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Assessment of Level-Of-Service for Freeway Segments Using HCM and Microsimulation Methods

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Abstract

The HCM2010 freeway facilities methodology offers a supplemental computational engine FREEVAL, which is a macroscopic/mesoscopic tool. It enables users to implement HCM-based freeway analysis quickly. Vissim is a microscopic simulation tool that enables users to model real-world conditions with high level of accuracy. One of the commonly used performance measures for freeway assessment is the Level-of-Service (LOS). The HCM freeway facility methodology uses density to estimate LOS. However, density is calculated differently in FREEVAL and Vissim, and comparing the estimated LOSs between the two may lead to invalid conclusions. The aim of this paper is to address a gap in the literature by comparing and contrasting the methodologies behind the two tools and by offering explanation and discussion of their outputs in terms of density and LOS. The study covers three major HCM freeway segment types (basic, on-ramp, and weaving) in under-saturated conditions. The assessment reveals that both tools are capable of replicating the field conditions after the calibration process. Finding show that LOS differs by maximum one grade between these tools. Segment density obtained from HCM methods is generally higher than the segment density from Vissim microsimulation.

Keywords: HCM, Level-of-Service, Vissim, Microsimulaton, FREEVAL, freeway analysis

1 Introduction

Level-Of-Service (LOS) is widely used performance measure to assess the freeway operations. In the Highway Capacity Manual (HCM) method, it is based on the vehicular density of the specific facility segment. Freeway facility methodology for LOS calculation consists of minimum five and maximum eight steps involving multiple analytical equations (Transportation Research Board, 2010).

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The number of steps depends on the segment type which can be basic, weave, merge, or diverge. The variation of methodology in different segment types makes the analysis time consuming, especially if the assessment has to cover several freeway segments.

To make the calculation process more convenient, HCM 2010 freeway facilities methodology is accompanied with a supplemental computational engine FREEVAL, which is a macroscopic/mesoscopic tool that enables users to implement HCM-based freeway analysis methodology quickly. FREEVAL has been associated with the HCM freeway facility chapter since the last decade. Original FREEVAL engine was developed in Microsoft Excel powered by Visual Basic for Applications (Rouphail, Schroeder, & Eads, 2011). The latest version is offered in Java environment with enhanced features, such as managed lanes and travel time reliability (Zegeer, et al., 2014). The latter is used in research. In the under saturated conditions, FREEVAL exactly matches the computational methods in the segment chapters in HCM 2010. In fact, one does not need to use FREEVAL in those cases. The difference is that FREEVAL does provide segment-based densities in vehicles/mile/lane or passenger cars/mile/lane. Even though FREEVAL is based on HCM methods, it is easier for use comparing to equation based HCM methodology.

Another way to evaluate freeway facilities is to use microsimulation tools, as proposed by HCM in alternative tools subsection. Although there are several microsimulation tools on the market, Vissim is one that enables users to model real-world traffic conditions with high level of accuracy and comprehension. Thus, the two tools represent quite opposite sides in freeway modelling – Vissim as a representative of microsimulation tools, requires time-consuming preparation and calibration of the model, but it usually provides better granularity of results. FREEVAL requires less on input and calibration sides but its results may not be as comprehensive and accurate as Vissim.

Researchers and practitioners use both tools for freeway analysis and tend to compare the outputs directly. The HCM freeway facilities methodology uses density in passenger cars per mile per lane (pc/mi/ln) to estimate LOS. However, density is calculated differently in Vissim, and comparing the estimated LOSs between the two may not represent a proper comparison, and can lead to invalid conclusions. Further, HCM 2010 states that Vissim density outputs should not be converted to pc/mi/ln using HCM equations (Transportation Research Board, 2010). Microsimulation already accounts for sluggish behavior of heavy vehicles, and using HCM equations would be equivalent to adding the heavy vehicle factor twice in the output.

HCM 2010 states that simulation tools should produce similar answers to the HCM output (Transportation Research Board, 2010). Further, it says the exact numerical match should not be expected due to different nature of the methodologies. HCM (FREEVAL) is based on deterministic equations, while Vissim is stochastic in nature. Current literature does not provide much insight into how different outputs from FREEVAL and microsimulation compare. Some research (Milam, Stanek, & Chris, 2006) has been done in the past, but it was based on the HCM 2000 guidelines. HCM 2010 has brought many changes, including supplemental chapters on how to use microsimulation tools along with HCM methods. Evidently, there is a gap in the common knowledge on how differences between these tools should be handled, so that practitioners can have an insight of how consistent results are.

This paper aims to address such a gap by comparing and contrasting the methodologies behind the two tools and by offering explanation and discussion of their outputs in terms of segment density and LOS. The paper covers three major HCM freeway segment types (basic, on-ramp, weaving) for under-saturated conditions and utilizes the methodology for segment density analysis. Field data are acquired from Performance Measurement System (PeMS) online database in California, for I-880 freeway. FREEVAL and Vissim models are calibrated and validated using the acquired data. The outputs of both tools are evaluated against the field data.

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