SAMPLING STRATEGY FOR
SPACE MEAN SPEED SURVEY

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Abstract

In most traffic projects, speed survey is required. If the speed survey uses detector, all data might be obtained. Otherwise a sampling strategy needs to be introduced. To ensure the collection of representative sample of speeds there were several sampling options, e.g. collecting sample every regular interval. In this paper three regular intervals were tested, i.e. 30 seconds, 1 minute and 2 minutes 30 seconds. Travel time data was collected in morning, mid day, and afternoon periods in a two-lanes two-ways underpass in Jakarta. Travel speeds were calculated by dividing light vehicle travel times with the underpass length. Space mean speeds were calculated as a light vehicle travel mean speeds/ 5 minutes. The observation of each light vehicle travel times (to get each light vehicle travel speeds) was conducted for the first 15 minutes of three observation periods. More frequent speed sample collection provides higher accuracy.

Keywords: space mean speed, sampling strategy, regular interval sampling

Abstrak

Dalam proyek sebagian besar lalulintas, survei kecepatan diperlukan. Jika survei kecepatan menggunakan detektor, semua data bisa diperoleh. Jika tidak, strategi sampling yang perlu dilakukan. Untuk memastikan pengumpulan sampel yang representatif, terdapat beberapa pilihan, misalnya mengumpulkan sampel setiap interval reguler. Dalam tulisan ini tiga interval teratur diuji, yaitu 30 detik, 1 menit dan 2 menit 30 detik. Waktu tempuh dikumpulkan di pagi hari, di pertengahan hari, dan di sore hari pada dua lajur dua arah *underpass* di Jakarta. Kecepatan perjalanan dihitung dengan membagi panjang *underpass* dengan waktu tempuh. Kecepatan rata-rata ruang dihitung sebagai kecepatan rata-rata perjalanan kendaraan ringan / 5 menit. Pengamatan setiap kali perjalanan kendaraan ringan (untuk mendapatkan masing-masing kecepatan kendaraan) dilakukan selama 15 menit pertama dari tiga periode pengamatan. Pengambilan sampel yang lebih sering akan memberikan akurasi yang lebih tinggi.

Kata-kata Kunci: kecepatan rata-rata ruang, strategi sampling, pengambilan sampel interval reguler

INTRODUCTION

In most traffic related projects, speed survey is required. If the speed survey is conducted using detector, all speeds data might be obtained. Otherwise a sampling stragegy needs to be introduced. To ensure the collection of representative sample of sppeds there were several sampling options. One of the most practical sampling strategy is by withdraw sample in a regular interval.

The objective of this study is to understad the effect speed sample withdrawal frequency to the accuracy of obtained space mean speeds.

Compare to other basic traffic variables such as flow and density, speed can express more direct performance indicator without the availability of other variables (Putranto, 2007). Low speed usually expresses congested situation and high speed usually expresses free flow. Therefore various studies regarding Greater Jakarta used speed as main variable to give immediate understanding regarding the performance of each part of the highway network. For example in SITRAMP (The Study on Integrated Transportation Master Plan for Jabodetabek-Indonesia) and JUTPI (Jabodetabek Urban Transportation Policy Integration Project).

Putranto (2010) conducted space mean speeds observations in 3 new development locations in Jakarta to fulfill traffic impact analysis required by Jakarta Transport Agency. As the alocated budget is very limited only 4 speed observations per hour per vehicle type (during 06.00-09.00 and 16.00-19.00) were carried out. Light vehicles, heavy vehicles and motorcycle speeds were observed. This cause doubt on the accuracy of the result. Therefore a study to understand the effect of speed sampling frequency is required.
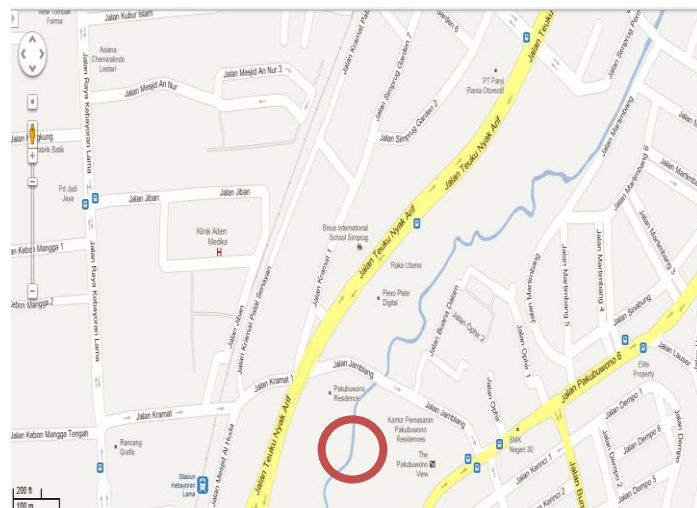

Figure 1 Location of the Underpass

In this paper three regular intervals were tested, i.e. 30 seconds, 1 minute and 2 minutes 30 seconds. Travel time data was collected in Thursday, 13 October 2011 in morning (06.10-08.08), mid day (10.45-12.47) and afternoon (14.40-16.38) periods in a two-lanes two-ways underpass in Teuku Nyak Arief Street, South Jakarta. These periods were deliberately chosen to avoid measurement in stop and go condition. Figure 1 shows the location of the underpass in red circle, Figure 2 shows view of underpass taken from Simprug side and Figure 3 shows the video camera view above the uderpass for speed and flow survey. Although the underpass is a two-lanes two ways street but it is quite wide (9,2 m) because its also serve Bus Rapid Transit Line 8 flow (non-exclusive BRT lane in the underpass but exclusive lane in most other parts of the line).

Figure 2 View of the Underpass Taken from Simprug

Figure 3 Camera View for Speed and Flow Flow Observation

Travel speeds were calculated by dividing light vehicle travel times with the underpass length (67.7 m). Space mean speeds were calculated as a light vehicle travel mean speeds/ 5 minutes. The observation of each light vehicle travel times (to get each light vehicle travel speeds) was conducted for the first 15 minutes of three observation periods. Sampling error of 30 seconds sampling interval was calculated by Equation 1.

$$Sampling\_error\_of\_per\_30s\_observatio\mathbf{n} = \frac{\mu_S from\_overall\_observatio\mathbf{n} - \mu_S from\_per\_30s\_observatio\mathbf{n}}{\mu_S from\_overall\_observatio\mathbf{n}} x100\% \tag{1}$$

From Santoso (2011), it was found that sampling error for speed observation every 30 seconds was only about 1-2 %. This was considerably small error. As conducting overall speed observation is very tidious and difficult task, using 30 seconds sampling interval as a bench mark to calculate sampling error of 1 minute interval (Equation 2) and 2 minutes 30 seconds interval (Equation 3) is considered to be sufficient.

$$Sampling\_error\_of\_per\_1m\_observatio\mathbf{n} = \frac{\mu_S from\_per\_30s\_observatio\mathbf{n} - \mu_S from\_per\_1m\_observatio\mathbf{n}}{\mu_S from\_per\_30s\_observatio\mathbf{n}} x100\% \tag{2}$$

$$Sampling\_error\_of\_per\_2m\_30s\_observation = \frac{\mu_S from\_per\_30s\_observation - \mu_S from\_per\_2m\_30s\_observation}{\mu_S from\_per\_30s\_observation} x100\% \tag{3}$$

Lower sampling error in % indicates closer similarity between the space mean speed in regular interval sampling with bench mark speed.

CONCLUSIONS

During the observation periods space mean speeds were between 7.8 kph and 41.9 kph, flow are between 1818 pcu/h and 3129 pcu/h and V/C between 0.39 and 1.00. Tables

1 to 6 show the results of the survey. Table 7 summarizes the minimum, mean and maximum sampling error in each direction and each observation period with indication of V/C range.

It can be seen that in general sampling error for more frequent sampling interval was in general less than sampling error for less frequent sampling interval. There was no pattern of relationship between sampling error and range of V/C or observation period, but it seems that moderate range of V/C in the mid day in general results in less sampling error.

Table 1 Space Mean Speed & Sampling Errors for North-South Direction in the Morning

No	Morning Observation Period	Space Mean Speed for 30 Secons Sampling Interval	Space Mean Speed for 1 Minute Sampling Interval	Space Mean Speed for 2 Minutes 30 Seconds Sampling Interval	Sampling Error of 1 Minute Sampling Interval (%)	Sampling Error of 2 Minutes and 30 Seconds Sampling Interval (%)
1	6:10:00 - 6:14:30	42.88	38.59	41.78	-0.10	-0.03
2	6:15:00 - 6:19:30	51.99	51.99	54.84	0.00	0.05
3	6:20:00 - 6:24:30	52.84	60.93	54.84	0.15	0.04
4	6:25:00 - 6:29:30	44.60	42.44	37.91	-0.05	-0.15
5	6:30:00 - 6:34:30	47.18	48.40	48.74	0.03	0.03
6	6:35:00 - 6:39:30	37.05	41.08	42.65	0.11	0.15
7	6:40:00 - 6:44:30	48.74	45.49	44.68	-0.07	-0.08
8	6:45:00 - 6:49:30	40.45	37.43	44.68	-0.07	0.10
9	6:50:00 - 6:54:30	43.04	37.62	55.85	-0.13	0.30
10	6:55:00 - 6:59:30	47.35	48.74	48.74	0.03	0.03
11	7:00:00 - 7:02:30	26.40	26.40	24.37	0.00	-0.08
12	7:10:30 - 7:14:30	24.88	23.77	20.31	-0.04	-0.18
13	7:15:00 - 7:19:30	28.98	28.46	26.31	-0.02	-0.09
14	7:20:00 - 7:24:30	41.87	43.87	54.84	0.05	0.31
15	7:25:00 - 7:29:30	30.48	28.40	29.59	-0.07	-0.03
16	7:30:00 - 7:34:30	26.17	25.69	23.26	-0.02	-0.11
17	7:35:00 - 7:39:30	45.29	45.09	39.60	0.00	-0.13
18	7:40:00 - 7:44:30	25.79	26.13	24.37	0.01	-0.06
19	7:45:00 - 7:49:30	29.00	29.79	37.72	0.03	0.30
20	7:50:00 - 7:54:30	40.18	41.08	30.95	0.02	-0.23
21	7:55:00 - 7:59:30	36.38	33.37	45.70	-0.08	0.26
22	8:00:00 - 8:04:30	25.89	25.32	24.62	-0.02	-0.05
23	8:05:00 - 8:07:30	24.00	19.76	27.08	-0.18	0.13

No	Mid Day Observation Period	Space Mean Speed for 30 Secons Sampling Interval	Space Mean Speed for 1 Minute Sampling Interval	Space Mean Speed for 2 Minutes 30 Seconds Sampling Interval	Sampling Error of 1 Minute Sampling Interval (%)	Sampling Error of 2 Minutes and 30 Seconds Sampling Interval (%)
1	10:45:00 - 10:49:30	26.61	26.54	27.08	0.00	0.02
2	10:50:00 - 10:54:30	27.55	26.67	27.42	-0.03	0.00
3	10:55:00 - 10:59:30	34.86	34.31	37.72	-0.02	0.08
4	11:00:00 - 11:04:30	30.48	30.60	23.26	0.00	-0.24
5	11:05:00 - 11:09:30	40.04	41.49	35.54	0.04	-0.11
6	11:10:00 - 11:14:30	31.61	28.99	26.78	-0.08	-0.15
7	11:15:00 - 11:19:30	34.15	34.64	34.82	0.01	0.02
8	11:20:00 - 11:24:30	34.95	34.72	32.64	-0.01	-0.07
9	11:25:00 - 11:29:30	31.43	30.47	32.64	-0.03	0.04
10	11:30:00 - 11:34:30	31.66	31.47	28.77	-0.01	-0.09
11	11:35:00 - 11:39:30	31.87	32.21	32.64	0.01	0.02
12	11:45:00 - 11:49:30	30.83	31.18	32.64	0.01	0.06
13	11:50:00 - 11:54:30	39.30	35.88	44.68	-0.09	0.14
14	11:55:00 - 11:59:30	36.62	35.34	44.68	-0.03	0.22
15	12:00:00 - 12:04:30	45.62	43.19	44.68	-0.05	-0.02
16	12:05:00 - 12:09:30	40.88	40.68	41.78	0.00	0.02
17	12:10:00 - 12:14:30	39.29	39.52	39.60	0.01	0.01
18	12:15:00 - 12:19:30	35.92	35.98	41.78	0.00	0.16
19	12:20:00 - 12:24:30	36.09	35.51	29.59	-0.02	-0.18
20	12:25:00 - 12:29:30	41.60	37.97	48.74	-0.09	0.17
21	12:30:00 - 12:34:30	41.90	39.81	48.74	-0.05	0.16
22	12:35:00 - 12:39:30	39.72	43.23	37.72	0.09	-0.05
23	12:40:00 - 12:42:30	0.00	0.00	0.00	0.00	0.00

Table 3 Space Mean Speed & Sampling Errors for North-South Direction in the Afternoon

No	Afternoon Observation Period	Space Mean Speed for 30 Secons Sampling Interval	Space Mean Speed for 1 Minute Sampling Interval	Space Mean Speed for 2 Minutes 30 Seconds Sampling Interval	Sampling Error of 1 Minute Sampling Interval (%)	Sampling Error of 2 Minutes and 30 Seconds Sampling Interval (%)
1	14:40:00 - 14:44:30	22.83	24.37	24.37	0.07	0.07
2	14:45:00 - 14:49:30	22.07	19.70	19.92	-0.11	-0.10
3	14:50:00 - 14:54:30	14.38	14.01	19.20	-0.03	0.34
4	14:55:00 - 14:59:30	18.33	17.56	13.30	-0.04	-0.27
5	15:00:00 - 15:04:30	19.99	15.90	28.43	-0.20	0.42
6	15:05:00 - 15:09:30	6.87	7.47	4.50	0.09	-0.34
7	15:10:00 - 15:14:30	16.37	15.86	10.70	-0.03	-0.35
8	15:15:00 - 15:19:30	11.35	11.37	5.56	0.00	-0.51
9	15:20:00 - 15:24:30	10.22	11.69	14.12	0.14	0.38
10	15:25:00 - 15:29:30	11.17	9.53	13.98	-0.15	0.25
11	15:30:00 - 15:34:30	8.20	7.58	5.92	-0.08	-0.28
12	15:40:00 - 15:44:30	9.07	8.54	9.32	-0.06	0.03
13	15:45:00 - 15:46:30	4.07	3.80	3.76	-0.07	-0.08
14	15:50:00 - 15:54:30	6.66	7.35	6.68	0.10	0.00
15	15:55:00 - 15:59:30	19.25	16.16	14.80	-0.16	-0.23
16	16:00:00 - 16:04:30	13.20	13.29	6.39	0.01	-0.52
17	16:05:00 - 16:09:30	7.46	7.18	4.73	-0.04	-0.37
18	16:10:00 - 16:14:30	6.08	4.66	3.99	-0.23	-0.34
19	16:15:00 - 16:19:30	9.72	9.20	4.98	-0.05	-0.49
20	16:20:00 - 16:24:30	9.89	11.46	8.77	0.16	-0.11
21	16:25:00 - 16:29:30	12.27	12.52	10.35	0.02	-0.16
22	16:30:00 - 16:34:30	14.79	13.85	18.96	-0.06	0.28
23	16:35:00 - 16:37:30	14.17	11.70	20.31	-0.17	0.43

No	Morning Observation Period	Space Mean Speed for 30 Secons Sampling Interval	Space Mean Speed for 1 Minute Sampling Interval	Space Mean Speed for 2 Minutes 30 Seconds Sampling Interval	Sampling Error of 1 Minute Sampling Interval (%)	Sampling Error of 2 Minutes and 30 Seconds Sampling Interval (%)
1	6:10:00 - 6:14:30	41.32	41.08	37.72	-0.01	-0.09
2	6:15:00 - 6:19:30	38.91	38.76	34.82	0.00	-0.03
3	6:20:00 - 6:24:30	33.87	33.56	33.85	-0.01	0.03
4	6:25:00 - 6:29:30	14.64	13.68	12.83	-0.07	-0.12
5	6:30:00 - 6:34:30	11.63	12.78	14.25	0.10	0.22
6	6:35:00 - 6:39:30	19.87	20.03	22.16	0.01	0.11
7	6:40:00 - 6:44:30	23.52	22.40	22.34	-0.05	-0.05
8	6:45:00 - 6:49:30	19.57	18.77	21.23	-0.04	0.09
9	6:50:00 - 6:54:30	18.42	18.97	18.75	0.03	0.02
10	6:55:00 - 6:59:30	17.80	17.21	14.39	-0.03	-0.19
11	7:00:00 - 7:02:00	16.14	16.61	14.34	0.03	-0.11
12	7:10:00 - 7:14:30	19.58	21.15	23.70	0.08	0.21
13	7:15:00 - 7:19:30	16.64	17.10	15.79	0.03	-0.05
14	7:20:00 - 7:24:30	16.57	16.31	15.87	-0.02	-0.04
15	7:25:00 - 7:29:30	12.84	13.34	15.29	0.04	0.19
16	7:30:00 - 7:34:30	17.08	17.44	17.50	0.02	0.02
17	7:35:00 - 7:39:30	18.22	19.47	16.93	0.07	-0.07
18	7:40:00 - 7:44:30	19.17	19.74	18.86	0.03	-0.02
19	7:45:00 - 7:49:30	18.69	17.59	16.83	-0.06	-0.10
20	7:50:00 - 7:54:30	20.56	19.71	25.39	-0.04	0.23
21	7:55:00 - 7:59:30	22.58	21.41	22.16	-0.05	-0.02
22	8:00:00 - 8:04:30	22.25	20.80	17.77	-0.07	-0.20
23	8:05:00 - 8:07:30	17.94	17.86	22.16	0.00	0.23

Table 5 Space Mean Speed & Sampling Errors for South-North Direction in the Mid Day

No	Mid Day Observation Period	Space Mean Speed for 30 Secons Sampling Interval	Space Mean Speed for 1 Minute Sampling Interval	Space Mean Speed for 2 Minutes 30 Seconds Sampling Interval	Sampling Error of 1 Minute Sampling Interval (%)	Sampling Error of 2 Minutes and 30 Seconds Sampling Interval (%)
1	10:45:00 - 10:49:30	30.36	30.74	30.95	0.01	0.02
2	10:50:00 - 10:54:30	30.30	30.74	30.95	0.01	0.02
3	10:55:00 - 10:59:30	30.96	35.98	34.82	0.16	0.12
4	11:00:00 - 11:04:30	32.09	31.28	30.47	-0.03	-0.05
5	11:05:00 - 11:09:30	32.11	33.56	32.64	0.05	0.02
6	11:10:00 - 11:14:30	30.15	32.21	28.77	0.07	-0.05
7	11:15:00 - 11:19:30	33.90	33.27	32.64	-0.02	-0.04
8	11:20:00 - 11:24:30	25.54	25.38	19.43	-0.01	-0.24
9	11:25:00 - 11:29:30	9.05	8.21	9.94	-0.09	0.10
10	11:30:00 - 11:34:30	11.66	11.85	10.65	0.02	-0.09
11	11:35:00 - 11:39:30	7.46	7.27	8.16	-0.03	0.09
12	11:45:00 - 11:49:30	13.23	15.02	11.12	0.14	-0.16
13	11:50:00 - 11:54:30	13.29	12.92	7.81	-0.03	-0.41
14	11:55:00 - 11:59:30	12.41	10.88	13.06	-0.12	0.05
15	12:00:00 - 12:04:30	31.43	32.21	30.47	0.02	-0.03
16	12:05:00 - 12:09:30	33.80	32.21	32.64	-0.05	-0.03
17	12:10:00 - 12:14:30	30.56	31.34	30.95	0.03	0.01
18	12:15:00 - 12:19:30	30.90	30.47	32.64	-0.01	0.06
19	12:20:00 - 12:24:30	33.37	33.37	35.54	0.00	0.07
20	12:25:00 - 12:29:30	30.56	29.79	28.77	-0.03	-0.06
21	12:30:00 - 12:34:30	32.27	31.86	32.64	-0.01	0.01
22	12:35:00 - 12:39:30	34.67	35.11	32.64	0.01	-0.06
23	12:40:00 - 12:42:30	27.66	27.31	30.95	-0.01	0.12

Table 6 Space Mean Speed & Sampling Errors for South-North Direction in the Afternoon

No	Afternoon Observation Period	Space Mean Speed for 30 Secons Sampling Interval	Space Mean Speed for 1 Minute Sampling Interval	Space Mean Speed for 2 Minutes 30 Seconds Sampling Interval	Sampling Error of 1 Minute Sampling Interval (%)	Sampling Error of 2 Minutes and 30 Seconds Sampling Interval (%)
1	14:40:00 - 14:44:30	15.80	16.38	18.28	0.04	0.16
2	14:45:00 - 14:49:30	22.07	22.59	28.49	0.02	0.29
3	14:50:00 - 14:54:30	24.04	23.52	22.16	-0.02	-0.08
4	14:55:00 - 14:59:30	17.88	19.43	15.23	0.09	-0.15
5	15:00:00 - 15:04:30	29.48	29.98	27.08	0.02	-0.08
6	15:05:00 - 15:09:30	33.43	35.40	33.85	0.06	0.01
7	15:10:00 - 15:14:30	28.10	23.21	20.45	-0.17	-0.27
8	15:15:00 - 15:19:30	13.08	13.70	10.78	0.05	-0.18
9	15:20:00 - 15:24:30	9.52	9.26	8.10	-0.03	-0.15
10	15:25:00 - 15:29:30	11.40	12.99	12.77	0.14	0.12
11	15:30:00 - 15:34:30	9.66	10.69	8.72	0.11	-0.10
12	15:40:00 - 15:44:30	7.81	7.25	5.38	-0.07	-0.31
13	15:45:00 - 15:46:30	9.45	9.65	9.96	0.02	0.05
14	15:50:00 - 15:54:30	9.04	9.01	6.35	0.00	-0.30
15	15:55:00 - 15:59:30	8.04	7.29	7.79	-0.09	-0.03
16	16:00:00 - 16:04:30	10.09	10.29	9.43	0.02	-0.07
17	16:05:00 - 16:09:30	8.61	9.13	8.12	0.06	-0.06
18	16:10:00 - 16:14:30	13.76	15.04	16.32	0.09	0.19
19	16:15:00 - 16:19:30	21.20	20.95	27.42	-0.01	0.29
20	16:20:00 - 16:24:30	22.51	20.82	21.16	-0.07	-0.06
21	16:25:00 - 16:29:30	24.29	22.61	17.06	-0.07	-0.30
22	16:30:00 - 16:34:30	27.75	24.85	27.42	-0.10	-0.01
23	16:35:00 - 16:37:30	31.75	29.92	34.82	-0.06	0.10

Table 7 Summary of Sampling Error

Observation Period	Mean Sampling Error of 1 Minute Sampling Interval	Range of Sampling Error of 1 Minute Sampling Interval	Mean Sampling Error of 2 Minutes and 30 Seconds Sampling Interval	Rane of Sampling Error of 2 Minutes and 30 Seconds Sampling Interval	Range of V/C
Gandaria – Simprug Direction					
Morning	-0.05%	-6.61% - 9.85%	27.11%	-20.12% - 23.5%	0.52 - 1.00
Mid Day	0.36%	-12.39% - 16.19%	-2.28%	-41.25% - 12.44%	0.40 - 0.85
Afternoon	0.00%	-17.43% - 14.03%	-4.02%	-31.06% - 29.35%	0.39 - 0.76
Simprug – Gandaria Direction					
Morning	-1.84%	-17.67% - 15.32%	2.14%	-22.97% - 30.98%	0.52 – 1.00
Mid Day	-1.47%	-8.72% - 8.84%	0.92%	-23.66% - 22.03%	0.40 - 0.85
Afternoon	-3.88%	-23.32% - 15.78%	-8.42%	-51.62% - 43.38%	0.39 - 0.76

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