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Heterogeneous Lanes' Saturation Flow Rates at Signalized Intersections

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Abstract

Correct saturation flow rates are very important for the calculation of delays and level of service at intersections. However, the Highway Capacity Manual (HCM) procedure and the related studies assumed ideal conditions and cannot be applicable under mixed traffic circumstances. A traffic survey on 36 signalized intersections inside the Beijing's 5th Ring was conducted and a large number of experimental data with different lane types were statistically analyzed in this paper. Results show that the saturation headways approximately follow the normal distributions and the following base saturation flow rates are appropriate for Beijing intersections: 1380 passenger cars per hour per lane (pc/h/ln) of the right-turn lane, 1520 pc/h/ln of the left-turn lane, 1535 pc/h/ln of the through lane, 1457 pc/h/ln of the through-right lane and 1411 pc/h/ln of the through-left lane. These results have been used and verified in the real-time traffic information systems of Beijing Traffic Management Bureau.

Keywords: Signalized intersection; saturation flow rate; headway; lane types

1. Introduction

Correct saturation flow rates for the specific circumstances are very important for the calculation of delays and Level of Service (LOS) at intersections. Due to lack of local data, software developers would have to use default or wrong values in such software systems as intelligent transportation systems, which can lead to wrong results and inappropriate guidance in real-time traffic information.

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The 2000 Highway Capacity Manual (HCM) describes a procedure for estimating the saturation flow rate at a signalized intersection. This procedure assumes that the base saturation flow rate for each lane type is given and numerous saturation flow rate adjustment factors are included to adjust the base rate. It seems that the estimated saturation flow can accurately reflect conditions on the intersection approach. However, ideal conditions are assumed as follows:

- 3.6 meter lane width;
- No heavy vehicles;
- Flat gradient;
- No parking or bus stops near the intersection;
- Uniform movement type, i.e. only straight movement or only turning movement; and
- No pedestrians or cyclists.

Obviously, these ideal conditions cannot be satisfied in each city. Factors that reflect the effect of traffic pressure, number of lanes in the lane group, or approach speed should be offered to yield confidence in the accuracy of the saturation flow rate estimate. Moreover, most of the recommended base saturation flow rates are based on the through lanes. And other lane types' saturation flow rates are calculated by certain formulas about the through lanes' base rates, which possibly lead to inconsistent results with real traffic. Many researchers pointed that the estimated saturation flow rate is higher than field measurements and they tried to found new base rates in specific countries or cities (Bonneson et al., 2005; Liu et al., 2009). For example, Bonneson et al. (2005) indicated that a base saturation flow rate of 1950 passenger cars per hour per lane (pc/h/ln) was appropriate for Florida intersections. The gap acceptance theory, the addition-conflict-flow theory, the regression methods and the simulation methods were introduced to investigate the saturation flow rate under various traffic conditions (Zhao et al., 2008; Jin et al., 2009; Tiwari et al., 1998; Chandra & Kumar, 2003; Tian & Wu, 2006; Pandian et al., 2009; Sharma et al., 2007; Li & Prevedouros, 2002).

In this paper we conducted a traffic survey on 36 signalized intersections inside the Beijing's Fifth Ring. Based on a large number of experimental data and accurate statistical analysis, the recommended saturation headways and the recommended saturation flow rates were given, including the right-turn lane, the left-turn lane, the through lane, the through-right lane, and the through-left lane. These results have been used and verified in the real-time traffic information systems of Beijing Traffic Management Bureau.

2. Data collection

2.1. Intersections surveyed

For the purposes of this study it was important to identify and observe intersections that represented the various conditions described above. The following criteria were also taken into account for selecting intersections:

- As typical and representative as possible to satisfy all the requirements in table 1, including the T-shaped intersections, the cross intersections and the complicated intersections.
- The traffic queues should be long enough to facilitate the observation of saturation flow rates;
- Have a wide view to be convenient to set up videos.

In order to eliminate the effects of the road hierarchy, the shape of intersections was considered, as shown in Table 1. According to these criteria, 36 intersections in Beijing were selected for observation (see, Fig. 1), among which 11 was in Beijing Haidian district, 4 in East district, 4 in Beijing Fengtai district, 5 in West district, 4 in Beijing Chaoyang district, 1 in Beijing Shijing-shan district, 3 in Beijing Chongwen district and 4 in Beijing Xuanwu district.