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A rationale for enhancing the German Highway Capacity Manual to incorporate oversaturated freeway facility analysis

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Abstract

Unlike the U.S. 2010 Highway Capacity Manual, the most recent edition of the German Highway Capacity Manual does not include methodology to evaluate the facility within oversaturated time periods. To incorporate this traffic flow regime within the methodology, we identify several aspects of the methodology that require enhancements and propose modifications. Next, we implement these modifications in a macroscopic traffic model developed as a software implementation of the German guideline. In this manner, the HBS user can conduct traffic flow analysis that includes volume-to-capacity ratios above 1.00 which has not been foreseen by the guideline until now. The main contribution of this paper is the identification of methods within the German Highway Capacity Manual that require modification to enable incorporation of oversaturated traffic flow within the analysis. Further, we introduce traffic density as a variable within the HBS methodology and show benefits of its incorporation during the oversaturated time periods. Finally, the paper includes illustrative examples of empirical and model-based evaluation of congested freeway facility in Germany. The paper concludes with a discussion of proposed methods and their limitations.

Keywords: freeway analysis, HBS, HCM, oversaturation, LOS

1 Introduction

The German Highway Capacity Manual (HBS) (FGSV, 2015) serves as a hands-on guideline for the freeway facility Level of Service (LOS) analysis. The manual includes methods to perform analysis of undersaturated basic segments, intersections and freeway facilities. However, an oversaturation of at least one of the component segments leads to termination of the analysis. In that case, the HBS assigns the complete facility a LOS F and does not analyze the facility further. To answer this discontinuity, we propose extensions to the current methodology to incorporate the oversaturation within the analysis. Furthermore, we developed a macroscopic traffic flow model encompassing all the current and proposed

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HBS methodology and implemented the model in a computational engine. The model is a faithful implementation of the researched traffic flow concepts included in the HBS chapters A3, A4 and A5.

Until now, the basic road segments, merge, diverge and weaving segments have been treated individually within the analysis of uninterrupted flow in the HBS. In our approach, we evaluate the freeway as a facility composed of a number of component segments that are mutually linked. Only in this manner the interactions between the interchanges and the basic road segments can be covered and fully investigated. With means of macroscopic traffic flow modelling, we enable the traffic shocks to propagate through the facility, investigate the suitability of the current methodology for assessment of congested facilities and propose modifications to allow for detailed LOS evaluation during oversaturation.

The structure of the paper is as follows: First, we give a brief overview of the HBS structure and give background on the development of the current HBS methodology. Next, we review the development of the LOS concept from both U.S. and German point of view. Further, we identify parts of the HBS methodology that are necessary to be extended in order to handle the oversaturation and to guarantee seamless linkage of methodology included in HBS chapters A3, A4 and A5. In Chapter 3 we propose modifications to the methodology and discuss them in a detailed manner. Chapter 4 provides an empirical and model-based analysis of a freeway facility comparing the current and proposed methodology. Finally, we give conclusions and discuss the objectives of the further research.

2 Literature review

2.1 HBS methodology

The German Highway Capacity Manual (HBS) determines the capacity and incorporates the methods for assessing the quality of traffic flow on freeway facilities, highways as well as on urban roads. HBS chapters devoted to the analysis of freeway facilities are based on an empirical research on German freeways over the last 20 years. The most relevant effort to this research was the work of (Brilon et al., 1994) that led to a draft of the guideline. Further developments of these concepts led to a publication of the first HBS manual in 2001 (FGSV, 2001). This guideline summed up the research efforts on freeway analysis, among other analyses of diverge areas (Schnüll, Hoffmann, & Irzik, 2000) and merge areas (Brilon & Westphal, 1994), (Wirth & Staufer, 2000). The methodology of the guideline was updated in 2009 to contain approved corrections and most recently, an update to 2015 HBS edition including the current state of research is in press.

Chapter A3 of the manual provides discrete capacities and revised speed-flow relationships of basic road segments based on an empirical analysis derived from data from 50 cross sections on German freeway facilities (Brilon & Geistefeldt, 2010) . This empirical evidence, enhanced among others by empirical analysis (Brilon & Ponzlet, 1996), (Brilon & Lemke, 2000) represents a revision of the original speed-flow relationships that created a basis for the previous HBS edition in 2001 and that were originally developed by (Brilon & Ponzlet, 1995). The capacities in Chapter A3 are expressed as cross sectional values and were determined using van Aerde model (van Aerde, 1995) and the empirical evidence mentioned above.

The analysis of grade separated junctions (chapter A4) is based among others on empirical findings by (Weiser & Sillus, 2006) , (Friedrich, Irzik, & Hoffmann, 2006) and (Friedrich, Hoffmann, Irzik, & Matschke, 2008). A new model for LOS analysis using combined volume-to-capacity (V/C) ratio, while considering all critical areas around the network element (merge/diverge/weaving), was introduced by (Wu & Lemke, 2011) and is incorporated in the updated HBS editions.

Finally, the 2015 HBS edition introduces a new chapter A5 that gives methods on analyzing the freeway facility as a whole. Unlike in chapters A3 and A4, the facility LOS is evaluated based on a mean travel speed and not on the V/C ratio to reflect qualitatively on the facility´s performance within