Berger-Robertson Method for Measuring Intersection Delay

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Vehicle delay is generally viewed by traffic engineers as a tangible measure of intersection performance, but not an easily obtained measure. Two major problems are encountered in the measurement of delay. The first problem is fundamental. Any measurement technique must be based on a conceptual model of the phenomenon being measured and most models that have been developed have probabilistic properties. However, theoreticians have generally limited their models to deal with circumstances of constant average volume levels that are below capacity. This technique makes the model generally inapplicable to peak-hour conditions in which traffic volume levels are not constant, do not follow any mathematical distribution, and often exceed capacity.

The second problem is that conventional methods of field measurement of vehicle delay generally require the microscopic observation of the traffic stream and recording of every vehicle involved. The considerable expense of these methods has generally limited their application to infrequent usage. The result is a lack of basic field data from which vehicle delay parameters can be developed.

BERGER-ROBERTSON METHOD

The Berger-Robertson method is a manual procedure that is based on several established mathematical and traffic engineering relationships. First, an estimate of a continuous function can be approximated by a linear fit over any sufficiently small interval. Second, where a linear equation is adequate, the center (or mean value) on that line represents the best least square estimate of the values contained in that region. Finally, when computing stopped delay, we assume that the earlier arriving vehicles in any one lane are released from the queue first. These three relations suggest a method for the manual collection of stop-time delay that should be bias-free relative to the saturation levels of the intersection and independent of the signal cycle length.

The procedure is to divide the total time period of interest (e.g., cycle length) into a sufficiently small number of equal intervals (e.g., 5s). Then the vehicles that stop in each interval are tallied separately, and the midpoint of the interval is assumed to represent the average arrivals of the vehicles in the interval. The number of previously stopped vehicles departing (clearing the intersection) is also tallied by interval. Again the departure of these vehicles is assumed to be randomly distributed in the interval.

A clipboard and tally sheet are required. The tally sheet consists of two rows (one for stopping and one for starting) divided into equal blocks representing the number of intervals in the sampling period. Having an interval timer with an auditory tone is helpful for signaling the onset of each interval.

The results from the above procedure have been compared with those obtained by using time-lapse photography (where frame counts per vehicle were recorded). The time-lapse film used for this comparison was taken during a recent project in the District of Columbia (1). The southbound approach on Wisconsin Avenue at the intersection of Western Avenue was used. The approach consists of three lanes (one left turn only and two through lanes). This approach carried 12 322 vehicles between 7 a.m. and 6 p.m. on the day the film was taken. The method was applied to 10 periods equally distributed through the 11-h data collection day. The results of the comparison appear in Table 1.

Two comparisons are provided in Table 1. The first represents the results of applying the Berger-Robertson method to the values obtained from the film scoring. This analytic use of the method provides a good indication of the extent to which real data meet the assumptions on which the method is based. The second comparison entailed viewing the film and manually coding the vehicles in real time. This application demonstrates the feasibility of real-time use of the method. The data obtained by manually coding the film included the component of human error and therefore provide some idea of the "real world" reliability of the method.

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Table 1. Comparison of intersection delay generated via time-lapse and Berger-Robertson method.

Signal Cycle	Left Lane Delay (vehicle·s) Time-Lapse	Left Lane Delay Berger-Robertson Analytic	Left Lane Delay Berger-Robertson Manual	Center Lane Delay (vehicle·s) Time-Lapse	Center Lane Delay Berger-Robertson Analytic	Center Lane Delay Berger-Robertson Manual	Right Lane Delay (vehicle·s) Time-Lapse	Right Lane Delay Berger-Robertson Analytic	Right Lane Delay Berger-Robertson Manual
1	27.5	25	25	40	40	40	46	45	45
2	58	50	65	185	185	165	0	0	0
3	29.5	30	30	83	95	80	41	35	40
4	2.5	5	5	87	85	90	38	35	35
5	80.5	75	70	79.5	75	70	15.5	15	15
6	412	405	405	86.5	80	95	52	50	55
7	186	185	185	144	140	135	66	65	55
8	120.5	120	120	60	60	55	64	60	55
9	439.5	440	445	120.5	115	115	21	20	20
10	592	580	590	283	280	300	138	140	155

Table 2. Statistical analysis of data in Table 1.

Lane	Method	Mean	Standard Deviation	Correlation Coefficient With Time-Lapse
Left	Time-lapse	194.80	209.36	-
	Berger-Robertson			
	Analytic	191.50	206.99	0.999
	Manual	194.00	208.99	0.999
Center	Time-lapse	116.85	71.87	-
	Berger-Robertson			
	Analytic	115.50	71.12	0.997
	Manual	114.50	75.00	0.991
Right	Time-lapse	48.15	37.92	-
	Berger-Robertson			
	Analytic	46.50	38.59	0.998
	Manual	47.50	42.18	0.998

CONCLUSIONS

Based on the data in Table 1, we can conclude that our method is theoretically sound and operationally practical. The theoretical soundness of the model is attested to by its analytic correspondence with the time-lapse data (Table 2). The means and standard deviations are nearly identical, and the correlation between the two procedures are uniformly high. The operational practicality of the method is reflected in a similarly consistent relationship between the time-lapse film data and the manual application of the method.

REFERENCES

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