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Original Research Paper

Macroscopic and microscopic analyses of managed lanes on freeway facilities in South Florida

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HIGHLIGHTS

- Speed-flow models and key freeway segments performance measures such as pre-breakdown capacity, queue discharge flow, percent drop in capacity after the breakdown, and free flow speed were surveyed from two sites in South Florida representing one-lane and two-lane managed lane facilities.
- Two microsimulation models were developed, calibrated, and validated utilizing South Florida managed lanes traffic data.
- The built-in VISSIM car-following model of Wiedemann 99 was calibrated effectively to demonstrate key performance measures such as pre-breakdown capacity, queue discharge flow, and free flow speed.

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ABSTRACT

As congestion grows in metropolitan areas, agencies tend to utilize managed lanes on their freeway systems. Managed lanes have several forms and names, such as high-occupancy vehicle (HOV) lanes, high-occupancy toll (HOT) lanes, express lanes, and bus-only lanes. Although managed lanes have received significant attention as they increased the overall throughput and improved mobility without adding more lanes, little has been known about their operational capabilities. In addition, calibrating managed lane facilities can be challenging as they do not necessarily follow the same behavior with general purpose freeway lanes.

This paper presents an operational analysis of two HOT lane segments located in South Florida. The sites are one-lane and two-lane segments separated by flexible pylons (FPs). The paper includes a macroscopic capacity analysis, and a microscopic calibration of the two sites using VISSIM microsimulation. The research findings assist in determining the capacity and speed-flow relationship of these segments, and also provide guidance for microsimulation model calibration for practitioners.

The results of the study indicate that the percent drop in capacity for the one-lane FP site is 7.6% while the flow did not substantially change after the breakdown in the two-lane FP site. The research findings also include guidelines for simulating the breakdown events and calibrating one-lane and two-lane managed lane facilities in VISSIM microsimulation software. The Wiedemann car-following parameters (CC0 = 3.9 ft, CC1 = 1.9 s, CC2 = 26.25 ft, CC4 = −0.35, and CC5 = 0.35) provided the best fit for the one-lane FP site, while the

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combination (CC0 = 4.92 ft, CC1 = 1.9 s, CC2 = 39.37 ft, CC4 = −0.7, and CC5 = 0.7) parameters is recommended for the two-lane FP site.

1. Introduction and motivation

As congestion grows in metropolitan areas, agencies tend to utilize managed lanes on their freeway systems. The roadway capacities increasing requires substantial amount of funding but public funding is limited. Built mostly on private sector funding, managed lanes (MLs) could increase existing roadway capacities and alleviate congestion in overly populated areas. Federal Highway Administration (FHWA) emphasizes that the managed lanes concept or definition varies from agency to agency. In some agencies, managed lanes are referred to high-occupancy toll (HOT) roads which are facilities that combine pricing and vehicle eligibility to traverse at free flow speed (FFS) even in the oversaturated conditions. Other agencies use a broader definition which may include high-occupancy vehicle (HOV) lanes, priced lanes, and special use lanes such as express, bus-only, or truck-only lanes. The FHWA defines managed lanes as "highway facilities or a set of lanes in which operational strategies are implemented and managed (in real time) in response to changing conditions" (Obenberger, 2004).

Although managed lanes have drawn the attention of transportation engineers as they increase the overall throughput, little has been known about the capacities of these segments. Managed lanes are not designed to breakdown, therefore, capacities as a function of the flow breakdown are difficult to be obtained. In addition, from a microscopic perspective, calibrating microsimulation models of managed lanes can be challenging, since the car-following logic on these facilities may be different from that on general purpose lanes.

The motivation of this paper is to provide insight on the managed lanes traffic operations performance and speed-flow characteristics of one-lane and two-lane managed lane segments with flexible pylon (FP) separators in South Florida. Also, the paper seeks to investigate the microsimulation modeling capabilities of VISSIM simulation software in terms of modeling and calibrating accurately managed lane facilities. Fig. 1 demonstrates an example of the flexible pylons on the roadway.

2. Objectives

The main objectives of this paper include:

(1) Analyze one-lane and two-lane managed lanes (HOT) segments with FP separators and report managed lane traffic key operations performance measures that correspond to pre-breakdown flow rate, post-breakdown flow rate, and FFS.
(2) Compare speed-flow curves obtained from the field data with the Highway Capacity Manual (HCM) models (Transportation Research Board, 2016), and develop new curves that correspond to the specific sites.
(3) Propose key microsimulation car-following calibration parameters in VISSIM (PTV Group, 2016a) for capacity determination based on the Objective (1) findings.

The following sections describe past research on speed-flow models for managed lane facilities as well as simulation calibration efforts using VISSIM. Next, the methodology undertaken in this study is briefly discussed and followed with the results of the macroscopic and the microscopic analysis. Research conclusions and future steps are presented at the end.

Fig. 1 – Flexible pylons on FP1 site merge area (Google, 2016).