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Validity of Reversible Flow Lanes between Kandy Road Flyover and New Kelani Bridge Roundabout along A01 to Accommodate Peak Traffic Flows

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Abstract: This paper examines ways of enhancing road capacity by improving lane efficiency along Colombo-Kandy Road (A01) at Colombo city entrance by introducing reversible traffic flow lanes between Kandy road flyover at Pattiya junction and New Kelani Bridge roundabout, to cater for peak traffic flows. A traffic study was conducted between Pattiya junction and New Kelani Bridge roundabout to find out the benefits and any losses, if reversible traffic flow lanes are introduced along this stretch of road during peak traffic flows in mornings and evenings. Two options of lane assignment were considered for the heavy flow direction during peak hours. Option (i) by adding one extra mixed traffic lane towards the heavy flow direction while reducing a lane from the opposite direction, and option (ii) adding an additional lane exclusively for buses towards the heavy flow direction while reducing a lane in the opposite direction. These two options were considered for both morning and evening peak traffic flows. By using Davidson's model the benefits or any losses in travel time was computed for the two options separately for both directional peak traffic flows.

The study proved that by the introduction of reversible flow lanes along the considered section, during morning and evening peak traffic flows, the benefits obtained by far outweigh the losses due to minor reduction in road capacity in the opposite directional traffic flows. It was also found that introduction of designated lanes for 'buses only' further improves the overall efficiency of the system with higher benefits. If 'buses only' lanes are introduced it is of the utmost importance to implement these lanes only for buses, as expected.

Keywords: Reversible Flow Lanes, Contra Flow, Tidal Flow, Bus Lanes

1. Introduction

Colombo – Kandy road (A01), is one of the main arterial roads of Sri Lanka radiating from Colombo, which carries traffic travelling towards the central hills as well as northern and north central areas of the country. Hence, this is one of the busiest roads in Sri Lanka which links Colombo with other major areas of the island. The inbound traffic towards Colombo is very heavy during the morning peak hours near the city entry, and severe congestion of traffic is experienced during the week days (Figure 1). Similar conditions are observed during evening peak hours on weekdays in the outbound direction. This traffic congestion costs the state dearly by means of increased travel time, fuel wastage, vehicle wear and tear, loss of safety, pollution of air and noise etc.

Figure 1 – Inbound Traffic towards Colombo

A newly built flyover above the main railway line at Pattiya junction is of four lanes with two lanes in either direction (Figure 2). The distance from the flyover to the New Kelani Bridge roundabout is 2 km. This stretch of 2 km road consists of six lanes in an undivided

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carriageway with 3 lanes in either direction. With the introduction of the new flyover at Pattiya junction the interruption to A01 traffic arising from frequent rail gate closures of the main railway line has been eliminated, but the congestion between Pattiya junction and the New Kelani Bridge roundabout has not reduced.

Figure 2 – Pattiya Junction Flyover along A01

It is observed that during peak flows, the traffic towards the heavy direction is extremely heavy, but in the opposite direction the road space is not utilised effectively (see Figure 1). Hence, this study intends to investigate the benefits that could be reaped by introducing *reversible* or c*ontra flow* traffic flow lanes.

2. Reversible Traffic Flow Lanes or Contra Flow Lanes

In busy arterial roads, when the movement of traffic is very heavy in one direction during a certain period of the day, and also becomes very heavy in the opposite direction during another time of the day, this phenomenon is commonly termed as 'tidal flow'. As a solution to address the tidal flows reversible lanes can be introduced. A reversible lane is one, where the direction of traffic movement is changed according to the intensity of traffic flow in a particular direction (Kadiyali [1]; Salter & Hounsell [2]).

3. Traffic Data Collection

A manual classified traffic count was performed for 16 hours at a location at 1 km south of Pattiya junction flyover (i.e. towards Colombo) on a normal working day from 6:00AM to 10:00PM. Two-directional traffic was recorded separately at 15 minute intervals at the counting location for 7 different categories of vehicles.

The seven broad categories of vehicles were; three-wheelers, cars & SUVs, all vans, all types of buses, goods carrying vehicles, all vehicles with 3 axles, and vehicle with 4 axles or more as indicated in Tables 1 & 2. The Passenger Car Unit (PCU) factors based on RDA records, for these separate categories of vehicles on flat terrain roads with multiple lanes are indicated in Table 3.

Table 1 – Hourly Traffic Volume (To Colombo) at Peliyagoda on A01

Time	TWL	CAR	VAN	BUS	GV	3A	≥4	**Total**
6 - 7	284	946	423	414	129	17	6	2218
7 - 8	644	1481	399	352	167	2	8	3052
8 - 9	503	1076	195	217	220	7	7	2224
9 - 10	411	863	162	184	245	2	21	1890
10- 11	333	694	146	155	219	14	10	1572
11- 12	502	468	189	197	195	11	28	1589
12- 13	421	541	230	233	169	13	31	1639
13- 14	428	407	233	210	176	22	20	1495
14- 15	321	562	175	197	160	10	17	1441
15- 16	354	571	170	225	163	12	20	1515
16- 17	294	504	226	209	188	18	14	1453
17- 18	224	485	266	256	97	14	21	1363
18- 19	305	484	204	309	118	13	26	1459
19- 20	303	478	161	225	101	17	17	1301
20- 21	165	311	166	186	91	24	15	958
21- 22	135	265	149	148	66	15	9	788
6 - 22	**5627**	**10136**	**3493**	**3717**	**2504**	**211**	**267**	**25955**

Table 2 – Hourly Traffic Volume (To Kandy) at Peliyagoda on A01

Time	TWL	CAR	VAN	BUS	GV	3AV	≥4A	**Total**
6 - 7	118	196	112	189	90	2	3	710
7 - 8	304	328	152	216	100	21	25	1146
8 - 9	251	309	114	226	171	3	10	1084
9 - 10	250	287	119	188	234	17	20	1114
10- 11	330	400	173	184	295	14	18	1414
11- 12	337	402	175	237	307	11	15	1484
12- 13	327	352	169	267	272	11	21	1419
13- 14	367	423	264	270	286	7	24	1641
14- 15	234	439	349	284	245	13	19	1584
15- 16	380	450	216	230	310	12	22	1620
16- 17	245	517	240	282	343	20	20	1668
17- 18	250	928	311	290	254	12	23	2068
18- 19	403	1024	323	300	211	21	14	2296
19- 20	433	1252	377	340	210	22	19	2653
20- 21	334	649	242	260	209	19	29	1741
21- 22	279	515	210	220	156	12	26	1419
6- 22	4841	8471	3548	3983	3694	217	308	**25061**

Table 3 – Equivalent Passenger Car Units (PCU) for Flat Terrain Multiple Lane Roads

TWL	CAR	VAN	BUS	GV	3A	≥4A
0.8	1.0	1.5	2.0	1.7	2.8	3.5

A separate short duration vehicle occupancy count was conducted during peak hours to observe the average number of passengers carried by different categories of vehicles.

Peak hour average passenger count indicated that, the average occupancy of a bus is around 40 passengers and all other vehicles considered as a mix is around 3.25 passengers per vehicle. These values were used for computing vehicle occupancy in the study.

Figure 3 shows two-directional hourly traffic flows separately, and also the total hourly traffic flow along the considered road section over the counting period from 6:00AM to 10:00PM.

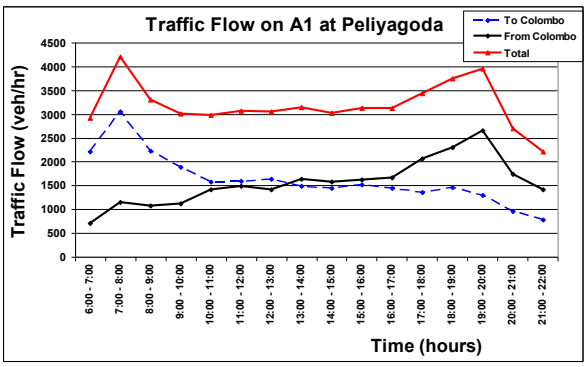

Figure 3 – Hourly Traffic Flows on A01 at Peliyagoda

4. Methodology & Analysis

From the traffic survey results it was identified that the morning peak is from 7:00AM to 8:00AM and the total vehicle volume towards Colombo is around 3050 vph. During the morning peak the total vehicle volume travelling out of Colombo was around 1150 vph (see Figure 3). The total two directional flow was around 4200 vph.

Similarly, the out-bound traffic reaches its peak in the evening between 7:00PM to 8:00PM and the volume is around 2650 vph. During the evening peak the total vehicle volume towards Colombo is around 1300 vph (see Figure 3). The total two directional flow was around 3950 vph, which was less than the morning peak flow. This can clearly be seen in Figure 3.

There are several models available to compute the travel time [3].

(i) The Bureau of Public Roads (BRP) model used in the UK, (ii) Greenshields model, and (iii) Davidson's model are few models that could be used in computing the travel time benefits or losses.

It was decided to use Davidson's model [4], to compute the travel time benefits or losses since it suited better with local parameters and for better relative accuracy. Davidson's model considers parameters such as type of road, road width, frequency of signals, pedestrian crossings, and parked vehicles etc.

Davidson [4] successfully used the following model to compute travel time differences for varying lane options for urban arterial roads as well as freeways.

$$t = t_0 \times \left[\frac{1-(1-j)y}{(1-y)}\right]$$

Where,

t - travel time at traffic flow q

t_0 - time taken to travel with no other traffic (i.e., zero flow travel time)

q – traffic flow (veh/hr/lane)

s - saturation flow (veh/hr/lane)

$y = q/s$

j - level of service parameter

j is the Level of Service (LOS) parameter which is related to the type of road, road width, frequency of signals, pedestrian crossings, and parked vehicles. Blunden and Black [5] suggest following values for j.

j = 0 to 0.2 for freeways
j = 0.4 to 0.6 for urban arterials
j = 1 to 1.5 for collector roads

Hence it is reasonable to assume j = 0.5 for Colombo – Kandy road.

Zero flow travel time (t_0) was taken as 2 minutes assuming a desired speed of 60 km/h over the study distance of 2 km with no other traffic.

This study intends to consider several options of lane operations between Pattiya junction and New Kelani Bridge roundabout. This road stretch of 2 km in length (Figure 4) consists of 3 lanes in each direction.

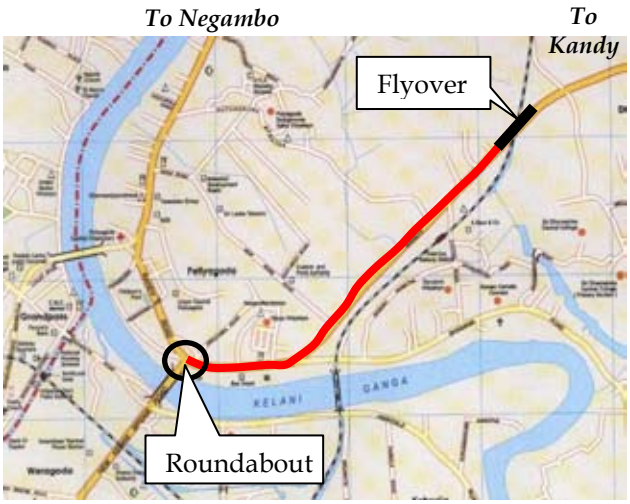

Figure 4 – Site Layout

Morning Peak Flows:

Option (1) – During the morning peak, to have 4 lanes (with mixed traffic) operating towards Colombo bound direction, and 2 lanes (with mixed traffic) operating for out of Colombo traffic as shown in Figure 5.

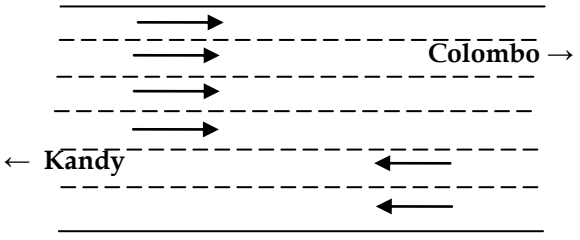

Figure 5 – Lane Operation Option (1)

Option (2) - During the morning peak, to have 3 lanes (with mixed traffic) and another lane exclusively for buses operating towards Colombo inbound direction, and 2 lanes (with mixed traffic) operating for out of Colombo traffic as shown in Figure 6.

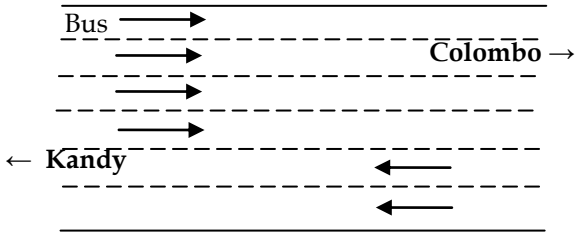

Figure 6 – Lane Operation Option (2)

Evening Peak Flows:

Option (3) – During the evening peak, to have 4 lanes (with mixed traffic) operating towards out of Colombo direction, and 2 lanes (mixed traffic) operating towards Colombo as shown in Figure 7.

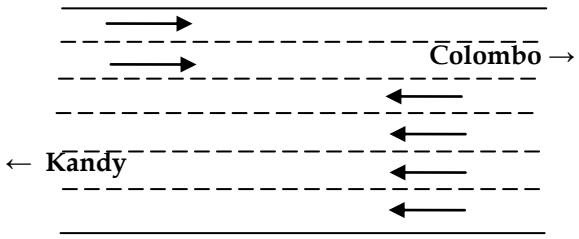

Figure 7 – Lane Operation Option (3)

Option (4) - During the evening peak, to have 3 lanes (with mixed traffic) and another lane exclusively for buses for traffic going out of Colombo, and 2 lanes (with mixed traffic) for Colombo bound traffic as shown in Figure 8.

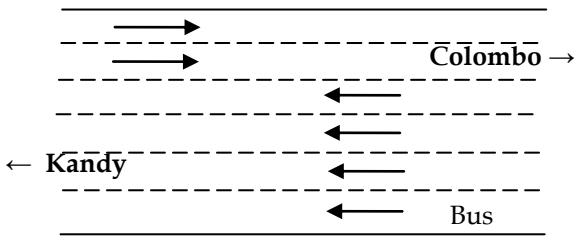

Figure 8 – Lane Operation Option (4)

Davidson's model was applied to compute the benefits or losses of saving on travel time, and then the best options were selected. Computation is summarised in Tables 4 & 5 respectively for morning and evening peak flows.

Table 4 – Application of Davidson's Model for Two Directional Traffic in the Morning Peak

To Colombo Direction (PHF 7:00AM to 8:00AM) ---------->

	Existing		Option (1)		Option (2)		
	Mixed ----> ----> ---->	Mixed <---- <---- <----	Mixed ----> ----> ----> ---->	Mixed <---- <----	Bus ---->	Mixed ----> ---->	Mixed <---- <----
vph	3050	1150	3050	1150	350	2700	1150
(Bus/hr)	350	220	350	220	350	-	220
pcu	3615	1550	3615	1550	700	2910	1550
Lanes	3	3	4	2	1	3	2
q	1205	517	904	775	700	970	775
s	2000	2000	2000	2000	2000	2000	2000
y = q / s	0.603	0.259	0.452	0.388	0.350	0.485	0.388
j	0.5	0.5	0.5	0.5	0.5	0.5	0.5
T	2	2	2	2	2	2	2
t = travel time	3.516	2.349	2.825	2.633	2.538	2.942	2.633
Occupancy - M	3.25	3.25	3.25	3.25	50	3.25	3.25
Occupancy - B	50	50	50	50			50
Persons	26275	14022.5	26275	14022.5	17500	8775	14022.5
Passenger minutes	92375.63	32933.49	74222.08	36916.38	44423.08	25813.83	36916.38
Benefit / Loss	-	-	18153.55 B	-3982.89 L	22138.72 B		-3982.89 L
Net Benefit / Loss			14170.66		18155.83		

Table 5 – Application of Davidson's Model for Two Directional Traffic in the Evening Peak

To Kandy Direction (PHF 7:00AM to 8:00PM) <----------

	Existing		Option (3)		Option (4)		
	Mixed ----> ----> ---->	Mixed <---- <---- <----	Mixed ----> ---->	Mixed <---- <---- <---- <----	Mixed ----> ---->	Mixed <---- <----	Bus <----
vph	1300	2650	1300	2650	1300	2310	340
(Bus/hr)	225	340	225	340	225	-	340
pcu	1690	3330	1690	3330	1690	2650	680
Lanes	3	3	2	4	2	3	1
q	565	1110	845	835	845	885	680
s	2000	2000	2000	2000	2000	2000	2000
y = q / s	0.283	0.555	0.423	0.418	0.423	0.443	0.340
j	0.5	0.5	0.5	0.5	0.5	0.5	0.5
T	2	2	2	2	2	2	2
t = travel time	2.394	3.247	2.732	2.717	2.732	2.794	2.515
Occupancy - M	3.25	3.25	3.25	3.25	3.25	3.25	50
Occupancy - B	50	50	50	50	50		
Persons	14744	24508	14744	24508	14744	7507.5	17000
Passenger minutes	35292.53	79580.53	40274.05	66580.46	40274.05	20973.87	42757.58
Benefit / Loss	-	-	-4981.52 L	13000.07 B	-4981.52 L	15849.09 B	
Net Benefit / Loss			8018.55		10867.57		

5. Findings of the Study

From Table 4 it could be seen that the introduction of a new mixed lane towards Colombo during the morning peak will have a net reduction in travel time by 14,170 passenger minutes during the peak hour. If one of the in-bound lanes is designated to buses only, there will be a reduction in travel time by 18,155 passenger minutes. Hence converting a lane towards Colombo direction is advantageous, and if this lane is designated to buses only the advantage is higher.

Similarly from Table 5 it could be seen that the introduction of a new mixed lane for vehicles travelling out of Colombo in the evening peak will have a net reduction in travel time by 8,018 passenger minutes during the peak hour. If one of the out-bound lanes is designated to buses only, there will be a reduction in travel time by 10,867 passenger minutes.

It was found that introduction of a reversible lane (mix or buses only) towards Colombo bound traffic was advantageous from 6:00AM to 9:00AM, since during this period Colombo bound traffic volume increases above 2000 vph (see Figure 3). Therefore, a 4th lane towards Colombo during this period is found to be beneficial to the system. Similarly, introduction of a 4th lane for out-bound traffic which is above 2000 vph from 5:30PM to 8:30PM (see Figure 3) is also beneficial.

6. Conclusions

From options (1) & (3), it is observed that benefits can be obtained by introduction of reversible lanes during morning and evening peaks for mixed traffic, to enhance the road efficiency during peak flows.

From options (2) & (4) results it is clear that introduction of designated lanes 'only for buses' will further improve the overall efficiency of the system. If 'buses only' lanes are introduced it is of the utmost importance to reserve these lanes only for buses as expected. To obtain the maximum benefits it should be ensured that buses will not enter the mixed traffic lanes. If this enforcement is neglected it can end up as a failure as shown in [6].

When implementing the reversible flow lanes, careful attention should be paid to the intersection at the turn-off to Biyagama road, and also to the terminal at New Kelani Bridge roundabout to ensure smooth flow of traffic at these critical points.

If the proposed scheme is implemented, one operational advantage is that, since this road stretch is located adjoining the Peliyagoda Police Station, strict implementation is possible with close supervision from the Peliyagoda traffic police division.

It is important that when flow direction is changed in reversible flow lanes, to pay the utmost care by the implementers towards the safety of the drivers during the transition. It is also important that strict lane discipline be maintained by all drivers for obtaining maximum benefits while ensuring safety of all the road users.

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