and smooth travel for the motoring public. There are a total of 1,400 Inductive loop detectors located every 1,500 ft (500 m) on open sections and every 180 ft (60 m) in tunnels that provide data on flows and occupancy every 20 sec to assess the operating conditions. Video surveillance cameras and freeway service patrols ensure the quick detection and removal of traffic incidents (Halkias, 2005).

The detector data are stored, processed and analyzed by the freeway performance measurement system (PeMS) (Chen, 2001). PeMS includes algorithms to compute system performance measures (veh-miles and veh-hours of travel), traveler related metrics (delay and travel time along system segments), and travel time reliability measures (Petty, 2006). We used the PeMS bottleneck algorithm supplemented by field observations to identify active off-ramp bottlenecks based on the detector data. The algorithm is based on the spatial and temporal differences in speeds at successive detector locations. Two bottleneck sites were identified: a three lane freeway section with an one lane off-ramp, and a four lane freeway weaving section with a two lane off-ramp.

The first study site is a freeway diverge segment at the Kifissias Avenue interchange. This is a three lane section with one lane off--ramp (Figure 1). The heavy exit flow from the off-ramp has to stop at a downstream signalized intersection. The insufficient capacity of the signal controlled ramp terminal causes long queues and spillback of the off-ramp traffic into the Attica Tollway mainline. This causes drop in total freeway discharge rate, long queues and very slow speeds as shown in Figure 2. These conditions occur between 8-10 AM each weekday and the queues often exceed 2 miles in length. An adaptive control algorithm has been proposed to improve the performance at the traffic signal controlling the off-ramp exit (Spiropoulou, 2010).
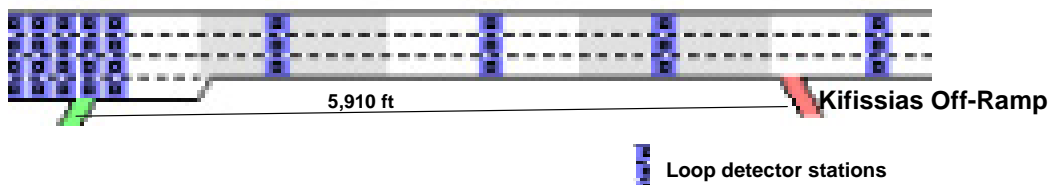

Figure 1: Study Location 1: Attica Tollway/Kifissias Avenue Off-Ramp