Margorejo Underpass Route Choice Study: Reviewed from Traffic Analysis

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Abstract— The signalized intersection at Ahmad Yani street and Margorejo street becomes an intersection with quite long delays at peak hours. street Ahmad Yani is an arterial road that connects Surabaya to Sidoarjo. The presence of high frequency train tracks and a u-turn on the frontage road in front of Giant Maspion Square has resulted in reduced green time on the east side traffic light heading north. One effort to reduce this congestion is to build an underpass. Before an underpass is built, it is necessary to select an underpass route referring to the 1997 Indonesian Road Capacity Manual (MKJI). The results obtained in this final assignment are the determination of the Margorejo-Ahmad Yani route which is recommended for an underpass to be built because the large delay that occurs is 687 sec/smp on Jalan Ahmad Yani Sidoarjo-Surabaya; 1938 det/smp on Jalan Ahmad Yani Surabaya- Sidoarjo; 149 sec/smp on Jalan Margorejo; and 120 on the frontage road. The DS that occurred was 1.33 on Jalan Ahmad Yani Sidoarjo-Surabaya; 1.66 on Jalan Ahmad Yani Surabaya-Sidoarjo; 0.9 on Jalan Margorejo; and 0.22 on road frontage. The queue length was 648 secondary schools on Jalan Ahmad Yani Sidoarjo-Surabaya; 2422 junior high schools on Jalan Ahmad Yani Surabaya-Sidoarjo; 68 junior high school on Jalan Margorejo; and 18 junior high schools on the frontage road. With the construction of the Margorejo underpass, the DS on all sections will be 1,074 on Jalan Ahmad Yani Sidoarjo-Surabaya; 1,385 on Jalan Ahmad Yani Surabaya-Sidoarjo; 0.5 on Jalan Margorejo; and 0.07 on road frontage. Delays and long queues no longer exist because there are no longer traffic lights.

Keywords— Route Selection Study, Underpass, Margorejo, Surabaya, Traffic Analysis.

I. INTRODUCTION

A. BACKGROUND

Street Ahmad Yani is one of the access roads that connects the city of Surabaya with the city of Sidoarjo. This road is an arterial road. In fact, the road that connects Surabaya and Sidoarjo is not only Jalan Ahmad Yani, but there is also the Middle East Ring Road (MERR), the Outer East Ring Road (OERR) which is still in the planning process, and via the Raya Rungkut-Jalan Rungkut Menanggal road. It's just that there are still many people who pass through Jalan Ahmad Yani to go to Sidoarjo because it is closer to the middle of Surabaya city and the middle of Sidoarjo city, besides the road is also wider. The large number of vehicles passing through this road causes traffic jams at each sidepeak hour. The bottleneck on the north side that leads to the south lies in the entrance to frontage road and the intersection of Jalan Ahmad Yani with Jalan Margorejo. The traffic jam on the south to north side is located only at the intersection of Jalan Ahmad Yani and Jalan Margorejo.

Red time which is quite long and the implementation of only one LTOR results in a long period of time to reduce the density on the road. The only traffic jam on the east side is at the intersection of Jalan Margorejo and Jalan Ahmad Yani.Red time is quite long, and the presence of high frequency train crossings results in a long breakdown of traffic jams, especially whenpeak hour.

This problem needs to be overcome by building an underpass as an alternative to reduce congestion. In evaluating the construction of an underpass to overcome congestion at the Margorejo-Ahmad Yani intersection, traffic analysis is needed. This traffic analysis is needed to determine the route that will be chosen as the location for the underpass construction. The stages of route selection analysis using traffic analysis are presented in Figure 1.

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II. METHODOLOGY

The research flow diagram is displayed in Figure 2.

III. DISCUSSION

A. TRAFFIC ANALYSIS AT AHMAD YANI INTERSECTION-EXISTING MARGOREJO

Determining the condition of the existing intersection is carried out through several levels, that is calculation degrees saturation, stop rate, delay, and interweaving.

1. Degrees Saturation (Degree of Saturation)
   To calculate the degree of saturation, traffic volume data obtained from the results is needed traffic counting moment peak hour.
   a) Passenger Car Equivalence Calculation
      For passenger car equivalent calculations, use a multiplier of 1 for LV emp; 1.2 for HV emp; 0.2 for emp MC. Complete calculation results can be seen in Table 1.
   b) Calculation of Signalized Intersection Capacity (C) In this analysis, the following data is known.
      Path width = 10.5 meters.
      S0 = 10,5 × 600 = 10,5 × 600 = 6300
      Correction factor:
      F1 = FCS = 1
      F2 = FSF = 0,8 F3 = FG = 1
      F4 = FP = none
      F5 = FRT = 1 + pLT × 0,26 = 1 + 0,47 × 0,26 = 1,1215
      F6 = FLT = 1 + pRT × 0,26 = 1 − 0,08801 × 0,16 = 0,9859
      S = 6300 × 1 × 0,83 × 1 × 1,1215 × 0,9859 = 5799

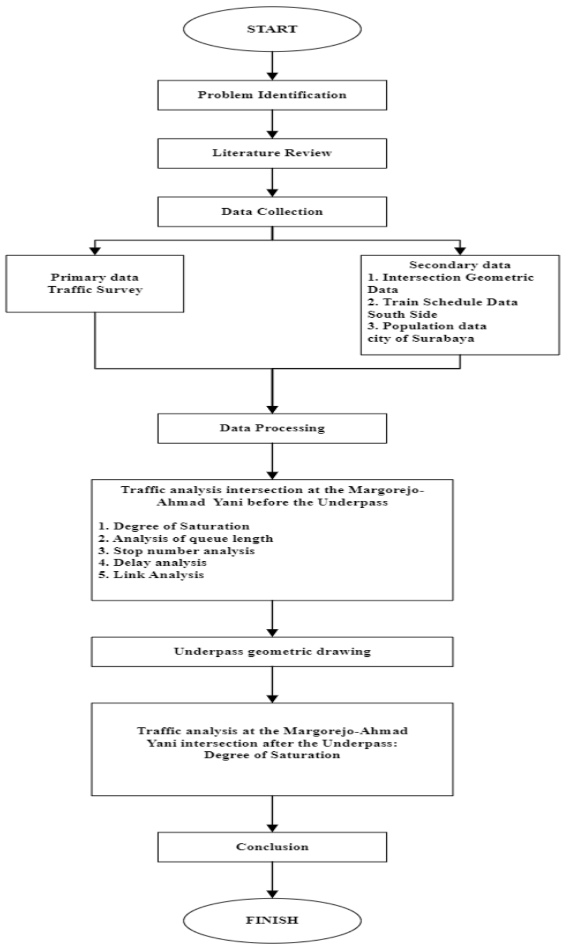

Fig 1. Methodology Election Route Underpasses

g = 45 seconds and c = 227 seconds

$$C = S\ x\ \frac{g}{c} = 5799\ x\ \frac{45}{227} = 1146$$

c) Calculation of Degree of Saturation

After getting the capacity in the calculation above, then calculate the degree of saturation using formula (6):

$$DS = \frac{Q}{C} = \frac{1034}{1146.1} = 0.9022$$

2. Calculation of Queue Length

After getting the degree of saturation, the next step is to calculate the queue length.

$$NQ1 = 0{,}25\ x\ C\ X\left[(DS-1) + \sqrt{(DS-1) + \frac{8x(DS-0{,}5)}{C}}\right]$$

$$= 0{,}25\ x\ 1146{,}1\ X\left[(0{,}9022-1) + \sqrt{(0{,}9022-1) + \frac{8\ x(0{,}9022-0{,}5)}{1146{,}1}}\right]$$

= 3,85

$$NQ2 = c\ x\ \frac{1\ -\ GR}{1\ -\ GR\ x\ DS}\ x\ \frac{Q}{3600}$$

$$= 227\ x\ \frac{1\ -\ 0{,}1982}{1\ -\ 0{,}1982\ x\ 0{,}9022}\ x\ \frac{1034}{3600} = 63{,}66$$

TABLE 1.

Passenger Car Equivalence Calculation for Ahmad Yani-Margorejo intersection

Approach	LV		HV		MC		total MV	
	vehicle	emp	vehicle	emp	vehicle	emp	vehicle	emp
S	3132	3132	30	39	5529	1107	8691	2852
N	3046	3046	54	72	10259	2053	17508	5171
AND	575	575	0	0	2288	459	2863	1034
EC	316	316	0	0	174	61	614	342

TABLE 2.

Intersection Analysis Calculation Table Before Adding Train Passing Time (1)

Approach	Approach width (We)	So	city size (Fcs)	Side obstacles (Fsf)	In the morning (Fg)	Turn right (Frt)	Turn left (Flt)	S
S	7	4200	1	0,95	1	0	0	3990
IN	10,5	6300	1	0,95	1	0	0,97	5799
T	10,5	6300	1	0,83	1	1,12	0,99	5781,49
TL	6	4800	1	0,9275	1	1,13	0,98	4965,03

TABLE 3.

Intersection Analysis Calculation Table Before Adding Train Passing Time (2)

Approach	g	c	C	DS	GR	NQ1	NQ2	NQ1+ NQ2	NQ max
S	122	227	2144,41	1,33	0,54	357	292	648	858,1318
U	122	227	3116,64	1,66	0,54	1029	1393	2422	3199,376
T	45	227	1146,11	0,90	0,20	4	64	68	91,94952
TL	51	227	1115,49	0,31	0,22	0	18	18	26,54311

TABLE 4.

Table Calculation Analysis Intersection Before Added Train Passing Time (3)

Approach	QL	NS	Nsv	psv	DT	PT	DG	D
S	2451,81	3,24	9248,25	1	683,29	0	4	687,2873
U	6094,05	6,68	34564,06	1	1933,84	0,31	4	1937,842
T	175,14	0,93	963,54	0,93	144,87	1	4,14	149,0097
TL	66,36	0,75	256,30	0,75	115,74	1	4,50	120,2447

NQ = NQ1 + NQ2 = 4 + 64 = 68 smp

The graph in MKJI shows the average NQ value is 50 pcu, whereas in this analysis, the average NQ is 68 pcu. Therefore, manual calculations using Excel are needed, taking pOL = 1%, then the NQ max value obtained for this study is:

NQmax = 1,4255 x 68 + 4,3 = 101 smp

$$QL = \frac{NQmax\ x\ 20}{Wetnters} = \frac{91{,}95\ x\ 20}{10{,}5} = 175{,}14$$

3. Stop Number Calculation

After calculating the queue length, the next step is to calculate the stopping number.

$$NS = 0{,}9\ x\ \frac{NQ}{Q\ x\ c}\ x\ 3600$$

$$NS = 0{,}9\ x\ \frac{67{,}507}{1034\ x\ 227}\ x\ 3600 = 0{,}93 = 1\ Stop/hour$$

Nsv = 1034 x 1,9319 = 963,54 pcu/hour

4. Delay Calculation

After calculating the stopped vehicle, the next step is to

TABLE 5.

Passenger Car Equivalence Calculation for Ahmad Yani-Margorejo intersection

approach	Wide approach (We)	So	size city (Fcs)	Obstacle side (Fsf)	Kelan daian (Fg)	Turn right (Frt)	Turn left (Flt)	S
S	7	4200	1	0.95	1	0	0	3990
U	10.5	6300	1	0.95	1	0	0.97	5799
Q	10.5	6300	1	0.95	1	1.12	0.99	6617.37
TL	6.5	3900	1	0.93	1	1.13	0.98	4034.09

TABLE 6.

Intersection Analysis Calculation Table Before Adding Train Passing Time (1)

approach	g	c	C	DS	GR	NQ1	NQ2	NQ1+NQ2	NQ max
S	232	337	2746.83	1.04	0.69	65	292	356	512
U	232	337	3992.2	1.30	0.69	593	1393	1985	2384
Q	45	337	787.93	1.31	0.13	79	100	178	259
TL	51	227	906.34	0.38	0.22	1	30	30	47

TABLE 7.

Intersection Analysis Calculation Table Before Adding Train Passing Time (2)

approach	QL	NS	Nsv	psv	DT	PT	DG	D
S	1349,88	1,20	3420,47	1	141,39	0	4	145,39
U	4995,69	3,69	19082,06	1	1352,45	0,31	4	1356,45
T	453,81	1,66	1714,6	1	517,75	0,09	4	521,75
TL	140,69	0,84	286,73	0,76	180,7	1	4,48	185,02

TABLE 8.

Table Calculation Analysis Intersection Before Added Train Passing Time (3)

Margorejo segment							
Time				Margorejo-royal	Margorejo-ayani	Margorejo-frontage	Total
16	0	17	0	1155	107	88	1350
	15		15	1176	99	90	1365
	30		30	1265	110	91	1466
	45		45	1333	122	92	1547
						TOTAL	5728

calculate the delay.

$$DT = c\ x\ \frac{0{,}5x(1-GR)^2}{(1-GRxDS)} + \frac{NQ1\ x\ 3600}{C}$$

$$DT = 202\ x\ \frac{0{,}5x(1-0{,}1982)^2}{(1-0{,}1982x0{,}9022)} + \frac{3{,}8474\ x\ 3600}{1146{,}1}$$

$$DT = 144{,}87\ sec/pcu$$

$$Psv = min(NS,1) = 1 karena NS < 1, maka diambil$$

$$NS = 0{,}9319$$

$$DG = (1-Psv)xPtx6 + (Psvx4)$$

$$DG = (1-1)x0{,}9319x6 + (1x4) = 3 sec/pcu$$

$$D = DT + DG = 114{,}0937 + 4 = 118{,}0937\ sec/pcu$$

5. Braided

After count analysis intersection, then the next step is to calculate the braid. To calculate PHF (Peak Hour Factor), enter the data in Table 5.9 into formula (16).

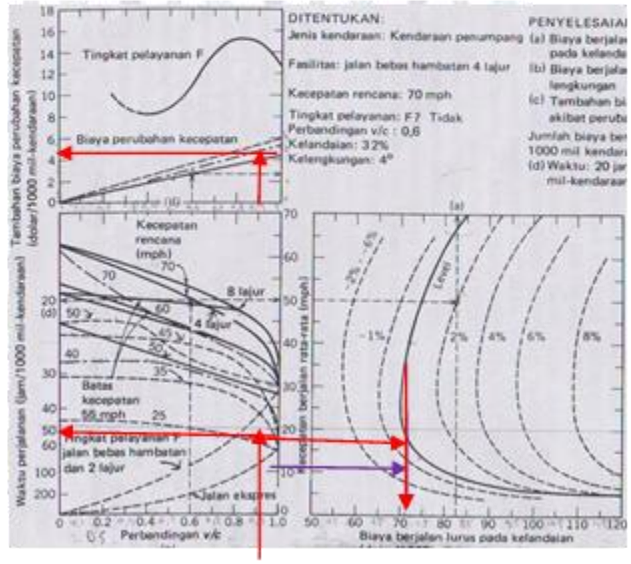

Fig 2. Method Processing

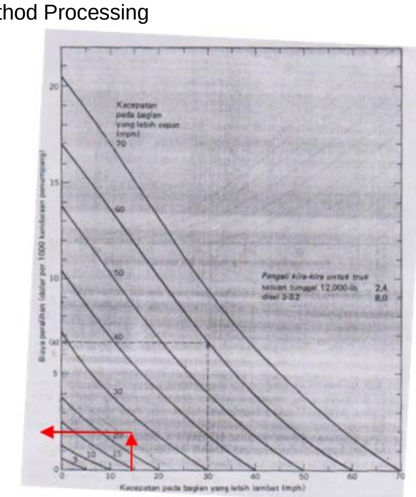

Fig 3. Method Processing

$$PHF = \frac{5728}{4\ x\ 1547} = 0{,}9257$$

Is known:

Er = 1.5 (for flat roads) in table 2.8

Fp= 1 (assuming the driver is familiar with the road)

$$fHV - r = \frac{1}{1+1(1-1)} = 1$$

$$Vr = \frac{371}{0{,}9257\ x\ 1\ x\ 1} = 400{,}794\ pcu/hour$$

$$fHV - f = \frac{1}{1+1(1-1)} = 1$$

$$Vf = \frac{1135}{0{,}9257\ x\ 1\ x\ 1} = 1226{,}1587\ pcu/hour$$

$P_{FM} = 0{,}5775 + 0{,}000028 \times L$

$= 0{,}5775 + 0{,}000028 \times 171{,}2598$

$= 0{,}5823$

$v_{12} = v_f \times P_{FM} = 1226{,}1587 \times 0{,}5823 = 713{,}98$ pc/h

$v_{FO} = v_f + v_r = 1226{,}1587 + 400{,}794 = 1626{,}9427$ pc/h

TABLE 9.

Results of Passenger Car Equivalence Calculations for Interwebs

		MC	LV	MC	LV	total
1a	margorejo-ayani	55	80	11	80	91
1b	margorejo-frontage	169	44	34	44	78
2	margorejo royal/2	1166	249	234	249	483
3a	margorejo-royal/2	1166	249	234	249	483
3b	frontage-royal	202	290	81	290	371
			total	594	912	1506

TABLE 10.

Passenger Car Equivalence Calculation for the Ahmad Yani-Margorejo Section

Approach	LV			H.V			MC			Q
	total	per column	emp	total	per column	emp	total	per column	emp	
S	3130	1044	1044	30	10	12	5529	1843	461	1517
N	3150	1050	1050	52	17	21	10611	3537	885	1956
AND	788	394	394	0	0	0	2534	1267	317	711
EC	124	42	42	0	0	0	706	236	59	101

TABLE 11.

Free Flow Speed Calculation Results

Approach	FvO	FVIn	FFVSF 6	FFVCS	FV
S	61	0	0,896	1	54,66
N	61	0	0,896	1	54,66
AND	61	0	0,896	1	54,66
EC	61	0	0,896	1	54,66

TABLE 12.

Results of Calculation of Degree of Saturation

Approach	FCIn	FCSP	FCSF 6	FCCS	C	DS
S	1	1	0,856	1	1412,4	1,074
N	1	1	0,856	1	1412,4	1,385
AND	1	1	0,856	1	1412,4	0,503
EC	1	1	0,856	1	1412,4	0,072

The maximum capacity of a 3-lane freeway at a speed of 40 km/h (or about 24.8 miles/h) is 5345.6425 pc/h. Because 1626.9427 pc/h < 5345.6425 pc/h, the freeway is still considered feasible.

Genre total Which enters in areas merge calculated:

$v_{r12} = v_r + v_{12}$ = 400,794+ 713.98 = 1114.7746 pc/h

The maximum capacity of a single-lane ramp at a speed of 20 km/h (or about 12.47 miles/h) is 1800 pc/h. Because 1114.7746 pc/h < 1800 pc/h so ramps still said to be feasible.

D_R = 5,475 + 0.00743 × v_R + +0.0078 × v12 − 0.00627 × L a

= 5,475 + 0.00743 × 400,794 + 0.0078 × 715.64767 - 0.0067 × 171.2598 = 2.4136 pc/m/ln

Because D_R = 2.4136 = 0-10 then it includes level of service A in the merging area.

$$M_S = 0.321 + 0.0039\ x\ e^{(vr12/1000)} - 0.002x\left(\frac{La\ x\ RFFS}{1000}\right)$$

$$= 0.321 + 0.0039\ x\ e^{1.1115} - 0.002x\left(\frac{171.2598\ x\ 20}{1000}\right)$$

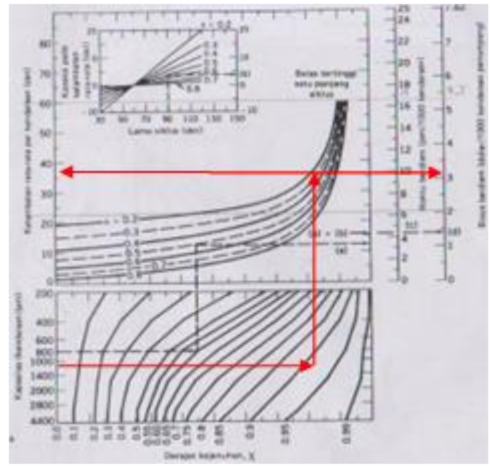

Fig 4. Method Processing with figure 2.

= 0,33

Sr = FFS − (FFS − 42) × M s

= 40 − (40 − 42) × 0.3361

= 40.66 km/h

$$V_{0a} = \frac{(V_f - V_{12})}{N_0} = \frac{(1226{,}15 - 1114{,}7746)}{1}$$

$$= 111{,}374\ pc/h$$

Because V oa = 111,374 < 500 so in Table 2.8 use formula (27) And (30).

$$S_0 = FFS = 40\ km/h$$

$$S = \frac{1114{,}7746 + 111{,}374\ x\ 1}{\left(\frac{1114{,}7746}{40{,}66}\right) + \left(\frac{111{,}374}{40}\right)} = 40{,}6\ km/h$$

B. Analysis Cost Operational Vehicle

After the DS (Degree of Saturation) data, queue length, vehicle stops and total delays are obtained, analysis is then carried out to determine operational costs. vehicle on intersection on condition existing based on the Highway Engineering book.

For the calculation example below, a road section is taken Margorejo, like on example on. After field survey and get an approaching speed of 35 km/h, which can be seen in Figure 3.1.

With DS = 0.9022 And speed plan Margorejo road is 40 km/h, from the graph above we get:

1. Cost walks straight = 71 dollars/1000 vehicle miles = 509,291 rupiah/km vehicle
2. Time journey = 35.5 hours/1000 miles vehicle = 79.4 sec/km vehicle
3. Speed walk average = 27.5 miles/h = 44.26 km/h
4. Additional speed change fee = 4.8 dollars/1000 miles = 34.43092 rupiah/km miles

With speed approach intersection ±25 km/h = 15.5 miles/h and speed stay away intersection ±40 km/h = 24.9 mile/h, from chart found:

1. Cost transition speed = 1.5 dollars/1000 passenger vehicles = 17.32 rupiah/1000 vehicles

From the graph we get:

1. Average stop per vehicle = 0.95 per signal

2. Additional stopping delay = 3.2 hours/1000 vehicles/signal = 11.52 seconds/vehicle/signal.
3. Additional stopping fee = 13 dollars running fee/1000 vehicles/signal = 150.07 rupiah walking fee/vehicle/signal

With DS = 0.9022 And C =1146.1, so from graph obtained:

1. Slowness average per vehicle = 46 second
2. Idle time = 12.85 hours/1000 vehicles = 46.26 seconds/vehicle
3. Dwelling fee = 3.2 dollars/1000 passenger vehicles = 36,941 rupiah/passenger vehicle

So that total time and total cost for a passenger vehicle at the intersection on Jalan Margorejo:

Total time = time journey + addition slowness stops + slowness average per vehicle + dwell time + average delay

Total time = 79.4 + 11.52 + 9.72 + 46 + 46.26 = 332.2 second

Total cost = cost of going straight + additional cost of changing speed + cost of changing speed + additional cost of stopping + additional cost of stopping

Total cost = 509,291 + 34.43092 + 17,316 + 150.07 + 36,941
= 748 rupiah

All calculations above are based on DS. Meanwhile, if the calculation above was based on approaching speed, the results would be different. The differences are as follows:

1. Travel time = 40 hours/1000 vehicle miles = 89.48 seconds/vehicle km
2. Additional stopping delay = 2.7 hours/1000 vehicle miles = 9.72 seconds/vehicle km
3. Additional stopping fee = 9.1 dollars running fee/1000 vehicles/signal = 105.05 rupiah walking fee/vehicle/signal

So that total cost based on approach speed = 703.3 rupiah and total time = 257.2 seconds.

All calculations on multiplied coefficient the truck multiplier is 1.00 because the percentage of single unit trucks is 0% and the percentage of 3-S2 combination diesel trucks is 0%. It can be seen in tables 2.13 and 2.14 that the adjustment factor for the percent of trucks due to staying in the traffic flow (time) is 1 and the adjustment factor for the percent of trucks due to staying in the traffic flow (cost) is 1.

For table results calculation in full can be seen in the attachment.

C. Analysis Cost Operational Vehicle

After determining the underpass route, then next a traffic analysis was carried out for the Ahmad Yani-Margorejo section to determine the degree of saturation. In this calculation, the example of the Margorejo section is taken.

1. Passenger Car Equivalence Calculation

For passenger car equivalence calculations, use a multiplier coefficient of 1 for emp LV; 1.2 for HV emp; 0.25 for emp MC. Complete calculations can be seen in Table 3.10.

2. Free Flow Speed Analysis

After calculating the equivalence, the next step is to calculate the free flow velocity analysis using formula (31) is known:

FV_0 = 61 (because of the six-lane-divided road type with vehicle LV)

FVw = 0 (because the road type is four-lane-divided, and the lane width is 3.5 meters).

FFV_{SF} = 0.896 (because of the four-lane-divided road type, high side resistance class, with a shoulder width of 0.5 and after being multiplied by the free flow speed adjustment factor for six-lane roads).

FFV_{CS} = 1 (because the population of the city of Surabaya is 2,815,603 people).

Then enter it into the free flow velocity formula, as below:

FV = (61 + 0) × 0.896 × 1 = 54,656 km/h

For free flow speed calculation results, you can see table 3.11.

3. Capacity Calculation

After calculating the free flow speed, the next step is to calculate the road capacity using formula (33) is known:

Co = 1650
FCIN= 1
FCSP = 1
FCSF = 0,82
FCCS = 1

Then enter it into the capacity formula, as below:

C = 1650 × 1 × 1 × 0.82 × 1 = 1412.4

4. Degrees Saturation

After count capacity, so Next, calculate the degree of saturation.

$$DS = \frac{711}{1412,4} = 0,5034$$

For results calculation can be seen on table 3.12.

D. Picture Geometric Underpasses

After analyzing Then cross after There is underpass, then next draw the geometric *underpass.*

Is known:
Point A = 471443,4737; - 793162,717
Point B = 471401.5977; - 792007,178
Point C = 472704.3962; - 792015,714

$$\alpha = arctan\left(\frac{471401.5977 - 471443,4737}{-792007,178 - (-793162,717)}\right) = 357,92$$

$$\beta = arctan\left(\frac{472704.3962 - 471401.5977}{-792015,714 - (-792007,178)}\right) = 90,38$$

$$\Delta = arctan\,(357,92 - 90,38) = 92,45$$

Planned:

1. V = 40 km/h
2. e max = 10%
3. R = 477 meters.

f max = −0.00065 × 40 + 0.192 = 0.166

$$Rmin = \frac{40^2}{(127\,x\,(10\% + 0,166))} = 47,36\,meters$$

$$Dmax = \frac{1432,4}{47,36} = 30,24$$

$$D = \frac{1432,4}{477} = 3$$

$$e = \left(-\left(\frac{10\%}{30,24}\right)\right) x\,D^2 + \left(\frac{2\text{ x }10\%}{30,24}\right) x\,3 = 1,89\%$$

Because e = 1.89% And not enough from 3%, so corners including full circles. Next, the calculation is carried out:

$$Tc = 477\ x\ tg\left(\frac{1}{2}x92,45\right) = 497,85\ meters$$

$$E = \frac{477}{cos\ \left(\frac{1}{2}x92,45\right)} - 477 = 212,48\ meters$$

$$Tc = \left(\frac{92,45\ x\ \pi}{180}\right)x\ 477 = 769,67\ meters$$

By using a guard depth of 3 meters, tall room underpass 5 meters, and slope 5%, then the horizontal slope distance is 299 meters.

IV. CONCLUSION AND RECOMMENDATIONS

1. Conclusion

This final project is an evaluation of the performance of the Ahmad Yani-Margorejo intersection if an underpass is built. The Ahmad Yani-Margorejo intersection is a signalized 3 intersection with 4 phases, which are long *cycle time* is 227 seconds. From the results of the analysis, the following conclusions were obtained.

1) The current performance of the Ahmad Yani-Margorejo intersection shows:
   a. The largest traffic flow is the North (N) approach, namely 5335 pcu/hour and the smallest are the Northeast (TL) approach, namely 673 pcu/hour.
   b. The degree of saturation for each approach is 1.33; 1.66; 0.9; and 0.4 for the South, North, East, and Northeast approaches.
   c. The delay that occurred was 687; 1938; 149; and 123 seconds for the South, North, East, and Northeast approaches.
   d. Total time on each approach is 926.0172; 2173,871; 332,2009; and 240.3873.
   seconds for the South, North, East, and Northeast approaches.
   e. The total cost for each approach is 758.91; 728.89; 748.05; and 788.45 rupiah for the South, North, East and Northeast approaches.

The values for the degree of saturation and delay are the values without including additional red time for the East (Margorejo) and Northeast (Frontage Road) approaches when trains pass. Meanwhile, the value of the degree of saturation and delay with the addition of the train variable is.
   a. The degree of saturation at each approach is 1.038; 1,295; 1.17; and 0.56 for the South, North, East, and Northeast approaches.
   b. The delay on each approach is 145.39; 1356.45; 521.75; and 185.02 seconds for the South, North, East and Northeast approaches.
   c. Total time on each approach is 384.115; 1592,476; 757.7788; and 239.4831 seconds for the South, North, East, and Northeast approaches.
   d. The total cost for each approach is 758.91; 728.89; 728.89; and 788.45 rupiah for the South, North, East and Northeast approaches.

2) From the results of the performance analysis in conclusion number 1, the route choice is determined underpass is route 3, namely Margorejo-Ahmad Yani, because route 3 can eliminate everything traffic light and nothing crash by railroad. Meanwhile, the distance between the mouth underpass with flyover Wonokromo on route 3 is the longest, namely 765 meters.
3) By selecting route 3 for underpass, it is obtained that the intersection performance becomes the section performance because there is no conflict between vehicles. The existing intersection performance is:
   a. The degree of saturation at each approach is 1.075; 1,385; 0.336; and 0.072 for the South, North, East, and Northeast approaches.
   b. The braid capacity is still said to be feasible because of the capacity freeway (INFO) 1626.9427 pc/h smaller maximum capacity is 5345.6425 pc/h and capacity ramp (INR12) 1114.7746 pc/h is smaller than the maximum capacity of 1800 pc/h. Level of service (LOS) A due to average density (DR) 2.4136, entered in the 0-10 scale for LOS A.

2. Suggestion

The analysis in this final project provides an overview of the performance improvement at the Ahmad Yani-Margorejo intersection. In this analysis there are still important things that need to be analyzed more deeply regarding design underpass. The analysis required is determining depth underpass related to the high frequency of train crossings. This depth is necessary to avoid the influence of vibrations on the building structure underpass. The depth obtained will influence the geometric design underpass.

REFERENCES

[1] Directorate of City Road Development. 1997.Indonesian Road Capacity Manual (MKJI). Director General of Highways, Republic of Indonesia.

[2] Kartika, A.A.G. 2006Road Economics Textbook.Surabaya: Civil Engineering Department, ITS Faculty of Civil Engineering and Planning.

[3] Oglesby, C.H. 1990. Road Engineering.Jakarta: Erlangga.

[4] Putra, Adiyarta Harvian Eka. 2013.Traffic Study at Non-Level Intersections at the Surabaya Satellite Roundabout. Surabaya: Civil Engineering Department, ITS Faculty of Civil Engineering and Planning.

[5] Roess, Roger P. 2004. Traffic Engineering. United States of America: Pearson Education Inc.

[6] Sukirman, Silvia. 1999.Basics of Geometric Highway Planning.Bandung: Nova.

[7] Tamin, OZ. 2000.Transportation Planning and Modeling, Second Edition.Bandung: Bandung Institute of Technology.