Title:

Empirical evaluation of the lost time in the inter-green period before protected right-turn after permitted phase

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Extended Abstract

The objective of this study is identifying the lost time in the inter-green period before protected right-turn after permitted phase as an empirical analysis in Japan with the left-hand side traffic. The proper identification of such lost time proved by empirical analysis can be applied to the design of phasing plan and/or the decision for the cycle length. If the total lost time per cycle is corrected as 8 seconds from 10 seconds, the cycle length can be shortened to 80 seconds from 100 seconds to keep the same volume-capacity ratio. Therefore, the proper identification of lost time has significant impact on the decision of cycle length.

The authors focused on the inter-green period before protected right-turn after permitted phase; the order of permitted and protected turning phases is very popular phasing plan in Japan (Figure 1). The green time for one approach starts with simultaneous green indication for confronting another approach followed by yellow time, and then the protected green time for right turners starts afterward with right green arrow. Because the permitted phase precedes the protected phase, the right turners in queue on the dedicated right turning lane can proceed into the intersection up to the location where the head vehicle in the queue can wait for the passing confronting through traffic; the location is defined as the downstream-end of waiting right turners' queue in this presentation.

The existence of waiting queue up to the downstream-end has a significant impact on the estimation of the starting time of effective green for the protected right turning traffic. The method to estimate the beginning time-point of the effective green for the protected right turners is introduced with the proposal of the reasonable estimation method of saturation flow rate for this right turning vehicles' movement. Suppose the ending time-point of the preceding effective green for the confronting through traffic is simply considered as the last passing time around the end of yellow time. The procedure for empirical study with the data collected in field surveys are proposed by five steps. First, determine the ending time-point of the confronting through traffic, and second, estimate the saturation flow rate for the protected right-turning flow observed at the downstream-end of the right turners' movement on the dedicated lane. Third, estimate the beginning time-point of the effective green for the protected right turners at the downstream-end of the dedicated right turners' queue. Fourth, calculate the expectation values of travel time from the stop line to the downstream-end and the beginning time-point of the protected right turners' effective green at the stop line is calculated subtracting the travel time from the beginning of the effective green at the downstream-end of right turners. And at last, calculate the lost time of this inter-green period.

The field surveys are conducted at five 4-leg intersections in Tokyo. The intersections include

different size, dimension, and number of lanes for each approach. Each intersection has enough traffic demand on the focused right turners and confronting through traffic. For the second step, start-up delay is found as almost same as the HCM suggestion, on the other hand, because the last a few vehicles rush to the intersection so that the expected flow rate for those vehicles may be higher than the normal saturation flow rate in the protected period. The authors also found the difficulty to estimate the expectation of the travel time from the stop line to the downstreem-end location.

From the result of the field survey, the estimated values of the lost time are listed in the table 1, and Figure 2 explains the meaning of the variables. There are no 'lost time' during the inter-green at all intersections, but some 'gaining time' exists on the contrary for all intersections. The duration of the 'gaining time' may reflect the geometric condition of the intersections and travel speed from stop line to the downstream-end. As a conclusion, in the case of the permitted phase preceding the protected phase, there are no 'lost time' at all, but rather 'gaining time' exists so that the total delay per cycle will decrease compared with the conventional intersections. The knowledge for the 'gaining time' must be generalized and the method to decide the cycle length in Japan should be modified.
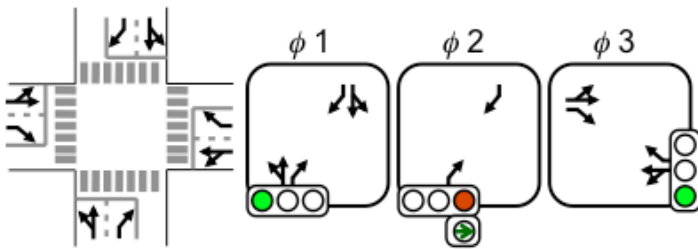

Figure 1 Popular phasing plan for right turners in Japan

Table 1 Calculated and estimated results for 5 junctions

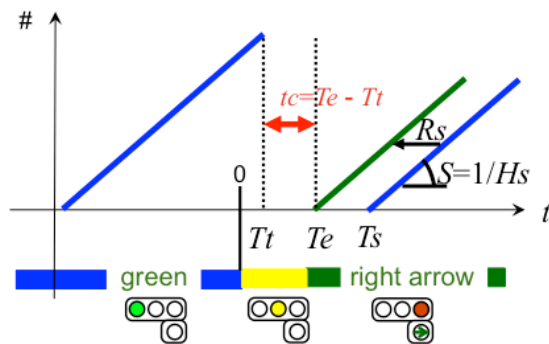|	Tt (s)	Hs (s/veh)	Ts (s)	Rs (s)	Te (s)	tc (s)	n
Junction 1	1.8	2.09	4.4	5.3	−0.9	−2.7	22
Junction 2	1.5	1.88	4.2	4.3	−0.1	−1.6	7
Junction 3	2.1	1.99	4.4	3.4	1.0	−1.1	36
Junction 4	1.5	1.90	4.6	7.3	−2.7	−4.2	19
Junction 5	1.4	2.08	2.1	4.7	−2.6	−4.0	8

Figure 2 Variables calculated and estimated